Ariketa fisikoaren eragina adineko pertsonen hauskortasunari lotutako parametroetan

Effects of physical exercise on frailty-related parameters in older adults

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FISIOLOGIA SAILA

ESKER ONAK

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AURKIBIDEA

LABURPENA

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Aurrekari nagusiak eta helburuak. Ikerketa gutxi daude zaurgarriak diren hirugarren adineko pertsonetan, zehazki hirugarren adineko egoitzetako pertsonetan eta minbizia dutenetan, ariketa/jarduera fisikoak hauskortasunari eta gaitasun funtzionalaren galerari aurre egiteko duen eraginkortasuna aztertu dutenak. Horregatik, Tesi honek barne hartzen dituen bi proiektuetako helburuak hauek dira:

1) Norbanakoan oinarrituriko eta intentsitate moderatuan buruturiko ariketa fisikoko programa progresibo eta gainbegiratu baten eragina aztertzea hirugarren adineko egoitzetako pertsonen hauskortasunari lotutako parametroetan eta ondorio kaltegarrietan.

2) Norbanakoan oinarrituriko eta telefono bitartez helarazitako gomendioetan oinarrituriko jarduera fisikoko programa batek minbizia duten hirugarren adineko pertsonek izan ohi duten gaitasun funtzionalaren galera ekiditeko eraginkorra den aztertzea.

Metodologia. Tesi honek barne hartzen dituen bi proiektuak ausazko entsegu klinikoak izan dira. Parte hartzaile guztiak zoriz bi taldetan banatu ziren: kontrol taldea eta talde esperimentala.

1) Lehenengo proiektuan hirugarren adineko egoitzetako 112 pertsonek parte hartu zuten, hurrengo irizpideak betetzen zituztenak: ≥ 70 urte, ≥ 50 puntu Barthel eskalan, ≥ 20 puntu MEC-35 eskalan eta bakarrik aulkitik altxa eta 10 metro ibiltzeko gai zirenak. Kontrol taldeko parte hartzaileek hirugarren adineko egoitzetan ohikoak diren jarduerak burutu zituzten. Talde esperimentaleko parte hartzaileek 6 hilabetetan zehar norbanakoari egokitutako ariketa fisikoko programa gainbegiratu eta progresibo bat burutu zuen intentsitate moderatuan. Aztertu ditugun aldagaien artean gorputz osaera, egoera fisikoa, jarduera fisikoa burutzeko ohitura, funtzio kognitiboa, afektibitate-egoera, biomarkatzaileak, hauskortasuna eta ondorio kaltegarriak izan dira.

2) Bigarren ikerketa proiektu honetan 70 urte edo gehiagoko eta minbizia zuten eta sendatzeko pronostikoa zuten 300 pertsonak parte hartu zuten. Kontrol

taldeak jarduera fisikoko gomendio orokorrak azaltzen dituen liburuxka bat jaso zuen. Talde esperimentalak urtebetez jarduera fisikoko programa bat burutu zuen, telefono bitartez helarazitako gomendioen bitartez burutu zena. Aztertu dugun aldagai nagusia, urte batean Short Physical Performance Battery (SPPB) testeko puntuazioan puntu bat edo gehiago okertu duten parte hartzaile zenbatekoa izan da. Gainera, egoera fisikoa, funtzio kognitiboa eta ondorio kaltegarriak ere aztertu dira. Neurketak minbiziaren tratamendua hasi aurretik eta 3, 6, 12, 18 eta 24 hilabeteren ondoren burutu ziren.

Emaitzak.

1) Hirugarren adineko egoitzetako pertsonen indarra eta ohiko jarduera fisikoa, hitzezko memoria eta bizi-kalitate hobearekin eta depresioa izateko arrisku baxuagoarekin lotuta dagoela frogatu dugu. Ariketa fisikoko programak ezberdintasun adierazgarriak eragin ditu, talde esperimentalaren alde, indarra, oreka, ibilera abiadura eta gaitasun aerobikoan. Emaitzak berdinak izan dira kognizio orokorra (Montreal kognizio azterketa) eta informazioa prozesatzeko abiadurari (ikurren bilaketa testa) dagokienez. Gainera, interbentzio taldeak bakardade pertzepzioa murriztu zuen 6 hilabeteren ondoren. Serum-eko miostatina kontzentrazio altuagoak behatu dira gihar-masaren ehuneko altuagoa, gantz-masaren ehuneko baxuagoa, gaitasun fisiko hobea, hauskortasun maila baxuagoa eta jarduera fisiko gehiago burutzen zuten pertsonetan. Gainera, ariketa fisikoko programak eragin dituen onura fisikoak serum-eko miostatina kontzentrazioan behatu dugun igoerarekin lotuta daudela behatu dugu. Bestetik, ariketa fisikoko programa eraginkorra izan da hauskortasuna, erorketak eta heriotza kopurua murrizteko.

2) Urte baten ondoren, kontrol taldeko parte hartzaileen %14,0k eta interbentzio taldeko %18,7k SPPB-n puntu bat edo gehiago okertu zuten. Bi urteren ondoren, ez ziren ezberdintasun adierazgarririk behatu SPPB, ibilera abiadura, ohiko jarduera fisikoa eta hitz-jarioan. Bi urtetara azpi-taldeetako emaitzak aztertzerakoan, bularreko minbizia zutenen kontrol taldeko parte hartzaileen %29,8k eta interbentzio taldeko %5,0k SPPB-n puntu bat edo gehiago okertu zutela behatu genuen, eta emakumeetan kontrol taldeko %21,7k eta

interbentzio taldeko %6,2k. Erorketak, ospitalizazioak, instituzionalizatuak eta heriotza kopuruak berdintsuak izan ziren bi taldeetan.

Ondorioak.

1) Hirugarren adineko egoitzetako pertsonen ohiko jarduera fisikoa eta egoera fisikoa, hitzezko memoria, bizi-kalitatea eta depresioarekin lotuta daudela behatu dugu. Miostatina kontzentrazio altuagoak behatu ditugu egoera fisiko hobea duten hirugarren adineko pertsonetan. Bestetik, norbanakoari egokitutako eta intentsitate moderatuan buruturiko ariketa fisikoko programa gainbegiratuak eraginkorra dirudi hirugarren adineko egoitzetako pertsonen egoera fisikoa, funtzio kognitiboa eta afektibitate-egoera hobetu edo mantentzeko, eta hauskortasuna eta ondorio kaltegarriak murrizteko.

2) Telefonoz helarazi diren eta norbanakoan oinarrituriko jarduera fisikoko gomendioek ez dute gaitasun funtzionalaren galera murriztu urte batera, baina ezberdintasun adierazgarriak lortu dira talde esperimentalaren alde emakumeetan eta bularreko minbizia zuten azpi-taldeetan bi urteren ondoren. Beraz, emaitza hauek minbizia duten hirugarren adineko pertsonetan norbanakoan oinarritu diren eta telefonoz helarazi diren jarduera fisikoko gomendioek duten garrantzia azpimarratzen dute. Etorkizunean burutuko diren ikerketek gainbegiratutako saio birtualen eragina aztertu beharko lukete.

ABSTRACT

Background and objectives. Few studies have focused on the capacity of physical exercise/activity interventions to tackle frailty and functional decline among especially vulnerable populations such as long-term nursing home (LTNH) residents and older adults with cancer. In consequence, the objectives of the two projects included in this Thesis are listed below:

1) To determine the effect of a supervised, individualized and progressive multicomponent exercise intervention at moderate intensity on the attenuation of frailty-related parameters and adverse outcomes in LTNH residents.

2) To determine the effect of an individualized phone physical activity advices on the prevention of functional decline in older adults with cancer.

Methods. The two projects included in this Thesis were randomized controlled trials. Participants were randomly assigned to either the control group or the intervention group.

1) First project included 112 LTNH residents who met the following criteria: aged ≥ 70 years, scored ≥ 50 on the Barthel Index, scored ≥ 20 on MEC-35 Test and who were all capable to stand up and walk independently for at least 10 meters. Subjects in the control group participated in routine activities that LTNHs usually offered to residents. The intervention group performed a 6-month supervised and progressive multicomponent physical exercise intervention at moderate intensity. Assessment included body composition, physical fitness, habitual physical activity, cognitive and affective functions, biological markers, frailty and related adverse events.

2) Second project included 300 participants who aged ≥ 70 years with cancer requiring curative treatment. The control group received a booklet that provides the current national recommendations for physical activity. The intervention group received individualized phone physical activity advices for 12 months. The primary outcome was the proportion of subjects with a one-year decreased Short Physical Performance Battery (SPPB) score of one point or more. Physical, cognitive and clinical secondary outcomes were also investigated.

Participants were assessed immediately before the cancer treatment and at 3, 6, 12, 18 and 24 months.

Results.

1) Muscle strength and physical activity were associated with better verbal memory, better quality of life and lower risk of depression in older adults living in LTNHs. A significant group by time interaction in favor of the intervention group was observed after the intervention for strength, balance, gait speed and endurance. The same effect has been observed for Montreal Cognitive Assessment (global cognition) and symbol search (processing speed) tests. In addition, loneliness perception was significantly reduced in the intervention group after the 6-month period. We found higher serum levels of myostatin in leaner, fitter, more active and non-frail LTNH residents. Additionally, the exercise program increased the myostatin concentration in men, and improvements in physical fitness after the intervention were positively related to increases in myostatin concentration. Moreover, the physical exercise program was effective to reduce frailty, the number of falls and mortality.

2) After one year, 14.0% of participants in the control group and 18.7% in the intervention group had a decrease in SPPB score of one point or more. At two years, there was no difference in SPPB, gait speed, habitual physical activity and verbal fluency. Subgroup analyses after two years showed a decline in SPPB for 29.8% of control group and 5.0% of intervention group breast cancer participants and in 21.7% of control group and 6.2% of intervention group female participants. Falls, hospitalization, institutionalization and death rates were similar in both groups.

Conclusions.

1) Physical activity and fitness are associated with verbal memory, quality of life and depression among older adults living in LTNHs. Higher serum levels of myostatin are associated with better physical fitness in LTNH residents. The individually adjusted, progressive and supervised multicomponent exercise programs at moderate intensity seem to be effective to improve or maintain

physical, cognitive and affective functions and to reduce frailty and related adverse events in older adults living in LTNHs.

2) Personalized phoned physical activity advice had not reduced functional decline at one year but significant group by time interaction in favor of the intervention group was observed at two years in women and those with breast cancer. Thus, these results highlight the potential for providing efficient personalized physical activity advice over the phone in older adults with cancer. Future work should focus on analyzing the effects of digital virtual supervised training.

LABURDURAK

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ACT: arm-curl test

AD: Alzheimer's disease

ADL: activities of daily living

ANOVA: analysis of variance

ANZCTR: Australian and New Zealand clinical trials registry

BDNF: brain-derived neurotrophic factor

BMI: body mass index

BST: back scratch test

CAPADOGE: conseils en activité physique pour la prévention de la perte d'autonomie des patients d'onco-geriatrie

CG: control group

CIRS-G: cumulative index rating scale–geriatric

CONSORT: consolidated standards of reporting trials

CPM: counts per minute

CRP: c-reactive protein

CSRT: chair sit-and-reach test

CST: 30-s chair-stand test

CV: co-efficient of variability

DJGLS: De Jong-Gierveld loneliness scale

DXA: dual energy x-ray absorptiometry

ECOG: eastern cooperative oncology group

ELISA: enzyme-linked immunosorbent assay

ES: effect size

FFP: Fried's frailty phenotype

HC: hip circumference

IG: intervention group

IL-6: interleukin 6

INE: instituto nacional de estadística

IPAQ: international physical activity questionnaire

IQR: interquartile range

ISAK: international society for the advancement of kinanthropometry

LPA: light physical activity

LT: long-term

LTNH: long-term nursing home

MEC: mini examen cognoscitivo

MMSE: mini mental state examination

MNA: mini nutritional assessment

MOCA: Montreal cognitive assessment

MPE: multicomponent physical exercise

MVPA: moderate to vigorous physical activity

NH: nursing home

PNNS: programme national nutrition santé

PTS: points

QOL: quality of life

RAVLT: rey auditory-verbal learning test

REP: repetitions

RM: repetition maximum

SD: standard deviation

SEE: standard error of the estimation

SFT: senior fitness test

SOF: study of osteoporotic fractures frailty

SPPB: short physical performance battery

TFI: Tilburg frailty indicator

TL: total learning

TMT-A: trail making test a

TNF-α: tumor necrosis factor alpha

TUG: timed up and go

UCG: usual care group

WAIS-IV: Wechsler adult intelligence scale, fourth edition

WC: waist circumference

WHO: World Health Organization

WHR: waist-to-hip ratio

6MWT: six minute walking test

8-FT TUGT: 8-ft timed up-and-go test

1. AURREKARI NAGUSIAK

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1.1. Biztanleriaren zahartzea eta gizartean duen eragina

Biztanleriaren zahartzea mundu osoan gertatzen ari den fenomeno bat da. Bizi-itxaropena igotzen ari denez, hirugarren adineko pertsonak gero eta gehiago dira (Scully, 2012). 2050. urterako, bizi-itxaropenaren luzapena eta jaiotza-tasaren murrizketaren ondorioz, 60 urtetik gorako biztanleria gaur egungoaren bikoitza izango dela iragarri da, biztanleria osoaren %11tik %22-ra pasatuz (WHO, 2007).

Euskadin bizi-itxaropena oso altua da Europako beste herrialdeekin alderatuz gero; Europako altuena emakumeetan (86,2 urte) eta bigarren altuena Italiarekin batera gizonetan, Suediaren atzetik (80,3 urte) (Eustat, 2018a). Bestetik, Euskadiko jaiotza-tasa Europako baxuenetarikoa da; Euskadin 1000 biztanleko 8,7 jaiotza izan ziren 2015ean, eta Europako bataz bestekoa 10,0 jaiotza dira 1000 biztanleko (Eustat, 2018b). Hau guztia dela eta, adinaren piramidea guztiz aldatuko dela aurreikusi da. Izan ere, 2000. urtean 65 urtetik gorakoak biztanleria osoaren %17,2a baziren, 2018an %22,1 dira eta 2030ean %27,6a izango direla iragarri da (Eustat, 2018c). Sexuen arteko banaketa orekatzen joango da, nahiz eta oraindik hirugarren adineko pertsonetan gehiengoak emakumeak izaten jarraitu; 2018an 65 urtetik gorako biztanlerian %57,5 emakumeak izatetik 2030ean %56,4 izatera pasako dira, eta 85 urte edo gehiago dituztenetan %68,4a izatetik %64,9a izatera (Eustat, 2018c).

Orohar, osasun gastua pertsonako areagotzen doa zahartzen goazen heinean, nahiz eta adinaren eta osasun gastuen arteko lotura lineala ez izan eta badirudien, bizitzako azken urteetan osasun gastuak murriztu egin ohi direla (INE, 2018). Hala ere, gero eta hirugarren adineko pertsona gehiago dagoenez, osasun-laguntzaren eskaera eta hauek eragindako gastua esponentzialki igoko dela aurreikusi da (Carone, 2005).

Biztanleriaren zahartzea osasun publikoaren politika zein garapen sozioekonomikoaren arrakastaren ondorio dira, baina aldi berean beste errealitate bat sortu du, eta gaur egungo gizartearen erronka nagusienetariko bat bilakatu da (The, 2017). Biztanleriaren banaketa berriak desoreka nabarmenak eragingo ditu osasun eta gizarte arreta sisteman eta zalantzan jarri dezake herrialde garatuen sostengua (The, 2017). Egoera berri honi aurre egiteko beraz, gizarteak prest egon beharko du, hirugarren adineko pertsonen osasuna eta gaitasun funtzional egokia mantentzeko interbentzioak bideratuz, eta parte hartze soziala eta segurtasuna bermatuz.

Biztanleriaren zahartzeak beraz zientzia zein politika sozial eta ekonomikoaren egokitzea eskatzen du. Gizarte aurreratuetako herrialdeetan administrazio publikoek bultzatutako politika publikoak eta ikerketa, garapen eta berrikuntza estrategiek lehentasuna ematen ari diote zahartze-prozesuaren ikerketari. Europar eremuan, zahartzaroaren alorra ikerketarako lehentasuna da, European Innovation Partnership for Active and Healthy Ageing edo Ikerketa eta Berrikuntzarako 2014-2020 Programa Markoa (Horizon 2020) bezalako ekimenek erakusten duten bezala (Rodríguez-Rodríguez V, Rodríguez-Mañas L, Sancho-Castiello M & Díaz-Martín R, 2012). Estrategia hauek logikoki, eragin zuzena dute Espainiar estatuan zein Euskadin ezarri diren estrategia berrietan (Gobierno de España, 2013; Eustat, 2014).

Biztanleriaren bizi-itxaropena luzatzearen ondorioz, gaur egungo gizarteari zahartze-prozesuarekin lotutako komorbilitate kronikoei, mendekotasunari, desgaitasunari, bakardeari… aurre egitea egokitzen zaio. Euskadiko Osasun Inkestak jaso zituen emaitzen arabera, desgaitasunik gabeko bizi-itxaropena mantendu egin zen gizonetan 2007tik 2013ra bitartean, eta jaitsi egin zen emakumeetan (Eustat, 2014). Horrez gain, desgaitasunarekin bizitako urteak areagotu egin ziren bai gizon zein emakumeetan (Eustat, 2014). Hortaz, biztanleriaren bizi-itxaropenaren areagotzea ez dator beti bat bizi-kalitate hobearekin (Kress & Herridge, 2012).

Estrategiak bideratzerako orduan beraz, ezinbestekoa da ea pertsonak bizitza luze eta osasuntsuagoak bizitzen ari diren kontuan izatea, edota luzatzen ari garen urte horiek orohar osasun-egoera txarrean bizitzen dituzten jakitea. Bizi-itxaropenaren areagotzea osasun onarekin lotuta badator, biztanleria aktiboagoa izatea lortuko dugu. Baina hirugarren adineko pertsonak denbora gehiagoz bizitzen badira, muga funtzionalak zein desgaitasuna izanda, osasun-laguntza zein sozialen eskakizunak nabarmenki areagotuko dira, eta adinduek egingo dituzten ekarpen sozialak ere mugatuak izango dira.

Hau guztiagatik, zenbait ikertzailek azpimarratu dutenez, hirugarren adineko pertsonen osasuna aztertzerako orduan, ez dira gaixotasunak bakarrik kontuan hartu beharko, baizik eta gaitasun funtzionala eta eguneroko bizitzako jarduerak burutzeko gaitasuna ere baloratzea gomendatzen da (Volpato et al., 2010; Pavasini et al., 2016).

Osasun-langileak ondorio kaltegarriak izateko arrisku altua duten adineko pertsonak antzematen saiatzen ari dira, ondoren asistentzia geriatrikoa modu eraginkorragoan aurrera eramateko. Jakina da ere, arrisku altua duten adineko pertsonak antzematerako orduan, ezin dela pertsonak duen adina edo morbilitatean bakarrik oinarritu, nahiz eta gaixotasun bera izan, pertsona batetik bestera zahartze-prozesuaren abiadura oso ezberdina izan daitekeelako gaitasun funtzionala, pronostiko eta ondorio kaltegarriak izateko arriskuaren arabera (Keeler, Guralnik, Tian, Wallace & Reuben, 2010).

Desgaitasunak bizi-kalitatea okertzen du eta ospitalizazioak zein heriotza gertatzeko aukera handitzen du, osasun gastuak igoz (Keeler et al., 2010). Desgaitasuna dela eta, adinduek eguneroko jarduerak burutzeko laguntza behar izaten dute eta horregatik askotan, hirugarren adineko egoitzetara bizitzera joan behar izaten dute. Gaur egun gero eta adindu gehiago daude hirugarren adineko egoitzetara joateko beharra dutenak, osasun zein arreta sozialen eskakizunak igo dira, eta farmazietako gastu publikoa eta laguntza teknikoen beharra areagotu egin dira. Desgaitasuna da hortaz, arazorik nagusienetariko bat, eta prebentzio interbentzioen bitartez, ekidin beharko litzatekeen egoera.

Osasunaren Mundu Erakundeak 2012an txosten bat argitaratu zuen, herrialde aurreratuetan hirugarren adinekoen osasuna mantentzeko eman beharreko pausoak zehazteko helburuarekin (WHO, 2012). Bestetik, Osasunaren Mundu Erakundeak 2015ean zahartzearen eta osasunaren inguruan argitaratutako beste txosten batean lehenengo kapituluak zera dio: “urteei osasuna gehitu” (WHO, 2015). Geriatriako beste zenbait espezialistek diotenez ere, gaur egun arte bizitza urtez betetzen saiatu gara, eta iada iritsi da ordua urteak bizitzaz betetzen hasteko. Bizi-itxaropena hortaz, areagotu egin da, baina gaur egungo erronka desgaitasunik gabe bizitzea da (Crimmins & Beltrán-Sánchez, 2011).

1.2. <u>Zahartze-prozesua</u>

Azkeen hamarkadetan gizakien adin maximoa ez da mugitu (115-120 urte gutxi gorabehera), eta beraz esan daiteke lortutako aurrerapen zientifiko zein medikoak ez direla gai izan biziraupen maximoa luzatzeko (Dong, Milholland & Vijg, 2016). Hala ere, gaur egun gero eta hirugarren adineko pertsona gehiago dago. Horregatik esan daitekeena da, areagotu dena bizi-itxaropena dela, baina ez gizakion biziraupen maximoa (Dong et al., 2016).

Zahartze-prozesuan gaitasun fisiko zein kognitiboen gainbehera dinamikoa eta progresiboa gertatzen da, eguneroko bizitzako jarduerak burutzeko zailtasunak eragiten dituen gaitasun funtzionalaren galera dakarrena (Rodríguez-López, Montero, Carmenate & Avendano, 2014; Blazer, Yaffe & Karlawish, 2015). Orohar zahartzea endekapen-prozesu bat da, non gertatzen diren aldaketa fisiologikoen ondorioz, gaitasun funtzionalaren eta inguruneko eskakizunetara egokitzeko gaitasunaren galera gertatzen den, pertsona ahulago bilakatuz (Rodríguez-López et al., 2014).

Gaitasun fisikoen endekapenari dagokionez, zahartze-prozesuan zehar orohar indarra, oreka eta gaitasun aerobikoa galtzen dira, ibiltzeko eta altxatzeko gaitasunak okertuz (Goodpaster et al., 2006; Reid, Naumova, Carabello, Phillips & Fielding, 2008; Sturnieks, St George & Lord, 2008; Milanović et al., 2013). Galera hauen ondorioz, ahulagoak bilakatu eta erorketak izateko arriskua handitzeaz gain, eguneroko bizitzako jarduerak burutzeko zailtasunak areagotzen dira (Delbaere, Crombez, Vanderstraeten, Willems & Cambier, 2004).

Arlo kognitiboari dagokionez, orohar galera dinamikoa eta progresiboa izan ohi bada ere, oso aldakorra izan daiteke, eta zenbait funtzio galtzen diren arren, beste zenbait mantendu edota hobetzen direla frogatu da (Blazer et al., 2015). Zahartzen ari garen heinean adibidez, oroimena eta erreakzio denbora galtzen direla behatu da (Blazer et al., 2015). Aldiz adimena eta jakituria funtzioak zahartzen goazen heinean mantendu edota hobetu daitezkeela frogatu da (Blazer et al., 2015). Hala ere, maiz gertatzen diren aldaketa hauen ondorioz, mendekotasuna areagotu eta bizi-kalitatea okertzen direla frogatu da (Blazer et al., 2015).

1.3. Hirugarren adineko egoitzak

Mendekotasuna izango duten hirugarren adineko pertsonen zenbatekoa areagotu egingo dela aurreikusi da, eta munduan 350 milioi pertsona izatetik (2010ean), 488 milioi izatera (2030ean) pasako gara (Prince, Prina & Guerchet, 2013). Eguneroko bizitzako jarduerak burutzeko desgaitasunaren ondorioz, hirugarren adineko pertsona asko egoitzetara bizitzera joan behar izaten dira eta beraz, mendekotasuna duten pertsona kopurua areagotzeak, hirugarren adineko egoitzetan eragin zuzena izango duela aurreikusi da (Hagen, 2013).

Zenbait ikertzailek aditzera eman dutenez, egoitzetan aurrera eramaten ari diren ekimenen helburu nagusia egoiliarren arreta kalitatea hobetzea da (Wiener, 2003; Castle & Ferguson, 2010). Arlo fisikoa zein soziala lantzeko jardueren gabezia da erakundeen kezka nagusietariko bat (Ice, 2002; Den Ouden et al., 2015). Beraz, hirugarren adineko egoitzetan bizi direnetan arlo fisiko, kognitibo eta sozialen arteko loturen azterketa garrantzitsua izan daiteke praktika klinikoak bideratu eta egoitzetako arreta hobetzen saiatzeko.

Egoitzetan bizi diren hirugarren adineko pertsonak adinduak, multimorbilitate, narriadura fisiko zein funtzional eta depresio kasu ugari izateaz gain, jarduera fisiko gutxi burutu ohi dute (Jones, Dwyer, Bercovitz & Strahan, 2009). Jarrera sedentarioak osasunean dituen eragin negatiboak jakinak dira: gaixotasun kardiobaskularrak, sindrome metabolikoa, obesitatea… (Shiroma, Freedson, Trost & Lee, 2013; De Rezende, Rey-López, Matsudo & Do Carmo Luiz, 2014). Gainera, zenbait ikerketetan jarrera sedentarioaren eta galera funtzionalaren arteko lotura frogatu da hirugarren adineko pertsonetan (Davis et al., 2014; Dunlop et al., 2015; Rosenberg et al., 2015). Hala ere, hirugarren adineko egoitzetako egoiliarrak egunean zehar orohar jarduera sedentarioak burutu ohi dituzte. Bates-Jensen eta lankideek (2004), 15 hirugarren adineko egoitzetako 451 egoiliarrekin bururutiko ikerketa batean frogatu zuten gehienak 17 ordu edo gehiago ohean egon ohi zirela.

1.4. Hauskortasuna

Hauskortasuna sistema fisiologikoetan gertatzen diren aldaketen ondorioz erreserba funtzionalen eta egokitzeko gaitasunaren urritasuna eragiten duen sindromea da, eta zenbait urteetan zehar luzatu daiteke (Rodríguez-Mañas et al., 2012; Rodríguez-Mañas & Fried, 2015). Sindrome hau oso ohikoa da hirugarren adineko pertsonetan, eta zahartzen ari garen heinean are eta ohikoagoa (Garcia-Garcia et al., 2011). Adibide gisa, orain dela urte gutxi batzuk argitaratu zen errebisio eta meta-analisi batean hirugarren adineko egoitzetan burututako ikerketak aztertu zituena, hauskortasun tasa %50etik gorakoa zela adierazi zuten (Kojima, 2015). Horregatik, gero eta ikerketa gehiago daude hirugarren adineko pertsonei zuzenduta, ondorio kaltegarriak eta desgaitasuna iragartzeko, komorbilitate edo multimorbilitatea neurtzeaz gain, hauskortasunaren neurketa gomendatzen dutenak (Abizanda et al., 2014; Esbrí-Víctor et al., 2017). Gainera aditzera eman dute hauskortasuna, desgaitasuna eta komorbilitatea zenbait kasutan lotuta daudela, baina beste zenbait kasutan balitekeena dela adindu hauskorrek ez desgaitasunik eta ez komorbilitaterik izatea (Alcalá et al., 2010).

Hau guztiagatik, hauskortasuna gaur egungo kezka nagusienetariko bat da; gaur egun dagoen adineko pertsona hauskor ugari izateagatik (Santos-Eggimann, Cuénoud, Spagnoli & Junod, 2009; Collard, Boter, Schoevers & Voshaar, 2012; Rodríguez-Mañas & Fried, 2015), eta mendekotasuna, erorketa, narriadura kognitiboa, infekzio, ospitalizazio, desgaitasuna, instituzionalizazioa eta heriotza izateko arrisku altuagoarekin frogatu den loturagatik (Rodríguez-Mañas et al., 2012; Cesari et al., 2016; Sacha, Sacha, Soboń, Borysiuk & Feusette, 2017; Trevisan et al., 2017). Ondorioz, hauskortasuna osasun publikoaren lehentasun nagusienetariko bat da gaur egun, eta osasun eta laguntza sozialen baliabideen garapenerako erronka garrantzitsu bat izango da (Cesari et al., 2016).

Nahiz eta hauskortasun hitza oso zabaldua egon, interpretazioa erraza dirudien eta urtean 2000 artikulutik gora argitaratzen diren gai honen inguruan, gaur egun ez dago hauskortasunaren esanahi bateraturik, eta ondorioz, ez dago hauskortasuna modu azkar eta erraz batean antzemateko tresnarik ere (Rodríguez-Mañas et al., 2012; Morley et al., 2013; Cardoso et al., 2018). Horregatik, eta nahiz eta orain dela zenbait urtetatik hainbat diren ikertzaileak hauskortasunaren inguruan lan egin dutenak, hauskortasunaren antzematea eta tratamendua eremu kliniko zein sozialean oso urria da. Hainbat dira geriatrian espezializatuta dauden egoitzetan eginiko ikerketak, baina ingurune horiez gain hauskortasunaren erabilera oso urria da. Erabiltzeko izaten ari den oztopo nagusia da ez dagoela erreminta bakar bat hauskortasuna modu eraginkor eta erraz batean antzeman eta mailakatzeko.

Gaur egungo esanahietan ez dago garbi ea hauskortasunak arlo fisikoa, funtzionala, kognitiboa, soziala edo aipatutako guztien arteko konbinazioa izan beharko lukeen (Rodríguez-Mañas et al., 2012; Morley et al., 2013). Adostasun gabezi hau dela eta, hauskorrak diren adinduak antzematerako orduan, aldagarritasun nabaria azaldu dute orain arte egin diren ikerketek (Kojima, 2015). Erabilitako irizpideak ere oso ezberdinak izan dira: gaitasun funtzionala, ibilera abiadura, egoera kognitiboa, pisu galera, jarduera fisikoa….

1.4.1. Hauskortasuna antzemateko tresnak

1.4.1.1. Proba fisikoak, kognitiboak eta sozialak

Hauskortasuna antzemateko hainbat eskala proposatu dira (Bouillon et al., 2013). Zenbait ikertzaile bakarrik arlo fisikoan oinarritu dira: Fried-en hauskortasun irizpidea (Fried et al., 2001), Short Physical Performance Battery (SPPB) (Guralnik et al., 2000), osteoporosi hausturen ikerketako hauskortasun indizea (Ensrud et al., 2008), hauskortasun eskala klinikoa (Rockwood et al., 2005)... Hala ere, gero eta ikerketa gehiago dago gaitasun fisiko zein kognitiboak hauskortasun zein narriadura kognitiboarekin lotzen dituztenak (Robertson, Savva & Kenny, 2013).

Hauskortasuna izateak narriadura kognitiboa eta dementzia izateko aukera areagotzen duela ondorioztatu da (Buchman, Boyle, Wilson, Tang & Bennett, 2007). Horregatik, hauskortasunaren eta narriadura kognitiboaren elkarrekintza, zahartze-prozesuarekin lotuta dijoala esan daiteke. Narriadura kognitiborik gabeko hirugarren adineko pertsonetan, 12 urteren ondoren berriz baloratzerako orduan, hauskortasuna narriadura kognitiboa izateko arrisku altuagoarekin lotuta dagoela ondorioztatu zuten (Boyle, Buchman, Wilson, Leurgans & Bennett, 2010). Aipaturiko ikerketa honetan, hauskortasun mailaren areagotzea narriadura kognitiboa zuten pertsona kopuruarekin lotuta zegoela adierazi zuten (Boyle et al., 2010). Gaitasun kognitiboen galerak ahultasun pertzepzioa areagotzen du, eta jarduera fisiko zein sozialen urritzea ere eragiten du, hauskortasunaren garapena areagotuz (Ávila-Funes et al., 2011; Shega et al., 2012). Bestetik, nahiz eta Alzheimer-en gaixotasunaren ezaugarri kliniko nagusia memoria zein beste zenbait gaitasun kognitiboren galera diren, gero eta ikerketa gehiago dago gaixotasun hau duten pertsonek pairatzen dituzten indar zein gorputz-osaeran dituzten aldaketak aztertzen dituztenak (Boyle, Buchman, Wilson, Leurgans & Bennett, 2009; Martín et al., 2018). Horregatik, Alzheimer-en gaixotasuna dutenak hauskorragoak izan daitezkeela ondorioztatu da (Buchman, Schneider, Leurgans & Bennett, 2008). Beste zenbait autorek aipatu zuten indarra, ibilera abiadura zein gorputz-osaeran izaten diren aldaketak dementzia agertu aurretik gerta daitezkeela (Buchman et al., 2005; Buchman, Wilson, Boyle, Bienias & Bennett, 2007; Buracchio, Dodge, Howieson, Wasserman & Kaye, 2010).

Aldagai sozialak ere gaitasun kognitiboarekin (Wetherell, Reynolds, Gatz & Pedersen, 2002; John, Patel, Rusted, Richards & Gaysina, 2018) zein hauskortasun fisikoarekin (Bernal-López, Potvin & Ávila-Funes, 2012; Rizzoli et al., 2013; St. John, Tyas & Montgomery, 2013) lotu dira. Hauskortasuna norbanakoaren bizi-espazioari lotuta dagoela frogatu da (Portegijs, Rantakokko, Viljanen, Sipilä & Rantanen, 2016). Horrez gain, antsietatea (Bernal-López et al., 2012), depresioa (St. John et al., 2013), ongizate subjektiboa (Gale, Cooper, Deary & Sayer, 2014) eta bizi-kalitatea (Mhaoláin et al., 2012; Rizzoli et al., 2013) ere hauskortasunarekin lotuta daudela ere frogatu da. Horregatik, zenbait ikertzailek hauskortasuna neurtzeko arlo fisikoa, psikologikoa eta soziala barne hartzen dituen test bat sortu zuten (Gobbens, Van Assen, Luijkx, Wijnen-Sponselee & Schols, 2010).

Azkeen urteetan, hainbat osasun erakundeetan saiakerak egiten ari dira hauskortasuna neurtzeko testak sistematikoki ohiko praktika bezala osasun sistema nazionalean txertatu ahal izateko.

1.4.1.2. Biomarkatzaileak

Hainbat dira zahartze-prozesuarekin lotura dutela adierazi duten biomarkatzaileak. Hantura (IL-6, TNF-α, CRP…), odol laginen bitartez neurtu ahal diren egoera kardiobaskularra (kolesterola, triglizeridoak…), glukosaren metabolismoa, nutrizio egoera (D bitamina), endokrinologia (hazkuntza-hormona, estrogenoa, testosterona…), adipokinak (adiponektina, leptina…) eta orohar hematologiari lotutako neurketek, gaixotasun kardiobaskularrak, multimorbilitatea, narriadura kognitiboa, hauskortasuna eta heriotza iragartzeko baliogarriak izan daitezkeela behatu da (Wagner, Cameron-Smith, Wessner & Franzke, 2016). Zenbait errebisio sistematiko zein meta-analisiren bitartez aditzera eman da lipidoen profilek morbilitatea eta hilkortasuna iragartzen dutela (Lewington et al., 2007; Briel et al., 2009).

Hauskortasunaren biomarkatzaileen bilaketa prozesua oso interesgarria da, etorkizunean markatzaile biologiko batekin hauskortasuna antzematea lortzen bada, prebentzio zein tratamendu interbentzioak ahalik eta azkarren martxan jartzeko aukera izango delako. Horregatik, zenbait ikertzaile izan dira narriadura fisiologikoan eragiten duten biomarkatzaile espezifikoak zehazten saiatu direnak.

Zenbait markatzaile izan dira, hauskortasunaren biomarkatzaile izateko proposatu direnak, baina gaur egun ez dago adostasunik esparru klinikoan markatzaile hauek duten baliotasuna frogatu duenik. Horregatik, gaur egun esparru klinikoan ez dira oraindik biomarkatzaileak erabiltzen hauskorrak diren pertsonak antzemateko.

1.4.1.2.1. *Miostatina*

Miostatina nagusiki muskulu zuntzetatik jariatzen den proteina bat da, metabolismo muskuloeskeletikoa erregulatzen duena eta masa muskularraren erregulatzaile negatiboa da (Rodgers & Garikipati, 2008). Miostatinak muskuluan proteolisia eragin eta proteinen sintesia ekiditen du. Proteina hau ezagutzera eman zenetik, sarkopeniaren erregulatzaile izateko potentzialaren inguruan interes handia izan da (White & LeBrasseur, 2014). Gainera, miostatina sarkopeniaren biomarkatzaile izateko proposamenak egin dira (Scharf & Heineke, 2012), hauskortasun muskuloeskeletikoaren garapenaren substratu biologikotzat kontsideratu dena (Calvani et al., 2015).

Hala ere, miostatina eta zahartze-prozesua, funtzio fisikoa, muskulu masa eta hauskortasunaren arteko lotura oraindik ez dago guztiz deskribatuta, eta zenbait ikerketek zalantzan jarri dute miostatinaren erabilera sarkopenia diagnostikatu edo tratamenduen erantzuna monitorizatzeko (Peng, Lee, Liu, Lin & Chen, 2018). Horrela, zenbait ikertzailek miostatina kontzentrazio altuagoak aurkitu zituzten hirugarren adineko emakume zein gizonetan (Yarasheski, Bhasin, Sinha-Hikim, Pak-Loduca & Gonzalez-Cadavid, 2002); beste batzuk kontzentrazio baxuagoak aurkitu zituzten hirugarren adineko gizonetan baina ez emakumeetan (Lakshman et al., 2009; Bergen et al., 2015; Schafer et al., 2016). Ildo berean, zenbait ikerketek muskulu masa miostatinarekin alderantziz korrelazionatuta dagoela diote (Yarasheski et al., 2002). Hala ere, berriki argitaratutako ikerketen emaitzek miostatinak gihar masa edo muskulu indarrarekin duen korrelazioa positiboa dela adierazi dute (Bergen et al., 2015; Peng et al., 2018).

Ariketa fisikoak miostatinaren kontzentrazioan duen eragina eztabaidagarria da. Jarduera aerobikoaren bitartez gizon eta emakume helduen miostatinaren mRNAren espresioa edo proteina maila jaisten dela frogatu da (Hittel et al., 2010; Konopka et al., 2010). Hala ere, beste ikerketa batzuek ez dute ariketa fisikoaren bitartez eragindako aldaketarik aurkitu biriketako gaixotasun buxatzaile kronikoa zuten pazienteen miostatina kontzentrazioan (Boeselt et al., 2017).

1.4.1.2.2. *Garunetik eratorritako faktore neurotrofikoa (brain-derived neurotrophic factor, BDNF)*

BDNF, neuronen biziraupena mantentzeaz arduratzeaz gain, hazkuntza eta neuronen eta sinapsien bereiztea eragiten duen proteina da. BDNF, egoera kognitiboan zein afektibitate-egoeran eragiten duen molekularik garrantzitsuenetariko bat da, eta zahartze-prozesuan zehar kontzentrazioa jaisten doala frogatu da (Scaccianoce et al., 2006; Bocchio-Chiavetto et al., 2010; Bekinschtein, Cammarota & Medina, 2014; Leckie et al., 2014; Buchman et al., 2016).

BDNF-k, ariketa fisikoko interbentzio batek funtzio exekutiboan eragiten dituen hobekuntzak erregulatu ditzakeela behatu da (Leckie et al., 2014). Hala ere, ariketa fisikoak BDNF-ren kontzentrazioan duen eragina gaur egun eztabaidagarria da (Erickson et al., 2011; Hvid, Nielsen, Simonsen, Andersen & Caserotti, 2017; Stigger, Zago-Marcolino, Portela & Plentz, 2018). Zenbait ikerketek ariketa fisikoko programa baten ondoren BDNF kontzentrazioaren igoera behatu dute ariketa aerobikoaren ondoren (Leckie et al., 2014; Kohanpour, Peeri & Azarbayjani, 2017). Bestetik, zenbait ikertzailek ez dute inolako aldaketarik somatu BDNF-ren kontzentrazioan ariketa aerobikoaren edo indar ariketen ondoren (Erickson et al., 2011; Forti et al., 2014; Hvid et al., 2017). Zenbait ikertzailek diote BDNF-ren kontzentrazioa igo egin ohi dela ariketa fisikoa burutzerako orduan (Knaepen, Goekint, Heyman & Meeusen, 2010; Ströhle et al., 2010), baina denbora tarte bat pasa ondoren berriz ere jaitsi daitekeela (Forti et al., 2014). Interbentzio luzeetan ariketa fisikoko programek ez dute frogatu BDNF-ren kontzentrazio igoerarik (Baker et al., 2010; Erickson et al., 2011; Ruscheweyh et al., 2011).

Hala ere, nahiz eta BDNF-ren kontzentrazioan aldaketarik ez adierazi, ikerketa hauetan ezin izan zuten frogatu muskuluan (Matthews et al., 2009) edota burmuinean (Rasmussen et al., 2009) izandako aldaketak. Horregatik, odol laginak noiz jaso diren kontuan izatea oso garrantzitsua izan daiteke.

1.4.2. Hauskortasunari aurre egiteko tratamenduak

Zenbait ikertzailek diotenez, hauskortasuna tratatu daitekeen sindrome bat da, eta itzulgarria da lehenengo faseetan, desgaitasuna ez bezala (Cesari et al., 2016). Hau da, hauskorra den adindu bat hauskorra ez izatera pasa daiteke garaiz antzeman eta tratamendu egoki bat martxan jartzen bada (Tarazona-Santabalbina et al., 2016). Hauskortasuna desgaitasunaren aurreko pausoa izan ohi denez, erabakigarria izango da hauskortasun egoeran dauden pertsonen antzemate zein tratamendua, desgaitasuna ekidin edo atzeratzeko (Cesari et al., 2014).

4 dira gaur egun hauskortasunari aurre egiteko eraginkortasuna frogatu duten tratamenduak: 1) ariketa fisikoa 2) kaloria- eta proteina-ekarpena 3) D bitamina 4) polifarmaziaren murrizketa.

1.5. Ariketa fisikoaren eragina hirugarren adineko pertsonetan

Osasunaren Mundu Erakundeak ekintza plan bat sortu du osasun muskuloeskeletikoak duen garrantzia azpimarratuz (Action Plan for the Prevention and Control of Non-Communicable Diseases in the WHO European Region from 2016 to 2025) (WHO, 2016). Gaur egun ezagunak dira ariketa eta jarduera fisikoaren onurak osasunean; presio arteriala eta hanturazko markatzaileen kontzentrazioa jaisten da, intsulinarekiko sentikortasuna hobetzen da, pisuaren kontrola izateko oso garrantzitsua dela ere ikusi da…(Diaz & Shimbo, 2013; Swift, Johannsen, Lavie, Earnest & Church, 2014). Gainera, eta batez ere adineko pertsonentzat garrantzitsua izan daitekeena, ariketa fisikoak masa muskularra eta hezurren masa mantentzen ditu eta honela, erorketak eta hezurren hausturak murriztu daitezkela frogatu da (Garber et al., 2011; Tarazona-Santabalbina et al., 2016; Nagai et al., 2018). Bestetik, ariketa fisikoa adineko pertsonen hauskortasuna ekidin edota atzeratzeko eraginkorra izan daitekeela behatu da, baina emaitzak eztabaidagarriak dira oraindik gaur egun (Puts et al., 2017; Nagai et al., 2018; Trombetti et al., 2018). Horregatik, zenbait ikerketek aditzera eman dute ariketa fisikoa adinaren eragina arintzeko eta prebentziorako baliogarria izan daitekeela (Morley et al., 2013; Miljkovic, Lim, Miljkovic & Frontera, 2015).

Bestalde, jarduera zein ariketa fisikoaren bitartez adinarekin lotuta dagoen gainbehera kognitiboa prebenitu edo moteltzea posible dela adierazi dute zenbait ikertzailek (Brisswalter, Collardeau & Arcelin, 2002; Colcombe & Kramer, 2003; Voss, Vivar, Kramer & Van Praag, 2013). Hainbat ikerketek azpimarratu dute lan aerobikoaren (Billinger, Vidoni, Morris, Thyfault & Burns, 2017; Hsu et al., 2017), indar entrenamenduaren (Chang, Pan, Chen, Tsai & Huang, 2012) eta jarduera fisikoaren (Kraft, 2012; Phillips, Edwards, Andel & Kilpatrick, 2016) onura hirugarren adineko pertsonen funtzio kognitiboan, nahiz eta eragin hauek sortzen dituzten mekanismo neuropsikologikoak ez diren oraindik ere guztiz ezagutzen.

Gainera, hirugarren adineko pertsonetan funtzionaltasun fisiko zein kognitiboa, osasunari lotutako bizi-kalitatearekin eta afektibitate-egoerarekin lotuta egon daitekeela adierazi da (Penedo & Dahn, 2005; Birch et al., 2016). Luzetarako ikerketa batean, jarduera fisiko gehiago burutzea, ondorengo 6 urteetan izango den bizi-kalitate hobearekin lotu da etxean bizi ziren pertsona osasuntsuetan (Balboa-Castillo, León-Muñoz, Graciani, Rodríguez-Artalejo & Guallar-Castillón, 2011). Era berean, jarduera fisikoak adineko pertsonen bizi-kalitatea, osasun psikologikoa eta mentala hobetu, integrazio soziala areagotu, eta antsietate eta depresioa murrizten lagundu dezakela adierazi dute zenbait ikertzailek (Mather et al., 2002; Vagetti et al., 2014).

Hala ere, azken hamarkadan ariketa fisikoaren onurak aztertu dituzten ikerketetan, hauskortasunaren fase goiztiarrean dauden eta komunitatean bizi diren hirugarren adinekoak izan ohi dira parte hartzaileak (Giné-Garriga, Roqué-Fíguls, Coll-Planas, Sitja-Rabert & Salvà, 2014), eta gutxi dira hirugarren adineko egoitzetan burutu diren ikerketak. Hirugarren adineko egoitzetan aurrera eraman diren ariketa fisikoko programek indarra, ibiltzeko gaitasuna eta oreka hobetu edo gutxienez mantentzeko eraginkorrak direla frogatu dute (Dechamps et al., 2010; Cadore et al., 2014). Hauskortasuna antzemateko test gehienek indarra eta ibiltzeko gaitasuna kontuan hartzen dituztenez, esan daitekeena da ariketa fisikoa eraginkorra izan daitekeela hauskortasunaren garapena lausotzeko. Gainera, berriki argitaratu diren ikerketek etorkizun handiko aurkikuntzak jakinarazi dituzte (Ferreira et al., 2018; Sahin et al., 2018), nahiz eta oraindik ikerketa gehiagoren beharra dagoen ariketa fisikoak populazio honetako hauskortasunean duen onura frogatzeko.

Horrez gain, zenbait ikertzailek ariketa fisikoak egoitzetan bizi direnen funtzio kognitiboan eta afektibitate-egoeran izan dezakeen eragin positiboa azaldu dute. Gainbehera kognitiboa ekiditeko baliagarria izateaz gain (Pereira, Rosado, Cruz-Ferreira & Marmeleira, 2018), bakardadea (Mimi, Tang, Wan & Vong, 2014) eta depresioa (De Carvalho Bastone & Filho, 2004; Dechamps et al., 2010; Mimi et al., 2014; Lok, Lok & Canbaz, 2017) murriztu, eta bizi-kalitatea (Cichocki et al., 2015; Lok, Lok & Canbaz, 2017) hobetzeko baliogarria izan daitekeela adierazi dute. Hala ere, beste zenbait ikerketek ariketa fisikoaren bitartez ez dute hobekuntza adierazgarririk lortu aurretik aipatutako aldagaietan (Rolland et al., 2007; Ouyang et al., 2009; Telenius, Engedal & Bergland, 2015; Frändin et al., 2016).

Ariketa fisikoko programak erorketak murrizteko duen eraginkortasuna eztabaidagarria da egoitzetan bizi diren pertsonetan; zenbait ikertzailek, ariketa fisikoko programa bat burutu zutenak kontrol talde batekin alderatzerakoan, erorketak murriztea lortu zuten bitartean (Serra-Rexach et al., 2011; Cadore et al., 2014), beste batzuek ez zuten ezberdintasun adierazgarririk lortu (Mulrow et al., 1994; Kato, Izumi, Hiramatsu & Shogenji, 2006; Rolland et al., 2007; Rosendahl, Gustafson, Nordin, Lundin-Olsson & Nyberg, 2008). “Cochrane” errebisio sistematiko batean, zortzi ikerketa barne hartzen zituenak, ez zuen erorketen murrizketarik aurkitu ariketa fisikoa bakarrik burutu zuten ikerketetan (Cameron et al., 2012). Hala ere, berriki argitaratu den ikerketa batean, ariketa fisikoko programa bat burutu zutenek, jarduera sozialak burutzen zituztenek baino erorketa gutxiago izan zituzten (De Souto Barreto et al., 2017). Ospitalizazioak murriztu eta heriotza atzeratzeko ariketa fisikoak duen eraginkortasuna ere eztabaidagarria da (Dechamps et al., 2010; Grönstedt et al., 2013; De Souto Barreto et al., 2017).

Hirugarren adineko egoitzetan buruturiko ikerketetako interbentzioak oso orokorrak izan ohi dira, norbanakoaren gaitasun funtzionala kontuan hartu gabe eta sarritan intentsitate eta bolumenaren datu objektiborik gabe. Informazio falta hau dela eta, zaila da ariketa fisikoko programa baten eraginkortasuna eta bideragarritasuna zehaztea. Hau guztia dela eta, interbentzio gutxi hauen informazioa jasotzeko asmoz, errebisio sistematiko bat burutu eta argitaratu genuen (1. Eranskina).

1.5.1. Ariketa motak

Ariketa fisikoko programa bat planifikatzerako orduan, indibidualizazio, espezifikotasun, karga progresibo, atsedenaldi eta errekuperazio printzipioak kontuan hartu behar dira (De Souto Barreto et al., 2016). Intentsitateari dagokionez, nahiz eta intentsitate baxuko (Cichocki et al., 2015) eta altuko (Toots et al., 2016) ariketa fisikoko programak onuragarriak izan daitezkeela ikusi den osasuneko zenbait parametrorentzat, hirugarren adineko egoitzetan intentsitate moderatua da gehien gomendatzen dena (De Souto Barreto et al., 2016). Printzipio hauetan oinarrituta, egoitzetan bizi diren adinduen egoera fisikoa zein kognitiboa mantentzeko indarra, lan aerobikoa, oreka eta malgutasuna lantzen dituen ariketa fisikoko programa gomendatzen da (De Souto Barreto et al., 2016).

Astean bi saio burutzea gomendatzen da, saio bakoitzaren gehienezko iraupena 60 minutu izanik (De Souto Barreto et al., 2016). Astean bi saio baino gehiago burutzea zaila eta nekagarria izan daiteke egoitzetan bizi direnentzat, eta gutxiago burutzea ez dela eraginkorra frogatu da (Paw, Van Poppel, Twisk & Van Mechelen, 2006). Asteko bi saioen artean 48 orduko tartea errespetatzea ere gomendatzen da (De Souto Barreto et al., 2016).

1.5.1.1. Indarra

Indar entrenamendua funtsezkoa da muskulu galera moteltzeko, funtzio eta masa muskularra gehitu eta oreka arazoak murrizten dituela frogatu baita (Montero-Fernandez & Serra-Rexach, 2013). Astean 2-3 indar entrenamendu saioen bitartez, adineko pertsonetan desgaitasun fisikoa murriztu, zenbait muga funtzional gainditu eta muskuluen ahultasuna hobetu daitekeela ikusi da (Liu & Latham, 2009). Indar ariketak burutzen hasiko dituzten adineko pertsonentzat, behin egin daitekeen indar maximoaren (RM1) %40-50 intentsitatea da gomendagarriena, eta egokitzapen fasea burutu ondoren %60-70 RM1 (ACSM, 2013). Errepikapen maximo bateko neurketa egin ezin denean, indar ariketen intentsitatea zehazteko 0tik 10erako eskala subjektiboa erabiltzea gomendatzen da: 5-6 intentsitate moderaturako eta 7-8 intentsitate alturako (Nelson et al., 2007).

Egoitzetan bizi diren hirugarren adineko pertsonentzat, lehen asteetan intentsitate baxuko ariketak burutzea gomendatzen da (De Souto Barreto et al., 2016). Egokitzapen fasearen ondoren, %60-70 RM1 intentsitatean 8-10 ariketa eta gehienez 13-15 errepikapeneko 1-2 serie burutzea gomendatzen da. Pisu libreak jasotzea gomendatzen da (makinen erabilera ez da ohikoa hirugarren adineko egoitzetan, nahiz eta erabilgarriak izan daitezkeen) (De Souto Barreto et al., 2016). Bestetik, ariketen zailtasuna handitzen joatea eta mugimenduaren abiadura areagotzen joatea gomendatzen da. Batez ere behe gorputz-adarrak indartzea gomendatzen da (De Souto Barreto et al., 2016).

1.5.1.2. Lan aerobikoa

Lan aerobikoaren bitartez onura nabariak frogatu dira adineko pertsona osasuntsu zein gaixoetan gorputzeko gantz masari eta gaitasun kardiobaskularraren eta erresistentziaren hobekuntzari dagokionez (Montero-Fernandez & Serra-Rexach, 2013). Hirugarren adineko pertsonentzat eguneko gutxienez 30 minutuz (ahal izanez gero 60 minutuz) jarduera fisiko moderatua burutzea gomendatzen da, gutxienezko 10 minutuko tarteekin, astean 150-300 minutu izateko edota intentsitate altuko 20-30 minutu egunean, astean 75-100 minutu izateko. Astean intentsitate moderatuko gutxienez 5 saio edo intentsitate altuko 3 saio burutzea gomendatzen da (ACSM, 2013). Intentsitateari dagokionez, gomendioa moderatuaren (5-6) eta altuaren (7-8) artean mantentzea da, 0tik 10erako eskala subjektiboa erabilita (Nelson et al., 2007).

Hala ere, hirugarren adineko egoitzetako pertsonak gomendio hauetatik oso urrun daudela frogatu da. Horregatik, ariketa fisikoko programaren hasierako asteetan ibililaldiak intentsitate baxuan burutzea gomendatzen da (De Souto Barreto et al., 2016). Egokitzapen fasearen ondoren, astean intentsitate moderatuko (5-6) bi saio burutzea gomendatzen da, saio bakoitzean bost minutuko hiru ibilaldi burutuz (30 minutu astean) (De Souto Barreto et al., 2016). Lan aerobikoa ibilaldien bitartez lantzea gomendatzen da (bai ibilaldi jarrai bat eginda zein atsedenekin tartekatuz) (De Souto Barreto et al., 2016). Intentsitatea nahikoa izan behar da arnasketa eta bihotz taupadak igotzeko, baina disneak edo gehiegizko nekea ekidinez (De Souto Barreto et al., 2016). Kontuz ibili behar da ere narriadura kognitiboa duten pertsonekin, intentsitate moderatua antzemateko zailtasuna dutenekin eta mina zein beste edozein arazo dutela ohartzeko gai ez direnekin (De Souto Barreto et al., 2016).

1.5.1.3. Oreka

Adineko pertsonen erorketen prebentzioak duen garrantzia dela eta, hauskortasuna edota mugikortasun mugatua duten pertsonekin, entrenamendu saioetan ariketa neuromotorren bitartez oreka lantzea gomendatzen da. Entrenamendu neuromotorretan oreka, propiozepzio eta arintasun ariketak lantzen dira, eta gomendioa astean 2-3 egunetan burutzea da (ACSM, 2009). Bertan, zailtasun maila handitzen doan jarreran ariketa egitea, oinarria txikitzen joatea, grabitate-zentroa aldatzen duten ariketa dinamikoak egitea, muskuluen uzkurdura jarrerak mantentzea (adibidez puntilletan jarriz), zentzumenak murriztea (adibidez begiak itxita) eta tai-chi egitea gomendatzen da (ACSM, 2013).

Hirugarren adineko egoitzetan erorketekin zuzenki lotuta dauden ariketa espezifikoak lantzea gomendatzen da, bereziki zutik baina geldirik egonda, eserita edo ibiltzen hasteko jarrera landuz (Robinovitch et al., 2013). Hala ere, oreka edo koordinazio ariketa espezifiko hauek egin aurretik zenbait indar entrenamendu saio burutzea gomendatzen da (De Souto Barreto et al., 2016).

Oreka ariketen intentsitatea zaila da definitzea, gaur egun oraindik ez baitago intentsitatea definitzen duen tresna balidaturik (Farlie, Robins, Keating, Molloy & Haines, 2013). Hala ere, zailtasuna areagotzen doan oreka estatiko (semi-tandem, tandem, hanka bakarrean) zein dinamikoa (marra baten gainetik ibiltzea, ibiltzen goazela norabide aldaketak egitea…) lantzea gomendatzen da (De Souto Barreto et al., 2016). Zentzumen guztiak erabili gabeko ariketak ere gomendatzen dira (begiak itxita adibidez) (ACSM, 2009).

1.5.1.4. Malgutasuna eta mugikortasun artikularra

Malgutasuna lantzea garrantzitsua izan daiteke erorketen prebentziorako, batez ere aldakaren, belaunen eta orkatilen mugikortasun mugatuak erorketa arriskua handitu eta ibileran izaten diren aldaketetan eragina izan dezaketelako (Montero-Fernandez & Serra-Rexach, 2013). Malgutasunaren entrenamendurako, luzaketak gomendatzen dira, tenkatasun edo deserosotasun puntu batean 20-30 segundoz jarrera mantenduz. Luzaketa estatikoak astean gutxienez 2 aldiz burutzea gomendatzen da (ACSM, 2013).

Hirugarren adineko egoitzetan, mugikortasun artikularra (saioaren hasieran) eta luzaketa (saioaren amaieran) ariketak burutzea gomendatzen da. Ariketa bakoitzak 10-30 segundo iraungo du eta kontu handiz ibili behar da mina dutela esateko zailtasunak dituztenekin (De Souto Barreto et al., 2016).

1.6. Jarduera fisikoa eta minbizia

Minbizia oso ohikoa da hirugarren adineko pertsonetan. 2040rako minbizia izango duten lau pertsonatik ia hiruk 65 urte edo gehiago izango dituztela iragarri da (Swartz et al., 2017). Minbizia izan eta bizirik dauden pertsonek tratamenduaren eragin negatibo eta iraunkorrak izan ohi dituzte: nekea, mina, nahasmendu kognitiboa, depresioa, antsietatea eta osasunarekin lotutako bizi-kalitate okerragoa (Agasi-Idenburg, Thong, Punt, Stuiver & Aaronson, 2017; Huang, Hudson, Robison & Krull, 2017). Minbizia izan duten pertsonak gainontzeko hirugarren adineko pertsonekin alderatzen baditugu, beste minbizi bat, gaixotasun kardiobaskularra, osteoporosia, diabetesa eta gaitasun funtzionalaren galera azkarra izateko arrisku handiagoa dutela frogatu da (Demark-Wahnefried et al., 2006). Hala ere, biziraupen ikerketa gehienak ume zein gazteekin burutu dira, eta gutxi dira hirugarren adineko pertsonetan burutu diren ikerketak (Extermann et al., 2017).

Ikerketa gutxi daude minbiziari aurre egin dioten pertsonekin burutu direnak, eta bizirik dauden edo ez jakiteaz gain, epe luzeko emaitzak behatu dituztenak (Avis & Deimling, 2008; Halpern et al., 2018). Gainera, hirugarren adineko pertsonetan minbiziak gaitasun funtzionalean eragin dezakeen galera gazteetan eragin dezakeena baino nabarmenagoa izan daitekeela behatu da (Avis & Deimling, 2008). Horregatik, oso garrantzitsua izan daiteke minbiziari aurre egin dioten hirugarren adineko pertsonei ohitura osasuntsuak helaraztea, horretarako prestatua izan den jarduera fisiko eta osasun arreta plan berezi baten bitartez. Plan berezi honetan, pazientearen eta osasun arretako profesionalen arteko elkarrizketa dinamiko bat proposatzen da, heziketa eta motibazioan oinarrituko dena (Rowland & Bellizzi, 2014).

Ameriketako Estatu Batuetako “National Cancer Institute” eta “National Academy of Medicine”-k, interbentzio onkologikoan zehar eta ondoren, pazienteak izandako aldagai funtzionalen aldaketa aztertzearen beharra azpimarratu dute (Duan-Porter et al., 2016). Gaitasun fisikoen neurketek desgaitasuna aurresan dezakete, eta ibilera abiadurak bakarrik (Pamoukdjian et al., 2017) zein beste neurketa batzuekin batera (adibidez SPPB), hilkortasuna, ospitalizazioak eta desgaitasuna iragartzeko baliogarriak direla frogatu da (Guralnik et al., 2000). Minbizia izan duten hirugarren adineko pertsonek jarduera fisiko gutxi burutu ohi dute, eta gutxik betetzen dituzte gomendatzen diren osasun sustapen jarraibideak (Morey et al., 2009). Hirugarren adineko pertsonak jarduera fisikoko programa erregular eta trinko bat burutzera erakartzea erronka bat izan daiteke. Hirugarren adineko pertsonek oztopo ugari izan ohi dituzte, parte hartzea jaistea eragiten dutenak: ariketa fisikoko saioetara garraiatzeko arazoak, osasun arazoak eta ariketa aproposak teknika egokiarekin burutzeko ezjakintasuna (Cowper et al., 2017).

Nahiz eta gainbegiratutako interbentzioekin konparatuz, norberaren etxean egiteko programek bizi-kalitatean eta gaitasun funtzionalean eragin txikiagoa dutela frogatu den, etxean burutzen diren programak merkeagoak izateaz gain, pertsona gehiagok parte hartzeko aukera ematen du (Cowper et al., 2017). Gainera, minbiziaren tratamendurako erreferentzia zentroa pazientearen etxetik urrun egon daiteke, eta hau oztopo nabarmena izan daiteke gainbegiratutako jarduera fisikoko saioak burutzerakoan. Bestetik, minbiziaren diagnostikoa jasotzean, hirugarren adineko paziente ugarik ezezkoa eman ohi dio ospitalean jarduera fisikoko programa batean parte hartzeari, jarduera fisikoari buruzko interes faltagatik, urrun bizi direlako edota lanpetuta egon ohi direlako (Adamsen et al., 2009). Horregatik, gomendioak eta laguntza oinarri dituen eta telefono bitartez burutu daitekeen jarduera fisikoko programak eraginkorrak izan daitezke minbizia duten hirugarren adineko pertsonek beren etxeetan jarduera fisikoa burutu ahal izateko.

2. HELBURUAK

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- **Norbanakoan oinarrituriko eta intentsitate moderatuan buruturiko ariketa fisikoko programa progresibo baten eragina aztertzea hirugarren adineko egoitzetako pertsonen hauskortasunari lotutako parametroetan.**
  - Partaideen egoera fisikoak eta ohiko jarduera fisikoak, funtzio kognitiboarekin, bizi-kalitatearekin eta depresioa izateko arriskuarekin duen lotura aztertzea. Gainera, lotura hauetan ea ibiltzeko laguntza behar izateak (makulua, bastoia…) eraginik ote duen aztertzea da gure beste helburu bat.
  - Programak hiru hilabetera antropometria, egoera fisikoa eta ohiko jarduera fisikoan duen eragina aztertzea. Gainera, programaren hasieran gaitasun funtzional baxua eta altua zuten pertsonetan ariketa fisikoak izan duen eragina alderatu dugu.
  - Hirugarren adineko egoitzetako pertsonen serum-eko miostatina kontzentrazioaren eta gorputz-osaera, egoera fisikoa, ohiko jarduera fisikoa eta hauskortasunaren lotura aztertzea. Gainera, norbanakoan oinarrituriko eta intentsitate moderatuan buruturiko ariketa fisikoko programa progresibo batek sei hilabeteren ondoren serum-eko miostatina kontzentrazioan duen eragina aztertu, eta ea interbentzioak eragin dituen aldaketa fisikoak, miostatinan izandako aldaketekin loturarik duten aztertzea. Miostatinaren eta egoera fisikoaren arteko loturak generoaren arabera ezberdinak izan daitezkeenez (Bergen et al., 2015), emaitza guztiak bananduta azaleratu dira emakume zein gizonetan. Hirugarren adineko egoitzetako pertsonetan norbanakoan oinarrituriko eta intentsitate moderatuan buruturiko ariketa fisikoko programa progresibo batek sei hilabetera BDNF-ren kontzentrazioan, funtzio kognitiboan eta afektibitate-egoeran duen eragina aztertzea.

    - Hirugarren adineko egoitzetako pertsonetan norbanakoan oinarrituriko eta intentsitate moderatuan bururuturiko ariketa fisikoko programa progresibo batek hauskortasunean eta osasunari lotutako ondorio kaltegarrietan duen eragina aztertzea.
    - Hirugarren adineko egoitzetako pertsonetan norbanakoan oinarrituriko eta intentsitate moderatuan bururuturiko sei hilabeteko ariketa fisikoko programa progresibo baten ondoren, sei hilabeteko geldiuneak gaitasun funtzionalean, funtzio kognitiboan eta ohiko jarduera fisikoan duen eragina aztertzea.

- **Norbanakoan oinarrituriko eta telefono bitartez helarazitako gomendioetan oinarrituriko jarduera fisikoko programa batek minbiziaren tratamendua hasiko duten hirugarren adineko pertsonek izan ohi duten gaitasun funtzionalaren galera ekiditeko eraginkorra den aztertzea. Bestetik, jarduera fisikoko programak urtebetera eta bi urtera bizitza kalitatean eta hauskortasunean duen eragina aztertzea.**

3. MATERIAL ETA METODOAK

3. MATERIAL ETA METODOAK

3.1. Ariketa fisikoaren eragina hirugarren adineko egoitzetan bizi diren pertsonetan

Ikerketa proiektu honetako material eta metodoen xehetasunak "Effectiveness of a multicomponent exercise program in the attenuation of frailty in long-term nursing home residents: study protocol for a randomized clinical controlled trial" izenburua duen artikuluan azaleratu genituen (2. Eranskina).

3.1.1. Ikerketaren diseinua

Ikerketa proiektu hau Matia eta Caser Fundazioen, Iurreamendi eta Uzturre egoitzen eta Universidad del País Vasco/Euskal Herriko Unibertsitatearen (UPV/EHU) arteko elkarlana izan da. Ikerketan parte hartzeko gonbidapena honako egoitzei helarazi zitzaien:

- Matia Fundazioako 6 egoitza:
  - 4 egoitza Donostian:
    - Bermingham
    - Rezola
    - Txara I
    - Lamourous
  - Otezuri, Zumaian
  - Fraisoro, Zizurkilen
- Caser Fundazioako 2 egoitza:
  - Anaka, Irunen
  - Betharram, Hondarribian
- Iurreamendi egoitza, Tolosan
- Uzturre egoitza, Tolosan

Ikerlan hau (UPV/EHU) Gizakiekin zerikusia duten Ikerketetarako Etika Batzordeak (M10/2016/105) eta Agente Biologikoen eta Genetikoki Eraldatutako Organismoen Ikerketetarako Etika Batzodeak (M30/2016/106) onartu zuten. Ikerketa proiektuaren protokoloa "Australian and New Zealand Clinical Trials Registry"-n erregistratu zen "ACTRN12616001044415" kodearekin. Bestetik, protokoloa Matia Fundazioako Etika Batzordean ere aurkeztu zen. Aurkezpen hau ahoz eta idatziz aurkeztu zen Matia Fundazioako Bermingham egoitzan. Behin Matia Fundazioako Etika Batzordearen oniritzia lortuta, Bermingham egoitzako arduradunekin kontaktuan jarri eta proba pilotua azaldu zitzaien. Proba pilotua Matia Fundazioako Bermingham egoitzan burutu zen eta sei hilabete iraun zituen.

Hurrengo urtean Matia Fundazioako Etika Batzordeari proba pilotuko emaitzak aurkezteaz gain, hurrengo urteko proiektua azaldu eta hau burutzeko oniritzia lortu zen. Ondoren, Matia Institutoako kideek Matia Fundazioako egoitza guztiei proiektu honen berri eman zieten, eta barneratze irizpideak betetzen zituzten parte hartzaile kopurua zehazteko eskatu zitzaien. Behin egoitza guztien kopurua izanda, irizpideak betetzen zituzten gutxienez 10 parte hartzaile zituzten egoitza guztiekin banan-bana kontaktuan jarri eta proiektua idatziz zein ahoz azaldu zitzaien.

Caser Fundazioan eta Iurreamendi eta Uzturre egoitzetan emandako pausoak antzekoak izan ziren, nahiz eta erakunde hauetan nahikoa izan UPV/EHU-ko aurretik aipaturiko bi Etika Batzordeen onarpena, eta Etika Batzorde gehigarri batera jo behar ez izan. Egoitza hauetan, zuzendari, sendagile, erizain, psikologo zein jarduera programen arduradunekin elkartu eta proiektua aurkeztu ondoren, barneratze irizpideak betetzen zituzten parte hartzaile kopurua eskatu zitzaien, gutxieneko kopurua 10 parte hartzaile zirela azpimarratuz.

Behin proiektua azalduta eta parte hartzaile kopurua jakinda, bai Matia zein Caser Fundazioetan, Iurreamendi eta Uzturre egoitzan prozesua berdina izan zen. Egoitzetako arduradunei barneratze irizpideak betetzen zituzten partaideekin kontaktuan jartzea eta proiektuaren berri ematea eskatu zitzaien, ondoren gure ikerketa taldearekin bilera batera etortzeko eskainiz.

Bilerara parte hartzaileez gain beren senitartekoak ere etortzea proposatu zitzaien, proiektua denoi batera aurkezteko. Bertan ikerketaren xehetasun guztiak azaldu zitzaizkien eta sortu zitzaizkien zalantzak argitu ziren. Proiektua aurkeztean, baimen informatuak banatu zitzaizkien (3. Eranskina) bai parte hartzaileek zein senitartekoek (parte hartzaileak bere kabuz dokumentua betetzeko zailtasunak zituenean) dokumentua bete eta sinatu zezaten. Baimen informatua pertsonak bere borondatez ikerketan parte hartzeko asmoa bermatzen duen dokumentua da. Dokumentu honez gain, argazkiak eta grabaketak egiteko baimena ere banatu zitzaien (4. Eranskina).

Ikerketa proiektu hau ausazko entsegu kliniko bat izan zen. Parte hartzaile guztiak zoriz bi taldetan banatu ziren: kontrol taldea eta talde esperimentala. Bi taldeen banaketa egoitza guztietan burutu zen 1:1 ratio banaketa errespetatuz eta generoa kontuan hartuz.

3.1.2. Laginaren ezaugarriak

Ikerketan parte hartzeko barneratze irizpideak ondorengo hauek izan ziren:

- 70 urte edo gehiago izatea
- Mini-examen cognoscitivo-35 (MEC-35) testean (Lobo et al., 1999) 20 puntu edo gehiago izatea
- Barthel eskalan (Wade & Collin, 1988) 50 puntu edo gehiago izatea
- Beren kabuz aulkitik altxa eta 10 metro ibiltzeko gaitasuna izatea (laguntza aparatua erabilita edo erabili gabe)

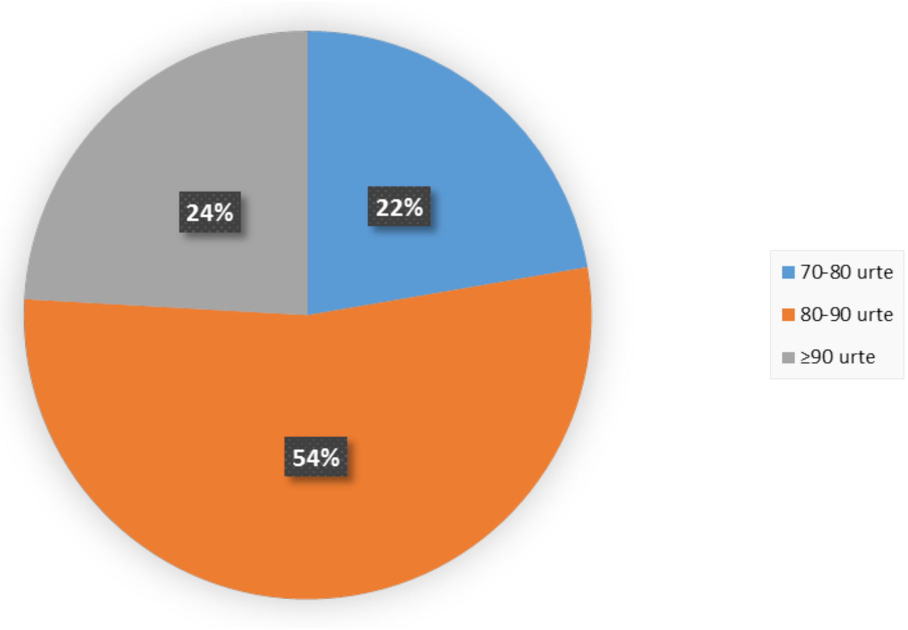
Irizpide hauez gain, ikerketatik kanpo geratu ziren, ezaugarri hauek zituzten parte hartzaileak:

- Ariketa fisikoa egiteko kontraindikazioa zutenak, hau da, ondorio kaltegarrien arriskuak onura posibleen gainetik zeudenean: angina ezegonkorra, bihotz-gutxiegitasun sintomatikoa…
- Dementzia aurreratua eta gaixotasun psikiatrikoak zituztenak

Ikerketan barneratze irizpideak betetzen zituzten 112 pertsonek hartu zuten parte, horietatik 79 (%70,5) emakumezkoak eta 33 (%29,5) gizonezkoak. Laginaren batezbesteko adina 84,9 urte izan zen.

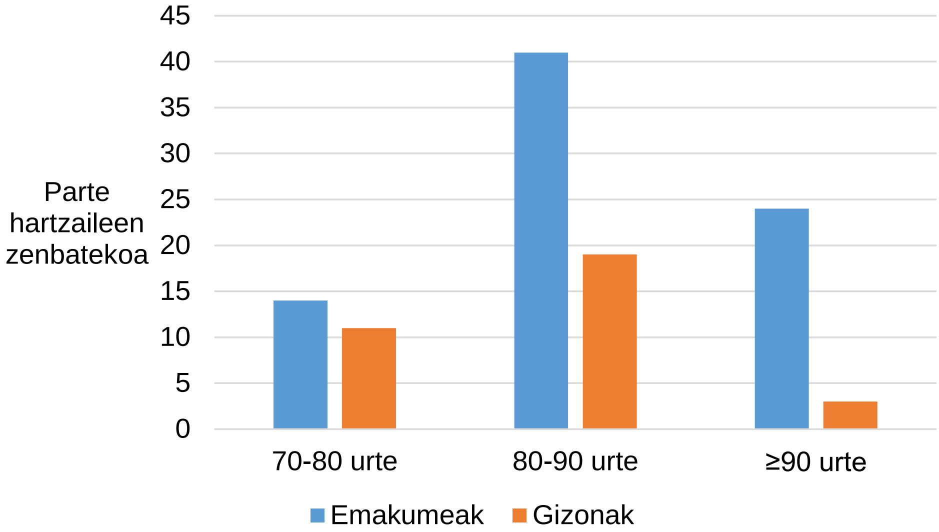
1. Irudian adin-tartekako parte hartzaileen banaketan ikus daitekeenez, 70-80 adin-tarteko 25 pertsona (%22,3), 80-90 urte bitarteko 60 (%53,6) eta ≥ 90 adin-tarteko 27 pertsona (%24,1) izan ziren parte hartu zutenak.

1. Irudia. Adin tartekako parte hartzaileen banaketa



2. Irudian laginaren ezaugarriak adierazi dira adin-tartearen eta generoaren arabera. 70-80 urteko 14 emakumek (emakumeen %17,7) parte hartu zuten, 80-90 urteko 41ek (%51,9) eta 90 urte baino gehiagoko 24k (%30,4). Gizonezkoei dagokienez, 70-80 urte bitarteko 11 gizonezkok parte hartu zuten (gizonezkoen %33,3), 80-90 urteko 19k (%57,6) eta 90 urte baino gehiagoko 3k (%9,1).

2. Irudia. Laginaren ezaugarriak adin-tartearen eta generoaren arabera



Lehen aipatu bezala, barneratze irizpideak betetzen zituzten gutxieneko 10 parte hartzaile izatea azpimarratu genuen egoitza bakoitzean. Hala ere, ondoren proiektuan parte hartzeko erabakia hartu zutenen zenbatekoa txikiagoa izan zen egoitza batzuetan. Matia Fundazioako Bermingham egoitzan 7 pertsonak parte hartu zuten ikerketan (egoitza guztiko laginaren %6,3k), Rezolan 10ek (%8,9k), Txara I-en 10ek (%8,9k), Lamourous-en 12k (%10,7k), Otezurin 10ek (%8,9k) eta Fraisoron 5ek (%4,5ek). Caser Fundazioako bi egoitzei dagokienez, Anaka egoitzatik 14 pertsonak hartu zuten parte ikerketan (%12,5ek) eta Betharrameko egoitzatik 17k (%15,2k). Iurreamendi egoitzako 16 pertsonak hartu zuten parte (%14,3k) eta Uzturre egoitzako 11k (%9,8k).

3.1.3. Balorazioak

Balorazioak burutzeko, orohar eskala jarraiak dituzten test multzoak aukeratu ziren. Test hauen bitartez parte hartzailearen gaitasunak, gorenetik baxuenera neurtzeko aukera ematen du, eta beste test batzuetan gertatu ohi den “sabai” (proba errazegiak) eta “lurzoru” (proba zailegiak) efektuak ekiditea lortzen da. Testetako neurketak fidagarriak, ziurrak eta eraginkorrak izateko, segurtasun eta erabilpen arau batzuk jarraitu behar dira:

- Ikertzaileak ariketa bakoitzeko prozedura ondo ikasi behar du eta datuen bilketa prestatu.
- Osasun arrazoiengatik probaren bat ez egitea aholkatzen zaien pertsonak antzeman behar dira probak burutu aurretik: bihotz gutxiegitasuna dutenak, mina artikulazioetan edo bularraldean, bertigoak edo angina bat pairatu dutenak ariketa egin bitartean edo kontrolatu gabeko odol-hodietako presio altua dutenak.
- Probak egingo diren egunean arropa eta oinetako erosoak janztea eskatu behar zaie parte hartzaileei.
- Probak egingo diren lekuetako ingurunearen baldintza egokiak ziurtatu behar izango dira. Tokia ziurra eta erosoa izatea eta tenperatura kontuan hartzea beharrezkoa izango da parte hartzaileak eroso egon daitezen.

Bestetik, ariketa fisikoko programaren eragina aztertu ahal izateko, ondoren zehaztuko diren probak programaren aurretik, hiru hilabeteren eta sei hilabeteren ondoren burutu ziren. Neurketa guztiak egoitzan bertan egin ziren, aurretik aipatu ditugun erakunde guztietan. Gorputz-osaera neurketak, odol-ateratzeak, eta test neuropsikologikoak partaide bakoitzaren logelan edo horretarako espresuki prestaturiko gela batean burutu ziren. Aldiz, egoera fisikoa eta hauskortasuna neurtzeko testak egoitza bakoitzeko gimnasio edo jarduera-gelan burutu genituen, 6 minutuko proba izan ezik, egoitzako garaje, terrazan… burutu bait genuen. Ondorengo lerroetan, proba hauek burutzeko erabilitako materiala zein prozedurak deskribatuko dira. Lehendabizi, gorputz-osaera eta odol analisiak aztertzeko erabilitako prozedurak deskribatu dira. Ondoren, egoera eta jarduera fisikoa neurtzeko erabilitako testak. Azkenik, ikerketa honetan erabilitako hauskortasuna, funtzio kognitiboa zein afektibitate-egoera neurtzeko erabili diren testak zehaztu dira.

3.1.3.1. <u>Gorputz-osaera</u>

3.1.3.1.1. *Antropometria*

Antropometriaren balorazioa baliagarria da pertsona baten pisuaren eta egitura fisikoaren arteko oreka egokia den ezagutzeko. Metodo hau ez da erasokorra ezta mingarria ere. Gainera, osasun egoeraren adierazlea izateaz gain, erabilgarria da ikerketa honetako emaitzak Mundu osoan zehar egindako ikerketetako erreferentziazko neurriekin alderatzea ahalbidetzen duelako (Marfell-Jones, Stewart & De Ridder, 2012).

- **Prozedura:** antropometria neurketak egin aurretik, International Society for the Advancement of Kineanthropometry-ren (ISAK) lehenengo mailako ikasketak burutu nituen, neurketa guztiak ISAK-en protokoloak dioen bezala burutu ahal izateko (Marfell-Jones et al., 2012).
- **Erabilitako materiala:**
    - Balantza (Omron HN288)
    - Tallimetroa (Seca 213)
    - Perimetroak neurtzeko zinta (Lufkin)
- **Aztertutako aldagaiak:**
    - **Pisua:** parte hartzaileek oinetakoak kendu eta arropa arinarekin, zutik eta geldirik plataformaren erdian jarri ziren, gorputzaren pisua bi oinetan banatuta. Omron markako (HN288) balantza digitala erabili zen parte hartzaileen pisua neurtzeko. Omron HN288, 0 eta 180 kg-ko balio-tartea eta 100 g-ko zehaztasunez kalibratutako baskula da.
    - **Altuera:** Seca 213 tallimetroarekin parte hartzaileen altuera cm-tan neurtu zen (mm 1eko zehaztasunez). Vertex (buruaren punturik altuena) eta euste-planoaren arteko distantzia neurtu zen. Parte hartzaileak zutik eta geldirik jarri ziren, oinak elkarren ondoan, besoak gorputzarekiko paralelo eta ipurdia eta sorbalda eskalaren kontra jarrita. Burua “Frankfurt-en planoan” mantendu eta parte hartzaileari aurrera begiratzeko eskatu zitzaion. Honetarako, begi-orbitaren behealdeko ertzetik kanpoko entzunbidearen goialdera,

lurrarekiko paralelo zihoan irudizko lerro bat imajinatu zen. Posizio hau mantenduz, arnas hartze sakon bat egiten zuenean hartu zen neurria.

- **Gorputz-masaren indizea (GMI):** GMI, pisua (kg) eta altueraren (m) arteko erlazioa da:

$$\textbf{\textit{GMI}} = \frac{\textbf{\textit{pisua (kg)}}}{\textbf{\textit{altuera (m)}}^2}$$

- **Gerriaren perimetroa:** gerriaren perimetroa neurtzeko (cm) zilborra izan zen erreferentzia puntua. Neurketa zutik eta besoak erlaxatuta gorputzaren alboan mantenduz jaso zen.
- **Aldakaren perimetroa:** ipurmasailen punturik irtenena erreferentzia izanik, aldakaren perimetro maximoa (cm) neurtu zen. Aztertutako pertsonari ipurmasailak ez estutzeko eskatu zitzaion.
- **Gerri-aldaka indizea:** gerri eta aldakaren perimetroen bitartez (cm), gerri-aldaka indizea kalkulatu zen:

$$\textbf{\textit{gerri-aldaka indizea}} = \frac{\textbf{\textit{gerriaren perimetroa (cm)}}}{\textbf{\textit{aldakaren perimetroa (cm)}}}$$

3.1.3.1.2. *Bioinpedantzia*

Bioinpedantziako neurketa, eroale bolumenaren eta erresistentzia elektrikoaren arteko erlazioan oinarritzen da (Janssen, Heymsfield, Baumgartner & Ross, 2000). Neurketa burutzeko testa merkea, erraza, errepikagarria eta aproposa dela frogatu da. Bioinpedantziaren bitartez eginiko neurketak orain dela 20 urte baino gehiago hasi ziren (Yanovski, Hubbard, Heymsfield & Lukashi, 1996), eta lortutako emaitzak ondo korrelazionatu dira erresonantzia magnetikoarekin lortutako emaitzekin (Janssen et al., 2000). Horregatik, zenbait ikertzailek hezur-dentsitometria probaren ordezko aukera erabilgarri eta eramangarria izan daitekeela proposatu dute (Cruz-Jentoft et al., 2010).

- **Erabilitako materiala:**
    - “BodyStat QuadScan 4000” bioinpedantzia
    - Ohatila bat
- **Prozedura:** neurketa burutzeko, parte hartzaile guztiei banan-banan eta ohatila batean baloratu zitzaien. Proba gosaldu aurretik burutu zen. Eskuineko oinetakoa zein galtzerdia kendu eta oinean zein eskuan bina elektrodo jarri zitzaizkien. Neurketa burutzerakoan parte hartzailea ohatilan etzanda, hankak eta besoak gurutzatu gabe eta gorputz-enborretik bereizita, eta 5-10 segundoz mugimendurik egin eta hitzik esan gabe egoteko eskatu zitzaien.
- **Aztertutako aldagaiak:**
    - Gantz-masa
    - Gantz-masaren ehunekoa
    - Gihar-masa
    - Gihar-masaren ehunekoa

3.1.3.2. <u>Odol analisiak</u>

Azken urteotan hauskortasunarekin lotura izan dezaketen zenbait biomarkatzaile proposatu dira. Horien artean, proiektu honetarako muskuluetatik eratorritako “miostatina” proteina eta BDNF aukeratu ziren.

- **Prozedura:**
    - Odol lagin guztiak goizean jaso ziren, gosariaren aurretik eta hortaz, baraurik. Egoitza bakoitzeko erizainarekin erabaki zen: 1) odol laginak bakoitzaren logelan jaso edo 2) espresuki horretarako prestatutako gela batean parte hartzaile guztienak jasotzea. Laginen analisia Leioako Medikuntza eta Erizaintza Fakultateko laborategietan burutu zen. Odol laginak jaso ondoren, hodiak 10 minutuz 5000 b/min-ra zentrifugatu ziren. Parte hartzaile bakoitzaren serum laginak alikuotetan -80ºC-tara gorde ziren, aurrerago lagin bilketa bukatzean denak batera aztertu ahal izateko. Enzyme-linked immunosorbent assay (ELISA) teknika

erabili zen bai miostatina zein BDNF-ren kontzentrazioak neurtzeko ariketa fisikoko programa hasi aurretik eta sei hilabetetara.

- **Aztertutako aldagaiak:**
  - Miostatina (pg/mL)
  - BDNF (ng/mL)

3.1.3.3. Egoera fisikoa

3.1.3.3.1. *Senior Fitness Test (SFT) (Rikli & Jones, 2001)*

Rikli eta Jones-ek 2001ean diseinaturiko SFT test multzoa adineko pertsonen egoera fisikoa modu seguru eta praktikoan aztertzeko prestatu zen. Ikasketa prozesuaren ondorioz izandako hobekuntzak ekiditeko, SFT-ko testak bi edo lau aldiz (Rikli eta Jones-ek zehaztutakoaren bikoitza), bi egun ezberdinetan burutu ziren.

- **Erabilitako materiala:**
  - Besaurrerik gabeko aulkia
  - Kronometroa
  - Neoprenozko mankuernak (Valeo HW5): bost librakoa emakumeentzat (2,27 kg) eta zortzi librakoa gizonentzat (3,63 kg)
  - Zinta itsaskorra
  - Distantziak neurtzeko zinta (15 m)
  - Lau kono
  - Polar pultsometro bat (Polar ft4, Polar, Finlandia)
  - Erregela bat
- **Aztertutako aldagaiak:**
  - **Aulkitik altxatzeko gaitasuna:**
    - **Prozedura:** proba honetan parte hartzailea aulkian eserita egon behar da, bizkarra zuzen, oinak lurrean eta besoak bularrean gurutzatuta. Aulkia beso-euskarririk gabekoa izan behar da. Bertatik, eskuak gurutzatuta mantenduz, aulkitik altxa eta hasierako jarrerara bueltatu behar du parte hartzaileak, 30 segundotan ahal bezain bestetan mugimendua errepikatuz. Proba ahoz azaltzeaz gain, parte

hartzaileari nahi bezain beste errepikapen egiteko aukera emango zaio, ondo burutzen duela eta benetan proba ulertu duela argi gelditu arte. Ondoren, behin ariketa ulertuta, mugimendua ahalik eta azkarren burutzeko azpimarratuko zaio parte hartzaileari. Proba honetan aulkia paretaren kontra jartzea gomendatzen da eta ebaluatzailea parte hartzailearen ondoan kokatzea, desoreka edo erorketa arriskurik sumatu ezkero proba era seguruan gelditu eta pertsonari esertzen lagundu ahal izateko. Proba hau bigarren aldiz errepikatu zen beste egun batean.

- **Puntuazioa:** 30 segundotan buruturiko errepikapen kopurua jasoko da. Denbora amaitutakoan parte hartzaileak mugimenduaren erdia (zutitu) edo gehiago burutu badu, mugimendu osotzat kontatuko da. Bi saiakeretatik errepikapen gehien burutu duen proba jasoko da. Errepikapen kopuru handiak beheko gorputz-adarren indar handiagoa adierazten du.

- **Beso-flexioa**:
  - **Prozedura:** parte hartzailea aulkiaren erdialdean jarrita, bizkarra zuzen eta oinak lurrean jarrita (90º-ko angelua osatzen) kokatuko da. Emakumeekin 2,27 kg-ko pisua erabiliko da eta gizonekin 3,63 kg-koa. Pisua esku dominantearekin hartu eta besoa luzatuta hasiko da proba, esku ahurra gorputzari begira jarriz. Horrela hasita, pisua altxatu beharko da eskumuturra biratu eta besoaren flexioa eginez, esku ahurra gora begira jarri eta pisua sorbaldara igo arte. Behin sorbaldara igo ondoren, pisua hasierako puntura jaitsiko da besoa luzatuz eta eskumuturra gorputz aldera begira biratuz. Parte hartzaileari mugimendu hau 30 segundoz ahal bezainbestetan errepikatzeko azalduko zaio. Proba ahoz azaltzeaz gain, parte hartzaileari mugimendua probatzeko aukera emango zaio, zeregina ondo ulertu duela ziurtatu arte. Ondoren, mugimendua ahal bezain azkar

egiteko azpimarratuko zaio. Probaren segurtasunerako parte hartzailearen alboan kokatzea gomendatzen da, parte hartzaileak pisua igo zein jaisterakoan ukalondoa mugitzen ez duela ziurtatuz. Gainera, golpeak ekiditeko, pisua jaisterakoan, pisua ez askatzeko azpimarratu behar da. Proba hau bigarren aldiz errepikatu zen beste egun batean.

- **Puntuazioa:** 30 segundotan bururuturiko errepikapen kopurua jasoko da. Denbora bukatzean, parte hartzaileak mugimenduaren erdia edo gehiago osatuz gero (tolestu eta luzatu), errepikapen osotzat jasoko da. Bi saiakeretatik errepikapen gehien burutu duen proba jasoko da. Errepikapen kopuru handiak goiko gorputz-adarren indar handiagoa adierazten du.

- **Sei minutuko proba:**
  - **Prozedura:** proba hau burutu ahal izateko leku handi bat behar da (4,57 x 18,38 metro). Garrantzitsua da ere irristakorra ez den zoru laua erabiltzea. Hirugarren adineko egoitzetan ez da oso erraza tamaina horretako leku bat topatzea. Proba hau burutzeko toki ezberdinak erabili genituen: egoitzako jardueren gela, terraza, garajea, kalea eta eliza. Proba hasi baino lehen, laukizuzena markatu behar da. Laukizuzenaren erpin bakoitzean kono bat jarri eta 4,57 metroro marra bat markatu behar da. “Hasi” esandakoan parte hartzailea ahalik eta azkarren ibili eta sei minututan zehar markatutako ibilbidea jarraitzeko esango zaio. Parte hartzaileak zenbat bira eman dituen kontrolatzen joateko, bira bakoitzeko denbora jasoko da. Proba amaitzeko hiru, bi eta minutu bat falta denean, parte hartzaileari falta den denbora adieraziko zaio, ibilera abiadura kontrolatzen joateko. Sei minutuak igarotzean, parte hartzaileari dagoen tokian geratzeko esan eta aulki bat gerturatuko zaio. Zirkuitu osoan zehar aulkiak jarriko dira, parte hartzailea gehiegi nekatzen ari dela dirudienean,

berehala gelditu eta atseden hartzeko. Parte hartzaileari gehiegizko neke edo esfortzua nabaritzen bazaio, deskantsatu edo proba amaitu dela esango zaio. Nahiz eta SFT-n ez den aipatzen, ikerketa proiektu honetan pultsometroak erabili ziren bihotz maiztasunaren kontrola eramateko. Proba hau bigarren aldiz errepikatu zen beste egun batean.

- **Puntuazioa:** proba amaitzean, distantzia totala kalkulatuko da, bira kopuruaren eta marren laguntzaz baliatuz. Bi saiakeretatik distantzia handiena lortu duen proba jasoko da. Distantzia handiak ahalmen aerobiko handiagoa adierazten du.

- **Gorputz-enbor flexioa:**
  - **Prozedura:** parte hartzailea aulkiaren ertzean eseriko da. Hanka bat 90º-tara tolestuta eta oina lurrean jarrita, beste hanka guztiz luzatuta jartzeko eskatuko zaio parte hartzaileari, oin punta gora begira jarrita. Aulkia paretaren kontra egotea garrantzitsua da, parte hartzailea proba burutzen ari denean aulkia atzeraka ez irristatzeko. Ondoren, eskuak elkarrekin jarrita eta aldaka flexionatuz, oineko behatzak ukitzen edo pasatzen saiatzeko eskatuko zaio parte hartzaileari. Luzatutako hanka tolesten hasi ezkero, hasierako jarrerara itzuli eta proba errepikatzeko esango zaio. Oina ukitzeko saiakera egiterakoan, puntu gorenera iristean, bertan bi segundotan posizioa mantentzea eskatuko zaio parte hartzaileari. Proba egin baino lehen, aztertutako pertsonak, bi hankekin saiakera bat egiteko eskatuko zaio. Ondoren, egokien moldatzen den hankarekin bakarrik burutuko da proba. Parte hartzaileari arnasa hartzeari ez uzteko eta mina ez duela sentitu behar azpimarratuko zaio. Osteoporosi larria duten pertsonek test hau ez lukete burutu behar. Proba hau birritan burutu zen

egun berean, eta beste birritan errepikatu zen beste egun batean.

- **Puntuazioa:** atzamarren puntatik oinetako behatz lodiraino dagoen distantzia neurtuko da. Behatz lodia ukitzera iritsiz gero, 0 puntu jasoko ditu parte hartzaileak. Behatz lodia ukitzera iristen ez bada, atzamarretatik behatz lodiraino dagoen distantzia neurtuko da zentimetrotan eta balore negatiboa emango zaio. Atzamarrek behatz lodia ukitzera iristeaz gain, pasa egiten badute, distantzia neurtu eta balore positiboa emango zaio zentimetrotan. Lau saiakeretatik puntuazio positiboena duen proba jasoko da. Puntuazio positiboak beheko gorputz-adarren malgutasun handiagoa adierazten du.

o **Eskuak bizkarretik ukitu:**

- **Prozedura:** parte hartzailea zutik jarrita, bi eskuak bizkarraldean elkartzen saiatuko da. Esku bat bizkarraldean jarri, eta gerrialdea inguratuz eta beste eskua sorbaldaren gainetik bizkarraldera jaisten saiatzeko eskatuko zaio parte hartzaileari. Proba egin aurretik, parte hartzaileak bi aldeetatik egingo du saiakera. Bi eskuetako atzamar luzeenekin bizkarraldean ukitzen saiatuko da. Eskuetako atzamar luzeenak elkarrekin ondo orientatuta daudela ziurtatuko da. Atzamarrak orientatzen lagunduko zaio, baina parte hartzailearen eskuak mugitu gabe. Mina sentitzen badu proba gelditu egingo da eta arnasa hartzeari ez uzteko azpimarratuko zaio. Bat-bateko mugimenduak ekiditeko esango zaio parte hartzaileari. Proba hau birritan burutu zen egun berean, eta beste birritan errepikatu zen beste egun batean.
- **Puntuazioa:** atzamar luzeen artean dagoen distantzia zentimetrotan neurtuko da. Bi eskuetako atzamarrak ukitzera iritsi bada “0” puntuazioa lortuko du. Atzamarrak elkar ukitzera iritsi ez bada, balio negatiboa emango zaio

atzamarren artean dagoen distantziari. Atzamarrak elkar ukitzera iristeaz gain, elkarren gainetik pasatzen badira, distantzia positiboki neurtuko da. Atzamarren arteko distantzia neurtuko da, hauen arteko lerrokatzea desegokia izan arren. Lau saiakeretatik puntuazio positiboa duen proba jasoko da. Puntuazio positiboak goiko gorputz-adarren malgutasun handiagoa adierazten du.

- **Altxa, ibili eta eseri:**
  - **Prozedura:** test hau egiteko aulki bat paretaren kontra jarri eta 2,44 metrora kono bat ipiniko da. Neurtutako distantzia, aulkiaren aurreko ertzetik konoaren atzeko alderaino neurtuko da. Proba egiteko parte hartzailea aulkiaren erdialdean eseriko da bizkarra zuzen mantenduz, oinak lurrean eta eskuak izterrean kokatuz. Oin bat bestea baino aurrerago ipiniko du eta gorputza pixka bat aurrealderantz, ateratzeko prest egoteko. Ikertzaileak hasteko hitza ematen duenean, parte hartzaileak ahalik eta azkarren zutitu beharko du, konoraino oinez joan, konoa inguratu eta berriz esertzeko. Denbora pertsona berriz ere aulkian esertzerakoan geldituko da. Testa ahoz azaldu ondoren, erakustaldi bat egingo zaio parte hartzaileari. Ikertzailea badaezpada parte hartzailearen alboan joango da testa burutzen den bitartean, pertsonak oreka galduz gero berehala laguntzeko prest egoteko. Parte hartzaile hauskorrenetan, modu seguruan zutitu eta esertzen ziren baloratzen zen, testa burutu edo ez erabakitzeko. Proba hau birritan burutu zen egun berean, eta beste birritan errepikatu zen beste egun batean.
  - **Puntuazioa:** lau saiakeretatik denbora gutxien behar izan zuen probaren denbora jaso zen. Denbora gutxi behar izateak oreka dinamiko hobea adierazten du.

3.1.3.3.2. *Short Physical Performance Battery (SPPB) (Guralnik et al., 2000)*

SPPB test multzoa oso erraz neurtzen da eta helburua hirugarren adineko pertsonen behe gorputzadarren funtzioa objektiboki neurtzea da. Test multzo hau Ameriketako Estatu Batuetako "National Institute on Ageing" taldeak garatu zuen eta gaur egun hirugarren adineko pertsonen gaitasun fisikoak neurtzeko erreminta erabilienetariko bat da. SPPB test multzoaren fidagarritasuna oso altua da eta gaitasun funtzionaleko aldaketak antzemateko sentikortasuna frogatua izan da. SPPB-ko puntuazio txarrak erorketak, eguneroko bizitzako jarduerak burutzeko ezintasuna, mugikortasun galera, desgaitasuna, ospitalizazioak, instituzionalizazioa eta heriotzarekin lotu dira (Guralnik et al., 2000).

- **Erabilitako materiala:**
    - Besaurrerik gabeko aulkia
    - Kronometroa
    - Zinta itsaskorra
    - Distantziak neurtzeko zinta (15 m)
- **Aztertutako aldagaiak:**
    - **Oreka estatikoa:**
        - **Prozedura:** parte hartzaileari 3 posiziotan mantentzen saiatzeko eskatuko zaio: bi oinak elkarrekin, semitandem eta tandem posizioan, 10 segundoz posizio bakoitzean. Azpi-test hauetan, lehenengoa egin ahal izanez gero hurrengoa burutuko da, baina posizioa ezin bada mantendu, ez da hurrengo proba burutuko.
        - **Puntuazioa:** oinak elkartuta 10 segundoz oreka mantentzeko gai ez bada, parte hartzaileak ez du punturik jasoko. Puntu bat emango zaio bi oinak elkartu eta oreka mantentzea lortzen badu, bi puntu semitandem posizioan, hiru puntu tandem posizioan 3-9,99 segundoz eta lau puntu tandem posizioan 10 segundoz oreka mantentzea lortzen badu. Puntuazio altuak oreka estatiko hobea adierazten du.

- **Ibilera abiadura:**
  - **Prozedura:** parte hartzaileari bere erritmoan lau metroko distantzia ibiltzeko eskatuko zaio. Parte hartzaileak laguntza tresna erabili ahal izango du, behar izango balu. Test hau bi aldiz burutuko da eta denborarik onena jasoko da.
  - **Puntuazioa:** lau metro oinez ibiltzeko gaitasunik ez badu, ez du punturik jasoko. Puntu bat jasoko du > 8,7 segundo behar baditu, bi puntu 6,21-8,79 segundo behar baditu, hiru puntu 4,82-6,20 segundo behar baditu eta lau puntu < 4,82 segundo behar baditu. Puntuazio altuak ibilera abiadura azkarragoa adierazten du.
- **Altxa eta eseri:**
  - **Prozedura:** bost aldiz aulkitik altxa eta esertzeko parte hartzaileak behar duen denbora jasoko da. Horretarako parte hartzaileari proba hau ahalik eta azkarren egiten saiatzeko azpimarratuko zaio. Parte hartzaileari une oro besoak gurutzatuta mantentzeko eskatuko zaio. Errepikapen bat modu egokian burutzen duela ziurtatzean, testa burutzeari ekingo zaio. Parte hartzaileari prest dagoela galdetu eta altxatzeari ekiten dionean hasiko da denbora kontatzen. Ozen zenbatuko da parte hartzaileak burutzen dituen errepikapen kopurua. Parte hartzaileak bosgarren aldiz altxatzea lortzen duenean denbora gelditu eta erregistro orrian jasoko da behar izan duen denbora. Proba bertan behera geratuko da parte hartzaileak altxatzeko eskuak erabiltzen baditu edo minutu bat baino gehiago igarotzen bada.
  - **Puntuazioa:** minutu batean aulkitik bost aldiz altxatzeko gai ez bada, ez du punturik jasoko. Puntu bat jasoko du > 16,7 segundo behar baditu, bi puntu 13,70-16,69 segundo behar baditu, hiru puntu 11,20-13,69 segundo behar baditu eta lau puntu ≤ 11,19 segundo behar baditu. Puntuazio altuak beheko gorputz-adarren indar handiagoa adierazten du.

3.1.3.3.3. *Ibilera abiadura*

Gaitasun funtzionalaren gainbehera gehienbat ibiltzeko gaitasunaren okertzeak dakar. Ibilera abiadura hirugarren adineko pertsonetan gaitasun funtzionalaren gainbehera antzemateko test erabilienetako bat da (Cesari et al., 2005; Rosano, Newman, Katz, Hirsch & Kuller, 2008; Cesari et al., 2009; Studenski et al., 2011). Komunitatean bizi diren adinduen ohiko ibilera abiadura < 1 m/s-koa dutenetan, osasunari loturiko ondorio kaltegarriak izateko arriskuan daudela frogatu da (Cesari et al., 2005). Egoitzetan bizi diren adinduak mantsoago ibili ohi dira: orain dela urte gutxi batzuk argitaratutako errebisio sistematiko batean adierazi zutenez, hirugarren adineko egoitzetako pertsonetan 0,47 m/s-ko ibilera abiadura duen pertsona jada funtzioanala dela adierazi zuten (Kuys, Peel, Klein, Slater & Hubbard, 2014).

- **Erabilitako materiala:**
  - Kronometroa
  - Zinta itsaskorra
  - Distantziak neurtzeko zinta (15 m)
- **Prozedura:** beheko irudian ikus daitekeen bezala, parte hartzaileek 10 metro ibili behar izan zituzten. Hasierako fasea (1.go metroa) eta azkenekoa (azken metroa) neurketatik kanpo utzi ziren, hasierako azelerazioa zein azken faseko desazelerazioa saihesteko. Horrela, 4 eta jarraian 8 metro ibiltzeko behar izan zuten denbora jaso zen. Proba hau birritan burutu zen egun berean, eta beste birritan errepikatu zen beste egun batean. Lau saiakeretatik parte hartzaileak denbora gutxien behar izan zuen denbora jaso eta distantziarekin zatituz, ibilera abiadura kalkulatu zen.
- **Aztertutako aldagaiak:**
  - Ohiko ibilera abiadura (4 m eta 8 m)
  - Ibilera abiadura azkarra (4 m eta 8 m)

3.1.3.3.4. *Timed Up and Go (TUG) (Podsiadlo & Richardson, 1991)*

TUG testa ere oso ohikoa da hirugarren adineko pertsonen gaitasun funtzionala aztertzeko (Bischoff et al., 2003; Bohannon, 2006). Izan ere, ibiltzeko eta aulkitik altxatzeko gaitasuna dira gainbehera funtzionala antzemateko aldagai garrantzitsuenak. Gaur egungo erorketa prebentzio gidaliburuek hirugarren adineko pertsonetan ibiltzeko zein oreka arazoak identifikatzeko TUG testa gomendatzen dute (American Geriatrics Society, Geriatrics Society & American Academy Of Orthopaedic Surgeons Panel On Falls Prevention, 2001). Izan ere, TUG testa burutzeko erabili den denboraren eta aurretik pertsonak izandako erorketen arteko lotura positiboa dela zehaztu dute zenbait ikertzailek (Beauchet et al., 2011). Hala ere, TUG testak etorkizunean izango diren erorketak aurreikusteko duen ahalmena mugatua da oraindik ere (Large, Gan, Basic & Jennings, 2006).

- **Erabilitako materiala:**
    - Besaurrerik gabeko aulkia
    - Kronometroa
    - Zinta itsaskorra
    - Distantziak neurtzeko zinta (15 m)
    - Kono bat
- **Prozedura:** parte hartzailea bizkarra aulkiaren bizkarraldean jarrita eta bi oinak lurra ukituz prest dagoenean, aulkitik altxa eta ohiko ibilera abiaduran hiru metrotara dagoen kono bati buelta eman eta esertzeko eskatuko zaio. Proba hau burutzeko behar izan duen denbora jasoko da. Proba hau birritan burutu zen egun berean, eta beste birritan errepikatu zen beste egun batean. Lau saiakeretatik denbora gutxien behar izan zuen saiakeraren denbora jaso zen. Denbora gutxi behar izateak oreka dinamiko hobea adierazten du.
- **Aztertutako aldagaiak:**
    - Proba burutu ahal izateko behar izan duen denbora

3.1.3.3.5. *Berg oreka testa (Berg, Wood-Dauphinee, Williams & Maki, 1992)*

Berg oreka testa balidatuta dagoen eta 14 proba dituen test multzo bat da, oreka galera antzemateko gai dena. Berg oreka testa erorketak izango ez dituena aurreikusteko baliogarria dela frogatu da, nahiz eta test honetan, balio baxuak ateratzen dituztenetan, testeko puntuazioaren eta erorketen zenbatekoaren lotura zuzenik ez den oraindik frogatu (Bogle-Thorbahn & Newton, 1996).

- **Erabilitako materiala:**
    - Besaurrerik gabeko aulkia
    - Besaurrea duen aulkia
    - Kronometroa
    - Zinta itsaskorra
    - Erregela
    - Zinta metrikoa (paretan itsastekoa)
    - Step edo eskaloi bat
    - Kono bat
- **Prozedura:** proba bakoitzean, ahoz azalpena eman ondoren demostrazio praktiko bat egingo zaio parte hartzaileari. Proba bakoitzak puntuazio jakin bat du, behean deskribatzen den bezala. Proba gehienetan, parte hartzaileari denbora batez posizio jakin bat mantentzeko eskatuko zaio. Gero eta puntu gutxiago emango zaizkio proba bakoitzeko, denboran posizioa mantentzeko gai ez baldin bada, gainbegiratzeko beharra badu, edo parte hartzaileak laguntza erreminta edo ebaluatzailearen laguntza behar izango balu. Parte hartzaileek garbi izan behar dute helburua oreka mantentzea dela. Parte hartzaileak erabaki beharko du ea zein oin erabiliko duen euskarri modura.
- **Aztertutako aldagaiak:**
    - **Aulkitik altxa:** parte hartzaileari aulkitik altxatzen saiatzeko esango zaio, eskuen laguntzarik gabe, ahal bada:
        - **4 puntu:** bakarrik eta eskuen laguntzarik gabe aulkitik altxatzeko gai bada.

    - **3 puntu:** bakarrik eta eskuen laguntzarekin aulkitik altxatzeko gai bada.
    - **2 puntu:** bakarrik eta eskuen laguntzarekin aulkitik altxatzeko gai bada, hainbat saiakeren ondoren.
    - **Puntu 1:** gutxieneko laguntza gehigarria behar badu aulkitik altxa eta ondoren oreka mantentzeko.
    - **0 puntu:** neurrizko edo laguntza handia behar badu aulkitik altxatzeko.
- **Zutik egon:** parte hartzaileari zutik eta euskarririk gabe oreka mantentzen saiatzeko eskatuko zaio:
    - **4 puntu:** zutik segurtasunez 2 minutuz egoteko gai bada.
    - **3 puntu:** zutik gainbegiratuta 2 minutuz egoteko gai bada.
    - **2 puntu:** euskarririk gabe 30 segundoz zutik egoteko gai bada.
    - **Puntu 1:** euskarririk gabe 30 segundoz zutik egoteko hainbat saiakera behar baditu.
    - **0 puntu:** laguntzarik gabe 30 segundoz zutik egoteko gai ez baldin bada.

  Parte hartzailea 2 minutuz inon eutsi gabe oreka mantentzeko gai bada, eman 4 puntu hurrengo proban eta pasa zuzenean 4. probara.

- **Eserita egon:** parte hartzaileari aulkian eserita, oinak lurrean eta bizkarra ezarri gabe 2 minutuz oreka mantentzen saiatzeko eskatuko zaio, besoak gorputzean gurutzaturik dituela:
    - **4 puntu:** 2 minutuz segurtasunez eserita egoteko gai bada.
    - **3 puntu:** 2 minutuz gainbegiratuta eserita egoteko gai bada.
    - **2 puntu:** eserita 30 segundoz egoteko gai bada.
    - **Puntu 1:** eserita 10 segundoz egoteko gai bada.
    - **0 puntu:** laguntzarik gabe 10 segundoz eserita egoteko gai ez baldin bada.

- **Aulkian eseri:** parte hartzaileari aulkian esertzeko esango zaio:
  - **4 puntu:** eskuen gutxieneko laguntzarekin segurtasunez aulkian esertzeko gai bada.
  - **3 puntu:** esertzerako orduan jaitsiera eskuen bitartez kontrolatzen badu.
  - **2 puntu:** esertzerako orduan hanken atzekaldea erabiltzen badu jaitsiera kontrolatzeko.
  - **Puntu 1:** bakarrik esertzeko gai baldin bada, baina ez badu jaitsiera kontrolatzen.
  - **0 puntu:** esertzeko laguntza behar badu.
- **Transferentziak:** parte hartzailea eserita dagoen aulkiaren ondoan beste aulki bat gerturatuko zaio (bata beso-euskarria duena izango da eta bestea ez). Eserita dagoen aulkitik altxa eta beste aulkian esertzeko eskatuko zaio. Ondoren, berriz ere eserita dagoen aulkitik altxa eta lehen eserita zegoen aulkira bueltatzeko eskatuko zaio:
  - **4 puntu:** eskuen gutxieneko laguntzarekin segurtasunez transferentzia burutzeko gai bada.
  - **3 puntu:** eskuen laguntzarekin segurtasunez transferentzia burutzeko gai bada.
  - **2 puntu:** argibide jasota eta gainbegiratuta transferentzia burutzeko gai bada.
  - **Puntu 1:** pertsona baten laguntza behar badu.
  - **0 puntu:** transferentzia segurtasunez burutzeko 2 pertsonen laguntza behar badu.
- **Begiak itxita:** parte hartzaileari zutik egonda begiak itxita dituela oreka 10 segundoz mantentzeko eskatuko zaio:
  - **4 puntu:** segurtasunez zutik 10 segundoz egoteko gai bada.
  - **3 puntu:** gainbegiratuta zutik 10 segundoz egoteko gai bada.
  - **2 puntu:** 3 segundoz zutik egoteko gai bada.
  - **Puntu 1:** 3 segundoz begiak itxita izatea lortzen ez badu baina zutik mantentzeko gai bada.

    - **0 puntu:** ez erortzeko laguntza behar badu.
- **Oinak elkartuta:** parte hartzaileari bi oinak elkartu eta zutik oreka mantentzeko eskatuko zaio, inon eutsi gabe:
    - **4 puntu:** laguntzarik gabe eta segurtasunez bi oinak elkartuta minutu batez zutik oreka mantentzeko gai bada.
    - **3 puntu:** gainbegiratuta baina laguntzarik gabe bi oinak elkartuta minutu batez zutik oreka mantentzeko gai bada.
    - **2 puntu:** laguntzarik gabe bi oinak elkartuta jartzeko gai bada, baina 30 segundoz oreka mantentzeko gai ez bada.
    - **Puntu 1:** bi oinak elkarrekin jartzeko laguntza behar badu, baina ondoren 15 segundoz oreka mantentzeko gai bada.
    - **0 puntu:** bi oinak elkarrekin jartzeko laguntza behar badu eta ondoren 15 segundoz oreka mantentzeko gai ez bada.
- **Besoa aurreraka luzatu:** parte hartzaileari, zutik dagoela, 90 gradutara beso bat aurreraka luzatzeko eskatuko zaio (parte hartzaileak nahi duen besoa). Gorputza zuzen duela oreka mantendu eta erregela batekin paretean itsatsita dagoen zinta metrikoan neurria hartuko zaio parte hartzaileak luzatutako besoaren hatz aurreratuenaren puntuan (hasiera puntua). Parte hartzaileari besoa aurreraka luzatu eta enborra aurreraka flexionatuz oreka mantentzea eskatuko zaio, ahalik eta puntu aurreratuena lortzeko eskatuz, baina oreka mantenduz eta oinak lurretik mugitu gabe. Oreka galdu gabe, parte hartzaileak lorturiko puntu aurreratuena neurtuko da:
    - **4 puntu:** > 25 cm aurreraka erraz luzatzeko gai bada.
    - **3 puntu:** > 12 cm aurreraka segurtasunez luzatzeko gai bada.
    - **2 puntu:** > 5 cm aurreraka segurtasunez luzatzeko gai bada.
    - **Puntu 1:** aurreraka luzatzeko gai bada, baina gainbegiratuta.
    - **0 puntu:** aurreraka luzatzen saiatzeko laguntza behar baldin badu edo saiakera egitean oreka galtzen baldin badu.

- **Lurretik objektu bat jaso:** parte hartzaileari, zutik egonda, lurretik objektu bat jasotzeko eskatuko zaio:
    - **4 puntu:** laguntzarik gabe, erraz eta segurtasunez objektua lurretik jasotzeko gai bada.
    - **3 puntu:** laguntzarik gabe baina gainbegiratuta objektua lurretik jasotzeko gai bada.
    - **2 puntu:** objektua jasotzeko gai ez baldin bada, baina objektutik 2-5 cm-ra gerturatu eta laguntzarik gabe oreka mantentzeko gai baldin bada.
    - **Puntu 1:** objektua jasotzeko gai ez baldin bada eta saiakera burutzeko gainbegiratuta egin behar izan badu.
    - **0 puntu:** oreka ez galdu edo erortzeko laguntza behar badu.
- **Atzera begiratu:** zutik egonda, oinak lurretik mugitu gabe, gorputza eta lepoa biratzeko esango diogu parte hartzaileari. Gu parte hartzailearen atzean jarriko gara eta guri begiratzeko esango diogu:
    - **4 puntu:** bi aldetara gorputza eta lepoa ondo biratzen baditu.
    - **3 puntu:** alde batera gorputza eta lepoa ondo biratzen baditu, baina beste aldera gutxiago biratzen badu.
    - **2 puntu:** alde batera bakarrik biratzen badu baina oreka mantentzen badu.
    - **Puntu 1:** saiakera burutzeko gainbegiratuta egin behar badu.
    - **0 puntu:** oreka ez galdu edo erortzeko laguntza behar badu.
- **360º-ko bira ematea:** 360º-ko bira ematea eskatuko zaio parte hartzaileari. Behin alde batera egin duenean, beste alderaka egiteko eskatuko zaio:
    - **4 puntu:** segurtasunez bi aldetara 4 segundo edo gutxiagoan bira emateko gai bada.
    - **3 puntu:** segurtasunez alde batera 4 segundo edo gutxiagoan bira emateko gai bada.
    - **2 puntu:** segurtasunez baino poliki bi aldetara bira emateko gai bada.

- **Puntu 1:** saiakera burutzeko gainbegiratuta egin behar badu.
- **0 puntu:** laguntza behar badu bira emateko.

- **Oinak step edo eskaloi baten gainean jarri:** parte hartzaileari oinak txandaka step edo eskaloi baten gainean jartzeko eskatuko zaio. 4 errepikapen burutzea eskatuko zaio oin bakoitzarekin:
  - **4 puntu:** laguntzarik gabe eta segurtasunez 20 segundotan 8 aldiz step edo eskaloian oinak jartzeko gai bada.
  - **3 puntu:** laguntzarik gabe 20 segundo baino gehiago behar baditu 8 aldiz step edo eskaloian oinak jartzeko.
  - **2 puntu:** laguntzarik gabe edo gainbegiratuta 4 aldiz step edo eskaloian oinak jartzeko gai bada.
  - **Puntu 1:** > 2 aldiz step edo eskaloian oinak jartzeko gutxieneko laguntza behar badu.
  - **0 puntu:** laguntza behar badu edo saiakera burutzeko gai ez bada.
- **Tandem:** oin bat bestearen aurrean jartzeko eskatuko zaio:
  - **4 puntu:** laguntzarik gabe oin bat bestearen aurrean jarri (tandem posizioan) eta 30 segundoz oreka mantentzeko gai bada.
  - **3 puntu:** laguntzarik gabe aurreraka pauso bat eman, aurreko oinaren orpoa atzeko oinaren punta baino aurrerago egonda, eta 30 segundoz oreka mantentzeko gai bada.
  - **2 puntu:** laguntzarik gabe aurreraka pauso txiki bat eman eta 30 segundoz oreka mantentzeko gai bada.
  - **Puntu 1:** aurreraka pauso txiki bat emateko laguntza behar badu, baina ondoren 15 segundoz oreka mantentzeko gai bada.
  - **0 puntu:** oreka galtzen badu pausoa ematerakoan edo zutik egoterakoan.

- **Hanka bakarrean:** hanka bakarrean eta euskarririk gabe oreka mantentzen saiatzeko eskatuko zaio:
  - **4 puntu:** laguntzarik gabe oina lurretik altxa eta > 10 segundoz oreka mantentzeko gai bada.
  - **3 puntu:** laguntzarik gabe oina lurretik altxa eta 5-10 segundoz oreka mantentzeko gai bada.
  - **2 puntu:** laguntzarik gabe oina lurretik altxa eta ≥ 3 segundoz oreka mantentzeko gai bada.
  - **Puntu 1:** laguntzarik gabe oina lurretik altxa, baino 3 segundoz oreka mantentzeko gai ez bada.
  - **0 puntu:** laguntza behar badu edo saiakera burutzeko gai ez bada.

- **Puntuazio orokorra:** proba guztietako puntuak gehituko dira puntuazio orokor bat izateko. Gehienezko puntuazioa 56 izango da. Puntuazio altuak oreka estatiko hobea adierazten du.

3.1.3.3.6. *Eskuko eta besaurreko indarra (Miranda, 2011)*

Eskuko eta besaurreko indarra, uneko zein etorkizuneko osasunarekin lotuta dagoela frogatu da. Zehazki, gaixotasun kardiobaskularrekin, desgaitasunarekin, morbilitatearekin eta heriotzarekin lotuta dagoela frogatu da zenbait ikerketetan (Leong et al., 2015; Sayer & Kirkwood, 2015). Hala ere, ikerketa gehiagoren beharra azpimarratu dute eskuko eta besaurreko indarraren handitzeak zein eragin izan dezakeen ondorioztatzeko (Leong et al., 2015).

- **Erabilitako materiala:**
  - Jamar Sammons Preston dinamometroa
  - Besaurrerik gabeko aulkia
- **Prozedura:** parte hartzaileari eserita egoteko eskatuko zaio. Dinamometroa eskuarekin nola hartu behar duen azaldu eta erakutsiko zaio. Dinamometroa eskuarekin eustean erdiko falangearekin indarra egingo duela ziurtatuko da. Hala ez bada, dinamometroaren neurria egokituko da. Ukondoa 90º-tara flexionatuta duela, dinamometroa esku batekin eutsi eta ahalik eta gehien estutzeko esango zaio parte

hartzaileari. Dinamometroak bi eskala ditu, bata libra-tan (0-200 lb) eta bestea kilogramo-tan dagoena (0-90 kg). Eskalan bertan orratz bat dago, indarra egiten ari garen heinean mugitu egiten dena. Orratza egin dugun indar maximoan geldituko da. Proba esku bakoitzarekin bi aldiz burutu zuten parte hartzaileek, eta proba birritan errepikatu zen beste egun batean. Eskalan bertan jartzen dituen indar maximoaren kilogramo kopurua apuntatu zen. Balio altuak eskuko zein besaurreko indar handiagoa adierazten du.

- **Aztertutako aldagaiak:**
  - Eskuko eta besaurreko indarra

3.1.3.4. Jarduera fisikoa burutzeko ohitura

Jarduera fisikoaren neurketa garrantzitsua da osasun arloko ikerketak burutu eta osasun-egoera mantentzeko egokiak diren aholkuak helarazi ahal izateko (Troiano et al., 2008; Bernard et al., 2018). Azelerometroen bitartez jarduera fisikoaren kantitatea, maiztasuna, iraupena eta intentsitateari buruzko informazioa jaso daiteke. Azelerometroa gerrian eta eskumuturrean jarri ohi da (Migueles et al., 2017), baina gerrian jartzean emaitza zehatzagoak lortzen direla dirudi (Migueles et al., 2017). Adineko pertsonen jarduera fisikoa neurtzeko ikerketa epidemiologikoetan gero eta ikerketa gehiago dago azelerometroak erabiltzen dituztenak (Lee & Shiroma, 2014; Lee et al., 2018). Hala ere, azelerometroekin jarduera fisikoa aztertu duten ikerketa gutxi daude gaur egun, egoitzetako adinduekin burutu direnak (Lobo, Santos, Carvalho & Mota, 2008).

- **Erabilitako materiala:**
  - wGT3XBT Actigraph azelerometroa
  - Actigraph analisi softwarea (Actigraph LLC, Pensacola, FL, USA)
- **Prozedura:** eguneroko tarte aktibo eta sedentarioak azelerometro baten bitartez jaso ziren (Actigraph wGT3XBT model; Actigraph LLC, Pensacola, FL, USA). Parte hartzaileek azelerometroa gerriko baten bitartez gerrian lotuta eraman zuten astebetez. Egunero esnatu eta dutxatu ondorenetik oheratu arte azelerometroa gerriaren eskuinaldean gerriko batekin lotuta izatea eskatu zitzaien. Horrez gain, egoitza bakoitzeko erizain zein

erizaintzako laguntzaileei informazio orri bat eman zitzaien azelerometroa nola jantzi (goizean) eta erantzi (dutxatzerakoan edo gauetan) erakusteko. Azelerometro batek gorputzaren mugimenduak jaso eta memorizatzea ahalbidetzen digula azaldu zitzaien. Parte hartzaileei azaltzeaz gain, erizain zein erizaintzako laguntzaileekin bilera bat antolatu zen, azelerometroaren inguruko informazioa helarazi eta zalantzak argitzeko. Azelerometroen datuak deskargatu ondoren, analisia Actilife software-aren 6.11.9 bertsioarekin burutu zen. Analisia burutzerakoan, zenbaitek ohera joaterakoan azelerometroa kendu ez zutela ohartu ginen proba pilotuan, eta beraz egoiliar guztietan goizeko zazpitatik gaueko hamarretara burutu zuten jarduera aztertzea erabaki genuen. Azelerometroen datuak aztertzerakoan, gutxienez hamar orduko hiru egun jantzita eraman zituzten parte hartzaileen erregistroak kontutan hartu ziren (Hart, Swartz, Cashin & Strath, 2011). Baldintza hauek betetzen ez zituzten erregistroak ez ziren aztertu. Ikerketa honetan Freedson, Melanson eta Sirard-ek 1998an proposaturiko ebaki-puntuak hautatu ziren. Ebaki-puntu hauek dira (ondoren azalduko direnak), hirugarren adineko egoitzako pertsonekin egindako ikerketa bakarrean erabili zituztenak (Lobo et al., 2008) eta parte hartzaileen ezaugarrientzako egokienak iruditu zitzaizkigunak.

- **Aztertutako aldagaiak:**
  - Eguneko batezbesteko pausoak (pausoak/egunak)
  - Tarte aktiboetan jardueren intentsitatea Freedson eta lankideek (1998) ezarritako irizpideen arabera:
    - Jarduera sedentarioa 100 kontu/minutu baino gutxiago
    - Jarduera arina 100 kontu/minututik 1951 kontu/minutura
    - Jarduera ertaina 1952 kontu/minututik 5724 kontu/minutura
    - Jarduera kementsua 5725 kontu/minututik 9498 kontu/minutura
    - Jarduera oso kementsua 9499 kontu/minututik gora

3.1.3.5. Proba neuropsikologikoak

Funtzio kognitiboak eta afektibitate-egoerak maiz okertzeko joera dute zahartzen goazen heinean (Robertson et al., 2013). Okertze prozesu hau oso aldakorra izan ohi da pertsona batetik bestera (Blazer et al., 2015), eta gaitasun kognitibo orokorrean, depresioan, bakardadean, bizi-kalitatean zein beste zenbait aldagaietan eragin dezake (Cohen-Mansfield, Shmotkin & Goldberg, 2009; Zhao et al., 2012; Bilgili & Arpaci, 2014; Blazer et al., 2015).

Gero eta ikerketa gehiago dago komunitatean bizi diren hirugarren adineko pertsonetan, ariketa fisikoak gaitasun fisikoetan onurak eragiteaz gain, gaitasun kognitibo orokorra eta afektibitate-egoera hobetu ditzakeela diotenak (Angevaren, Aufdemkampe, Verhaar, Aleman & Vanhees, 2008; Figueira et al., 2012; Falck, Davis & Liu-Ambrose, 2017; Aguiñaga et al., 2018; Chekroud et al., 2018). Hala ere, gutxiago dira egoitzetan bizi diren pertsona nagusiekin buruturikoak (Lok, Lok & Canbaz, 2017; Pereira et al., 2018).

Proba neuropsikologiko guztiak neuropsikologa berberak burutu zituen.

3.1.3.5.1. *Montreal kognizio azterketa (Coen, Robertson, Kenny & King-Kallimanis, 2015)*

Montreal kognizio azterketa test sinple eta azkar bat da, narriadura kognitibo arina eta Alzheimer dementzia hasiera antzemateko sortu zena (Doerflinger, 2012). Hainbat hizkuntzetan erabilia izan da eta adin-tarte zabalak aztertu dira test honen bitartez (Doerflinger, 2012).

- **Prozedura:** test hau burutzeko 10-15 minutu inguru behar izaten dira normalean, baina gutxiago (ikusmen arazoak izan ohi dituztenetan, proba batzuk ezin baitituzte egin) edo gehiago (narriadura kognitiboa edo entzumen arazoak dituztenean) izan daiteke.
- **Aztertutako aldagaiak:**
    - **Gaitasun bisuoespazial/exekutiboa:**
        - **Trazua marraztea zenbakiak eta letrak tartekatuz:**
            - **Prozedura:** parte hartzaileak marra bat marraztuko du zenbaki batetik letra batera, zenbakien ordena

eta ordenamendu alfabetikoa errespetatuz. “1” zenbakitik hasi, “A” letrara marra bat marraztu, ondoren “2” zenbakira…eta “E” letran amaitzeko esango zaio.

- **Puntuazioa:** puntu bat lortuko du parte hartzaileak zenbaki eta letrak ordenean lotzen baditu, marra gehigarririk marraztu gabe: 1-A-2-B-3-C-4-D-5-E.

- **Kuboa:**
  - **Prozedura:** hiru dimentsiotako kubo bat erakutsiko zaio parte hartzaileari. Kubo hori kopiatzeko eskatuko zaio.
  - **Puntuazioa:** puntu bat lortuko du parte hartzaileak kuboa ondo kopiatu badu eta hurrengo irizpide guztiak betetzen baditu:
    - Kuboa hiru dimentsiotakoa bada.
    - Kuboaren marra guztiak marraztu baditu.
    - Ez badu marra gehigarririk marraztu.
    - Marrak gutxi gorabehera paraleloak badira eta ereduaren hedadura antzekoa bada.
- **Erlojua:**
  - **Prozedura:** parte hartzaileari erloju bat marrazteko eskatuko zaio. Erlojuaren zenbaki guztiak jartzeko eta orratzek 11ak eta 10 ordua adierazteko eskatuko zaio.
  - **Puntuazioa:** puntu bat lortuko du parte hartzaileak, erlojuak ondorengo irizpide bakoitza betetzen badu. Gehiengo puntuazioa beraz hiru izango da:
    - Erlojuaren ertza (puntu 1): erlojuak borobila izan beharko du, nahiz eta pixka bat desitxuratuta egon (adibidez akats txikiren bat borobila ixterakoan).

- Zenbakiak (puntu 1): erlojuan zenbaki guztiak egon beharko dute, zenbaki gehigarririk ipini gabe: ordenean eta gutxi gorabehera erlojuan dagokien lekuan kokatuta egon beharko dute. Zenbaki erromatarrak onartuko dira. Zenbakiak erlojuaren ertzaren kanpoaldean ipintzea onartu egingo da.
- Orratzak (puntu 1): bi orratz marraztu beharko du, erdian elkartuta daudela eta ordu egokia adierazten dutela (11ak eta 10). Orduak adierazten dituen orratzak minutuak adierazten dituena baino txikiagoa izan beharko du.

o **Nor/zein den jakitea:**
  - **Prozedura:** testean agertzen diren hiru animalien izenak ozen esateko eskatuko zaio parte hartzaileari.
  - **Puntuazioa:** puntu bat jasoko du parte hartzaileak ondo esaten duen animalia izen bakoitzarengatik: lehoia, errinozeroa eta dromedarioa. Gehiengo puntuazioa beraz hiru izango da.

o **Oroimena:**
  - **Prozedura:** parte hartzaileari memoria proba bat dela azalduko zaio. Ikertzaileak zerrenda bat ozen irakurriko duela esango dio parte hartzaileari, eta momentuan bertan eta denbora baten ondoren hitz horiek gogoratzen saiatu beharko dela adieraziko dio. Zerrendako hitzen ordenak ez duela inporta azpimarratuko zaio. Ikertzaileak bost hitzetako zerrenda bat ozen irakurriko du (gutxi gorabehera hitz bat segundoko abiaduran). Ondoren parte hartzaileak gogoratzen dituen hitzak ozen esan beharko ditu. Proba berriz errepikatuko da eta parte hartzaileari berriz ere gogoratzen dituen hitz guztiak ozen esateko eskatuko zaio

(lehenengo saiakeran esandakoak ere bai). Proba amaitzean, hitz horiek probaren amaierara arte gogoratzen saiatzeko eskatuko zaio.

- **Puntuazioa:** bi saiakera hauengatik parte hartzaileak ez du punturik jasoko.

- **Atentzioa:**
  - **Zenbakiak aurreraka:**
    - **Prozedura:** ikertzaileak bost zenbaki ozen esango ditu (gutxi gorabehera zenbaki bat segundoko abiaduran) eta parte hartzaileari bost zenbakiak orden berdinean errepikatzeko eskatuko zaio.
    - **Puntuazioa:** parte hartzaileak puntu bat jasoko du bost zenbakiak ordenean esaten baditu.
  - **Zenbakiak atzeraka:**
    - **Prozedura:** ikertzaileak hiru zenbaki ozen esango ditu (gutxi gorabehera zenbaki bat segundoko abiaduran) eta parte hartzaileari hiru zenbakiak atzeraka errepikatzeko eskatuko zaio (ikertzaileak esan duen azken zenbakitik lehenengora arte).
    - **Puntuazioa:** parte hartzaileak puntu bat jasoko du hiru zenbakiak atzerakako ordenean esaten baditu.
  - **Kontzentrazioa:**
    - **Prozedura:** ikertzaileak letra zerrenda bat ozen irakurriko du (gutxi gorabehera zenbaki bat segundoko abiaduran). Parte hartzaileari “A” letra entzuten duenean mahaian eskuarekin kolpe txiki bat emateko eskatuko zaio. Beste edozein letra entzutean kolperik ez emateko eskatuko zaio.
    - **Puntuazioa:** puntu bat jasoko du akats bat egiten badu edo ez badu akatsik egiten (akatsa izango da “A” letra esan ez bada eta parte hartzaileak mahaian

kolpe bat eman badu edo “A” letra esatean mahaian kolperik eman ez badu).

- **Kenketak:**
  - **Prozedura:** parte hartzaileari 100 zenbakitik hasita, zazpi kentzen joateko eskatuko zaio (kenketa bost aldiz burutzeko eskatuko zaio).
  - **Puntuazioa:** proba honetan gehiengo puntuazioa hiru izango da. Parte hartzaileak ez du punturik jasoko kenketak gaizki egin baditu; puntu bat jasoko du kenketa bat ondo egin badu; bi puntu jasoko ditu bi edo hiru kenketa ondo egin baditu; hiru puntu jasoko ditu lau edo bost kenketa ondo egin baditu. Kenketa bakoitza banaka aztertuko da. Hau da, parte hartzaileak akats bat egiten badu kenketa batean eta zenbaki okerra adierazten badu, baina zenbaki honi zazpi kentzen badizkio, puntu bat jasoko du bigarren kenketa egokia izan delako. Adibidez parte hartzaileak 100etik hasita “92-85-78-71-64” esan badu, “92” okerra izango litzateke, baino beste zenbakien kenketak egokiak izango lirateke, eta beraz hiru puntu jasoko lituzke, lau kenketa ondo egin dituelako.

- **Hizkuntza:**
  - **Esaldiak errepikatu:**
    - **Prozedura:** ikertzaileak esaldi bat ozen irakurriko du eta amaitzean, parte hartzaileari esaldia errepikatzeko eskatuko dio. Ondoren ikertzaileak beste esaldi bat ozen irakurri eta berriz ere parte hartzaileari esaldia errepikatzeko eskatuko dio.
    - **Puntuazioa:** gehienez bi puntu lortu ahal izango dira. Esaldi bakoitza ondo errepikatzeagatik puntu bat jasoko du parte hartzaileak. Ez du puntu bat jasoko

esaldian hitzen bat falta bada edota esaldiko hitz bat antzekoa den beste hitz batekin ordezkatu badu.

- **Hitz-jarioa:**
  - **Prozedura:** parte hartzaileak 60 segundo izango ditu, "p" letraz hasten diren ahalik eta hitz gehien esateko. Edozein hitzek balio izango du, izen propioak (adibidez Euskadi, Miren) eta hitzaren hasiera berdina duten hitzak izan ezik (adibidez erori, erorikoa, erorketa).
  - **Puntuazioa:** puntu bat jasoko du "p" letraz 11 hitz edo gehiago esateko gai izan bada.

- **Abstrakzioa:**
  - **Prozedura:** parte hartzaileari sagarraren eta laranjaren antzekotasuna esateko eskatuko zaio, eta ez badu "fruituak" direla esaten, ikertzaileak azaldu egingo dio. Ondoren, 1) trena eta bizikletaren, eta 2) erloju eta erregelaren antzekotasuna esateko eskatuko dio, baino oraingo honetan inongo laguntzarik izan gabe.
  - **Puntuazioa:** gehienezko puntuazioa bi izango da. Trena eta bizikletaren antzekotasuna asmatuz gero puntu bat jasoko du (garraiobideak); erloju eta erregelaren antzekotasuna asmatuz gero puntu bat jasoko du (neurtzeko gailuak).
- **Iraupen luzeko oroimena:**
  - **Prozedura:** parte hartzaileari "oroimena" proban gogorarazteko esan zaizkion hitzak ozen esateko eskatuko zaio.
  - **Puntuazioa:** gehienez bost puntu jasoko ditu. Gogoratzen den hitz bakoitzeko parte hartzaileak puntu bat jasoko du.
- **Orientazioa:**
  - **Prozedura:** parte hartzaileari egungo data esatea eskatuko zaio (urtea, hilabetea, eguna eta asteguna). Ondoren, non

dauden galdetuko dio ikertzaileak parte hartzaileari eta zein herri/hiritan dauden.

- **Puntuazioa:** gehienez sei puntu jasoko ditu. Puntu bat jasoko du ondo erantzun duen item bakoitzeko (urtea, hilabetea, eguna, asteguna, lekua eta herri/hiria).

- **Puntuazio orokorra:** gehiengo puntuazioa 30 izango da. 12 urte edo gutxiagoko ikasketak izan dituztenek puntu gehigarri bat izango dute puntuazio orokorrean. Puntuazio altuak gaitasun kognitibo orokor hobea adierazten du.

3.1.3.5.2. *Hitzezko oroimena (Ponton, 2001)*

Hitzezko oroimen testaren bitartez adinaren ondorioz gertatzen den oroitzeko gaitasunaren galera neur daiteke (Bezdicek et al., 2014). Zehazki, hitzezko oroimena eta hitz metatuak oroitzeko gaitasuna neurtzeko erabiltzen da (Ponton, 2001).

- **Prozedura:** testa burutzeko 15 minutu inguru behar dira. 15 hitzetako zerrenda bat ozen irakurriko du ikertzaileak (A zerrenda), eta hitz guztiak esaterakoan, parte hartzaileari gogoratzen dituen hitz guztiak esateko eskatuko zaio. Beste lau aldiz A zerrendako hitzak errepikatuko zaizkio, ikertzaileak 15 hitzeko zerrenda bera ozen esanez eta amaitzean parte hartzaileari ahal dituen hitzak gogorarazteko eskatuz. Amaitu bezain pronto, 15 hitz ezberdin dituen beste zerrenda bat ozen irakurriko du ikertzaileak (B zerrenda), eta parte hartzaileari gogoratzen dituen hitz guztiak esateko eskatuko dio. Ondoren, A zerrendako hitzak esateko eskatuko dio (zerrenda hau berriz ere ozen irakurri gabe). Azkenik, 20 minuturen ondoren, A zerrendako hitzak gogorarazteko eskatuko dio (zerrenda hau ozen irakurri gabe).
- **Aztertutako aldagaiak:** hainbat dira test honetatik jaso daitezkeen neurketak, baina proiektu honetan bi dira jaso direnak:
    - Bost saiakeretan esan duen hitz kopurua batuko da (1.go saiakera + 2. saiakera + 3. saiakera + 4. saiakera + 5. saiakera). Puntuazio altuak emaitza hobea adierazten du.

- o Lehenengo saiakeratik azken saiakerara arte gogoratu duen hitz kopurua jasoko da (5. saiakera – 1.go saiakera). Puntuazio altuak emaitza hobea adierazten du.

3.1.3.5.3. *Trazu testa (Reitan & Wolfson, 1985)*

Trazu testa informazioa prozesatzeko abiadura neurtzeko, eta konkretuki kontrol motorra, abiadura motorra eta ikusmen abiadura neurtzeko tresna bat da (Reitan & Wolfson, 1985). Espainian neuropsikologoek erabiltzen dituzten erraminta neuropsikologikoetatik erabilienetariko bat da Trazu testa (Olabarrieta-Landa et al., 2016). Test honek bi atal ditu; A eta B atalak. Ikerketa proiektu honetan Trazu testaren A atala bakarrik burutu zen.

- **Prozedura:** trazu testaren A atala burutzeko, parte hartzaileari ahalik eta azkarren zenbakidun zirkuluak banan-banan eta ordenean lerro bat marraztuz lotzeko eskatuko zaio.
- **Puntuazioa:** zirkulu guztiak ordenean lotzeko behar izan duen denbora jasoko da. Gero eta denbora gutxiago behar izateak emaitza hobea adierazten du.

3.1.3.5.4. *Wechsler-en helduentzako adimen eskalaren laugarren edizioa (Wechsler, 2010)*

Wechsler-en inteligentzia test multzoa, Espainian zein Europan eta Ameriketako Estatu Batuetan gaitasun intelektualak neurtzeko tresna erabilienetariko bat da (Amador, 2013; Olabarrieta-Landa et al., 2016). Ikerketetan aztertu diren berrikuntzen ondorioz, Wechsler-en test multzoaren jatorrizko bertsioak zenbait aldaketa izan ditu. Hala ere, bertsio guztietan Wechsler-en inteligentziari buruzko hasierako ikuspegia mantendu da: “inteligentzia, helburu bati lotutako ekintzak burutzeko gaitasuna da, zentzuz pentsatu eta bere ingurunean eraginkortasunez moldatu ahal izateko balio duena” (Amador, 2013). Wechsler-en helduentzako adimen eskalaren laugarren edizioa test multzoak 15 proba ditu, eta bertsio eguneratuena da. 15 proba horien artean, proiektu honetan burutu diren Zenbakien kodea eta ikurren bilaketa testa ditugu. Bi test hauen bitartez prozesatze abiadura neurtu daiteke (Wechsler, 2010).

3.1.3.5.4.1. Zenbakien kodea

- **Prozedura:** testaren orriaren goiko aldean zenbaki zerrenda bat erakutsiko zaio parte hartzaileari (batetik bederatzira). Zenbaki bakoitzaren azpian irudi bat egongo da. Orriaren behealdean, parte hartzaileak ordenean ez dauden zenbaki zerrenda bat izango du eta zenbaki hauen azpian hutsik dauden laukiak izango ditu. Parte hartzaileak goiko zerrendan begiratuta, zenbaki bakoitzari dagokion irudia ikusi eta behean kopiatuko du. Lehen hiru zenbakiak ikertzaileak egingo ditu, eta ondoren sei zenbakirekin proba egingo du parte hartzaileak. Ondoren bi minutu emango zaizkio parte hartzaileari, ahalik eta lauki gehienetan dagokion irudia marrazten joateko.
- **Puntuazioa:** bi minututan ordenean eta egoki marraztu dituen irudi kopurua zenbatuko da. Puntuazio altuak emaitza hobea adierazten du.

3.1.3.5.4.2. Ikurren bilaketa

- **Prozedura:** testeko orriaren ezkerraldean, grisez nabarmenduta, bi irudi egongo dira lerro bakoitzean. Lerro berean beste bost irudi eta “NO” dioen lauki bat izango dira. Bost irudi hauetariko bat grisez nabarmenduta dagoen irudi baten berdina bada, marra bat egin beharko dio parte hartzaileak antzeman duela jakinarazteko. Bost irudi horietariko bat ere ez bada grisez nabarmenduta dauden bi irudi horien berdina, “NO” dioen laukian marra bat egingo du parte hartzaileak. Lehenengo hiru lerroak ikertzaileak egingo ditu, eta ondoren beste hiru lerro parte hartzaileak egingo ditu. Proba ondo ulertu duela ziurtatzeko, sei lerro hauetan behar bezainbesteko azalpenak emango dira. Ondoren bi minutu emango zaizkio parte hartzaileari, ahalik eta lerro gehienetan dagokion irudiari edo “NO” laukiari marratxoa egiteko.
- **Puntuazioa:** bi minututan egoki antzeman dituen irudi eta “NO” lauki kopuruak zenbatuko dira, eta oker egin dituen lerro kopuruarekin kenketa egingo da (ondo egin dituenak – oker egin dituenak). Puntuazio altuak emaitza hobea adierazten du.

3.1.3.5.5. *Hitz-jarioa*

Hitz-jarioa bakoitzak bere kabuz hitz egiterakoan hitzak bilatzeko isilune luzeak behar ez izateko gaitasuna da (Butman, Allegri, Harris & Drake, 2000). Hitz-jarioa okertu egiten da zenbait prozesu patologikoren agerpenarekin batera; Alzheimer gaixotasuna, eskizofrenia, depresioa (Norris, Blankenship-Reuter, Snow-Turek & Finch, 1995; Gourovitch, Goldberg & Weinberger, 1996; Pachana, Boone, Miller, Cummings & Berman, 1996)… Gainera, oso azkar eta erraz burutu ahal den test bat denez, ebaluazio neuropsikologiko gehienetan erabili ohi den test bat da (Parkin, Belinchón & Vargas, 1999).

3.1.3.5.5.1. “p” hizkiz hasten diren hitzak (Serrani, 2013)

- **Prozedura:** parte hartzaileari “p” hizkiz hasten diren ahalik eta hitz gehien esateko eskatuko zaio.
- **Puntuazioa:** 60 segundotan esandako hitz kopurua jasoko da. Puntuazio altuak emaitza hobea adierazten du.

3.1.3.5.5.2. Animaliak (Serrani, 2013)

- **Prozedura:** parte hartzaileari ahalik eta animalia gehien esateko eskatuko zaio.
- **Puntuazioa:** 60 segundotan esandako animalia kopurua jasoko da. Puntuazio altuak emaitza hobea adierazten du.

3.1.3.5.6. *Goldberg-en antsietatea eta depresioa testa (Goldberg, Bridges, Duncan-Jones & Grayson, 1988)*

- **Prozedura:** parte hartzaileari testean dauden galderak egingo zaizkio.
- **Puntuazioa:** baietz esandako galderak zenbatuko dira bai antsietatearen zein depresioaren azpi-ataletan. Puntuazio altuak antsietate eta depresio sentsazio altua adierazten du.

3.1.3.5.7. *De Jong-Gierveld-en bakardadea testa (De Jong-Gierveld & Kamphuls, 1985)*

- **Prozedura:** parte hartzaileari testean dauden galderak egingo zaizkio.

- **Puntuazioa:** 1, 4, 7, 8 eta 11 galderetan “gutxi gorabehera” edo “ez” erantzuten badu puntu bat jasoko du parte hartzaileak. Beste galdera guztietan “bai” erantzuten badu, puntu bat jasoko du erantzun bakoitzeko. Puntu guztien batura egingo da. Puntuazio altuak bakardade pertzepzio altua adierazten du.

3.1.3.5.8. *Bizi-kalitatea (Gómez-Gallego, Gómez-Amor & Gómez-García, 2012)*

- **Prozedura:** parte hartzaileari testean dauden galderak egingo zaizkio.
- **Puntuazioa:** galdera bakoitzean parte hartzailearen erantzuna “malo” bada puntu bat jasoko da, “normal” bada bi puntu, “bueno” bada hiru puntu eta “excelente” bada lau puntu. 13 galderetako erantzunen batura egingo da. Gutxieneko puntuazioa beraz 13 izango da eta gehinezkoa 52. Gero eta puntuazio altuagoak bizi-kalitate hobea adierazten du.

3.1.3.6. Hauskortasuna

Hauskortasuna antzemateko hainbat eskala proposatu dira (Bouillon et al., 2013). Zenbait ikertzaile bakarrik arlo fisikoan oinarritu dira. Horien artean, orain arte ikerketetan erabiliena izan den eskala Fried-en hauskortasun irizpidea izan da (Fried et al., 2001; Bouillon et al., 2013). Fried-en hauskortasun irizpidea bost seinale/sintometan oinarritzen da: nahi gabeko pisu galera, nekea, ahultasuna, ibilera abiadura motela eta jarduera fisiko gutxi burutzea (Fried et al., 2001). Arlo fisikoan oinarritu diren beste test batzuen artean Short Physical Performance Battery (SPPB), osteoporosi hausturen ikerketako hauskortasun indizea eta hauskortasun eskala klinikoa ditugu (Guralnik et al., 2000; Rockwood et al., 2005; Ensrud et al., 2008; Abizanda et al., 2012; Bouillon et al., 2013). SPPB test multzoak ibilera abiadura, oreka eta aulkitik altxatzeko gaitasuna neurtzen ditu (Guralnik et al., 2000). Osteoporosi hausturen ikerketako hauskortasun indizea test multzoak aulkitik altxatzeko gaitasuna, energia gabeziaren pertzepzioa eta nahi gabeko pisu galera neurtzen ditu (Ensrud et al., 2008). Hauskortasun eskala klinikoa iritzi klinikoan oinarritzen den testa da, forma fisiko eta gaitasun funtzionalean oinarritzen dena (Rockwood et al., 2005).

Hala ere, zenbait ikertzailek hauskortasuna aztertzeko arlo fisikoaz gain arlo kognitibo eta soziala kontuan izan behar direla proposatu zuten (Gobbens et al., 2010). Ikertzaile hauek Tilburg-en hauskortasun indizea sortu zuten arlo fisikoa, psikologikoa eta soziala galdeketa baten bitartez neurtzen dituena (Gobbens et al., 2010).

3.1.3.6.1. *Fried-en hauskortasun irizpidea (Fried et al., 2001)*

- **Aztertutako aldagaiak:**
  - **Nahi gabeko pisu galera:**
    - **Prozedura:** Tilburg-en hauskortasun indizea galdetegian, azkenaldian ea nahi gabeko pisu galera izan duen galdetu zitzaion.
    - **Puntuazioa:** galderari baiezkoa ematen badio, puntu bat jasoko du.
  - **Nekea:**
    - **Prozedura:** Goldberg-en antsietatea eta depresioa galdetegian, azkenaldian ea gehiegizko neke sentsazioa izan duen galdetu zitzaion.
    - **Puntuazioa:** galderari baiezkoa ematen badio, puntu bat jasoko du.

- o **Ahultasuna:**
  - **Prozedura:** eskuko zein besaurreko indarra neurtu zen.
  - **Puntuazioa:** behean adierazita dauden mozketa-puntuetan oinarrituz, puntu bat jasoko du parte hartzaileak GMI-aren araberako mozketa-puntuak adierazten duena baino indar gutxiago baldin badu.

GMI ♂	Eskuko eta besaurreko indarra	GMI ♀	Eskuko eta besaurreko indarra
< 24	≤ 29kg	< 23	≤ 17kg
24,1-26	≤ 30 kg	23,1-26	≤ 17,3kg
26,1-28	≤ 30kg	26,1-29	≤ 18kg
> 28	≤ 32kg	> 29	≤ 21kg

- o **Ibilera abiadura motela:**
  - **Prozedura:** lau metro ibiltzeko eskatu zitzaion parte hartzaileari.
  - **Puntuazioa:** behean adierazita dauden mozketa-puntuetan oinarrituz (parte hartzailearen altueraren arabera), puntu bat jasoko du parte hartzaileak mozketa-puntuak adierazten duena baino denbora gehiago behar izan badu lau metro ibiltzeko.

Altuera ♂	denbora (abiadura)	Altuera ♀	denbora (abiadura)
≤173cm	≥6,1s (0,66m/s)	≤159cm	≥6,1s (0,66 m/s)
>173cm	≥5,2s (0,77m/s)	>159cm	≥ 5,2s (0,77 m/s)

- o **Jarduera fisiko gutxi burutzea:**
  - **Prozedura:** azelerometro baten bitartez parte hartzaileak egunean eman ohi zituen pausoak neurtu ziren.

        - **Puntuazioa:** 5000 pauso baino gutxiago egin zituztenek puntu bat jaso zuten.
- **Puntuazio orokorra:** gehienezko puntuazioa bost izango da. Hiru puntutik gora dituzten parte hartzaileak hauskorrak izango dira. Puntuazio altuak hauskortasun maila altuagoa adierazten du.

3.1.3.6.2. *Hauskortasun eskala klinikoa (Rockwood et al., 2005)*

- **Prozedura:** ikertzailea iritzi klinikoan oinarrituko da parte hartzailearen forma fisiko eta gaitasun funtzionala baloratzeko.
- **Puntuazioa:** gehienezko puntuazioa bederatzi da. Sei puntutik gora dituzten parte hartzaileak hauskorrak izango dira. Puntuazio altuak hauskortasun maila altuagoa adierazten du.

3.1.3.6.3. *Osteoporosi hausturen ikerketako hauskortasun indizea (Ensrud et al., 2008)*

- **Aztertutako aldagaiak:**
    - **Aulkitik altxatzeko gaitasuna:**
        - **Prozedura:** SPPB-ko testean burutzen den bost altxaldiko proba burutuko da.
        - **Puntuazioa:** parte hartzailea minutu batean bost altxaldi burutzeko gai ez bada, puntu bat jasoko du.
    - **Energia falta pertzepzioa:**
        - **Prozedura:** Goldberg-en antsietatea eta depresioa galdetegian, azkenaldian ea energia falta pertzepzioa izan duen galdetu zitzaion.
        - **Puntuazioa:** parte hartzaileak galderari baiezkoa ematen badio, puntu bat jasoko du.
    - **Nahi gabeko pisu galera:**
        - **Prozedura:** Tilburg-en hauskortasun indizea galdetegian, azkenaldian ea nahi gabeko pisu galera izan duen galdetu zitzaion.
        - **Puntuazioa:** galderari baiezkoa ematen badio, puntu bat jasoko du.

- **Puntuazio orokorra:** gehienezko puntuazioa hiru da. Bi puntutik gora dituzten parte hartzaileak hauskorrak izango dira. Puntuazio altuak hauskortasun maila altuagoa adierazten du.

3.1.3.6.4. *Tilburg-en hauskortasun indizea (Gobbens et al., 2010)*

- **Galdetegia:**
    - **Prozedura:** Tilburg-en hauskortasun indizea galdeketak bi atal ditu: A eta B. Hauskortasuna baloratzeko B ataleko 15 galderak egingo zaizkio parte hartzaileari. “Bai”, “noizbait” edo “ez” erantzuteko galderak dira. Zortzi galdera arlo fisikoari loturikoak izango dira, lau arlo psikologikoari eta hiru arlo sozialari.
    - **Aztertutako aldagaiak:** testean agertzen diren irizpideetan oinarritu beharko da arlo fisiko, psikologiko, sozial zein puntuazio orokor bat lortu ahal izateko.
- **Puntuazio orokorra:** gehienezko puntuazioa hamabost da. Bost puntutik gora dituzten parte hartzaileak hauskorrak izango dira. Puntuazio altuak hauskortasun maila altuagoa adierazten du.

3.1.3.7. <u>Historia klinikoak</u>

Hirugarren adineko egoitzetako pertsonen historia klinikoen inguruko informazioa ezagutzea oso garrantzitsua da parte hartzaileak gehiago ezagutu eta interbentzio bat diseinatu eta norbanakoari egokitzeko. Hirugarren adineko egoitzetan, egoiliar bakoitzaren jarraipen-txosten bat egin ohi da. Bertan egoiliarraren gaixotasun, komorbilitate, erorketa, ospitalizazio zein larrialdietara eginiko deien jarraipena egiten da, pertsona bakoitzaren arrisku eta beharrak antzeman eta interbentzio estrategiak ahalik eta azkarren bideratzeko.

- **Prozedura:** ondoren aipatuko diren aldagaiak sendagile zein erizainek egoitza bakoitzeko programa informatikotik jasotzeko eskatu zitzaien.
- **Aztertutako aldagaiak:**
    - Lehentasunezko hizkuntza
    - Hezkuntza-maila

- Sendagaiak (interbentzioa hasi zuten egunean eta interbentzioa amaitu zen egunean hartzen zutena)
- Mini-examen cognoscitivo test-eko puntuaketa (Lobo et al., 1999) (interbentzioa hasi zuten egunekoa eta interbentzioa hasi zenetik urtebetera)
- Barthel Index test-eko puntuaketa (Wade & Collin, 1988) (interbentzioa hasi zuten egunekoa eta interbentzioa hasi zenetik urtebetera)
- Diagnostikoak (interbentzioa hasi zuten egunekoa eta interbentzioa hasi zenetik urtebetera)
- Erorketen zenbatekoa eta ondorioak (interbentzioa hasi aurreko urtean izan zituztenak eta interbentzioa hasi zenetik urtebetera izandakoak)
- Ospitalizazioen zenbatekoa eta zergatia (interbentzioa hasi aurreko urtean izan zituztenak eta interbentzioa hasi zenetik urtebetera izandakoak)
- Larrialdietarako deien zenbatekoa eta zergatia (interbentzioa hasi aurreko urtean izan zituztenak eta interbentzioa hasi zenetik urtebetera izandakoak)
- Heriotza (interbentzioa hasi zutenetik urtebetera hildako parte hartzaileen heriotza datak)

3.1.4. Kontrol taldea

Kontrol taldeko parte hartzaileek hirugarren adineko egoitzetan ohikoak diren jarduerak burutu zituzten: memoria ariketak, irakurketa, kantuak, mugikortasun ariketak eta antzekoak ziren beste zenbait jarduera.

3.1.5. Talde esperimentala

Talde esperimentaleko parte hartzaileek, egoitzako programako jarduerak burutzeaz gain, norbanakoari egokitutako ariketa fisikoko programa progresibo bat burutu zuten intentsitate moderatuan. Sei hilabetetan zehar, talde esperimentaleko kideek 45-60 minutuko ariketa fisikoko bi saio burutu zituzten. Saioak 3-8ko partaide taldeetan burutu ziren egoitza bakoitzeko gimnasioan edo talde-jarduerak burutzen zituzten gelan. Gelak tamaina ertainekoak ziren (9 pertsona eroso sentitzeko modukoak). Gelan bertan, barra paralelolak, aulki sendoak edo mahai handi eta sendo bat eskatu genuen, oreka zein indar ariketak burutzerakoan euskarri modura erabilgarri izateko. Bestetik, gelan ahalik eta oztopo gutxien egotea eskatu genuen, estropezu egin eta erorketak ekiditeko eta partaideen segurtasuna bermatzeko. Saioak burutzeko beharrezko materiala jarduera-gelan bertan edo ondoko gelaren batean gordetzen zen, orohar armairu batean eta giltzapean.

Entrenamendu programaren lehen hilabetean ariketen familiarizazioa burutzeari ekin zitzaion eta programako ariketak pisu gehigarririk gabe burutu ziren. Lehen hilabetearen ondoren, pisu gehigarriak erabili genituen ariketetan (ondoren deskribatuko direnak), Brzycki ekuazioaren (Brzycki, 1993) bitartez errepikapen maximoaren estimazio testa egin zen (RM1) lan kargak zehazteko. Ondoren, parte hartzaileek kargak ondo jasaten zituztenean, bolumena eta intentsitatea progresiboki handitzen joan zitzaizkien, hurrengo ataletan azalduko den bezala.

Brzycki ekuazioa: RM1 = Pisua / (1,0278 - (0,0278 x errepikapenak))

Ariketa fisikoko programak 6 hilabete iraun zituen. Programa honetan 3 hilabetetako 2 makroziklo egin ziren. Makroziklo bakoitzean 3 mesoziklo egin ziren, eta bi mesozikloren amaieran (bi hilabetez behin) RM1-en estimazio proba egin zen kargak doitzeko eta hauen kontrola eramateko. Hirugarren mesozikloa amaitutakoan, aipatutako proba honez gain, aurretik azaldutako balorazioak egin ziren. Mesoziklo bakoitzean 4-5 mikroziklo egin ziren, astebete iraun zutenak. Mikroziklo bakoitzean ariketa fisikoko bi saio egin ziren indarra, oreka eta malgutasuna landuz. Entrenamendu saio bakoitza hiru zatitan banatu zen:

- **Girotze aldia (10-15 minutu):**
  - **Mugikortasun artikularra:**
    - **Burua mugituz:**
      - Aurrera eta atzeraka mugituz
      - Ezkerrera eta eskuineraka mugituz
    - **Sorbaldak mugituz:**
      - Gora eta beheraka mugituz
    - **Besoak mugituz:**
      - Eskuekin belaunak eta sorbaldak ukituz
    - **Eskuak estutuz:**
      - 5 segundoz pilota bat estutuz esku batekin zein birekin
    - **Hankak mugituz:**
      - Belaunak igo eta jaitsiz (eserita)
      - Oin puntak eta orpoak igo eta jaitsiz (zutik)

- **Atal nagusia (20-40 minutu):**
  - **Indarra:**
    - **Egokitzapen fasean** (1.go, 2. eta 3. hilabeteak) 4 ariketa egin ziren, 1-2 serie eta 8-12 errepikapenekin. Indar entrenamendua, egin ahal zuten indar maximoaren (RM1) %40-50eko intentsitatean hasi zuten. Kargaren bolumena eta intentsitatea handitzen joan ziren parte hartzaileen arabera. Serieen artean 1-3 minutuko atsedena izan zuten. Ariketa batzuetan, ariketaren konplexutasuna zela eta, ez zen pisu gehigarririk erabili.
    - **Indar garapenaren fasean** (4tik 6. hilabetera arte) 4-5 ariketa egin ziren, bakoitzean 8-12 errepikapeneko 2 serie eginez intentsitate moderatuan (RM1-eko %60-70).
    - **Beso-flexioa:**
      - Asteko 1.go eta 2. saioan
      - Pisu gehigarriarekin
      - Intentsitatea: aurretik aipatutako printzipioetan oinarrituta doitu zen.

- **Altxa eta eseri:**
  - Asteko 1.go eta 2. saioan
  - Pisu gehigarririk gabe
  - Intentsitatea: RM1-eko proba egitean 10 errepikapen baino gehiago burutzen zituzten parte hartzaileek, saioetako serie bakoitzean 10 errepikapen burutu zituzten, eta ariketa ahalik eta azkarren burutzeko azpimarratzen zitzaien. Aldiz, RM1-ko proban 10 errepikapen edo gutxiago burutu ahal zituztenek, programak zehazten zuen intentsitatearen arabera errepikapen kopurua doitzen zitzaien (adibidez: 10 errepikapen egin ahal zituenak programaren intentsitatea %40a zenean, 4 errepikapen burutzen zituen…). Serie kopurua programak zehaztutakoa izan zen denentzat.

- **Ipurmasaileko muskulu ertaina:**
  - Asteko 1.go saioan
  - Pisu gehigarririk gabe
  - Intentsitatea: interbentzioa burutu aurretik egin genuen proba pilotuan ariketa konplexua iruditu zitzaigun, eta pisu gehigarririk gabe burutzea erabaki genuen. Denek 10 errepikapen burutu zituzten (serie kopurua programak zehaztutakoa).

- **Iskiotibiala:**
  - Asteko 1.go saioan
  - Pisu gehigarriarekin
  - Intentsitatea: aurretik aipatutako printzipioetan oinarrituta doitu zen.

- **Ipurmasaileko muskulu handia:**
  - Asteko 2. saioan
  - Pisu gehigarririk gabe
  - Intentsitatea: interbentzioa burutu aurretik egin genuen proba pilotuan ariketa konplexua iruditu zitzaigun, eta pisu gehigarririk gabe burutzea erabaki genuen. Denek 10 errepikapen burutu zituzten (serie kopurua programak zehaztutakoa).


- **Koadrizepsa:**
  - Asteko 2. saioan
  - Pisu gehigarriarekin
  - Intentsitatea: aurretik aipatutako printzipioetan oinarrituta doitu zen.

- **Oreka:**
  - **Orekaren lehenengo fasean** (1.go, 2. eta 3. hilabeteak) ariketak ezagutzea eta eserita edo zutik euskarrien bitartez konfidantza areagotzea izan zen helburu nagusia. Oreka estatikoa zutik landu genuen eta oreka dinamikoa, eserita. Saio bakoitzean 2-3 oreka ariketa burutu ziren fase honetan.
  - **Orekaren bigarren fasean** (4tik 6.hilabetera arte) oreka ariketak zailtzen joan ziren. Fase honetan, oreka estatikoa eta dinamikoa zutik landu genituen. Saio bakoitzean 4-5 oreka ariketa burutu ziren.
    - **Oreka dinamikoa eserita:**
      - Asteko 1.go saioan
      - Eserita parte hartzaileak bata bestearen parean jarri eta baloia pasatzea (baloia bota gabe)
      - 10 errepikapen, pixkanaka bata bestearen lekutik urrutirago jarrita

– **Oreka estatikoa zutik:**
  - Asteko 2. saioan
  - Bi oinak elkarrekin, semitandem, tandem jarreran eta oin bakarrean mantenduz (euskarriaren laguntzaz beharrezkoa ikusiko bagenu)

- **Oreka dinamikoa zutik:**
    - Asteko 2. saioan
    - Step bat aurrean jarri eta zutik egonda, oin bat step-aren gainean jarri eta gero bestea, txandaka eginez (euskarriaren laguntzaz beharrezkoa ikusiko bagenu)

- **Lasaitasunera itzulera (5-10 minutu):**
  - **Erlaxazio-ariketak:**
    - Begiak itxi eta arnasketa sakonak burutu
  - **Malgutasuna:**
    - Pilota bat hartu eta pixkanaka oin puntara eramanez. Tenkatasun edo deserosotasun puntuan 20-30 segundoz jarrera mantenduz.

- **Lan aerobikoa**
  - Gomendio zehatzak eman dira parte hartzaileek saioez gain egunero ibilaldi konkretu bat egiteko. Sei minutuko proban (SFT-ko testa) lortutako emaitzetan oinarrituta, 5 minutuko banan-banako ibilaldiak programatu ziren. Gomendioak interbentzioaren lehenengo hilabetearen amaieran jarri ziren martxan egoitza guztietan (5 minutuko gomendioekin hasi, ondoren 10 minutu, 15 eta azkenik 20 minutu). Ibilaldien jarraipena egiteko, saioen amaieran galdetu egin zitzaien ea parte hartzaileek izaten ari zuten esperientzia zer moduzkoa zen. Honez gain, 2., 4. eta 6. hilabeteetan, ibilaldien jarraipen txosten bat pasa zitzaien egoitzako langileei, parte hartzaileen betetze maila zehazteko. Bertan egoitzetako langileen parte hartzea eskatu da parte hartzaileei eguneroko ibilaldiak egiten gogorarazteko zein laguntza behar zutenei ibilaldia beraiekin egiteko.

3.1.6. Siel Bleuko praktikak

2015ean doktorego praktikak egin nituen "Asociación Siel Bleu Euskadi Elkartean" (jarduera fisikoaren bitartez zahartze aktibo eta osasuntsuaren sustapenera bideratuta dagoen elkartea). Bertan, Euskadiko hainbat egoitzetan dauden adineko pertsonekin ariketa fisikoko programa ezberdinak burutzeko aukera izan nuen.

3.1.7. Finantziazioa

Tecnalia, Biodonostia, Ceit, Cidetec, Gaiker, Vicomtech, Matia Instituto eta Tekniker-ekin batera "Elkartek 2015" deialdian diru laguntza lortu genuen, eta proiekturako material eta baliabide gehigarriak izateko dirua lortu zen. Sortu zen lantaldearen ikerketa proiektuari esker, jarraipena eman ahal izan genion eta "Elkartek 2016", "Elkartek 2017" eta "Elkartek 2018"ko deialdietan ere diru laguntza lortu genuen.

Diru laguntza hauez gain, 2016, 2017 eta 2018an "Espezializazio adimenduneko RIS3 Euskadi estrategiako biozientziak-osasuna lehentasunari lotutako ikerketa- eta garapen-proiektuetarako laguntzak" deialdietan, eta Gipuzkoako Foru Aldundiak eta UPV/EHU-k 2018an sinatutako hitzarmenean (Gipuzkoa Eraikiz) ere diru laguntza lortu genuen.

Bestetik, "UPV/EHUn mugikortasuna sustatzeko eta ikerketaren emaitzak hedatzeko laguntzen 2016ko deialdian" diru laguntza jaso nuen Bordeleko Unibertsitatean hiru hilabeteko egonaldia burutzeko.

3.2. <u>Jarduera fisikoaren eragina minbizia dutenen hirugarren adineko pertsonetan</u>

Bordeleko Unibertsitatean hiru hilabeteko egonaldia burutu nuen. Bertan, minbizia zuten hirugarren adineko pertsonetan jarduera fisikoko programa batek duen eragina aztertu zen. Proiektu honetan emaitzen analisian parte hartu ahal izan nuen. Proiektuko neurketa zein interbentzio programa burutu zutenekin elkartu eta proiektuari buruzko informazioa jaso ahal izan nuen, ondoren artikulu bat idatzi eta argitaratu egin zena ("Effects of a physical activity program to prevent physical performance decline in onco-geriatric patients").

3.2.1. Ikerketaren diseinua

CAPADOGE (Conseils en Activité physique pour la Prévention de la perte d'Autonomie Des patients d'Onco-GEriatrie) ikerketa proiektua ausazko entsegu kliniko bat izan zen eta 12 ospital ezberdinetako pazienteek parte hartu zuten (Durrieu et al., 2012). Interbentzioa 2011ko urritik 2016ko maiatzera burutu zen. Ikerketa Bordeleko Unibertsitate Ospitaleak koordinatu zuen. Pazienteek ikerketa proiektuaren informazio guztia minbiziaren tratamendua hasi aurretik jaso zuten.

3.2.2. Laginaren ezaugarriak

Ikerketa proiektu honetan parte hartu zutenen irizpideak hurrengo hauek izan ziren: 1) 70 urte edo gehiago zituztenak 2) minbizia zutenak eta sendatzeko pronostikoa zutenak (medikuak subjektiboki baloratuta). Ikerketa proiektu honetan kokaleku ezberdinetako tumoreak zituzten pertsonek parte hartu zuten (ikus "Effects of a physical activity program to prevent physical performance decline in onco-geriatric patients" artikuluko "Supplemental file 1" taulan).

Ikerketa honetatik kanpo geratu ziren Eastern Cooperative Oncology Group (ECOG) testean 2 puntu baino gehiago zituztenak, kognizio edo arazo psikiatriko larria zutenak, frantsesa ez zekitenak eta ibiltzeko gaitasuna ez zutenak. Bestetik, proiektu honez gain jarduera fisikoa burutzen ari ziren beste ikerketa proiektu batean parte hartzen ari zirenak eta zainketa aringarrietan zeudenak ere ez zuten ikerketa proiektu honetan parte hartu.

2011ko urritik 2014ko maiatzera arte 452 parte hartzailerekin jarri zen harremanetan. Horietatik, 300ek ikerketa proiektuan parte hartzea onartu zuten, eta kontrol taldea eta talde esperimentalean banatu ziren. Laginaren batazbesteko adina 76,7 urte izan zen eta %60a emakumeak izan ziren. 300 parte hartzaileetatik 249k (%83) burutu zituzten 12 hilabeteetako neurketak, eta 186k (%62k) 24 hilabeteetako neurketak.

3.2.3. Balorazioak

Jarduera fisikoko programaren eragina aztertu ahal izateko, ondoren zehaztuko diren probak programaren aurretik eta hiru, sei, hamabi, hemezortzi eta hogeita lau hilabetetara burutu ziren.

3.2.3.1. Egoera fisikoa

3.2.3.1.1. *Short Physical Performance Battery (Guralnik et al., 2000)*

Aurretik azaldu den SPPB testa burutu zen proiektu honetan ere.

3.2.3.1.2. *Ibilera abiadura*

Aurretik azaldu den 4 metroko ibilera abiadura testa burutu zen proiektu honetan ere.

3.2.3.2. Jarduera fisikoa burutzeko ohitura (Craig et al., 2003)

Jarduera fisikoa burutzeko ohitura International Physical Activity Questionnaire (IPAQ) galdeketaren bitartez burutu zen.

3.2.3.3. Nutrizioa (Kaiser et al., 2009)

Nutrizioa Mini Nutritional Assessment - Short Form testaren bitartez neurtu zen.

3.2.3.4. Proba neuropsikologikoak

3.2.3.4.1. *Hitz-jarioa (Serrani, 2013)*

Aurretik azaldu den Animaliak testa burutu zen proiektu honetan ere.

3.2.3.5. Hauskortasuna

3.2.3.5.1. *Fried-en hauskortasun irizpidea (Fried et al., 2001)*

Aurretik azaldu den Fried-en hauskortasun irizpidea baloratu zen proiektu honetan ere.

3.2.4. Kontrol taldea

Kontrol taldeak jarduera fisikoko gomendio orokorrak azaltzen dituen (adibidez egunero ordu erdi batez edozein jarduera fisiko mota burutzea) “Programme National Nutrition Santé (PNNS) liburuxka” jaso zuen (Frantziako nutrizio osasun programa nazionala). Liburuxka hau eman zitzaienean ez zitzaien gomendio zehatz gehigarririk eman.

3.2.5. Talde esperimentala

Talde esperimentalak jarduera fisikoko programa bat burutu zuen, telefono bitartez helarazitako gomendioen bitartez burutu zena. Jarduera fisikoko programan indarra, oreka, propiozepzioa, malgutasuna eta ariketa aerobikoak burutu ziren (Durrieu et al., 2012). Programa honen helburua gaitasun fisikoak mantentzea izan zen. Ariketa fisikoko saioak astean bitan burutu ziren programaren hasieran, baina saio gehiago burutzeko proposamena helarazi zitzaien parte hartzaileen motibazio eta gaitasunen arabera. Indarrari dagokionez, goi eta behe gorputz-adarretako indar ariketak burutu ziren: beso-flexioa, sentadila, aldakaren abdukzioa, aldakaren adukzioa…Programaren hasieran, ariketa bakoitzean 10 errepikapen pisurik gabe burutzeko gomendioa helarazi zitzaien. Ariketak ondo toleratu ahala, pisu gehiagarriak eta errepikapen kopurua gehitu zitzaizkien. Parte hartzaileek, telefono bitartez jaso zituzten gomendioez gain, CAPADOGE liburuxka jaso zuten (indar, oreka, propiozepzio, malgutasun eta ariketa aerobikoen irudiak agertzen zirena) irudien laguntza ere izateko. Gomendaturiko intentsitatea aldakorra izan zen (intentsitate baxutik intentsitate altura bitartean), betiere mina eta gehiegizko nekea ekidinez. Instruktoreak parte hartzaileen hasierako zein programan zehar baloratutako SPPB eta IPAQ testetako emaitzak jaso zituen, beraien gaitasun funtzionalean eta ohiko jarduera fisikoan izandako aldaketen berri izateko. Ondoren, instruktorea parte hartzailearekin izandako telefono deietako erantzunetan oinarritu zen, ariketa bakoitzeko intentsitatea maximoa izateko helburuarekin. Oreka eta propiozepzio ariketak zailtzen joan ziren programan zehar. Hasieran ariketak eserita edota zutik bi euskarri izanda burutu ziren, eta ondoren parte hartzaileei mugimendu konplexuagoak burutzeko gomendioa helarazi zitzaien, betiere telefonoz emandako erantzunetan oinarrituta: ariketak euskarri batekin edota euskarririk gabe burututa. Ariketa fisikoko saioen amaieran malgutasun ariketak burutu ziren.

Lan aerobikoari dagokionez, norbanakoan oinarritutako gomendio zehatzak eman ziren ariketa bakoitzaren denbora eta intentsitatea zehaztuz. Lehen telefono deian instruktoreak parte hartzaileei beraien ohiko jarduera fisikoaz galdetu zien (adibidez ibilaldiak, erosketak, eskailerak igotzea…). Instruktoreak deietan eta neurketetan (SPPB eta IPAQ testetako emaitzak) jasotako informazioa kontuan izan zuen parte hartzaileen eguneroko jarduera fisikoa areagotzeko gomendioak emateko.

Telefono deien bitartez gomendioak helarazi zituena jarduera fisikoaren eta kirolaren zientzietako graduatua izan zen, hirugarren adineko pertsonei jarduera fisikoko programa egokituak burutzen aditua. Telefono deiak hilabetean bitan burutu ziren programaren lehenengo sei hilabeteetan, eta ondoren hilabetean behin urte bat igaro arte. Instruktoreak, telefono deietan parte hartzaileak burutu zituela esandako ariketa guztiak jaso zituen, ondoren ariketak berrikusi eta hurrengo telefono deirako norbanakoan oinarritutako jarduera fisikoko gomendioak prestatu ahal izateko.

4. EMAITZAK

4. EMAITZAK

4.1. Ariketa fisikoaren eragina hirugarren adineko egoitzetako pertsonetan

4.1.1. Physical activity and fitness are associated with verbal memory, quality of life and depression among nursing home residents: preliminary data of a randomized controlled trial

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Abstract

Few studies have simultaneously examined changes in physical, cognitive and emotional performance throughout the aging process.

Baseline data from an ongoing experimental randomized study were analyzed. Physical activity, handgrip, the Senior Fitness Test, Trail Making Test A, Rey Auditory-Verbal Learning Test, Quality of Life-Alzheimer's Disease Scale (QoL-AD) and the Goldberg Depression Scale were used to assess study participants. Logistic regression models were applied.

Trial registration: ACTRN12616001044415 (04/08/2016).

The study enrolled 112 participants with a mean age of 84.9 (standard deviation 6.9) years from ten different nursing homes. After adjusting for age, gender and education level, upper limb muscle strength was found to be associated with Rey Auditory-Verbal Learning Test [EXP(B): 1.16, 95% confidence interval (CI): 1.04–1.30] and QoL-AD [EXP(B): 1.18, 95% CI: 1.06–1.31]. Similarly, the number of steps taken per day was negatively associated with the risk of depression according to the Goldberg Depression Scale [EXP(B): 1.14, 95% CI: 1.000–1.003]. Additional analyses suggest that the factors associated with these variables are different according to the need for using an assistive device for walking. In those participants who used it, upper limb muscle strength remained associated with Rey Auditory-Verbal Learning Test [EXP(B): 1.21, 95% CI: 1.01–1.44] and QoL-AD tests [EXP(B): 1.19, 95% CI: 1.02–1.40]. In those individuals who did not need an assistive device for walking, lower limb muscle strength was associated with Rey Auditory-Verbal Learning Test [EXP(B): 1.35, 95% CI: 1.07–1.69], time spent in light physical activity was associated with QoL-AD test [EXP(B): 1.13, 95% CI: 1.00–1.02], and the number of steps walked per day was negatively associated with the risk of depression according to the Goldberg Depression Scale [EXP(B): 1.27, 95% CI: 1.000–1.004].

Muscle strength and physical activity are factors positively associated with a better performance on the Rey Auditory-Verbal Learning Test, QoL-AD and Goldberg Depression Scale in older adults with mild to moderate cognitive

impairment living in nursing homes. These associations appeared to differ according to the use of an assistive device for walking.

Our findings support the need for the implementation of interventions directed to increase the strength and physical activity of individuals living in nursing homes to promote physical, cognitive and emotional benefits.

Keywords: Physical activity, Exercise, Cognition, Quality of life, Depression, Older adults, Nursing home

Background

Aging is a dynamic and progressive decline in physical and cognitive performance leading to the loss of overall function for the activities of daily living. Increasing evidence supports an interaction between physical and cognitive impairment within the cycle of decline associated with aging [1]. In other words, brain health is strongly linked to physical health, and physical performance is, to a large extent, thought to be cognitively mediated.

Moreover, physical activity and exercise, as beneficial lifestyle factors, may attenuate or prevent cognitive decline associated with aging [2–4]. Multiple studies have highlighted the beneficial effects of aerobic exercise [5, 6], resistance training [7] and physical activity [8, 9] on cognitive function in older adults, although the neurophysiologic mechanisms driving these effects are not well understood. Further, physical and cognitive function could be linked to health-related quality of life [10] (QoL) and affective conditions [11] in older adults. Previous works examining these relationships are largely restricted to people with cognitive impairments. Nevertheless, a longitudinal study performed in healthy older community-dwelling adults, found that greater levels of physical activity were independently associated with better long-term health-related QoL in a follow-up period of six years [12].

Despite the evidence supporting associations between physical, cognitive and affective aspects related to the aging process, few studies considered these conditions simultaneously. In addition, to our knowledge, no such studies have focused on older adults who live in nursing home settings, although this is one of the fastest-growing demographics worldwide [13]. Older adults living in nursing homes are characterized by old age, a high prevalence of multimorbidity, functional impairment, severe cognitive deficits, depression, and very low physical activity [14]. However, there is a subgroup of residents that maintains the ability to walk and some of these residents even present wandering behavior [15].

Many residents of nursing homes require assistive walking devices to carry out the activities of daily living. The need to incorporate the upper limbs for getting up from a chair or for discharging the body weight while walking will affect their physical performance, specifically those features associated with muscle strength of the upper limbs. Therefore, it may be pertinent to think that, if associations between physical, cognitive and affective aspects exist, they could be conditioned by the need to use assistive devices for walking.

Further, although recent initiatives have aimed at improving the quality of care in nursing homes [16, 17], physical and social inactivity remain a concern in these institutions [18, 19]. Investigating the associations between physical, cognitive and affective aspects in older adults living in nursing homes may provide valuable insights for guiding clinical practice and consequently support nursing home management in evidence based decisions.

With this in mind, we sought to evaluate the associations between physical fitness and physical activity, and cognitive performance, QoL and depression risk in older adults living in long-term (LT) nursing homes. We hypothesized that better physical fitness and higher levels of physical activity might be independent factors for better cognitive performance, better QoL and lower risk of depression in older adults living in LT nursing homes. Secondarily, we examined whether these potential associations could differ for residents who require an assistive device for walking (for example crutches or canes).

Methods

Study design and participants

Data from a multicenter, randomized study carried out in ten LT nursing homes between October 2016 and June 2017 were available for analysis in this study. Seven residents out of 206 potential participants did not meet the inclusion criteria, 84 declined to participate, and three did not sign the informed consent document, leaving 112 participants. A flow diagram depicting the selection process is shown in Fig. 1. Details of the methods for designing and conducting the study were previously published [20].

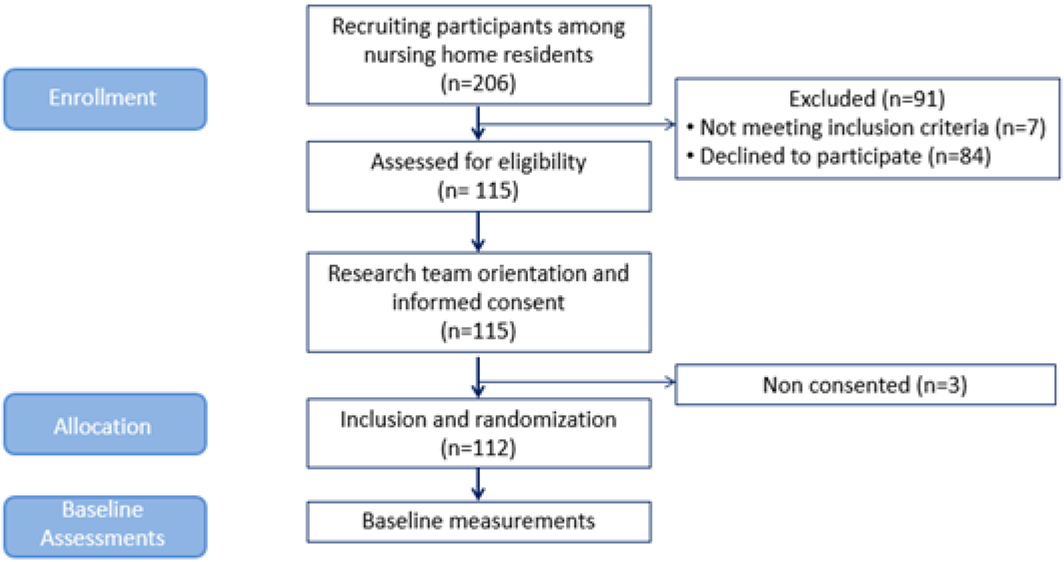

Figure 1. Flow diagram.

Briefly, eligible participants included men and women aged ≥ 70 years, who scored ≥ 50 on the Barthel Index [21], scored ≥ 20 on the MEC-35 Test [22] (an adapted and validated version of the Mini Mental State Examination in Spanish), and who were able to stand and walk independently for at least ten meters. The study was approved by the Committee on Ethics in Research at the University of the Basque Country (Humans Committee Code M10/2016/105). The protocol is registered under the Australian and New Zealand Clinical Trials Registry (ANZCTR) with the identifier: ACTRN12616001044415. Date of registration: 04/08/2016.

Measurements

Physical activity performed by the participants was objectively recorded with an accelerometer (Actigraph wGT3X model, Actigraph LLC, Pensacola, FL, USA), worn on the hip with a belt for seven days. Activity was recorded using 60-s epochs. Data files recorded on the accelerometers were downloaded and processed with Actilife software (version 6.11.9, Actigraph). The analyzed variables were: number of steps per day and number of minutes per day spent in intensity specific categories. Selecting cut-off points to classify the intensity of physical activity in older people was difficult because there is no current consensus in the scientific literature. Thus, we followed the protocol developed by Freedson and collaborators [23], where the cut-off point for light physical activity was set in the range of 100–1951 counts per minute (cpm), and moderate to vigorous physical activity (MVPA) was defined as all activity ≥ 1952 cpm. The number of minutes per day at different intensities was calculated by summing all minutes where the count met the criterion for the specific intensity and then dividing by the number of valid days.

Physical fitness was assessed through the handgrip strength test [24] (Jamar dynamometer) of the dominant upper limb and the Senior Fitness Test [25] (SFT), a battery of six independent tests encompassing: chair stand test (lower limb strength), arm curl test (upper limb strength), six minute walking test (6MWT) (aerobic endurance), chair sit and reach test (lower limb flexibility), back scratch test (upper limb flexibility) and the 8-ft up and go test (dynamic balance).

Cognitive performance tests were evaluated by the same trained neuropsychologist; assessments were carried out individually in participants` own rooms. The MEC-35 test [22] was used for screening and scaling cognitive impairment. Trail Making Test A [26] was administered to assess the speed of information processing, and more concretely, aspects of motor control, motor speed and visual scanning speed. To administer the Trail Making Test A, participants were instructed to draw lines connecting consecutively numbered circles as quickly as possible. The resultant score is the number of seconds required to complete the task; shorter time indicates better performance. A Spanish validated version of the Rey Auditory-Verbal Learning Test [27] (RAVLT) was administered to participants to assess verbal memory. The test lasted approximately 15 min. Consisted of two lists that had to be read aloud; one of 15 words (List A) and a new list of 15 different words (List B). The participant was asked to freely recall the words read aloud by the evaluator in List A. Four more trials were performed in the same way. After five trials, the List B was presented, and a free recall trial was asked for the words in List B. Immediately after, participants were asked to freely recall again the words in List A. Twenty minutes later the participants were asked to recall the words on List A. Then, the evaluator read aloud the 30 words from List A and List B, and the participants were asked to recognize the words from List A. Even though RALVT can be analyzed trial by trial, the authors recommend to establish different measures for its clinical use [28]. In this study, the Total Learning measure (RAVLT-TL) was calculated, which evaluates the capacity to recall and to accumulate words through the 5 learning trials. The RAVLT-TL score resulted from the sum of the five consecutive learning trials (trial1 + trial2 + trial3 + trial4 + trial5).

Health-related quality of life was evaluated by a Spanish validated version of the Quality of Life-Alzheimer's Disease Scale [29] (QoL-AD). Considering that many of the participants showed different levels of cognitive impairments or were at risk to develop dementia during the program, we selected the QoL-AD scale as the best tool for assessing health-related quality of life in our participants. The scale comprises 13 items (physical health, energy, mood, living situation, memory, family, marriage, friends, self as a whole, ability to do chores, ability to do things for fun, money and life as a whole). Each item is answered according to a Likert scale from 1 (poor) to 4 (excellent), for a total score between 13 and 52, with higher scores indicating better QoL.

Depression was measured by the Goldberg Depression Scale [30], which comprises four screening items and five supplementary ones. Participants who respond positively to two or more screening items go on responding to the following five. Participants scoring two or more have a 50% chance of having a clinically important disturbance of depression.

Statistical analysis

Continuous variables were expressed as means with standard deviations (SD), and categorical variables as frequency counts and percentages (%). Taking into account that up-to-date reference values for the dependent variables MEC-35, Trail Making Test A, RAVLT-TL, and QoL-AD have not been reported for older adults living in nursing homes, the cut-off point in the current study was determined according to the median, as used in other studies [31, 32]. Thus, the dependent continuous variables were transformed into binary variables according to whether they had a value above or below their median. Comparisons of sociodemographic characteristics, physical fitness and physical activity between participants who were above or below the median on MEC-35, Trail Making Test A, RAVLT-TL, QoL-AD and Goldberg Depression Scale were performed using appropriate statistical tests according to the type and distribution of the data: t-test or Mann-Whitney U-test for continuous variables and Chi-squared test for categorical variables. A p value < 0.05 was considered significant. We also performed logistic regressions, with demographic, accelerometry and physical fitness data as independent variables, and cognitive performance tests, health-related quality of life and depression risk data as dependent variables. Those variables that reached a p value < 0.05 on univariate analysis were considered eligible for entry into the multiple logistic regression analysis. Backward regression models were then fitted. All multiple models were adjusted for age and gender. In addition, Hosmer-Lemershow goodness-of-fit, Omnibus and Nagelkerke's R^2 values for each model were specified. A Hosmer-Lemershow test was used to determine the goodnessof-fit of the models, that is, to determine if the observed event rates matched expected ones; a number closest to 1 show a better goodness of fit. Omnibus was used to test whether the explained variance was significantly greater than the unexplained variance; a p value < 0.05 was considered significant. Nagelkerke's R^2 values estimated the proportion of the dependent variable explained by the independent variables. Then, the sample was divided according to the need of any assistive device for walking, and multiple regression models were performed for each group. Statistical analysis was performed using SPSS v.21 software.

Results

Characteristics of study participants

This study adheres to the Consolidated Standards of Reporting Trials (CONSORT) guidelines. The study included 112 participants from ten LT nursing homes. Accelerometer monitoring showed that they performed very low levels of physical activity during the day (Table 1). Further, 46% of the participants scored lower than the median level of QoL-AD, and 25% of the participants had a 50% chance of having a clinically important disturbance of depression according to the

Goldberg depression scale. In addition, 55% of the participants needed an assistive device for carrying out the activities of daily living.

Table 1. Baseline characteristics of the participants (n = 112).

Variable	Value
Age (yr) mean (SD)	84.9 (6.9)
70-79 (yr) % (n)	22.8 % (26)
80-89 (yr) % (n)	53.5 % (61)
≥ 90 (yr) % (n)	23.7 % (27)
Gender	
Men % (n)	29.5 % (33)
Women % (n)	70.5 % (79)
Barthel Index mean (SD)	80.6 (12.9)
MEC-35 mean (SD)	27.5 (3.8)
BMI (kg/m^2) mean (SD)	28.2 (5.1)
Education	
≤ 12 years %(n)	91 % (102)
> 12 years %(n)	9 % (10)
Steps/day mean (SD)	1162.3 (1776.4)
Light physical activity (min/day) mean (SD)	86.7 (59.6)
MVPA (min/day) mean (SD)	1.3 (3.1)
Handgrip (Kg) mean (SD)	21.1 (8.1)
Chair stand test (rep) mean (SD)	7.6 (3.9)
Arm curl test (rep) mean (SD)	12.2 (4.3)
6-minute walk test (m) mean (SD)	230.7 (95.9)
Chair sit-and-reach test (cm) mean (SD)	-11.8 (9.3)
Back scratch test (cm) mean (SD)	-21.3 (12.9)
8-foot up-and-go test (sec) mean (SD)	15.4 (9.3)

Abbreviations: MEC-35= Mini Examen Cognoscitivo-35; BMI= Body Mass Index; MVPA: moderate-vigorous physical activity; rep= repetitions.

Participant characteristics according to their performance on MEC-35 test, Trail Making Test A, RAVLT-TL test, QoL-AD test and Goldberg depression scale

Individuals who scored below the median of the sample on the MEC-35 test presented less flexibility of the lower limbs (p = 0.011) compared to the participants scoring equal to or higher than the median of the sample (Table 2). Similarly, participants who scored below the median of the sample on the RAVLT-TL test presented lower muscle strength in both upper and lower limbs (Chair stand test p = 0.009; Arm curl test p = 0.005) along with lower flexibility in the chair sit-and-reach test (p = 0.015) than individuals scoring equal to or higher than the median of the sample. In addition, those perceiving their QoL below the median of the sample presented lower levels of physical activity (Steps/day p = 0.007; Light physical activity p = 0.013) and lower levels of muscle strength (Handgrip test p = 0.032; Chair stand test p = 0.025; Arm curl test p = 0.002) compared to those perceiving their QoL equal to or higher than the median (Table 3). Older adults with a 50% chance of having a clinically relevant disturbance of depression according to the Goldberg depression scale scored lower in terms of physical activity (Steps/day p = 0.004; Light physical activity p = 0.009) and lower body muscle strength (Chair stand test p = 0.048; Arm curl test p = 0.004) than older adults with no risk of depression. There were no significant differences in physical fitness or physical activity characteristics of the participants in this study between those individuals above and below the median in Trail Making Test A performance.

Table 2. Characteristics of the participants according to their MEC-35 test, Trail Making A Test and RAVLT-TL test performance.

	MEC-35		Trail Making A		RAVLT-TL	
Variables	**< median**	**≥ median**	**< median**	**≥ median**	**< median**	**≥ median**
Age (yr) mean (SD)	85.3 (8.0)	84.5 (5.8)	84.6 (6.2)	84.6 (5.6)	85.1 (5.8)	84.5 (7.4)
Gender						
Men %	29.4%	29.0%	34.4%	31.2%	36.2%	25.5%
Women %	70.6%	71.0%	65.6%	68.8%	63.8%	74.5%
Barthel Index mean (SD)	79.8 (12.5)	81.8 (13.4)	81.7 (12.8)	80.6 (14.2)	82.6 (11.7)	80.7 (12.9)
BMI (kg/m^2) mean (SD)	28.6 (5.5)	27.8 (4.8)	28.0 (5.3)	28.0 (5.1)	27.4 (4.6)	28.8 (5.6)
Education						
≤ 12 years %	96.1%	88.5%	100%	81.2%*	89.1%	92.2%
> 12 years %	3.9%	11.5%	-	18.8%	10.9%	7.8%
Steps/day mean (SD)	912.3 (1326.1)	1248.5 (1967.1)	1376.0 (2575.2)	1312.4 (1649.8)	888.7 (702.8)	1375.2 (2363.9)
Light physical activity (min/day) mean (SD)	79.1 (59.5)	85.4 (58.7)	95.6 (69.7)	89.9 (59.8)	82.7 (52.6)	90.3 (65.9)
MVPA (min/day) mean (SD)	0.7 (0.6)	1.8 (4.2)	1.9 (5.2)	0.6 (0.6)	0.9 (1.0)	1.7 (4.5)
Handgrip (Kg) mean (SD)	19.9 (6.9)	21.8 (8.6)	22.3 (8.9)	21.8 (8.2)	20.9 (7.0)	21.2 (7.5)
Chair stand test (rep) mean (SD)	7.2 (3.4)	7.9 (4.5)	8.3 (4.0)	7.4 (4.3)	6.5 (3.7)	8.8 (3.9)**
Arm curl test (rep) mean (SD)	11.3 (3.7)	12.9 (4.5)	12.6 (4.4)	12.7 (3.7)	11.0 (3.8)	13.4 (4.1)**
6-minute walk test (m) mean (SD)	220.9 (96.7)	241.8 (92.7)	253.5 (85.9)	233.1 (93.1)	234.6 (91.6)	231.2 (90.4)

Table 2 (Continued)

	MEC-35		Trail Making A		RAVLT-TL	
Variables	**< median**	**≥ median**	**< median**	**≥ median**	**< median**	**≥ median**
Chair sit-and-reach test (cm) mean (SD)	-13.4 (8.8)	-9.8 (9.4)*	-11.7 (8.9)	-10.8 (9.9)	-13.6 (8.5)	-9.8 (10.1)*
Back scratch test (cm) mean (SD)	-23.5 (13.1)	-18.4 (12.8)	-23.1 (14.0)	-16.5 (13.1)	-21.9 (13.8)	-19.7 (12.7)
8-foot up-and-go test (sec) mean (SD)	16.2 (8.8)	14.4 (9.5)	13.4 (6.5)	14.4 (7.0)	14.9 (6.7)	14.5 (8.3)

* $p < 0.05$; ** $p < 0.01$

Abbreviations: MEC-35= Mini Examen Cognoscitivo-35; RAVLT-TL= Rey Auditory-Verbal Learning Test-Total Learning; BMI= Body Mass Index; MVPA: moderate-vigorous physical activity; rep= repetitions.

Table 3. Characteristics of the participants according to their performance on the QoL-AD Test and their depression risk assessed by the Goldberg Depression Scale.

	QoL-AD Test		Goldberg Depression Scale	
Variables	**< median**	**≥ median**	**50% risk Depression**	**No depression risk**
Age (yr) mean (SD)	85.4 (6.4)	84.0 (7.2)	86.1 (6.7)	84.2 (6.9)
Gender				
Men %	25.5%	34.5%	11.5%	36.8%*
Women %	74.5%	65.5%	88.5%	63.2%
Barthel Index mean (SD)	81.1 (12.9)	81.2 (12.6)	80.8 (14.4)	81.2 (12.1)
BMI (kg/m^2) mean (SD)	27.7 (4.7)	28.7 (5.6)	28.7 (5.5)	28.1 (5.1)
Education				
≤ 12 years %	93.5%	89.1%	96.2%	89.3%
> 12 years %	6.5%	10.9%	3.8%	10.7%
Steps/day mean (SD)	742.40 (727.20)	1484.2 (2266.8)**	554.7 (295.3)	1339.7 (1997.2)**
Light physical activity (min/day) mean (SD)	70.84 (44.61)	99.8 (67.0)*	61.7 (37.5)	94.8 (63.0)**
MVPA (min/day) mean (SD)	0.9 (1.7)	1.6 (4.2)	0.9 (1.2)	1.5 (3.7)
Handgrip (Kg) mean (SD)	19.38 (6.91)	22.7 (8.0)*	18.7 (5.4)	22.0 (8.2)
Chair stand test (rep) mean (SD)	6.80 (3.96)	8.4 (3.9)*	6.7 (3.9)	7.9 (4.0)*
Arm curl test (rep) mean (SD)	10.98 (4.19)	13.4 (3.7)**	10.4 (3.0)	12.9 (4.2)**

Table 3 (Continued)

	QoL-AD Test		Goldberg Depression Scale	
Variables	**< median**	**≥ median**	**50% risk Depression**	**No depression risk**
6-minute walk test (m) mean (SD)	219.92 (75.90)	242.3 (100.8)	221.8 (72.5)	235.4 (95.8)
Chair sit-and-reach test (cm) mean (SD)	-11.56 (9.29)	-11.5 (9.5)	-12.9 (8.7)	-11.1 (9.6)
Back scratch test (cm) mean (SD)	-21.22 (15.12)	-20.9 (11.7)	-20.2 (15.1)	-21.2 (12.8)
8-foot up-and-go test (sec) mean (SD)	16.34 (8.88)	13.41 (6.2)	15.5 (7.3)	14.5 (7.8)

* $p < 0.05$; ** $p < 0.01$

Abbreviations: QoL-AD Test= Quality of Life-Alzheimer Disease Test; BMI= Body Mass Index; MVPA: moderate-vigorous physical activity; rep= repetitions.

Logistic regression models

We applied univariate logistic regression models to determine associations between each dependent and independent variable (Appendices 1, 2, 3, 4, 5 and 6). Those independent variables that reached a p value < 0.05 on the univariate analysis were included in the multiple logistic regression models that are detailed below (Tables 4, 5, 6 and 7).

Appendix 1. Univariate logistic regression analysis with MEC-35 as dependent variable.

	B	EXP(B) (95% CI)	p-value
Age	-0.017	0.983 (0.931-1.038)	0.539
Gender (Female)	0.018	1.019 (0.451-2.300)	0.965
Barthel Index	0.012	1.012 (0.984-1.042)	0.402
BMI	-0.033	0.968 (0.898-1.042)	0.382
Education (> 12 years)	1.156	3.176 (0.630-16.022)	0.162
Steps/day	0.000	1.000 (1.000-1.000)	0.336
Light physical activity	0.002	1.002 (0.995-1.008)	0.579
MVPA	0.362	1.436 (0.899-2.291)	0.130
Handgrip	0.032	1.033 (0.984-1.085)	0.196
Chair stand test	-0.004	0.996 (0.914-1.086)	0.933
Arm curl test	0.077	1.080 (0.984-1.184)	0.106
6-minute walk test	0.002	1.002 (0.998-1.006)	0.362
Chair sit-and-reach test	0.053	1.055 (1.011-1.100)	0.014*
Backscratch test	0.030	1.031 (0.999-1.064)	0.059
8-foot up-and-go test	-0.009	0.991 (0.953-1.030)	0.644

Notes: with the exception of gender and education, all the independent variables are continuous.

* p < 0.05.

Abbreviations: BMI= Body Mass Index; MVPA= moderate-vigorous physical activity.

Appendix 2. Univariate logistic regression analysis with Trail Making A Test as dependent variable.

	B	EXP(B) (95% CI)	p-value
Age	0.000	1.000 (0.919-1.088)	0.997
Gender (Female)	1.142	1.152 (0.405-3.275)	0.790
Barthel Index	-0.007	0.993 (0.957-1.031)	0.728
BMI	0.000	1.000 (0.909-1.101)	0.997
Education (> 12 years)	21.379	1,926,143,082	0.999
Steps/day	0.000	1.000 (1.000-1.000)	0.906
Light physical activity	-0.001	0.999 (0.991-1.006)	0.727
MVPA	-0.389	0.678 (0.297-1.547)	0.356
Handgrip	-0.011	0.989 (0.932-1.049)	0.718
Chair stand test	-0.062	0.940 (0.837-1.054)	0.289
Arm curl test	0.020	1.020 (0.906-1.149)	0.740
6-minute walk test	-0.004	0.996 (0.991-1.002)	0.206
Chair sit-and-reach test	0.022	1.022 (0.971-1.076)	0.395
Backscratch test	0.038	1.039 (0.997-1.083)	0.072
8-foot up-and-go test	0.045	1.046 (0.973-1.125)	0.226

Notes: with the exception of gender and education, all the independent variables are continuous.

Abbreviations: BMI= Body Mass Index; MVPA= moderate-vigorous physical activity.

Appendix 3. Univariate logistic regression analysis with RAVLT-TL test as dependent variable.

	B	EXP(B) (95% CI)	p-value
Age	-0.023	0.978 (0.921-1.038)	0.460
Gender (Female)	0.505	1.656 (0.696-3.939)	0.254
Barthel Index	-0.021	0.980 (0.949-1.011)	0.207
BMI	0.032	1.032 (0.955-1.116)	0.425
Education (> 12 years)	-0.360	0.698 (0.176-2.774)	0.609
Steps/day	0.000	1.000 (1.000-1.001)	0.237
Light physical activity	0.002	1.002 (0.995-1.009)	0.532
MVPA	0.098	1.103 (0.917-1.326)	0.296
Handgrip	0.004	1.004 (0.950-1.060)	0.892
Chair stand test	0.133	1.142 (1.030-1.266)	0.012*
Arm curl test	0.148	1.159 (1.041-1.291)	0.007**
6-minute walk test	0.000	1.000 (0.995-1.004)	0.847
Chair sit-and-reach test	0.053	1.054 (1.009-1.101)	0.018*
Backscratch test	0.013	1.013 (0.982-1.045)	0.421
8-foot up-and-go test	-0.009	0.991 (0.942-1.044)	0.743

Notes: with the exception of gender and education, all the independent variables are continuous.

* $p < 0.05$; **$p < 0.01$

Abbreviations: BMI= Body Mass Index; MVPA= moderate-vigorous physical activity.

Appendix 4. Univariate logistic regression analysis with QoL-AD test as dependent variable.

	B	EXP(B) (95% CI)	p-value
Age	-0.030	0.970 (0.916-1.028)	0.309
Gender (Female)	-0.431	0.650 (0.275-1.534)	0.325
Barthel Index	0.000	1.000 (0.970-1.032)	0.975
BMI	0.036	1.036 (0.960-1.119)	0.359
Education (> 12 years)	0.563	1.755 (0.414-7.446)	0.446
Steps/day	0.001	1.001 (1.000-1.001)	0.039*
Light physical activity	0.010	1.010 (1.002-1.019)	0.019*
MVPA	0.078	1.082 (0.916-1.276)	0.354
Handgrip	0.061	1.063 (1.005-1.125)	0.034*
Chair stand test	0.110	1.116 (1.012-1.231)	0.028*
Arm curl test	0.166	1.181 (1.059-1.317)	0.003**
6-minute walk test	0.003	1.003 (0.998-1.007)	0.231
Chair sit-and-reach test	0.012	1.012 (0.972-1.054)	0.558
Backscratch test	0.002	1.002 (0.972-1.033)	0.889
8-foot up-and-go test	-0.050	0.951 (0.902-1.003)	0.067

Notes: with the exception of gender and education, all the independent variables are continuous.

* $p < 0.05$; **$p < 0.01$

Abbreviations: BMI= Body Mass Index; MVPA= moderate-vigorous physical activity.

Appendix 5. Univariate logistic regression analysis with Goldberg Depression Scale as dependent variable.

	B	**EXP(B) (95% CI)**	**p-value**
Age	-0.043	0.958 (0.895-1.025)	0.216
Gender (Female)	-1.498	0.224 (0.062-0.812)	0.023*
Barthel Index	0.002	1.002 (0.968-1.038)	0.895
BMI	-0.024	0.976 (0.896-1.063)	0.579
Education (> 12 years)	1.094	2.985 (0.355-25.094)	0.314
Steps/day	0.002	1.002 (1.000-1.003)	0.008**
Light physical activity	0.014	1.014 (1.003-1.026)	0.014*
MVPA	0.098	1.103 (0.852-1.428)	0.456
Handgrip	0.067	1.070 (0.997-1.148)	0.061
Chair stand test	0.108	1.114 (0.999-1.243)	0.051
Arm curl test	0.177	1.194 (1.052-1.356)	0.006**
6-minute walk test	0.002	1.002 (0.997-1.007)	0.431
Chair sit-and-reach test	0.033	1.033 (0.984-1.084)	0.188
Backscratch test	-0.006	0.994 (0.959-1.030)	0.749
8-foot up-and-go test	-0.025	0.975 (0.923-1.029)	0.360

Notes: with the exception of gender and education, all the independent variables are continuous.

* $p < 0.05$; **$p < 0.001$

Abbreviations: BMI= Body Mass Index; MVPA= moderate-vigorous physical activity.

Appendix 6. Variables that reached statistical significance on univariate logistic regression models according to the MEC-35, RAVLT-TL, QoL-AD and Goldberg depression scale.

		B	EXP(B) (95% CI)	p-value
MEC-35				
	Chair sit and reach test	0.053	1.055 (1.011-1.100)	0.014
RAVLT-TL				
	Chair stand test	0.133	1.142 (1.030-1.266)	0.012
	Arm curl test	0.148	1.159 (1.041-1.291)	0.007
	Chair sit-and-reach test	0.053	1.054 (1.009-1.101)	0.018
QoL-AD				
	Steps/day	0.001	1.001 (1.000-1.001)	0.039
	Light physical activity	0.010	1.010 (1.002-1.019)	0.019
	Handgrip	0.061	1.063 (1.005-1.125)	0.034
	Chair stand test	0.110	1.116 (1.012-1.231)	0.028
	Arm curl test	0.166	1.181 (1.059-1.317)	0.003
Goldberg Depression Scale				
	Gender (Female)	-1.498	0.224 (0.062-0.812)	0.023
	Steps/day	0.002	1.002 (1.000-1.003)	0.008
	Light physical activity	0.014	1.014 (1.003-1.026)	0.014
	Arm curl test	0.177	1.194 (1.052-1.356)	0.006

Notes: with the exception of gender, all the independent variables are continuous.

Factors associated with RAVLT-TL test performance

After adjusting for age, gender and education level, the variables that were associated with a RAVLT-TL test score equal to or above the median of the sample were upper limb muscle strength and lower limb flexibility (Table 4). To address the second objective of the study, we divided the sample according to the need of any assistive device for walking and performed the same regression model in each group. After adjusting for age, gender and education level, the lower limb muscle strength was associated with a score in the RAVLT-TL test equal to or above the median in those individuals who did not need any assistive device for walking. Upper limb muscle strength and flexibility in the chair sit-and-reach test were associated with a score equal to or higher than the median on the RAVLT-TL test in those individuals needing any assistive device for walking.

Table 4. Logistic regression models according to the RAVLT-TL performance adjusted by age, gender, and education level.

	Whole sample		
	B	**EXP(B) (95% CI)**	**p-value**
Arm curl test	0.15	1.16 (1.04-1.30)	0.009
Chair sit-and-reach test	0.04	1.05 (1.00-1.10)	0.039
	Variables in the model: chair stand test, arm curl test and chair sit-and-reach test; Estimates are based on n=95 participants due to missing values; Hosmer-Lemershow goodness of fit, p = 0.444; Omnibus, p = 0.001; R^2 Nagelkerke= 0.175.		
	No aids for walking (n=46)		
	B	**EXP(B) (95% CI)**	**p-value**
Chair stand test	0.29	1.35 (1.07-1.69)	0.010
	Hosmer-Lemershow goodness of fit, p = 0.811; Omnibus, p = 0.004; R^2 Nagelkerke= 0.225.		
	Aids for walking (n=49)		
	B	**EXP(B) (95% CI)**	**p-value**
Arm curl test	0.19	1.21 (1.01-1.44)	0.035
Chair sit-and-reach test	0.07	1.08 (1.00-1.16)	0.040
	Hosmer-Lemershow goodness of fit, p = 0.405; Omnibus, p = 0.008; R^2 Nagelkerke= 0.285.		

Factors associated with QoL-AD test performance

Regarding QoL, the multiple regression model performed with the whole sample revealed that upper limb muscle strength was associated with a score equal to or higher than the median on the QoL-AD test (Table 5). When we stratified the sample according to the use of any assistive device for walking, light physical activity was associated with a QoL-AD score equal to or higher than the median in those individuals who did not need any help for walking, while upper limb muscle strength appeared to be associated for those needing assistance.

Table 5. Logistic regression models according to the QoL-AD performance adjusted by age and gender.

	Whole sample		
	B	**EXP(B) (95% CI)**	**p-value**
Arm curl test	0.17	1.18 (1.06-1.31)	0.003
Variables in the model: steps/day, light physical activity, handgrip, chair stand test, arm curl test; Estimates are based on n=99 participants due to missing values; Hosmer-Lemershow goodness of fit, p = 0.905; Omnibus, p = 0.001; R^2 Nagelkerke= 0.132.			
	No aids for walking (n=45)		
	B	**EXP(B) (95% CI)**	**p-value**
Light physical activity*	0.01	1.132 (1.00-1.02)	0.048
* One unit = 10 minutes of light physical activity/day Hosmer-Lemershow goodness of fit, p = 0.911; Omnibus, p = 0.020; R^2 Nagelkerke= 0.152.			
	Aids for walking (n=54)		
	B	**EXP(B) (95% CI)**	**p-value**
Arm curl test	0.18	1.19 (1.02-1.40)	0.026
Hosmer-Lemershow goodness of fit, p = 0.545; Omnibus, p = 0.016; R^2 Nagelkerke= 0.136.			

Factors associated with Goldberg Depression Scale performance

In the regression model performed with the whole sample, the number of steps/day walked by the participants was associated with the absence of risk of depression according to the Goldberg Depression Scale (Table 6). In those individuals who did not need any assistive device for walking, the number of steps/day was again associated with the absence of risk of depression. In addition, in those individuals needing walking assistance, female gender was associated with a 50% greater risk of depression.

Table 6. Logistic regression models according to the Goldberg Depression Scale adjusted by age, gender and education level.

		Whole sample	
	B	**EXP(B) (95% CI)**	**p-value**
Steps/day*	0.001	1.142 (1.000-1.003)	0.028

* One unit = 100 steps/day

Variables in the model: steps/day, light physical activity, arm curl test; Estimates are based on n=99 participants due to missing values; Hosmer-Lemershow goodness of fit, p = 0.031; Omnibus, p = 0.000; R^2 Nagelkerke= 0.209.

		No aids for walking (n=45)	
	B	**EXP(B) (95% CI)**	**p-value**
Steps/day*	0.002	1.274 (1.000-1.004)	0.022

* One unit = 100 steps/day

Hosmer-Lemershow goodness of fit, p = 0.326; Omnibus, p = 0.001; R^2 Nagelkerke= 0.419.

		Aids for walking (n=54)	
	B	**EXP(B) (95% CI)**	**p-value**
Gender (Female)	-2.169	0.114 (0.014-0.961)	0.046

Hosmer-Lemershow goodness of fit, p= . ; Omnibus, p= 0.012; R^2 Nagelkerke= 0.159.

Factors associated with MEC-35 test performance

Finally, when the whole sample was analyzed, chair sit-and-reach test was associated with performance on the MEC-35 test equal to or above the median of the sample (Table 7). No independent variables were found to be associated with higher score on MEC-35 performance when the analysis was stratified according to the use of an assistive device for walking.

Table 7. Logistic regression models according to the MEC-35 performance adjusted by age, gender and education level.

	Whole sample		
	B	**EXP(B) (95% CI)**	**p-value**
Chair sit-and-reach test	0.06	1.06 (1.02-1.11)	0.006
Estimates are based on n=104 participants due to missing values; Hosmer-Lemershow goodness of fit, p = 0.587; Omnibus, p = 0.004; R^2 Nagelkerke= 0.13.			
	No aids for walking (n=49)		
	B	**EXP(B) (95% CI)**	**p-value**
Chair sit-and-reach test	0.06	1.07 (0.99-1.14)	0.053
Hosmer-Lemershow goodness of fit, p = 0.138; Omnibus, p = 0.042; R^2 Nagelkerke= 0.108.			
	Aids for walking (n=55)		
	B	**EXP(B) (95% CI)**	**p-value**
Chair sit-and-reach test	0.05	1.05 (0.99-1.11)	0.09
Hosmer-Lemershow goodness of fit, p = 0.103; Omnibus, p = 0.083; R^2 Nagelkerke= 0.071.			

Discussion

The results of this study showed that physical fitness and, more specifically, upper limb muscle strength were associated with RAVLT-TL and QoL-AD tests in older adults living in LT nursing homes. Similarly, the number of steps taken by the participants per day was negatively associated with the risk of depression according to the Goldberg Depression Scale. Lower limb flexibility was also associated with a better score on the MEC-35 test. Additional analyses suggest that the factors associated with these variables are different according to the need for using an assistive device for walking. In those participants who used an assistive device for walking, upper limb muscle strength remained associated with RAVLT-TL and QoL-AD tests. In those individuals who did not need any assistive device for walking, lower limb muscle strength was associated with RAVLT-TL test, the time spent in light physical activity proved to be associated with QoL-AD test, and the number of steps walked by the participants remained a factor negatively associated with the risk of depression according to the Goldberg Depression Scale.

The results of the current study partially support our hypothesis that better physical fitness and higher levels of physical activity might be factors associated with better performance in the RAVLT-TL test, the QoL-AD test, the MEC-35 test or the Goldberg Depression Scale. However, we found that specific parameters of physical fitness (muscle strength and the level of physical activity in particular) were associated with specific cognitive variables. Other studies have recently observed this specificity in the link between physical and cognitive performance in the older adult population. An intervention study [33] reported a dose-response effect of aerobic exercise on components of visuospatial function in a group of community-living older sedentary adults without cognitive impairment. Another prospective study [34] found a dose-response effect of resistance training on executive cognitive function of selective attention and conflict resolution among senior community-dwelling women aged 65 to 75 years. In addition, links between physical activity and processing speed have also been observed [3, 35, 36]. Nevertheless, to our knowledge, no study has assessed the specificity in the association between physical, cognitive and emotional functions among LT nursing home residents. Previous works have focused exclusively on high functioning older community-dwelling adults or have been largely restricted to people with cognitive impairments [37, 38]. Thus, this is the first study identifying muscle strength and physical activity as factors that could explain a better verbal memory, better QoL and lower risk of depression in older adults living in LT nursing homes.

The regression model showed that for a one-unit increase in the arm curl test (one repetition), the probability of performing at or above the median on the RAVLT-TL test increased by 16%. This is a novel finding of the potential mediating effects of muscle strength on the verbal memory capacity of the participants. This result is in agreement with other studies that have identified strength as a factor mediating cognitive adaptations in older adults [38–40]. Yet, data on the effects of resistance-based exercise programs on cognitive parameters are scarce. Including a combination of multiple exercise modalities, particularly resistance training, in long-term exercise programs is reported to enhance cognition in the older population to a greater extent than programs including only aerobic training [3]. In addition, the evidence concerning the possible association of muscle strength with QoL is more limited. Further, a one-unit increase in the arm curl test (one repetition) also led to a higher probability of performing at or above the median on the QoL-AD test by 18%. Thus, the current study provides new data on the potential associations between muscle strength and RAVLT-TL and QoL-AD tests that warrant further investigation. It could be hypothesized that encouraging older adults living in LT nursing homes to engage in exercise programs that include resistance training could benefit not only physical but also cognitive function.

In addition, for an increase of 100 steps/day in the physical activity of the participants, the probability of being in the group with no risk of depression according to the Goldberg Depression Scale increased by 14%. Hence, physical activity could be proposed as a protective factor for reducing the risk of suffering from depression. This result aligns with other studies finding that depression in older people living in nursing homes is correlated, among other factors, with the activities performed outside the nursing home [41]. Thus, the higher their level of physical activity, the more opportunities could arise for residents to visit personally meaningful places and to interact socially with others. In fact, the objectively measured physical activity of the participants was extremely low, which is consistent with previous studies reporting that nursing homes residents` life-space (that is, the spatial extension of an individual’s environment that s/he moves in during a specified time period [42]) is severely limited to private rooms and adjacent living units [43]. Thus, nowadays, there is sufficient evidence to support the urgent implementation of interventions aimed at encouraging physical activity of older adults living in nursing homes.

For a one-unit increase in the chair sit-and-reach test (one cm), the probability of performing at or above the median on the MEC-35 test increased by 6%. This unexpected finding in the association between flexibility and MEC-35 could be masking the difficulty patients have to understand the chair sit-and-reach test that we have observed during the assessments. Thus, it should be interpreted cautiously.

Our results also showed that the associations between the muscle strength and RAVLT-TL and QoL-AD tests are different according to the use of an assistive device for walking. In those participants needing assistance, the regression models demonstrated that a one-unit increase in the arm curl test (one repetition) increased the probability of performing at or above the median on the RAVLT-TL test by 21%, and on the QoL-AD test by 19%. Thereby, the association between upper limb strength and RAVLT-TL test performance is higher than that found when the whole sample was analyzed (from 16% to 21%). In contrast, in those participants who did not need any assistive device for walking, lower limb muscle strength was the variable associated with RAVLT-TL test, and time performing light physical activity was the variable associated with QoL-AD test. Specifically, for a one-unit increase in the chair stand test (one repetition), the probability of performing at or above than the median on the RAVLT-TL test increased by 35%. Further, for a 10-min/day increase in light physical activity, the probability of being in the group with a QoL-AD test score equal to or higher than the median increased by 13%. We can only speculate regarding these findings, but it could be related to how the participants used their upper or lower limbs to carry out the activities of daily life. For example, those older adults who need to incorporate the upper limbs for walking, for maintaining balance or for getting up from a chair may have undergone adaptations in the muscle physiology that could somehow influence the associations. Thereby, we surmise that participants with higher levels of well-being also have a more active lifestyle, and this could explain why they might have higher strength (this assumption could also work in the inverse sense). However, an alternative explanation could be that those individuals with a more active lifestyle could have higher strength and, consequently, might have higher levels of well-being (and vice versa).

According to the Goldberg Depression Scale and as seen for the whole cohort, the regression model in those participants that did not need aids for walking showed that for a 100-step/day increase in physical activity, the probability of being in the group with no risk of depression increased by 27%. In those participants who needed aids for walking, the regression model result showed that being female increased the probability of being in the group with 50% risk of depression, according to the Goldberg Depression Scale, by 11%. This result agrees with other studies where gender, specifically being female, has been identified as a risk factor for experiencing depression [44]. Nevertheless, an important limitation in this study when studying depression is the failure to consider other variables such as social support, comorbidity or pharmacology. The current study aimed at focusing only on the associations between physical conditions and depression risk, thus, these results should be interpreted cautiously.

Several molecular and physiological mechanisms have been proposed to link strength and cognition, including insulin-like growth factor, brain-derived neurotrophic factor, myokines, fibroblast growth factor 2, and vascular endothelial growth factor [7, 45, 46]. These factors are thought to enhance neurogenesis and to play a key role in the positive effects of exercise on cognition, although the mechanisms need to be fully investigated.

There are a few limitations to this study; first, it is limited by its cross-sectional nature, precluding any ability to ascertain temporality. Second, some variables that could also be relevant, such as social support, comorbidity or pharmacology, have not been assessed and thus the results should be interpreted with caution. Third, the results cannot be directly applied to all the nursing home residents; we could not ascertain whether these results would apply to those who refused participation or did not fulfill the physical and cognitive criteria. Finally, the strength of this study is that physical activity has been objectively measured through accelerometers and that the sample size is one of the largest among studies focused on the associations between physical, cognitive and emotional aspects of the aging processes that characterize nursing home residents.

Conclusions

The present work described the associations between physical, cognitive and emotional performance in a sample of older adults living in LT nursing homes. Specifically, muscle strength and physical activity were factors associated with a better performance on the RAVLT-TL, QoL-AD and Goldberg Depression Scale. These associations appeared to differ according to the use of an assistive device for walking. Further investigation is required to understand the physiological mechanisms underlying links between skeletal muscle physiology, cognition and well-being in this vulnerable population. The results offer further evidence to support the urgent need to implement interventions directed to increase the strength and physical activity of individuals living in nursing homes, as they might benefit not only physically, but also in terms of cognitive and emotional functioning.

Abbreviations

6MWT: 6 Minutes walking test; LT: Long term; MEC-35: Mini Examen Cognoscitivo-35; MVPA: Moderate to vigorous physical activity; QoL: Quality of life; QoL-AD: Quality of life-Alzheimer's disease; RAVLT: Rey Auditory-Verbal Learning Test; SFT: Senior Fitness Test

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Availability of data and materials

The database set was available to all authors of the study and are available from the corresponding author on non-commercial and reasonable request.

Authors' contributions

HA, SG, JY, JI, MI and AR participated in the design of the study. MI, HA and AR participated in the recruitment process of the participants. HA, CR and IE were responsible for data collection. AR and JI performed the statistical analyses. HA, CR, IE, MI, SG, JY, JI, and AR drafted the manuscript. All authors read and approved the final version of the manuscript.

Ethics approval and consent to participate

The present study has been approved by the Committee on Ethics in Research of the University of the Basque Country (Humans Committee Code M10/2016/105) and has also received a letter of support from the senior administrator of Matia, Caser Residential Care Facilities, Iurreamendi and Uzturre Nursing Homes. Furthermore, the study protocol has been registered under the Australian and New Zealand Clinical Trials Registry (ANZCTR) with the identifier: ACTRN12616001044415 and all participants have provided written informed consent based on documents approved by the University of the Basque Country Institutional Review Board. The study has been carried out in accordance with Good Clinical Practice, applicable local regulatory requirements, and the guiding principles of the Declaration of Helsinki. Universal Trial Number U1111–1185-6368.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interest.

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References

1. Robertson DA, Savva GM, Kenny RA. Frailty and cognitive impairment–a review of the evidence and causal mechanisms. Ageing Res Rev. 2013;12(4):840–51. https://doi.org/10.1016/j.arr.2013.06.004.

2. Brisswalter J, Collardeau M, Arcelin R. Effects of acute physical exercise characteristics on cognitive performance. Sports Med. 2002;32:555–66. https://doi.org/10.2165/00007256-200232090-00002.

3. Colcombe S, Kramer AF. Fitness effects on the cognitive function of older adults: a meta-analytic study. Psychol Sci. 2003;14:125–30. https://doi.org/10.1111/1467- 9280.t01-1-01430.

4. Voss MW, Vivar C, Kramer AF, Van Praag H. Bridging animal and human models of exercise-induced brain plasticity. Trends Cogn Sci. 2013;17:525–44. https://doi.org/10.1016/j.tics.2013.08.001.

5. Billinger SA, Vidoni ED, Morris JK, Thyfault JP, Burns JM. Exercise test performance reveals evidence of the cardiorespiratory fitness hypothesis. J Aging Phys Act. 2017;25(2):240–6. https://doi.org/10.1123/japa.2015-0321.

6. Hsu CL, Best JR, Wang S, Voss MW, Hsiung RGY, Munkacsy M, et al. The impact of aerobic exercise on Fronto-parietal network connectivity and its relation to mobility: an exploratory analysis of a 6-month randomized controlled trial. Front Hum Neurosci. 2017;11 https://doi.org/10.3389/fnhum.2017.00344.

7. Chang YK, Pan CY, Chen FT, Tsai CL, Huang CC. Effect of resistance-exercise training on cognitive function in healthy older adults: a review. J Aging Phys Act. 2012;20(4):497–517.

8. Phillips CB, Edwards JD, Andel R, Kilpatrick M. Daily physical activity and cognitive function variability in older adults. J Aging Phys Act. 2016;24(2):256–67. https://doi.org/10.1123/japa.2014-0222.

9. Kraft E. Cognitive function, physical activity, and aging: possible biological links and implications for multimodal interventions. Neuropsychol Dev Cogn B Aging Neuropsychol Cogn. 2012;19:248–63. https://doi.org/10.1080/13825585.2011.645010.

10. Penedo FJ, Dahn JR. Exercise and well-being: a review of mental and physical health benefits associated with physical activity. Curr Opin Psychiatry. 2005;18:189–93. https://doi.org/10.1097/00001504-200503000-00013.

11. Birch K, Ten Hope M, Malek-Ahmadi M, O'Connor K, Schofield S, Coon D, et al. Cognitive function as a mediator in the relationship between physical activity and depression status in older adults. J Aging Phys Act. 2016;24(4):540–6. https://doi.org/10.1123/japa.2015-0029.

12. Balboa-Castillo T, León-Muñoz LM, Graciani A, León-Muñoz LM, Graciani A, Rodríguez-Artalejo F, et al. Longitudinal association of physical activity and sedentary behavior during leisure time with health-related quality of life in community-dwelling older adults. Health Qual Life Outcomes. 2011;9(1):47. https://doi.org/10.1186/1477-7525-9-47.

13. Prince M, Prina M, Guerchet M. Journey of caring, an analysis of long-term Care for Dementia. World Alzheimer report 2013 executive summary. Alzheimer's disease international (ADI). London. http://www.alz.co.uk/research/WorldAlzheimerReport2013.pdf. Accessed 20 Mar 2018.

14. Jones AL, Dwyer LL, Bercovitz AR, Strahan GW. The National Nursing Home Survey: 2004 overview. Vital Health Stat. 2009;13:1–155.

15. Miskelly F. Electronic tracking of patients with dementia and wandering using mobile phone technology. Age Ageing. 2005;34:497–9. https://doi.org/10.1093/ageing/afi145.

16. Castle NG, Ferguson JC. What is nursing home quality and how is it measured? Gerontologist. 2010;50(4):426–42.

https://doi.org/10.1093/geront/gnq052.

17. Wiener JM. An assessment of strategies for improving quality of care in nursing homes. Gerontologist. 2003;43(suppl2):19–27. https://doi.org/10.1093/geront/43.suppl_2.19.

18. Den Ouden M, Bleijlevens MH, Meijers JM, Zwakhalen SM, Braun SM, Tan FE, et al. Daily (in) activities of nursing home residents in their wards: an observation study. J Am Med Dir Assoc. 2015;16(11):963–8. https://doi.org/10.1016/j.jamda.2015.05.016.

19. Ice GH. Daily life in a nursing home: has it changed in 25 years? J Aging Stud. 2002;16(4):345–59. https://doi.org/10.1016/S0890-4065(02)00069-5.

20. Rodriguez-Larrad A, Arrieta H, Rezola C, Kortajarena M, Yanguas JJ, Iturburu M, et al. Effectiveness of a multicomponent exercise program in the attenuation of frailty in long-term nursing home residents: study protocol for a randomized clinical controlled trial. BMC Geriatr. 2017;17(1):60. https://doi.org/10.1186/s12877-017-0453-0.

21. Wade DT, Collin C. The Barthel ADL index: a standard measure of physical disability? Int Disabil Stud. 1988;10(2):64–7. https://doi.org/10.3109/09638288809164105.

22. Lobo A, Saz P, Marcos G, Día JL, De la Cámara C, Ventura T, et al. Revalidación y normalización del Mini-Examen Cognoscitivo (primera versión en castellano del Mini-Mental Status Examination) en la población general geriátrica. Med Clin (Barc). 1999;112(20):767–74.

23. Freedson PS, Melanson E, Sirard J. Calibration of the computer science and applications Inc. accelerometer. Med Sci Sports Exerc. 1998;30(5):777–81. https://doi.org/10.1097/00005768-199805000-00021.

24. Fess E. Clinical assessment recommendations. Grip strength. In: Casanova JS, editor. 2nd ed. Chicago: American Society of Hand Therapists; 1992. p. 41–5.

25. Rikli RE, Jones CJ. Senior fitness test. Champaign: human kinetics; 2001. ISBN 0-7360-3356-4.

26. Reitan RM, Wolfson D. The Halstead-Reitan neuropsychological test battery: theory and clinical interpretation (Vol. 4). Reitan neuropsychology; 1985.

27. Ponton MO. Research and assessment issues with Hispanic populations. In: Neuropsychology and the Hispanic patient: a clinical handbook. Mahwah, NJ: Lawrence Erlbaum Associates; 2001. p. 39–58.

28. Ivnik RJ, Malec JF, Tangalos ER, Petersen RC, Kokmen E, Kurland LT. The auditory-verbal learning test (AVLT): norms for ages 55 years and older. Psychol Assessment. 1990;2:304–12. https://doi.org/10.1037/1040-3590.2.3.304.

29. Gómez-Gallego M, Gómez-Amor J, Gómez-García J. Validación de la versión española de la escala QoL-AD en pacientes con enfermedad de Alzheimer, cuidadores y profesionales sanitarios. Neurologia. 2012;27(1):4–10. https://doi.org/10.1016/j.nrl.2011.03.006.

30. Goldberg D, Bridges K, Duncan-Jones P, Grayson D. Detecting anxiety and depression in general medical settings. BMJ. 2012;297(6653):897–9.

31. Ferrer A, Formiga F, Almeda J, Alonso J, Brotons C, Pujol R. Calidad de vida en nonagenarios: género, funcionalidad y riesgo nutricional como factores asociados. Med Clin (Barc). 2010;13:303–6. https://doi.org/10.1016/j.medcli.2009.06.070.

32. Pereira C, Fernandes J, Raimundo A, Biehl-Printes C, Marmeleira J, Tomas-Carus P. Increased physical activity and fitness above the 50th percentile avoid the threat of older adults becoming institutionalized: a cross-sectional pilot study. Rejuvenation Res. 2016;19(1):13–20. https://doi.org/10.1089/rej.2015.1669.

33. Vidoni ED, Johnson DK, Morris JK, Van Sciver A, Greer CS, Billinger SA, et al. Dose-response of aerobic exercise on cognition: a community-based, pilot randomized controlled trial. PLoS One. 2015;10(7):e0131647. https://doi.org/10.1371/journal.pone.0131647.

34. Liu-Ambrose T, Nagamatsu LS, Graf P, Beattie BL, Ashe MC, Handy TC. Resistance training and executive functions: a 12-month randomized controlled trial. Arch Intern Med. 2010;170(2):170–8. https://doi.org/10.1001/archinternmed.2009.494.

35. Angevaren M, Aufdemkampe G, Verhaar H. Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment. Cochrane Database Syst Rev. 2008;3(3) https://doi.org/10.1002/14651858.CD005381.pub3.

36. Angevaren M, Vanhees L, Wendel-Vos W, Verhaar HJ, Aufdemkampe G, Aleman A, et al. Intensity, but not duration, of physical activities is related to cognitive function. Eur J Cardiovasc Prev Rehabil. 2007;14(6):825–30. https://doi.org/10.1097/HJR.0b013e3282ef995b.

37. Berryman N, Bherer L, Nadeau S, Lauzière S, Lehr L, Bobeuf F, et al. Executive functions, physical fitness and mobility in well-functioning older adults. Exp Gerontol. 2013;48(12):1402–9. https://doi.org/10.1016/j.exger.2013.08.017.

38. Mavros Y, Gates N, Wilson GC, Jain N, Meiklejohn J, Brodaty H, et al. Mediation of cognitive function improvements by strength gains after resistance training in older adults with mild cognitive impairment: outcomes of the study of mental and resistance training. J Am Geriatr Soc. 2017;65(3):550–9. https://doi.org/10.1111/jgs.14542.

39. Boyle PA, Buchman AS, Wilson RS, Leurgans SE, Benett DA. Association of muscle strength with the risk of Alzheimer disease and the rate of cognitive decline in community-dwelling older persons. Arch Neurol. 2009;66:1339–44. https://doi.org/10.1001/archneurol.2009.240.

40. Tolea MI, Galvin JE. Sarcopenia and impairment in cognitive and physical performance. Clin Interv Aging. 2015;10:663–71. https://doi.org/10.2147/CIA.S76275.

41. Patra P, Alikari V, Fradelos EC, Sachlas A, Kourakos M, Gil APR, et al. Assessment of depression in elderly. Is perceived social support related? A nursing home study. Adv Exp Med Biol. 2017;987:139–50. https://doi.org/10.1007/978-3-319-57379-3_13.

42. Tsai LT, Portegijs E, Rantakokko M, Viljanen A, Saajanaho M, Eronen J, et al. The association between objectively measured physical activity and lifespace mobility among older people. Scand J Med Sci Sports. 2015;25(4):e368–73. https://doi.org/10.1111/sms.12337.

43. Jansen CP, Diegelmann M, Schnabel EL, Wahl HW, Hauer K. Life-space and movement behavior in nursing home residents: results of a new sensorbased assessment and associated factors. BMC Geriatr. 2017;17(1):36. https://doi.org/10.1186/s12877-017-0430-7.

44. Tintle N, Bacon B, Kostyuchenko S, Gutkovich Z, Bromet EJ. Depression and its correlates in older adults in Ukraine. Int J Geriatr Psychiatry. 2011;26(12):1292–9. https://doi.org/10.1002/gps.2681.

45. Pratesi A, Tarantini F, Di Bari M. Skeletal muscle: an endocrine organ. Clin Cases Miner Bone Metab. 2013;10(1):11. https://doi.org/10.11138/ccmbm/2013.10.1.011.

46. Meng SJ, Yu LJ. Oxidative stress, molecular inflammation and sarcopenia. Int J Mol Sci. 2010;11(4):1509–26. https://doi.org/10.3390/ijms11041509.

4.1.2. A multicomponent exercise program improves physical function in long-term nursing home residents: A randomized controlled trial

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Abstract

To investigate the impact of a multicomponent exercise program on anthropometry, physical function, and physical activity on older adults living in long-term nursing homes (LTNH), we conducted a randomized controlled trial involving 112 participants aged 84.9 ± 6.9 years. Participants were randomly assigned to an intervention (IG) or control group (CG). The IG participated in a 3-month multicomponent exercise intervention focused on strength, balance, stretching exercises, and walking recommendations. Subjects in the CG participated in routine activities. Analyses of outcome parameters were performed in the entire sample and in two subgroups, classified according to participants' physical function score at baseline. The group-by-time interaction, favoring the IG, was significant for the entire sample and for the participants in the low physical function subgroup for the following parameters: waist circumference, 30-s chair-stand, arm-curl, 8-ft timed up-and-go, SPPB score, gait speed, and Berg scale ($p < .05$). In participants with higher physical function at baseline, significant group-by-time interaction was observed in the SPPB score and Berg scale ($p < .05$). When differences were analyzed within groups, the IG maintained or improved in all assessed parameters, while participants in the CG showed a marked decline. Our study showed that a multicomponent exercise program is effective for older people living in LTNH. This is especially relevant in those with lower physical function scores. The lower efficacy of the program in participants with better function might be due to the insufficient exercise demands of our intervention for more fit residents. Future studies should analyze the effects of programs with higher intensities in older people with intermediate to high physical function.

Introduction

Projections worldwide predict an increase in the number of dependent older adults, which is expected to rise from 350 million in 2010 to 488 million in 2030 (Prince et al., 2013). This growth will directly influence the number of long-term nursing home (LTNH) residents as the need for older adult care grows (Pereira et al., 2018). LTNH residents typically experience a high level of multi-morbidity, functional impairment, severe cognitive deficits, depression, and very low physical activity (Jones et al., 2009). Furthermore, LTNH residents have been found to spend most of the day engaged in sedentary activities (Bates-Jensen et al., 2004). Although physical inactivity is toxic for LTNH residents, falls and concerns about fall-related injuries are the main reasons for restricting physical activity in LTNHs (Schulz et al., 2017). The preservation of physical functions such as muscle strength, balance, and mobility is fundamental to maintaining the functional capacity necessary to perform routine activities of daily living (ADL) (Frändin et al., 2016). In consequence, there is a need to develop interventions that help avoid physical deterioration among LTNH residents and instead enable them to thrive (Schulz et al., 2017).

Physical exercise interventions can prevent or slow the functional decline of older adults living in LTNHs (Laffon de Mazières et al., 2017). In community-dwelling older adults, exercise has been shown to reduce all-cause mortality along with the risk of falls and fractures because of falling (Smith et al., 2017; Park et al., 2008). However, few randomized controlled trials with large sample sizes have analyzed the efficacy of multicomponent exercise programs at moderate intensity in LTNH residents (Dechamps et al., 2010; Rolland et al., 2007). In most studies performed in LTNHs, the intensity of the physical exercise programs was not stated, but interventions appeared to be carried out at a low intensity (Brett et al., 2016). As such, evidence supporting the need for adequate exercise programs in LTNH settings remains scarce.

Due to the heterogeneity of physical function among older adults, some studies highlight the need to focus on personal skills to achieve optimal brain–body stimulus (Frändin et al., 2016). Thus, some exercise demands may be lower for higher-functioning older adults (Pereira et al., 2018). This problem highlights a need to focus on the participant's physical function to ensure an appropriate load and intensity to resistance, balance, and walking retraining exercises to obtain sufficient benefit. To date, no research has focused on developing an optimized multicomponent exercise program for LTNH residents with varying levels of physical functioning. To fill this gap, we sought to evaluate the effects of multicomponent exercise intervention on anthropometry, physical function, and physical activity within an LTNH-based older adult population. Furthermore, we compared the effectiveness of the program among participants with low and high levels of physical function according to the participants' score at baseline.

Materials and methods

Trial design and participants

This study was a three-month single-blinded and multicenter randomized controlled trial. A flow diagram describing the recruitment of participants from ten long-term LTNHs (Gipuzkoa, Basque Country, Spain) is presented in Fig. 1.

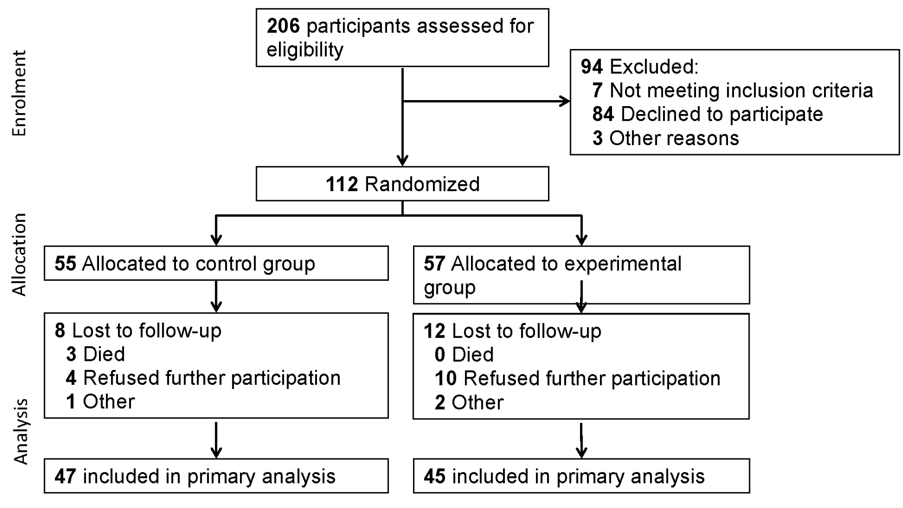

Fig. 1. Flow diagram.

Details of our methodology were published previously (Rodriguez-Larrad et al., 2017). Briefly, eligibility criteria consisted of men and women aged ≥ 70 years who scored ≥ 50 on the Barthel Index (Wade and Collin, 1988) and scored ≥ 20 on the MEC-35 Test (Lobo et al., 1999) [Mini-examen cognoscitivo, an adapted and validated version of the Mini Mental State Examination (MMSE) in Spanish] who were all capable of standing up and walking independently for at least 10 m. Age, gender, Barthel Index (0–100) (Wade and Collin, 1988), MEC-35 (0–35) (Lobo et al., 1999), and anthropometric data of the subjects are shown in Table 1.

Table 1. Descriptive characteristics of the subjects (mean ± SD)

	Control group (n=55)	Intervention group (n=57)	p value
Age (years)	84.7 ± 6.1	85.1 ± 7.6	0.81
Female n (%)	37 (67.3)	42 (73.7)	0.46
Body mass (kg)	66.6 ± 15.1	66.0 ± 13.8	0.81
Body height (cm)	153.5 ± 9.6	152.7 ± 8.9	0.65
BMI (kg/m^2)	28.2 ± 5.3	28.2 ± 5.1	0.99
Waist circumference (cm)	97.6 ± 12.6	98.9 ± 13.6	0.61
Hip circumference (cm)	100.1 ± 9.7	100.7 ± 9.8	0.75
WHR	0.97 ± 0.08	0.98 ± 0.07	0.70
MEC	28.0 ± 3.5	27.0 ± 4.0	0.16
Barthel	82.8 ± 13.1	79.2 ± 12.9	0.15

BMI = Body mass index; WHR = Waist-to-hip ratio; MEC = Mini-examen cognoscitivo.

The present study was approved by the Committee on Ethics in Research of the University of the Basque Country (Humans Committee Code M10/2016/105). Written informed consent was obtained from all study participants. The protocol was registered under the Australian and New Zealand Clinical Trials Registry (ANZCTR) with the identifier: ACTRN12616001044415.

Randomization

The participants were randomly assigned (in a 1:1 ratio) through sealed opaque envelopes to either the control (CG) or the intervention group (IG) by coin-tossing sequence generation. Subjects, rather than LTNHs, were randomized to intervention to avoid confounding effects of the setting area. All the volunteers received detailed study information in their reference sites through the research team: objectives, measurement variables, and other details about the interventions were explained orally and in writing to both potential participants and their families.

Control group activities

Subjects in the CG participated in the routine activities that the LTNHs typically offered to the attendees: memory workshops, reading, singing, etc. Activities were low intensity in all cases.

Intervention group activities

The multicomponent exercise intervention involved strength, balance, stretching exercises, and walking recommendations (Rodriguez-Larrad et al., 2017). Forty-five minute supervised sessions directed toward improving strength and balance were conducted twice a week in an enclosed room to prevent contamination between the IG and the CG. All sessions began with a brief warm-up of 5 min (range-of-motion exercises for the neck, wrists, shoulders, hip, knees, and ankles). Strength training (25 min) comprised upper and lower body exercises performed with external weights, and was tailored to the individual's functional capacity based on the Brzycki equation (Brzycki, 1993) for the estimation of 1-RM (repetition maximum). The exercises were performed with light loads (40–60% 1-RM) to ensure an appropriate adaptation to resistance exercise, and thereafter loads, if they were well tolerated, were increased to 65–70% 1-RM for additional benefits. Balance training (10 min) included exercises progressing in difficulty starting by the highest arm support (with two arms at first, then with one hand, and finally no hands if possible) along with decreasing the base of support (both feet together, semi-tandem, and tandem positions) and increasing the complexity of movements so as to challenge participants' balance as they progressed. The progression of each balance exercise was adapted monthly based on the mentioned criteria to ensure an appropriate adaptation to each participant's physical function. Class size in the IG ranged from three to eight participants at a time. In addition to the supervised sessions, walking retraining was also implemented through individualized recommendations regarding distance and intensity to perform on their own. Walking recommendations started with paths that lasted 5 min per day at the beginning of the intervention, and with the goal of completing 15 min/day after the 3-month period, was carried out through individualized recommendations based on baseline 6mWT performance.

Evaluation procedures

Measurements were recorded before the intervention period (month 0) and after the three-month intervention period. All measurements were collected by the same investigators.

All outcome measurements were evaluated in the subjects' place of residence. First, participants wore an accelerometer on the hip with a belt for seven days to record physical activity during everyday life. After the seven-day period, the rest of the functional outcomes were measured after breakfast or lunch in an attempt to disrupt the regular activities of daily living as little as possible.

Adherence, compliance, and adverse events

Adherence was determined by participants' presence at physical exercise sessions, whereas compliance of walking retraining recommendations was measured through each LTNH principal nurse at the end of months two and three. The medical doctor in charge of each facility evaluated the possible potential adverse events during the intervention period.

Anthropometry

Anthropometry measurements were collected before breakfast in each participant's room. Height was measured with a Holtain stadiometer to the nearest 0.1 cm, and body mass was measured with a Omron digital scale to the nearest 0.1 kg. Waist and hip circumference was measured with a non-elastic anthropometric tape to the nearest 0.1 cm. The body mass index (BMI) was calculated based on height and mass, and the waist-to-hip ratio was based on waist and hip circumferences. Anthropometric measurements were taken following “The International Society for the Advancement of Kinanthropometry” (ISAK) protocol (Marfell-Jones et al., 2012). All anthropometric measurements were obtained by the same researcher, who was internationally certified in anthropometric testing (ISAK level 1).

Physical fitness

Physical fitness examination included the following: Senior Fitness Test (Rikli and Jones, 2001), Short Physical Performance Battery (SPPB) (Guralnik et al., 2000), bilateral handgrip strength test (Jamar dynamometer) (Fess, 1992), fast 4-meter walking speed (Bohannon et al., 1996), and static balance (measured with Berg Scale) (Berg et al., 1992). Details of these measures are described elsewhere (Rodriguez-Larrad et al., 2017).

Habitual physical activity

Active and sedentary periods during everyday life were recorded with an accelerometer (Actigraph wGT3X model; Actigraph LLC, Pensacola, FL, USA) that participants wore on the hip with a belt for a seven-day period. Participants did not receive instructions to walk during the assessment period. An information sheet was given to nurses at each LTNH who were instructed to help participants to wear the accelerometer in the morning (if necessary) and take it off at shower times as well as in the evenings. The accelerometer was set to record the number of steps taken per day. Active-period intensities were classified following the criteria developed by Freedson et al. (1998) as light, moderate, or vigorous intensity and measured in minutes performed at each intensity.

Power and sample size

Sample size was calculated to detect minimal significant effects on the variable of physical performance (SPPB) (Kwon et al., 2009; Perera et al., 2006): accepting an alpha risk of 0.05 and a beta risk of 0.20 in a bilateral contrast, 86 individuals were required to detect a difference equal to or > 1 unit in the SPPB (SD=2.34). It was increased the sample size in an additional 20% (loses during follow-up) and 5% (mortality). The resultant sample size was determinate in 114 individuals.

Statistical considerations

Data are presented as mean ± SD. Normal distribution of the data was checked through the Kolmogorov–Smirnov test. When not normally distributed, the data were square-root transformed. Statistical comparisons at baseline were performed using an unpaired t-test. Between-group differences were assessed using mixed design analysis of variance (ANOVA; 2 time points×2 groups) with two levels (months 0 and 3). η^2 was calculated for the estimation of the effect size (*ES*). Values for η^2 of ≤ 0.02, ≤ 0.13, and ≥ 0.26 were considered as *small*, *medium*, and *large*, respectively (Bakeman, 2005). When a significant difference was detected, a paired sample t-test was applied to detect changes within groups. These analyses were performed in the entire sample and in two subgroups classified according to participants' physical function score at baseline (low performance: SPPB 0–6 and intermediate to high performance: SPPB 7–12) (Cruz-Jentoft et al., 2010). The significance level for all tests was set at $p < .05$. Statistical analysis was performed using IBM SPSS Statistics 24 statistical software package (SPSS, Inc., Chicago, IL).

Results

Study participants

From September to December 2016, 206 participants from ten LTNHs were screened; of these 112 were eligible and randomized (55 to CG and 57 to IG, Fig. 1). The percentage of the LTNH population that was eligible for this study was 17%, ranging from 10% to 27% between settings. Baseline characteristics were similar in both groups (Table 1). The mean age was 84.9 years and 70.5% were women.

Adherence to exercise, compliance with physical activity recommendations, and adverse effects

Of the 112 participants who began the study, 92 completed the three-month assessments (Fig. 1). Attendance rates for the exercise sessions were

90.6%, and compliance for the walking retraining recommendations was 92.0%. The physical exercise did not elicit any adverse event during the intervention.

Anthropometry

Both groups had similar body mass index, hip circumference, and waist-to-hip ratio at baseline and after three months ($p > .05$); however, waist circumference significantly decreased at three months in the IG ($p < .05$) and consequently the time-by-group interaction was significant ($p < .05$; ES^2=*small*) (Table 2). Subgroup analyses revealed a non-significant reduction in the waist circumference of the IG in the subgroups with low (−2.0 cm) (Table 3) and higher functional performance (+0.5 cm) (Table 4) at baseline. In the CG, the waist circumference after the three-month period was higher in both subgroups ($p > .05$). A significant group-by-time interaction in waist circumference was observed only in those with low functional performance at baseline ($p < .05$; ES^2=*small*).

Physical fitness

After three months of exercise training, changes in physical fitness were more noticeable in the IG than in the CG. The group-by-time interaction in mixed design ANOVA was significant in the 30-s chair-stand ($p < .001$; ES^2=*medium*), arm-curl ($p < .01$; ES^2=*small*), 8-ft timed up-and-go ($p < .05$; ES^2=*small*), SPPB ($p < .001$; ES^2=*medium*), gait speed ($p < .01$; ES^2=*small*), fast gait speed ($p < .05$; ES^2=*small*), and Berg scale ($p < .001$; ES^2=*small*) (Table 2). When differences were analyzed within groups by a paired Student's t-test, the IG had a 34% higher score on the SPPB ($p < .001$), gait speed was 15% faster ($p < .01$), and Berg scale score was 9% higher ($p < .05$); performance in the remaining parameters was maintained. In contrast, in the CG there was a significant decline in all parameters ($p < .001$–$p < .05$).

Similar results were found for participants with lower functional performance at baseline with significant group-by-time interaction in the 30-s chair-stand ($p < .01$; ES^2=*medium*), arm-curl ($p < .001$; ES^2=medium), 8-ft timed up-and-go ($p < .05$; ES^2=*small*), SPPB ($p < .001$; ES^2=*large*), gait speed ($p < .01$; ES^2=*small*), and Berg scale ($p < .01$; ES^2=*small*) (Table 3). A paired Student's t-test showed that the IG performed 14% more repetitions in the 30-s chair-stand ($p < .05$), 17% more in the arm-curl ($p < .05$), had a 52% higher score in the SPPB ($p < .001$), gait speed was 18% faster ($p < .01$), and had a 13% higher score on the Berg scale ($p < .05$); remaining parameters were maintained at baseline levels. In contrast, in the CG there was a significant decline in all parameters ($p < .001$–$p < .05$) (Table 3).

The analysis of participants with higher functional performance at baseline (Table 4) showed that there was an improvement of 4% in the SPPB ($p < .05$) in the IG group and a decline of 13% in the CG ($p < .05$). Thus, the time-by-group interaction was significant ($p < .05$; ES^2=*medium*). In addition, there was an improvement of 3% in the Berg scale within the IG participants ($p < .05$) and a significant effect of the interaction ($p < .05$; ES^2=*medium*). However, the time-by-group interaction in the ANOVA test was not significant for the rest of the measured parameters.

Physical activity level

The IG experienced an increase in the meantime of light physical activity (+5.2 min) and in the number of steps taken per day (+141 steps). In the CG, the mean time spent in physical activity (−6.0 min) and the number of steps taken per day decreased (−148 steps). These differences, in favor of the IG, were not significant ($p > .05$) (Table 2). Subgroup analysis did not show any significant differences in either group ($p > .05$) (Table 3 and Table 4).

Table 2. Functional outcomes (mean ± S.D.) following exercise intervention in LTNH residents.

	Control group (n=47)		Exercise intervention group (n=45)			
	Pre	**Post**	**Pre**	**Post**	**Time * group effect**	η^2
Anthropometry						
BMI (kg/m²)	28.8 ± 5.1	29.0 ± 5.3	28.3 ± 4.7	28.5 ± 4.7	0.591	0.003
Waist circumference (cm)	99.1 ± 11.9	99.5 ± 13.1	99.2 ± 12.2	97.8 ± 12.6*	0.048	0.043
Hip circumference (cm)	100.9 ± 9.7	101.5 ± 10.6	101.4 ± 9.6	101.0 ± 10.0	0.333	0.010
WHR	0.98 ± 0.08	0.98 ± 0.07	0.98 ± 0.07	0.97 ± 0.07	0.571	0.004
Physical fitness						
CST (n of stands)	7.4 ± 4.1	5.9 ± 4.2**	7.6 ± 3.9	8.0 ± 3.8	<0.001	0.131
ACT (n of repetitions)	11.9 ± 4.1	10.2 ± 4.7**	13.1 ± 3.9	13.8 ± 3.8	0.003	0.100
8-ft TUGT (m/s)	0.38 ± 0.16	0.33 ± 0.17***	0.42 ± 0.19	0.40 ± 0.19	0.025	0.055
6mWT (m)	217.4 ± 93.8	188.8 ± 83.5	244.7 ± 96.9	238.6 ± 110.2	0.071	0.036
CSRT (cm)	-12.7 ± 10.9	-10.3 ± 12.2	-10.5 ± 9.4	-6.9 ± 9.3	0.508	0.005
BST (cm)	-19.6 ± 11.9	-21.3 ± 12.7	-20.5 ± 13.4	-19.0 ± 12.2	0.084	0.036
SPPB Score	5.9 ± 2.7	5.1 ± 2.8**	6.0 ± 3.0	7.2 ± 3.2***	<0.001	0.245
Gait speed 4m (m/s)	0.64 ± 0.24	0.59 ± 0.26*	0.66 ± 0.24	0.75 ± 0.28**	0.001	0.125
Hand grip Dominant (kg)	21.6 ± 8.6	18.1 ± 7.9	21.9 ± 7.8	20.1 ± 8.7	0.095	0.031
Hand grip No Dominant (kg)	18.6 ± 7.6	15.6 ± 7.6	18.4 ± 7.5	17.1 ± 8.6	0.107	0.030

Table 2 (Continued)

	Control group (n=47)		Exercise intervention group (n=45)			
	Pre	**Post**	**Pre**	**Post**	**Time * group effect**	η^2
Physical fitness						
Fast gait speed 4m (m/s)	0.85 ± 0.34	0.79 ± 0.36	0.91 ± 0.35	0.96 ± 0.40	0.026	0.055
Berg Scale (Pts)	45.5 ± 6.8	41.7 ± 11.4**	45.3 ± 8.3	47.5 ± 6.3*	<0.001	0.130
Physical Activity level						
LPA (min/day)	88.0 ± 74.4	82.0 ± 63.1	88.4 ± 48.6	93.6 ± 67.2	0.511	0.005
MVPA (min/day)	1.3 ± 4.4	1.2 ± 2.4	1.5 ± 2.8	1.7 ± 3.5	0.445	0.007
Steps (n of steps/day)	1399 ± 2628	1251 ± 2642	1132 ± 975	1273 ± 1686	0.195	0.021

LTNH = Long-term nursing home; WHR = Waist-to-hip ratio; CST = 30-s chair-stand test; ACT = Arm-curl test; 8-ft TUGT = 8-ft timed up-and-go test; 6mWT = 6-min walk test; CSRT = Chair sit-and-reach test; BST = Back scratch test; Pts = Points; LPA = Light physical activity; MVPA = Moderate-to-vigorous physical activity.

*** $p < 0.001$, significantly different from baseline; ** $p < 0.01$, significantly different from baseline; * $p < 0.05$, significantly different from baseline.

Table 3. Comparison of functional outcomes (mean ± S.D.) following exercise intervention in LTNH residents. Low physical function score at baseline: SPPB 0-6

	Control group (n=30)		Exercise intervention group (n=27)			
	Pre	**Post**	**Pre**	**Post**	**Time * group effect**	η^2
Anthropometry						
BMI (kg/m²)	30.6 ± 4.6	30.8 ± 4.6	29.0 ± 4.6	29.1 ± 4.7	0.600	0.005
Waist circumference (cm)	102.6 ± 9.9	103.1 ± 11.1	102.3 ± 11.6	100.3 ± 12.7	0.041	0.074
Hip circumference (cm)	103.9 ± 10.0	104.4 ± 10.3	102.8 ± 9.5	102.9 ± 9.7	0.791	0.001
WHR	0.99 ± 0.06	0.99 ± 0.06	0.99 ± 0.06	0.97 ± 0.07	0.223	0.027
Physical fitness						
CST (n of stands)	5.7 ± 3.7	4.1 ± 3.2**	5.6 ± 3.1	6.4 ± 3.1*	0.002	0.165
ACT (n of repetitions)	10.7 ± 3.8	8.4 ± 3.7**	12.2 ± 3.6	13.6 ± 3.4*	<0.001	0.239
8-ft TUGT (m/s)	0.30 ± 0.10	0.24 ± 0.12**	0.31 ± 0.13	0.31 ± 0.13	0.022	0.093
6mWT (m)	174.2 ± 73.8	151.0 ± 66.8	194.6 ± 80.2	193.7 ± 91.7	0.105	0.048
CSRT (cm)	-13.9 ± 9.9	-12.3 ± 11.3	-10.6 ± 10.3	-6.7 ± 9.8	0.366	0.015
BST (cm)	-21.4 ± 12.3	-24.2 ± 12.5	-21.3 ± 14.6	-19.1 ± 13.3	0.090	0.060
SPPB Score	4.2 ± 1.4	3.6 ± 1.6*	3.9 ± 1.6	5.6 ± 2.8***	<0.001	0.331
Gait speed 4m (m/s)	0.53 ± 0.18	0.47 ± 0.17	0.53 ± 0.16	0.63 ± 0.24**	0.003	0.149
Hand grip Dominant (kg)	19.9 ± 7.4	16.5 ± 6.6	22.4 ± 7.2	20.9 ± 7.0	0.058	0.065

Table 3 (Continued)

	Control group (n=30)		Exercise intervention group (n=27)			
	Pre	**Post**	**Pre**	**Post**	**Time * group effect**	η^2
Physical fitness						
Hand grip No Dominant (kg)	17.2 ± 6.5	13.9 ± 6.3	19.2 ± 7.0	17.9 ± 7.7	0.131	0.044
Fast gait speed 4m (m/s)	0.69 ± 0.25	0.63 ± 0.24	0.72 ± 0.26	0.77 ± 0.30	0.095	0.051
Berg Scale (Pts)	42.3 ± 6.3	37.0 ± 11.5**	41.6 ± 8.6	44.5 ± 6.1*	0.002	0.170
Physical Activity level						
LPA (min/day)	66.9 ± 39.2	63.2 ± 32.8	79.7 ± 54.2	76.0 ± 52.3	0.877	0.001
MVPA (min/day)	0.53 ± 0.51	0.70 ± 0.77	1.08 ± 1.48	0.76 ± 0.87	0.057	0.075
Steps (n of steps/day)	621 ± 380	543 ± 310	781 ± 643	773 ± 647	0.558	0.007

LTNH = Long-term nursing home; WHR = Waist-to-hip ratio; CST = 30-s chair-stand test; ACT = Arm-curl test; 8-ft TUGT = 8-ft timed up-and-go test; 6mWT = 6-min walk test; CSRT = Chair sit-and-reach test; BST = Back scratch test; Pts = Points; LPA = Light physical activity; MVPA = Moderate-to-vigorous physical activity.

*** $p < 0.001$, significantly different from baseline; ** $p < 0.01$, significantly different from baseline; * $p < 0.05$, significantly different from baseline.

Table 4. Comparison of functional outcomes (mean ± S.D.) following exercise intervention in LTNH residents. Intermediate to high physical function at baseline: SPPB 7-12

	Control group (n=17)		Exercise intervention group (n=18)			
	Pre	**Post**	**Pre**	**Post**	**Time * group effect**	η^2
Anthropometry						
BMI (kg/m^2)	25.6 ± 4.6	25.9 ± 5.0	27.4 ± 4.9	27.6 ± 4.7	0.809	0.002
Waist circumference (cm)	92.8 ± 12.8	93.0 ± 14.1	94.5 ± 11.9	94.0 ± 11.7	0.625	0.007
Hip circumference (cm)	95.7 ± 6.6	96.5 ± 9.5	99.1 ± 9.6	98.0 ± 9.9	0.183	0.053
WHR	0.97 ± 0.10	0.96 ± 0.07	0.95 ± 0.07	0.96 ± 0.07	0.463	0.016
Physical fitness						
CST (n of stands)	10.5 ± 2.7	9.3 ± 3.7	10.7 ± 2.6	10.4 ±3.5	0.470	0.016
ACT (n of repetitions)	14.0 ± 3.9	13.4 ± 4.7	14.4 ± 4.0	14.1 ± 4.4	0.848	0.001
8-ft TUGT (m/s)	0.54 ± 0.13	0.48 ± 0.15	0.58 ± 0.13	0.54 ± 0.17	0.705	0.005
6mWT (m)	294.4 ± 79.1	256.3 ± 70.4	319.9 ± 67.3	305.8 ± 102.9	0.176	0.056
CSRT (cm)	-10.7 ± 12.4	-6.9 ± 13.4	-10.2 ± 8.1	-7.1 ± 8.7	0.803	0.002
BST (cm)	-16.9 ± 11.2	-16.8 ± 12.1	-19.5 ± 11.9	-19.0 ± 10.9	0.920	<0.001
SPPB Score	9.0 ± 1.5	7.9 ± 2.4*	9.1 ± 1.6	9.5 ± 2.3*	0.025	0.147
Gait speed 4m (m/s)	0.85 ± 0.19	0.81 ± 0.27	0.86 ± 0.21	0.93 ± 0.23	0.117	0.075
Hand grip Dominant (kg)	25.0 ± 10.1	21.3 ± 9.6	21.1 ± 8.7	19.0 ± 11.0	0.704	0.005

Table 4 (Continued)

	Control group (n=17)		Exercise intervention group (n=18)			
	Pre	**Post**	**Pre**	**Post**	**Time * group effect**	η^2
Physical fitness						
Hand grip No Dominant (kg)	21.5 ± 8.8	18.8 ± 8.9	17.4 ± 8.3	16.1 ± 9.9	0.609	0.008
Fast gait speed 4m (m/s)	1.15 ± 0.28	1.09 ± 0.37	1.19 ± 0.28	1.24 ± 0.38	0.112	0.077
Berg Scale (Pts)	51.3 ± 2.8	50.3 ± 2.9	50.9 ± 3.4	52.0 ± 3.0*	0.033	0.134
Physical Activity level						
LPA (min/day)	127.1 ± 102.1	116.8 ± 85.7	100.3 ± 37.9	117.7 ± 78.6	0.247	0.043
MVPA (min/day)	2.65 ± 7.20	2.14 ± 3.67	2.06 ± 3.88	2.95 ± 5.10	0.564	0.011
Steps (n of steps/day)	2764 ± 4027	2481 ± 4137	1611 ± 1152	1956 ± 2348	0.211	0.050

LTNH = Long-term nursing home; WHR = Waist-to-hip ratio; CST = 30-s chair-stand test; ACT = Arm-curl test; 8-ft TUGT = 8-ft timed up-and-go test; 6mWT = 6-min walk test; CSRT = Chair sit-and-reach test; BST = Back scratch test; Pts = Points; LPA = Light physical activity; MVPA = Moderate-to-vigorous physical activity.

*** $p < 0.001$, significantly different from baseline; ** $p < 0.01$, significantly different from baseline; * $p < 0.05$, significantly different from baseline.

Discussion

Physical exercise has repeatedly been shown to improve the overall health and vitality of LTNH residents; however, many LTNHs are hesitant to implement exercise programs due to fear of injury. To provide a large-scale, randomized controlled study of the effectiveness of multicomponent exercise programs in LTNH residents, we divided participants randomly into two groups: a control group, who continued with the normal activities of the LTNH, and an intervention group, who underwent three months of specialized exercise training. Three months of the exercise program proved to be sufficient for the IG to differ significantly from the CG in terms of upper and lower limb strength, gait speed, and static and dynamic balance. In fact, while there was significant improvement observed in the IG, participants in the CG showed a marked decline in all assessed parameters in a short period of time. This finding further supports the notion that exercise programs are a vital component of healthy aging and also has implications for the study of the process of functional decline (Jerez-Roig et al., 2017).

Studies previously performed with institutionalized older adults have reported conflicting results depending on the duration and the type of individualized exercise interventions (Serra-Rexach et al., 2011; Cadore et al., 2014). Sample size could also be a reason for the lack of consistency among previous trials. Our results are based on a large sample of LTNH residents and agree with studies showing that multicomponent exercise interventions at moderate intensity could be efficient for improving gait, balance, and strength, and reducing waist circumference in older individuals (Cadore et al., 2013). Indeed, our intervention was effective in reducing waist circumference, an indicator of obesity related to cardiovascular disease risk factors such as type 2 diabetes, hypertension, and dyslipidemia (Dalton et al., 2003). However, these results should be interpreted cautiously due to the association observed between the reduction of central adiposity and mortality within frail older adults (Zaslavsky et al., 2017).

The improvements in functional parameters promoted by physical exercise interventions are especially relevant because physical decline is increasingly related to a number of adverse outcomes. In this regard, gait speed, strength, and dynamic balance can predict accelerated functional decline, ADL difficulty, falls, disability, and mortality in older adults (McGough et al., 2011; Pavasini et al., 2016; Viccaro et al., 2011). Hence, physical exercise can be an effective tool in preventing the incidence of these events in LTNH residents. Multicomponent interventions appear to be the most effective interventions for improving the overall physical status of older adults and preventing disability and other adverse outcomes (Cadore et al., 2014; Cadore et al., 2013). Notably, no adverse events were observed in the IG. Due to this fact, we suggest that our retraining protocol is feasible for LTNH residents who fulfill the described inclusion criteria. Some studies evaluating multicomponent interventions reported significant improvements in gait ability and physical function among LTNH residents (Cadore et al., 2014; Rolland et al., 2007). However, most have not accounted for differences in functional status to facilitate creating an optimal exercise program for low and high levels of functionality of older people living in LTNHs.

The exercise demands of previous programs may have been relatively low for higher-functioning older adults (Pereira et al., 2018). Hence, we analyzed the effectiveness of a multicomponent exercise program within two subgroups considering participants' level of functionality. Because of the heterogeneity of physical function among older adults, some studies highlight the relevance of focusing on personal skills to achieve optimal stimulus (Frändin et al., 2016). Our study showed significant improvements in the IG with lower physical functioning. However, there were few significant intervention effects in participants with better baseline scores on the SPPB. The lower efficacy of the program in participants with better functional status might be due to the insufficient exercise demands of this program for higher-functioning older adults (Pereira et al., 2018). To our knowledge, this study is the first to compare subgroups with different physical abilities to develop an optimal multicomponent exercise program for LTNH residents. Thus, to determine what kind of exercise program is more effective to enhance the functional capacity in all participants, future studies should analyze the effects of multicomponent programs with higher intensities in older people with intermediate to high physical function performance.

Few studies have focused on the physical activity patterns of people residing in LTNHs (Ikezoe et al., 2013). This study supports the evidence that the level of physical activity is low in these institutions (Lobo et al., 2008). It has been reported that LTNH residents spend 65.5% of their day in passive activities conducted in a seated position and only walk for 0.9% of the daytime (Ice, 2002). Lobo et al. (2008) are the only authors using Actigraph accelerometers to report an objective measure of physical activity of LTNH residents, and they observed that levels of physical activity were much lower than those recommended, even taking into account that the study only included participants who were independent or moderately dependent in ADL. After participation in a multicomponent exercise program, the IG increased slightly the number of steps taken while participants in the CG walked fewer steps. However, these differences were not statistically significant. One possible explanation might be the limited duration (15 min) of the walking retraining sessions. Another could be the result of institutionalization described by Król-Zielińska et al. (2011) such as physical barriers imposed because of safety concerns, the building and physical environment (e.g., aesthetics, availability, and facility size, outdoor walking paths, handrails in hallways and on stairs).

The strength of this study is that the sample size is one of the largest among studies focused on the effectiveness of multicomponent exercise programs for LTNH residents. This study is also the first to compare subgroups with different physical functioning to develop an optimal program. In addition, physical activity was objectively measured via accelerometers. This point gives more weight and credibility to this study than earlier studies in which physical activity was measured using subjective questionnaires, where responses often reflected wishful thinking, more than the actual physical exertion. A limitation of this study is that the results cannot be applied directly to all residents of LTNH, and we could not ascertain whether participants who refused participation or were excluded because of their low level of physical function or severe cognitive deficits would also benefit from physical activity.

Conclusions

The multicomponent exercise intervention used in this randomized controlled trial was both feasible and well tolerated, and promoted improvements in anthropometric and functional parameters. Our participants had high adherence to the multicomponent exercise sessions, which proved to be well tolerated by those with lower physical function and enhanced their capacity to perform daily activities and avoid falls. These results provide evidence that individually adjusted and supported physical exercise is effective in delaying disability and reversing the loss of physical function observed in institutionalized older adults (Frändin et al., 2016). It is also effective in reducing the risk for future health-related events, falls, disability, hospitalization, and mortality that are associated with physical function of older adults (Cesari et al., 2008; Puthoff, 2008; Shumway-Cook et al., 1997). From a practical standpoint, routine multicomponent exercise intervention composed of resistance, balance, and gait exercises should be included for institutionalized older adults, as it seems to be effective for improving overall physical outcomes and preventing disability and other outcomes in this population.

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References

Bakeman, R., 2005. Recommended effect size statistics for repeated measures designs. Behav. Res. Methods 37 (3), 379–384. http://dx.doi.org/10.3758/BF03192707.

Bates-Jensen, B.M., Alessi, C.A., Cadogan, M., Levy-Storms, L., Jorge, J., Yoshii, J., ... Schnelle, J.F., 2004. The Minimum Data Set bedfast quality indicator: differences among nursing homes. Nurs. Res. 53 (4), 260–272. http://dx.doi.org/10.1097/00006199-200407000-00009.

Jones, A.L., Dwyer, L.L., Bercovitz, A.R., Strahan, G.W., 2009. The National Nursing Home Survey; 2004 Overview.

Berg, K.O., Wood-Dauphinee, S.L., Williams, J.I., Maki, B., 1992. Measuring balance in the elderly: validation of an instrument. Can. J. Public Health Rev. Can. Sante Publique 83, S7–11.

Bohannon, R.W., Andrews, A.W., Thomas, M.W., 1996. Walking speed: reference values and correlates for older adults. J. Orthop. Sports Phys. Ther. 24 (2), 86–90. http://dx.doi.org/10.2519/jospt.1996.24.2.86.

Brett, L., Traynor, V., Stapley, P., 2016. Effects of physical exercise on health and wellbeing of individuals living with a dementia in nursing homes: a systematic review. J. Am. Med. Dir. Assoc. 17 (2), 104–116. http://dx.doi.org/10.1016/j.jamda.2015.08.016.

Brzycki, M., 1993. Strength testing—predicting a one-rep max from reps-to-fatigue. J. Phys. Educ. Recrea. Dance 64 (1), 88–90. http://dx.doi.org/10.1080/07303084.1993.10606684.

Cadore, E.L., Rodríguez-Mañas, L., Sinclair, A., Izquierdo, M., 2013. Effects of different exercise interventions on risk of falls, gait ability, and balance in physically frail older adults: a systematic review. Rejuvenation Res. 16 (2), 105–114. http://dx.doi.org/10.1089/rej.2012.1397.

Cadore, E.L., Casas-Herrero, A., Zambom-Ferraresi, F., Idoate, F., Millor, N., Gómez, M., ... Izquierdo, M., 2014. Multicomponent exercises including muscle power training enhance muscle mass, power output, and functional outcomes in institutionalized frail nonagenarians. Age 36 (2), 773–785. http://dx.doi.org/10.1007/s11357-013-9586-z.

Cesari, M., Onder, G., Zamboni, V., Manini, T., Shorr, R.I., Russo, A., ... Landi, F., 2008. Physical function and self-rated health status as predictors of mortality: results from longitudinal analysis in the ilSIRENTE study. BMC Geriatr. 8 (1), 34. http://dx.doi.org/10.1186/1471-2318-8-34.

Cruz-Jentoft, A.J., Baeyens, J.P., Bauer, J.M., Boirie, Y., Cederholm, T., Landi, F., ... Zamboni, M., 2010. Sarcopenia: European consensus on definition and diagnosis: report of the European Working Group on Sarcopenia in Older People. Age Ageing 39 (4), 412–423. http://dx.doi.org/10.1093/ageing/afq034.

Dechamps, A., Diolez, P., Thiaudière, E., Tulon, A., Onifade, C., Vuong, T., ... Bourdel-Marchasson, I., 2010. Effects of exercise programs to prevent decline in health-related quality of life in highly deconditioned institutionalized elderly persons: a randomized controlled trial. Arch. Intern. Med. 170 (2), 162–169. http://dx.doi.org/10.1001/archinternmed.2009.489.

Fess, E., 1992. In: Casanova, J.S. (Ed.), Clinical Assessment Recommendations. Grip Strength, 2 ed. American Society of Hand Therapists, Chicago, pp. 41–45.

Frändin, K., Grönstedt, H., Helbostad, J.L., Bergland, A., Andresen, M., Puggaard, L., ... Hellström, K., 2016. Long-term effects of individually tailored physical training and activity on physical function, well-being and cognition in Scandinavian nursing home residents: a randomized controlled trial. Gerontology 62 (6), 571–580. http://dx.doi.org/10.1159/000443611.

Freedson, P.S., Melanson, E., Sirard, J., 1998. Calibration of the Computer Science and Applications, Inc. accelerometer. Med. Sci. Sports Exerc. 30 (5), 777–781. http://dx.doi.org/10.1097/00005768-199805000-00021.

Guralnik, J.M., Ferrucci, L., Pieper, C.F., Leveille, S.G., Markides, K.S., Ostir, G.V., ... Wallace, R.B., 2000. Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. J. Gerontol. Ser. A Biol. Med. Sci. 55 (4), M221–M231. http://dx.doi.org/10.1093/gerona/55.4.M221.

Ice, G.H., 2002. Daily life in a nursing home: has it changed in 25 years? J. Aging Stud. 16 (4), 345–359. http://dx.doi.org/10.1016/S0890-4065(02)00069-5.

Ikezoe, T., Asakawa, Y., Shima, H., Kishibuchi, K., Ichihashi, N., 2013. Daytime physical activity patterns and physical fitness in institutionalized elderly women: an exploratory study. Arch. Gerontol. Geriatr. 57 (2), 221–225. http://dx.doi.org/10.1016/j.archger.2013.04.004.

Jerez-Roig, J., Ferreira, L.M.B.M., de Araújo, J.R.T., Lima, K.C., 2017. Functional decline in nursing home residents: a prognostic study. PLoS One 12 (5), e0177353. http://dx.doi.org/10.1371/journal.pone.0177353.

Król-Zielińska, M., Kusy, K., Zieliński, J., Osiński, W., 2011. Physical activity and functional fitness in institutionalized vs. independently living elderly: a comparison of 70–80-year-old city-dwellers. Arch. Gerontol. Geriatr. 53 (1), e10–e16. http://dx.doi.org/10.1016/j.archger.2010.07.013.

Kwon, S., Perera, S., Pahor, M., Katula, J.A., King, A.C., Groessl, E.J., Studenski, S.A., 2009. What is a meaningful change in physical performance? Findings from a clinical trial in older adults (the LIFE-P study). J. Nutr. Health Aging 13 (6), 538–544.

Laffon de Mazières, C., Morley, J.E., Levy, C., Agenes, F., Barbagallo, M., Cesari, M., ...Rolland, Y., 2017. Prevention of functional decline by reframing the role of nursing homes? J. Am. Med. Dir. Assoc. 18 (2), 105–110. http://dx.doi.org/10.1016/j.jamda.2016.11.019.

Lobo, A., Saz, P., Marcos, G., Día, J.L., de la Cámara, C., Ventura, T., ... Aznar, S., 1999. Revalidación y normalización del Mini-Examen Cognoscitivo (primera versión en castellano del Mini-Mental Status Examination) en la población general geriátrica. Med. Clín. (Barc) 112 (20), 767–774.

Lobo, A., Santos, P., Carvalho, J., Mota, J., 2008. Relationship between intensity of physical activity and health-related quality of life in Portuguese institutionalized elderly. Geriatr Gerontol Int 8 (4), 284–290. http://dx.doi.org/10.1111/j.1447-0594.2008.00478.x.

Marfell-Jones, M.J., Stewart, A.D., De Ridder, J.H., 2012. International Standards for Anthropometric Assessment.

McGough, E.L., Kelly, V.E., Logsdon, R.G., McCurry, S.M., Cochrane, B.B., Engel, J.M., Teri, L., 2011. Associations between physical performance and executive function in older adults with mild cognitive impairment: gait speed and the timed “up & go” test. Phys. Ther. 91 (8), 1198–1207. http://dx.doi.org/10.2522/ptj.20100372.

Park, H., Kim, K.J., Komatsu, T., Park, S.K., Mutoh, Y., 2008. Effect of combined exercise training on bone, body balance, and gait ability: a randomized controlled study in community-dwelling elderly women. J. Bone Miner. Metab. 26 (3), 254–259. http://dx.doi.org/10.1007/s00774-007-0819-z.

Pavasini, R., Guralnik, J., Brown, J.C., di Bari, M., Cesari, M., Landi, F., ... Campo, G., 2016. Short Physical Performance Battery and all-cause mortality: systematic review and meta-analysis. BMC Med. 14 (1), 215. http://dx.doi.org/10.1186/s12916-016-0763-7.

Pereira, C., Rosado, H., Cruz-Ferreira, A., Marmeleira, J., 2018. Effects of a 10-week multimodal exercise program on physical and cognitive function of nursing home residents: a psychomotor intervention pilot study. Aging Clin. Exp. Res. 1–9. http://dx.doi.org/10.1007/s40520-017-0803-y.

Perera, S., Mody, S.H., Woodman, R.C., Studenski, S.A., 2006. Meaningful change and responsiveness in common physical performance measures in older adults. J. Am. Geriatr. Soc. 54 (5), 743–749. http://dx.doi.org/10.1111/j.1532-5415.2006.00701.x.

Prince, M., Prina, M., Guerchet, M., 2013. Journey of caring, an analysis of long-term care for dementia. World Alzheimer Report 2013. London: Alzheimer's Disease International. http://www.alz.co.uk/research/WorldAlzheimerReport2013.pdf.

Puthoff, M.L., 2008. Outcome measures in cardiopulmonary physical therapy: short physical performance battery. Cardiopulm. Phys. Ther. J. 19 (1), 17–22.

Rikli, R.E., Jones, C.J., 2001. Senior Fitness Test. Human Kinetics, Champaign (IL) (ISBN 0-7360-3356-4).

Rodriguez-Larrad, A., Arrieta, H., Rezola, C., Kortajarena, M., Yanguas, J.J., Iturburu, M., ... Irazusta, J., 2017. Effectiveness of a multicomponent exercise program in the attenuation of frailty in long-term nursing home residents: study protocol for a randomized clinical controlled trial. BMC Geriatr. 17 (1), 60. http://dx.doi.org/10.1186/s12877-017-0453-0.

Rolland, Y., Pillard, F., Klapouszczak, A., Reynish, E., Thomas, D., Andrieu, S., ... Vellas, B., 2007. Exercise program for nursing home residents with Alzheimer's disease: a 1-year randomized, controlled trial. J. Am. Geriatr. Soc. 55 (2), 158–165. http://dx.doi.org/10.1111/j.1532-5415.2007.01035.x.

Schulz, C., Lindlbauer, I., Rapp, K., Becker, C., König, H.H., 2017. Long-term effectiveness of a multifactorial fall and fracture prevention program in Bavarian nursing homes: an analysis based on health insurance claims data. J. Am. Med. Dir. Assoc. 18 (6). http://dx.doi.org/10.1016/j.jamda.2017.03.012. (552.e7-552.e17).

Serra-Rexach, J.A., Bustamante-Ara, N., Hierro Villarán, M., González Gil, P., Sanz Ibáñez, M.J., Blanco Sanz, N., ... Lucia, A., 2011. Short-term, light-to moderate-intensity exercise training improves leg muscle strength in the oldest old: a randomized controlled trial. J. Am. Geriatr. Soc. 59 (4), 594–602. http://dx.doi.org/10.1111/j.1532-5415.2011.03356.x.

Shumway-Cook, A., Baldwin, M., Polissar, N.L., Gruber, W., 1997. Predicting the probability for falls in community-dwelling older adults. Phys. Ther. 77 (8), 812–819. http://dx.doi.org/10.1093/ptj/77.8.812.

Smith, G.L., Banting, L., Eime, R., O'Sullivan, G., van Uffelen, J.G., 2017. The association between social support and physical activity in older adults: a systematic review. Int. J. Behav. Nutr. Phys. Act. 14 (1), 56. http://dx.doi.org/10.1016/j.healthplace.2010.11.010.

Viccaro, L.J., Perera, S., Studenski, S.A., 2011. Is timed up and go better than gait speed in predicting health, function, and falls in older adults? J. Am. Geriatr. Soc. 59 (5), 887–892. http://dx.doi.org/10.1111/j.1532-5415.2011.03336.x.

Wade, D.T., Collin, C., 1988. The Barthel ADL Index: a standard measure of physical disability? Int. Disabil. Stud. 10 (2), 64–67. http://dx.doi.org/10.3109/09638288809164105.

Zaslavsky, O., Rillamas-Sun, E., Li, W., Going, S., Datta, M., Snetselaar, L., Zelber-Sagi, S., 2017. Association of dynamics in lean and fat mass measures with mortality in frail older women. J. Nutr. Health Aging 21 (1), 112–119. http://dx.doi.org/10.1007/s12603-016-0730-1.

4.1.3. Serum myostatin levels are higher in fitter, more active, and non-frail long-term nursing home residents and increase after a physical exercise intervention

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Abstract

Background: Myostatin has been proposed as a candidate biomarker for frailty and sarcopenia. However, the relationship of myostatin with these conditions remains inconclusive.

Objective: To determine the association of serum myostatin concentration with body composition, physical fitness, physical activity level, and frailty in long-term nursing home residents. We also aimed to ascertain the effect of an exercise program on myostatin levels.

Methods: We obtained study data on 112 participants from long-term nursing homes. Participants were randomly assigned to a control or an intervention group and performed a 6-month multicomponent exercise program. Serum myostatin levels were analyzed by ELISA. Assessments also included body composition (anthropometry and bioelectrical impedance), physical fitness (Senior Fitness Test), physical activity level (accelerometry), and frailty (Fried frailty criteria, Clinical Frailty Scale, and Tilburg frailty indicator).

Results: The concentration of myostatin at baseline was positively correlated with: a leaner body composition ($p < 0.05$), and a higher number of steps per day and light and moderate-vigorous physical activity in women ($p < 0.005$); greater upper and lower limb strength, endurance, and poorer flexibility ($p < 0.05$) in men; and better performance (less time) in the 8-ft timed up-and-go test in both women ($p < 0.01$) and men ($p < 0.005$). We observed higher concentrations of serum myostatin in non-frail than in frail participants ($p < 0.05$). Additionally, we found that the implemented physical exercise intervention, which was effective to improve physical fitness, increased myostatin concentration in men ($p < 0.05$) but not in women. The improvements in physical condition were related with increases in serum myostatin only in men ($p < 0.05$–0.01).

Conclusions: Higher serum levels of myostatin were found to be associated with better physical fitness. The improvements in physical fitness after the intervention were positively related to increases in myostatin concentrations in men. These results seem to rule out the idea that high serum myostatin levels are indicative of frailty in long-term nursing home residents. However, although the direction of association was opposite to that expected for the function of myostatin, the use of this protein as a biomarker for physical fitness, rather than frailty, merits further study.

Keywords: biomarkers; exercise training; frailty; nursing homes

Introduction

Frailty syndrome is prevalent in older people and is a major concern in geriatrics due to its association with a high risk of dependency, falls, cognitive decline, infections, hospitalization, disability, institutionalization, and death [1–3]. Five major criteria are used to identify a frail person: a low walking speed, a lack of strength, low levels of physical activity, unintentional weight loss, and fatigue [4]. Frailty is often associated with sarcopenia, defined as a progressive loss of skeletal muscle mass, strength, and power [5].

Over the past few years, there has been considerable effort in the search for blood biomarkers to aid the diagnosis of frailty and sarcopenia. Myostatin, a muscle-derived protein, regulates skeletal muscle metabolism and is a robust negative regulator of muscle mass [6]. Myostatin enhances proteolysis and inhibits protein synthesis in skeletal muscle. Since myostatin was discovered, it has generated increasing interest as a potential regulator of sarcopenia [7]. It has also been proposed as a candidate biomarker of sarcopenia [8], which is considered the biological substrate for the development of musculoskeletal frailty [9].

Nevertheless, the relationship between levels of circulating myostatin and aging, physical function, muscle mass, and frailty is rather inconclusive, and recent studies cast some doubt on the use of myostatin levels to diagnose sarcopenia or to monitor how it responds to treatment [10]. In this regard, some studies found higher myostatin concentrations in older men and women [11]; others found that the concentration of myostatin decreased with age in men but not in women [12–14]. Along the same lines, in some studies, muscle mass was inversely correlated with serum myostatin levels [11]. However, more recent studies have shown a positive correlation between lean mass or muscle strength and myostatin [10, 12].

Physical exercise may be effective in reducing frailty and its severity in older adults, but results remain inconclusive [15, 16]. The influence of physical exercise interventions on serum myostatin levels also remains controversial. Aerobic training was reported to reduce myostatin expression in myocytes or serum protein levels in middle-aged men and older women [17, 18]. However, other studies did not find exercise-induced changes in serum myostatin concentration in patients with obstructive pulmonary disease [19].

Taking into account these inconclusive results, the aim of this study was to determine the association of serum myostatin concentration with body composition, physical fitness, physical activity level, and frailty in older adults living in long-term nursing homes (LTNHs). We also aimed to assess the effect of a multicomponent exercise program on the serum myostatin levels and ascertain if the changes in physical parameters after the intervention are related to changes in myostatin concentration. We selected LTNH residents for this study due to the high prevalence of frail individuals in these institutions, and hope that the results of our study might lead to a better understanding of the potential of myostatin as a biomarker of frailty. Considering that the association of myostatin with these variables seems to depend on gender [12], all results were analyzed separately in women and men.

Methods

Design and Sample

This study was a 6-month, single-blind, multicenter, randomized controlled trial (ACTRN12616001044415) [20]. We recruited 112 participants from 10 LTNHs (in Gipuzkoa Province, Basque Country, Spain) (Fig. 1). The study sample comprised men and women aged ≥ 70 years who scored ≥ 50 on the Barthel Index [21], ≥ 20 in the MEC-35 test [22] (an adapted and validated version of the Mini-Mental-State Examination [MMSE] in Spanish), and were capable of standing up and walking independently for at least 10 m. Participants were randomly assigned (1: 1 ratio) by center through sealed opaque envelopes to either the control group (CG) or the intervention group (IG) generated by a coin-tossing sequence. Assessments in each center were conducted by clinical research assistants blinded to group allocation. Data were anonymized by the use of an identification code.

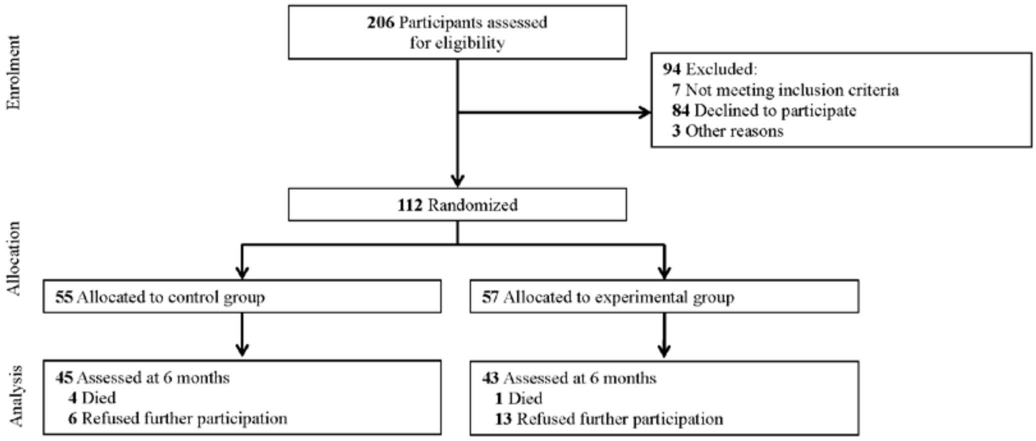

Figure 1. Study flow diagram.

Procedure

The intervention took place between October 2016 and July 2017. Of the 112 participants that were randomized and measured at baseline, 5 died and 19 refused further participation, leaving 88 participants for the 6-month assessment (Fig. 1). Each participant provided written informed consent before being randomly assigned to one of the groups.

Control Group

Subjects in the CG participated in the routine low-intensity activities that the LTNHs typically offered to the attendees.

Intervention Group

In addition to the routine activities, the IG performed a previously described multicomponent exercise intervention [20]. Briefly, the intervention consisted of supervised group training classes twice a week for a 6-month period, involving strength, balance, stretching exercises, and walking recommendations. The intensity of the strength exercises was progressively increased for each participant from 40 to 70% 1-RM (repetition maximum) through the program. Balance training also included exercises progressing in difficulty, so as to challenge participants' balance as they progressed. Walking recommendations, based on baseline 6-min walk test performance, started with walking routines that lasted for 5 min per day at the beginning of the intervention, with the goal of completing 20 min per day before the end of the 6-month period.

Outcomes

Blood samples were collected in the morning after an overnight fast. After collection, the tubes were centrifuged at 5,000 rpm for 10 min. The serum obtained for each participant was stored in aliquots at –80°C for further analysis. A commercial enzymelinked immunosorbent assay (ELISA) was performed to measure myostatin serum concentrations for all participants at baseline and 6 months. Total myostatin (pg/mL) was measured according to the manufacturer's protocol (GDF-8/myostatin quantikine ELISA kit, R&D Systems Inc., Minneapolis, MN, USA). To remove the propeptide from GDF-8 and to activate myostatin to an immunoreactive protein detectable by the kit, a first step of sample activation was performed by acidification and neutralization reagents (pH 7.2–7.6). The sensitivity of the myostatin assay, reported by the manufacturer, was 5.52 pg/mL and intra- and interassay coefficient of variation was < 7%. The analyses were performed blinded for group allocation, measured in duplicate, and averaged.

Anthropometric measurements were collected before breakfast in each participant's room. Height was measured with a Holtain stadiometer to the nearest 0.1 cm, and body mass was measured with an Omron digital scale to the nearest 0.1 kg. Waist and hip circumference were measured with a non-elastic anthropometric tape measure to the nearest 0.1 cm. Fat mass and lean mass were measured with the QuadScan 4000 bioelectrical impedance unit (Bodystat Ltd., Isle of Man, UK). All anthropometric measurements were obtained by the same researcher, who was internationally certified in anthropometric testing (ISAK level 1).

Physical fitness was measured using the Senior Fitness Test battery, which is designed to assess strength, agility, endurance, and flexibility in older adults [23]. Muscle strength was determined using 30-s chair-stand and arm-curl tests for lower and upper limbs, respectively. The 8-ft timed up-and-go test was used to assess agility and the 6-min walk test was used to assess endurance. To assess flexibility in the lower and upper body, chair sit-and-reach and back-scratch tests were performed.

Physical activity level was recorded with an accelerometer (Actigraph wGT3X model; Actigraph LLC, Pensacola, FL, USA) that participants wore on the hip with a belt for 7 days. Participants did not receive additional instructions to walk during the assessment period. An information sheet was given to nurses at each LTNH who were instructed to help participants wear the accelerometer in the morning (if necessary) and take it off at shower times and in the evenings. The accelerometer was set to record the number of steps taken per day. Active-period intensities were classified by following the criteria developed by Freedson et al. [24] as light, moderate, or vigorous, and were measured in minutes per day at each intensity.

Frailty status was assessed with the Fried frailty criteria [4], the Clinical Frailty Scale [25], and the Tilburg frailty indicator [26].

Statistical Analysis

Normal distribution of the data was checked via the Kolmogorov-Smirnov test. For parametric tests, when data were not normally distributed, values were square-root transformed. Comparisons between gender or frailty status at baseline were performed using an unpaired t test for continuous data and the χ^2 test for categorical data. The magnitudes of these differences were calculated according to Cohen's *d* parameter. Thresholds of 0.2, 0.5, and 0.8 were considered for small, medium, and large Cohen's *d* values, respectively [27]. Pearson's correlation analysis, controlling for age, was used to test the degree of association between myostatin and performance-related parameters (both as absolute values at baseline and as changes induced by the intervention). Threshold values for effect size statistics were 0.1, 0.3, and 0.5 for small, moderate, and large effect sizes, respectively [28]. Multiple linear regressions were performed (backward elimination) for each gender to indicate the proportion of variance in the serum myostatin concentration explained by those parameters significantly associated with myostatin in the Pearson correlations. When there was > 1 parameter (lean and fat mass) with a high degree of collinearity, we selected the parameter with the higher degree of correlation with myostatin. Between-group differences for the effects of the exercise intervention were assessed using 2-way mixed-design analysis of variance (ANOVA; 2 time points × 2 groups) with 2 levels (baseline and 6 months). Post hoc Bonferroni tests were used to control for multiple testing. Partial η^2 was calculated for the estimation of the effect size; η^2 values ≤0.02, ≤0.13, and ≥0.26 were considered as small, medium, and large, respectively [29]. The significance level for all tests was set at $p < 0.05$. All reported p values are two-tailed. Statistical analysis was performed using the IBM SPSS v24 statistical software package (SPSS, Inc., Chicago, IL, USA).

Results

Study participants

Baseline characteristics of the study participants were comparable in the CG and IG for all studied variables. When analyzing the data by gender, the blood levels of myostatin did not differ significantly ($p > 0.05$). Women were significantly older than men ($p < 0.005$; *d* = medium). Women showed significantly lower body mass ($p < 0.005$; *d* = medium), body height ($p < 0.001$; *d* = large), lean mass ($p < 0.001$; *d* = large) and lean mass percentage ($p < 0.001$; *d* = large), and higher values of fat mass ($p < 0.001$; *d* = large) and fat mass percentage ($p < 0.001$; *d* = large) than men, whereas the body mass index, waist and hip circumferences, and waist-to-hip ratio were similar in both genders ($p > 0.05$). Women showed significantly lower physical fitness scores than men ($p < 0.05$), except in the 30-s chair-stand test ($p > 0.05$) and back-scratch test ($p < 0.005$; *d* = medium), where the values were better in women. Steps taken per day were significantly fewer in women than in men ($p < 0.05$; *d* = small), but the physical activity performed at light and moderate-to-vigorous intensity was similar in the 2 genders ($p > 0.05$). Fried frailty criteria and the Tilburg frailty indicator showed no significantly different rates of frail participants between women and men ($p > 0.05$). However, more women ($p < 0.005$) than men were considered frail according to the Clinical Frailty Scale (69.7 vs. 39.4%). Finally, there were more participants ($p < 0.05$) considered moderate-to-severely dependent (Barthel Index < 90) among women (82.3%) than among men (60.6%) (Table 1).

Table 1. Descriptive characteristics of the subjects at baseline (mean ± SD).

	Women (*n* = 79)	Men (*n* = 33)	*p* value	Cohen's *d*
Myostatin (pg/mL)	1695 ± 784	1943 ± 883	0.130	0.297
Age (years)	86.2 ± 6.8	82.0 ± 6.3	0.003	0.641
Body composition				
Body mass (kg)	63.7 ± 13.7	72.5 ± 14.3	0.003	0.628
Body height (cm)	149.2 ± 6.6	162.5 ± 7.9	< 0.001	1.729
BMI (kg/m^2)	28.5 ± 5.4	27.4 ± 4.3	0.298	0.225
Fat mass (kg)	32.8 ± 8.4	25.7 ± 5.4	< 0.001	1.006
Fat mass (%)	51.5 ± 5.4	35.6 ± 4.0	< 0.001	3.346
Lean mass (kg)	30.8 ± 6.6	46.9 ± 10.0	< 0.001	1.900
Lean mass (%)	48.6 ± 5.1	64.5 ± 4.0	< 0.001	3.469
WC (cm)	98.3 ± 13.6	98.4 ± 11.8	0.977	0.008
HC (cm)	101.0 ± 10.4	99.0 ± 7.8	0.260	0.218
WHR	0.97 ± 0.07	0.99 ± 0.08	0.173	0.266
Physical fitness				
CST (n of stands)	6.6 ± 4.4	8.2 ± 3.7	0.080	0.385
ACT (n of repetitions)	11.5 ± 4.0	13.4 ± 4.3	0.029	0.451
8-ft TUGT (s)	17.5 ± 10.5	12.8 ± 6.9	0.009	0.529
6mWT (m)	207 ± 82	275 ± 109	< 0.001	0.705
CSRT (cm)	-10.5 ± 9.6	-12.5 ± 10.3	0.346	0.201
BST (cm)	-18.0 ± 11.4	-27.3 ± 14.7	0.001	0.707
Physical activity level				
LPA (min/day)	78.6 ± 58.3	98.7 ± 60.5	0.069	0.338
MVPA (min/day)	1.3 ± 3.7	1.4 ± 2.2	0.233	0.073
Steps (n of steps/day)	943 ± 1757	1610 ± 1691	0.005	0.387
Frailty				
Fried frailty criteria (%)	69.0	50.0	0.064	
Clinical Frailty Scale (%)	69.7	39.4	0.003	
Tilburg frailty indicator (%)	64.8	61.3	0.735	
Dependent (%)[a]	82.3	60.6	0.015	

SD, standard deviation; BMI, body mass index; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; CST, 30-s chair-stand test; ACT, arm-curl test; 8-ft TUGT, 8-ft timed up-and-go test; 6Mwt, 6-min walk test; CSRT, chair sit-and-reach test; BST, back scratch test; LPA, light physical activity; MVPA, moderate-to-vigorous physical activity.

[a] Moderate to severely dependent (Barthel Index < 90).

Association between serum myostatin and body composition, physical fitness, and physical activity level at baseline

Baseline serum myostatin levels were negatively correlated with fat mass percentage ($p < 0.05$; R = small) and positively correlated with lean mass percentage in women ($p < 0.05$; R = small; Table 2). The concentration of myostatin at baseline was positively correlated with the performance (less time) in the 8-ft timed up-and-go test ($p < 0.01$; R = moderate) in women. In men, serum myostatin was positively correlated with performance in the 30-s chair-stand ($p < 0.05$; R = moderate), arm-curl ($p < 0.05$; R = moderate), 6-min walk ($p < 0.05$; R = moderate), and 8-ft timed up-and-go ($p < 0.005$; R = large) tests, and negatively correlated with the chair sit-and-reach test ($p < 0.05$; R = moderate; Table 2). Myostatin concentration at baseline was also positively correlated with light physical activity ($p < 0.005$; R = moderate), moderate-to-vigorous physical activity ($p < 0.005$; R = moderate), and the number of steps per day ($p < 0.005$; R = large) in women (Table 2).

Table 2. Correlation between myostatin, body composition, physical fitness, and physical activity level among long-term nursing home residents at baseline.

	Women (*n* = 79)	**Men (*n* = 33)**
Body composition		
Body mass (kg)	-0.075	0.108
Body height (m)	-0.012	0.118
BMI (kg/m^2)	-0.079	0.066
Fat mass (kg)	-0.154	0.076
Fat mass (%)	-0.232*	-0.013
Lean mass (kg)	0.035	0.083
Lean mass (%)	0.252*	0.014
WC (cm)	-0.114	0.024
HC (cm)	-0.064	-0.030
WHR	-0.126	0.033
Physical fitness		
CST (n of stands)	0.195	0.409*
ACT (n of repetitions)	0.220	0.396*
8-ft TUGT (s)	-0.321**	-0.540***
6mWT (m)	0.226	0.355*
CSRT (cm)	0.103	-0.367*
BST (cm)	0.039	0.070
Physical activity level		
LPA (min/day)	0.393***	0.170
MVPA (min/day)	0.452***	0.301
Steps (n of steps/day)	0.515***	0.203

BMI, body mass index; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; CST, 30-s chair-stand test; ACT, arm-curl test; 8-ft TUGT, 8-ft timed up-and-go test; 6Mwt, 6-min walk test; CSRT, chair sit-and-reach test; BST, back scratch test; LPA, light physical activity; MVPA, moderate-to-vigorous physical activity.

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.005$.

Linear regression models

Variables that reached a *p* value < 0.05 in the partial correlation at baseline were included in the backward linear regression models detailed below. In women, the number of steps per day (β = 0.498, *p* < 0.001) remained a significant predictor of serum myostatin concentration in the last equation of the backward regression. In men, performance in the 8-ft timed up-and-go test (β = –0.484, *p* < 0.005) was a positive predictor, while performance in the chair sit-and-reach test (β = –0.347, *p* < 0.05) was a negative predictor of serum myostatin concentration (Table 3).

Table 3. Linear regression models according to the serum myostatin concentration at baseline, adjusted by age.

Women

Dependent Variable	Predictors	B (95% CI)	β	R^2	Adjusted R^2	SEE	*p*
Myostatin	Model [a]			0.248	0.237	7.585	< 0.001
	Steps (n of steps/day)	0.285 (0.163, 0.407)	0.498				< 0.001
	Constant	33 (29, 36)					< 0.001

Men

Dependent Variable	Predictors	B (95% CI)	β	R^2	Adjusted R^2	SEE	*p*
Myostatin	Model [b]			0.377	0.334	721	0.001
	8-ft TUGT	-488 (-790, -185)	-0.484				0.003
	CSRT	-29 (-55, -4)	-0.347				0.025
	Constant	3260 (2112, 4408)					< 0.001

SEE, standard error of the estimation; 8-ft TUGT, 8-ft timed up-and-go test; CSRT, chair sit-and-reach test.

[a] Variables in the model in women: lean mass percentage, 8-ft timed up-and-go test, n of steps/day.

[b] Variables in the model in men: 30-s chair-stand, arm-curl, 8-ft timed up-and-go, 6-min walk and chair sit-and-reach tests.

Frailty status and serum myostatin

Higher concentrations of serum myostatin were observed in non-frail males than in frail male participants according to the Fried frailty criteria (p < 0.005, d = large). The same tendency was found in women, but the differences did not reach significance (p > 0.05; Fig. 2a). Using the Clinical Frailty Scale, significantly higher values of myostatin were observed in non-frail than in frail individuals among women (p < 0.05, d = medium). This tendency was similar in men but did not reach significance (p > 0.05; Fig. 2b). There were no significant differences between groups when non-frail and frail individuals were compared using the Tilburg frailty indicator (p > 0.05; Fig. 2c).

Exercise intervention effects on body composition

Using a mixed-design ANOVA, after 6 months of exercise intervention, a significant group × time interaction was observed among women, favoring the IG in the fat mass and lean mass percentages (p < 0.05; η^2 = small). While the fat mass was increased in the CG (p < 0.05), the lean mass percentage increased in the IG (p < 0.05) after the intervention period (Table 4). Among men, no significant group × time interaction was observed (p > 0.05). Yet, body mass and body mass index were higher among men in the IG (p < 0.05) after the intervention period (Table 5). The effect of time was not significant for the abovementioned variables (p > 0.05; Tables 4, 5).

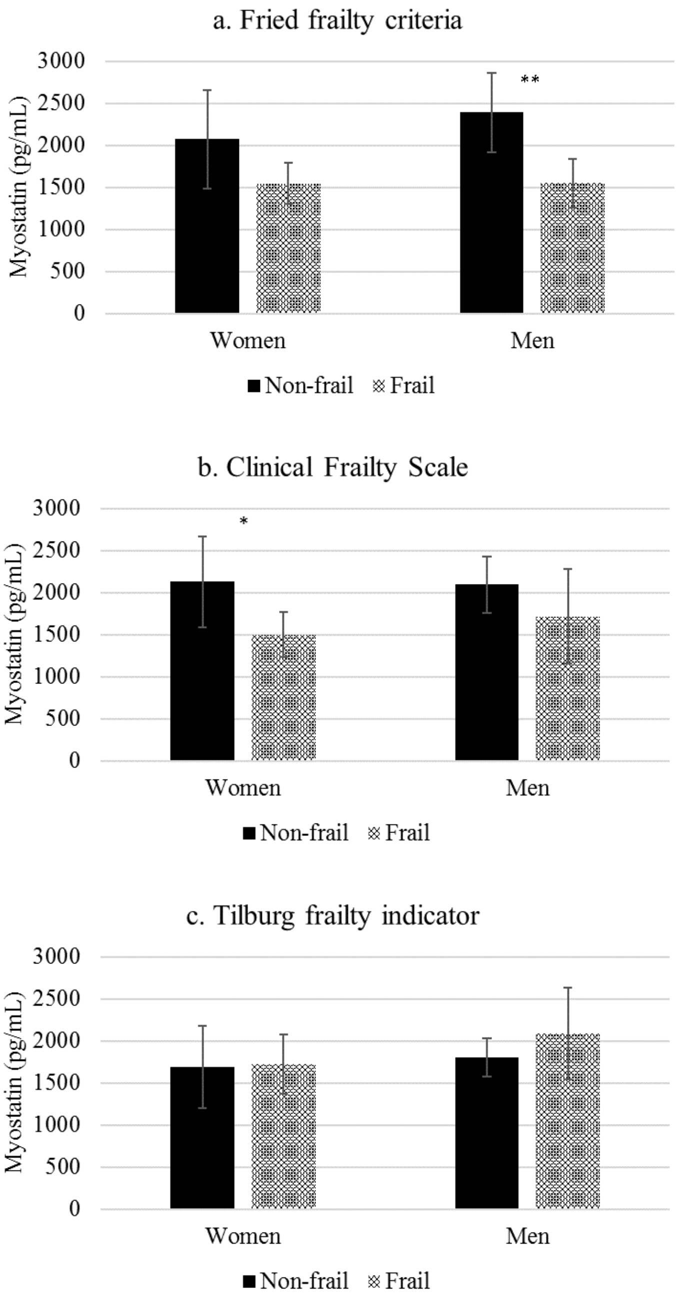

Figure 2. Association between baseline serum myostatin and frailty using a) the Fried frailty criteria, b) the Clinical Frailty Scale, and c) the Tilburg frailty indicator. $*p < 0.05$; $**p < 0.005$.

Exercise intervention effects on physical fitness

Among women, after 6 months of exercise training, a significant group × time interaction was observed, favoring the IG, in the 30-s chair-stand, arm-curl, and 8-ft timed up-and-go tests (p < 0.005; η^2 = medium), as revealed through a mixed-design ANOVA. In particular, we detected a significant improvement of the IG in the arm-curl test (p < 0.005), and a significant decline of the CG in the 8-ft timed up-and-go (p < 0.005) and 6-min walk tests (p < 0.05). Moreover, in the CG, there was a significant decline in the 30-s chair-stand test (p < 0.05) whereas the IG had experienced a significant improvement (p < 0.01) after 6 months. There was a significant positive effect of time among women participants in the arm-curl test (p < 0.05) and a significant negative effect on the performance of the 8-ft timed up-and-go (p < 0.01) and 6-min walk tests (p < 0.05; Table 4).

Among men, a significant group × time interaction favoring the IG was observed in the 30-s chair-stand (p < 0.001; η^2 = large), arm-curl (p < 0.001; η^2 = large), 8-ft timed up-and-go (p < 0.05; η^2 = medium), and 6-min walk (p < 0.001; η^2 = large) tests.

In the CG, there was a significant decline in the 30-s chair-stand (p < 0.01), arm-curl (p < 0.01), 8-ft timed upand-go (p < 0.05), and 6-min walk tests after 6 months (p < 0.005). The IG experienced a significant improvement in the 30-s chair-stand (p < 0.05) and arm-curl (p < 0.01) tests. The effect of time in men was only significant in the 6-min walk test (p < 0.01; Table 5).

Exercise intervention effects on physical activity level

After the intervention, no statistically significant changes in physical activity level were observed (mixed ANOVA for the interaction group × time and within groups, p > 0.05; Tables 4, 5). In women, the CG experienced a decline in the steps taken per day (p < 0.05; Table 4). The effect of time was not significant for the abovementioned variables (p > 0.05; Tables 4, 5).

Exercise intervention effects on serum levels of myostatin

After 6 months of exercise training, serum levels of myostatin were increased in men but not in women (Tables 4, 5). Thus, a two-way mixed-design ANOVA showed that, although the time and group effects were not significant, the group × time interaction was significant, with the levels of myostatin increased after the exercise intervention in men ($p < 0.05$; η^2 = medium) when compared with the CG (Table 5). In women, the myostatin concentration did not change significantly after the intervention ($p > 0.05$; Table 4).

Association between the mean difference in myostatin and body composition, physical fitness, and physical activity level over the six-month study period

Significant positive correlations between changes in myostatin and improvements in performance in the 30-s chair-stand ($p < 0.01$; R = moderate), arm-curl ($p < 0.05$; R = moderate), 8-ft timed up-and-go ($p < 0.05$; R = moderate), and chair sit-and-reach tests ($p < 0.05$; R = moderate) during the intervention were observed in men. No significant correlations were found between changes in myostatin and changes in any other outcome in women ($p > 0.05$; Table 6).

Table 4. Effects of the exercise intervention on myostatin, body composition, physical fitness, and physical activity level in women participants (mean ± S.D.).

	Control group (*n* = 31)		Intervention group (*n* = 28)				
	Baseline mean (SD)	**6 months mean (SD)**	**Baseline mean (SD)**	**6 months mean (SD)**	***p*** [a]	***p*** [b]	**Partial η^2** [c]
Body composition							
Body mass (kg)	65.0 (13.3)	65.8 (12.8)	65.3 (15.1)	65.3 (15.0)	0.397	0.335	0.017
BMI (kg/m^2)	29.4 (5.2)	29.7 (5.0)	28.7 (5.8)	28.7 (5.9)	0.322	0.365	0.015
Fat mass (kg)	33.4 (8.8)	34.2 (8.7)*	33.8 (8.4)	33.4 (8.9)	0.586	0.064	0.061
Fat mass (%)	51.0 (5.1)	51.4 (4.3)	51.7 (4.1)	51.0 (4.6)	0.614	0.030	0.083
Lean mass (kg)	31.6 (5.6)	31.6 (4.8)	31.5 (7.5)	31.9 (7.2)	0.265	0.540	0.007
Lean mass (%)	49.0 (5.1)	48.6 (4.3)	48.3 (4.1)	49.0 (4.6)*	0.568	0.026	0.086
WC (cm)	99.2 (11.6)	100.2 (12.6)	99.6 (14.2)	98.4 (14.4)	0.944	0.088	0.052
HC (cm)	101.8 (9.9)	103.1 (10.5)	102.4 (11.7)	102.0 (11.9)	0.461	0.154	0.037
WHR	0.98 (0.08)	0.97 (0.07)	0.97 (0.06)	0.96 (0.07)	0.504	0.798	0.001
Physical fitness							
CST (n of stands)	6.9 (4.5)	5.6 (4.6)*	7.9 (3.6)	9.8 (3.5)**	0.862	0.001	0.191
ACT (n of repetitions)	10.8 (3.6)	10.4 (4.5)	13.1 (3.8)	15.6 (3.1)***	0.035	0.003	0.145
8-ft TUGT (s)	17.4 (10.1)	22.6 (16.6)***	14.2 (5.9)	14.0 (6.6)	0.005	0.002	0.166

Table 4 (Continued)

	Control group (n = 31)		Intervention group (n = 28)				
	Baseline mean (SD)	6 months mean (SD)	Baseline mean (SD)	6 months mean (SD)	p [a]	p [b]	Partial η^{2} [c]
Physical fitness							
6Mwt (m)	198 (81)	175 (82)*	229 (81)	219 (84)	0.037	0.441	0.011
CSRT (cm)	-10.3 (10.9)	-.9.6 (11.7)	-10.2 (9.6)	-7.7 (12.7)	0.600	0.857	0.001
BST (cm)	-19.2 (12.6)	-19.2 (12.1)	-17.1 (11.0)	-17.7 (10.2)	0.823	0.795	0.001
Physical activity level							
LPA (min/day)	94.4 (79.4)	79.0 (73.8)	82.5 (48.1)	86.9 (66.9)	0.258	0.221	0.035
MVPA (min/day)	1.78 (6.08)	1.42 (3.92)	1.37 (2.82)	0.77 (1.03)	0.349	0.150	0.047
Steps (n of steps/day)	1445 (3102)	1309 (3304)*	902 (745)	1024 (1204)	0.296	0.168	0.044
Myostatin (pg/mL)	1811 (930)	1641 (695)	1554 (718)	1612 (717)	0.558	0.247	0.022

BMI, body mass index; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; SPPB, Short Physical Performance Battery; pts, points; CST, 30-s chair-stand test; ACT, arm-curl test; 8-ft TUGT, 8-ft timed up-and-go test; 6Mwt, 6-min walk test; CSRT, chair sit-and-reach test; BST, back scratch test; LPA, light physical activity; MVPA, moderate-to-vigorous physical activity.

[a] *p* for the effect of time; [b] *p* for the group x time interaction; [c] estimation of the effect size for the group x time interaction.

* $p < 0.05$, significantly different from baseline; ** $p < 0.01$, significantly different from baseline; *** $p < 0.005$, significantly different from baseline.

Table 5. Effects of the exercise intervention on myostatin, body composition, physical fitness, and physical activity level in men participants (mean ± S.D.).

	Control group (n = 14)		Intervention group (n = 15)				
	Baseline mean (SD)	**6 months mean (SD)**	**Baseline mean (SD)**	**6 months mean (SD)**	p [a]	p [b]	**Partial** η^{2} [c]
Body composition							
Body mass (kg)	73.9 (16.8)	74.2 (17.9)	73.1 (9.7)	74.7 (9.2)*	0.108	0.276	0.047
BMI (kg/m²)	27.8 (4.6)	27.8 (4.7)	27.7 (3.2)	28.3 (3.3)*	0.131	0.197	0.066
Fat mass (kg)	26.7 (6.6)	26.4 (7.4)	25.1 (4.1)	25.9 (3.8)	0.681	0.267	0.047
Fat mass (%)	36.0 (4.8)	35.2 (3.7)	34.3 (2.6)	34.6 (2.4)	0.637	0.296	0.042
Lean mass (kg)	47.8 (11.0)	48.4 (10.6)	48.0 (6.2)	48.8 (6.0)	0.088	0.740	0.004
Lean mass (%)	64.1 (5.0)	64.8 (3.8)	65.7 (2.6)	65.4 (2.4)	0.683	0.337	0.037
WC (cm)	100.0 (10.9)	99.4 (13.3)	98.8 (10.4)	99.6 (8.9)	0.867	0.324	0.037
HC (cm)	99.2 (8.7)	99.7 (9.5)	100.0 (5.7)	99.6 (5.5)	1.000	0.585	0.012
WHR	1.01 (0.08)	1.00 (0.06)	0.99 (0.08)	1.00 (0.06)	0.979	0.221	0.057
Physical fitness							
CST (n of stands)	8.4 (2.7)	5.7 (4.0)**	8.3 (4.3)	9.9 (4.2)*	0.162	< 0.001	0.415
ACT (n of repetitions)	13.6 (4.1)	10.3 (4.6)**	13.5 (4.5)	17.9 (3.9)**	0.863	< 0.001	0.430
8-ft TUGT (s)	12.9 (5.1)	16.4 (6.8)*	13.8 (8.9)	13.3 (8.8)	0.099	0.027	0.182

Table 5 (Continued)

	Control group (n = 14)		Intervention group (n = 15)				
	Baseline mean (SD)	6 months mean (SD)	Baseline mean (SD)	6 months mean (SD)	p [a]	p [b]	Partial η^{2} [c]
Physical fitness							
6mWT (m)	236 (91)	173 (82)***	281 (121)	292 (136)	0.008	< 0.001	0.392
CSRT (cm)	-16.8 (10.3)	-18.9 (9.8)	-10.5 (9.4)	-9.0 (10.8)	0.877	0.318	0.040
BST (cm)	-23.0 (9.1)	-26.1 (10.7)	-26.9 (15.3)	-22.2 (13.9)	0.744	0.112	0.106
Physical activity level							
LPA (min/day)	96.3 (93.4)	87.5 (81.3)	98.9 (48.6)	125.8 (79.8)	0.474	0.163	0.091
MVPA (min/day)	0.50 (0.34)	0.45 (0.33)	1.73 (3.04)	3.60 (6.72)	0.321	0.268	0.058
Steps (n of steps/day)	1845 (2819)	1722 (2714)	1699 (1232)	2117 (2345)	0.740	0.302	0.051
Myostatin (pg/mL)	2041 (1000)	1864 (1481)	1892 (879)	2166 (827)	0.980	0.028	0.167

BMI, body mass index; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; SPPB, Short Physical Performance Battery; pts, points; CST, 30-s chair-stand test; ACT, arm-curl test; 8-ft TUGT, 8-ft timed up-and-go test; 6Mwt, 6-min walk test; CSRT, chair sit-and-reach test; BST, back scratch test; LPA, light physical activity; MVPA, moderate-to-vigorous physical activity.

[a] p for the effect of time; [b] p for the group x time interaction; [c] estimation of the effect size for the group x time interaction.

* $p < 0.05$, significantly different from baseline; ** $p < 0.01$, significantly different from baseline; *** $p < 0.005$, significantly different from baseline.

Table 6. Correlation between the mean difference in myostatin, body composition, physical fitness, and physical activity level over the six-month study period among long-term nursing home residents.

	Women (*n* = 59)	**Men (*n* = 29)**
Body composition		
Body mass (kg)	0.194	0.387
BMI (kg/m^2)	0.205	0.382
Fat mass (kg)	0.109	0.172
Fat mass (%)	-0.099	0.053
Lean mass (kg)	0.220	0.264
Lean mass (%)	0.100	-0.044
WC (cm)	0.070	0.269
HC (cm)	0.102	0.269
WHR	-0.018	-0.101
Physical fitness		
CST (n of stands)	0.191	0.492**
ACT (n of repetitions)	0.029	0.438*
8-ft TUGT (s)	0.100	-0.470*
6mWT (m)	0.013	0.267
CSRT (cm)	-0.149	0.433*
BST (cm)	0.260	0.125
Physical activity level		
LPA (min/day)	0.160	-0.304
MVPA (min/day)	0.199	-0.004
Steps (n of steps/day)	0.208	-0.068

BMI, body mass index; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; SPPB, Short Physical Performance Battery; pts, points; CST, 30-s chair-stand test; ACT, arm-curl test; 8-ft TUGT, 8-ft timed up-and-go test; 6Mwt, 6-min walk test; CSRT, chair sit-and-reach test; BST, back scratch test; LPA, light physical activity; MVPA, moderate-to-vigorous physical activity.
* $p < 0.05$; ** $p < 0.01$.

Discussion

This work represents, to our knowledge, the first analysis of the relation of serum levels of myostatin with parameters of body composition, physical fitness, physical activity level, and different scales of frailty in older adults living in LTNHs. Higher concentrations of serum myostatin were observed in fitter and less frail individuals of both genders and in leaner and more active women. Additionally, we found that a multicomponent physical exercise intervention, which is effective to improve physical fitness in both genders, increased circulating myostatin concentration in men. The improvements in physical parameters after the intervention were positively associated with increases in myostatin levels in men.

The relationship of serum myostatin levels with age and other parameters related to frailty are far from being established. A cross-sectional study found higher myostatin concentrations in aged men and women [11]. Accordingly, relative muscle mass was inversely correlated with serum myostatin [11]. However, other studies reported that the concentration of myostatin decreases with age in men [12, 13]. Fewer studies analyzed the interaction between frailty indexes and serum myostatin levels. Some of them found higher levels of myostatin in physically frail women than in their non-frail counterparts [11, 30]. In contrast, in the present study, we observed higher serum myostatin levels in non-frail than in frail people. In addition to methodological issues of former studies, including binding of myostatin to plasma proteins and cross-reactivity of assay reagents with other proteins [13], other possible reasons for these discrepancies could be that the populations under study were heterogeneous. In this regard, it is important to take into account that our sample was on average older and frailer than the majority of populations analyzed in other studies. In addition, since myostatin is derived from skeletal muscle, participants with low muscle mass at baseline may secrete less myostatin [12]. The positive correlations between lean mass and myostatin at baseline and the observed changes in myostatin and lean mass during the intervention in the present study could support the mentioned hypothesis.

Accordingly, our results also showed positive relationships between myostatin and physical fitness and physical activity levels. These results partially agree with Bergen et al. [12], who observed, using mass spectroscopy, higher serum myostatin concentration related to greater handgrip and knee extension strength; however, they did not find association with physical activity. Notably, they assessed physical activity through surveys, while we objectively measured it using accelerometers. In addition, we analyzed a larger set of physical fitness features. Thus, our correlational analysis showed that the performance on strength, endurance, and agility tests was positively associated with the levels of myostatin in men; the correlation with agility was also significant in women. When all the parameters significantly associated with serum myostatin in correlational analysis were introduced in a linear regression equation, the model showed that men with better performance on the 8-ft timed up-and-go test and lower flexibility of the lower limbs had higher concentration of myostatin in serum. In women, the number of steps per day was a positive predictor of blood myostatin. The associations with myostatin found for frailty and physical fitness/activity were congruent and suggest that, in this population, a higher myostatin level could be an indicator of lower levels of frailty and higher functional status. However, caution should be applied to generalize these findings to other populations due to the specific characteristics of the sample under study and the variable relationship between myostatin and frailty-related parameters depending on age and gender.

Data regarding physical exercise interventions are sparse and have shown contradictory results. Some studies reported that aerobic training reduced myostatin concentration in middle-aged men and older women [17, 18]. However, other studies did not find exercise-induced changes in serum myostatin in patients with obstructive pulmonary disease [19]. The observed effect of our intervention on serum levels of myostatin does not align with previous works because myostatin was increased after a physical exercise intervention in men [18]. However, our results are in line with the effect of a pharmacological intervention with testosterone that enhanced skeletal muscle mass and myostatin concentration in parallel in older men [13]. Animal studies, using knockout mice and molecular techniques, seem to confirm the positive effects of testosterone on myostatin expression [31]. Our results showed differential effects of the exercise program on serum myostatin in men and women. The program improved physical fitness in both genders; however, the changes in the functional outcomes had higher magnitudes in men and the intervention only increased myostatin levels in men. Accordingly, other authors reported that serum myostatin was increased in interventions to prevent sarcopenia in men [13], but not in women [32]. In addition, improvements in physical fitness after the intervention were related to changes in myostatin concentration only in men. Gender-related differences regarding the interaction between physical exercise and myostatin could be due to the stimulatory effects of androgens on muscle myostatin expression, as was reported in an animal model [31]. Those authors proposed that androgens induced myostatin signaling to restrain their own anabolic actions.

Our results, together with some of the previously mentioned works [12, 13] support the hypothesis that myostatin can act as a chalone, a counter-regulatory hormone, to restrain skeletal muscle growth in response to an anabolic stimulus [13, 31, 33]. Myostatin could act as a homeostatic regulator of excessive muscle hypertrophy, and as such, would be associated with greater muscle mass and strength [12]. The lower level of myostatin found in less-fit participants in our study may be a compensatory mechanism to limit the decrease in muscle mass [34].

Our study has certain limitations. Myostatin was measured using ELISA instead of more sensitive techniques such as mass spectroscopy. Notably, however, our results are consistent with one study that used mass spectroscopy to measure myostatin [12]. In addition, muscle biopsy samples were not collected. With this regard, it is necessary to highlight that the aim of this study was to identify a circulating biomarker; further, obtaining biopsy samples could be ethically questionable in LTNH residents. We also note that body composition was determined using bioelectrical impedance and not by computed tomography, magnetic resonance imaging, or dual energy X-ray absorptiometry (DXA), which are considered to be more reliable in the measurement of fat, bone mineral, and lean tissue masses [5]. The concentration of other substances such as testosterone, estrogen, vitamin D, or C-reactive protein levels, which were not measured in the participants, would give us additional information regarding mechanisms of the relation between myostatin and frailty. Finally, although the population size is one of the largest among trials focusing on the effects of a physical exercise program on LTNH residents, even larger studies would certainly be welcome. The main strength of our study is that it is one of the first to describe the effects of physical exercise on blood biomarkers of older people living in LTNHs and to relate the levels of myostatin to parameters of body composition, physical fitness, physical activity level, frailty, and to the effects of a physical exercise intervention. Moreover, associations between myostatin and parameters of physical fitness are high and consistent for almost all variables under study.

In summary, we found higher serum levels of myostatin in leaner, fitter, more active, and non-frail LTNH residents. Additionally, the exercise program increased the myostatin concentration in men, and improvements in physical fitness after the intervention were positively related to increases in myostatin concentration. These results appear to rule out the idea that high serum myostatin levels are indicative of frailty in older adults. However, although the direction of association was opposite to that expected by the function of myostatin, the use of this protein as a biomarker for physical fitness, rather than frailty, merits further study.

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Disclosure Statement

The authors have no conflicts of interest to declare.

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References

1. Sacha J, Sacha M, Soboń J, Borysiuk Z, Feusette P: Is It Time to Begin a Public Campaign Concerning Frailty and Pre-frailty? A Review Article. Front Physiol 2017;8:484.

2. Trevisan C, Veronese N, Maggi S, Baggio G, Toffanello ED, Zambon S, Sartori L, Musacchio E, Perissinotto E, Crepaldi G, Manzato E, Sergi G: Factors Influencing Transitions Between Frailty States in Elderly Adults: The Progetto Veneto Anziani Longitudinal Study. J Am Geriatr Soc 2017;65:179-184.

3. Cesari M, Prince M, Thiyagarajan JA, De Carvalho IA, Bernabei R, Chan P, Gutierrez-Robledo LM, Michel JP, Morley JE, Ong P, Rodríguez Mañas L, Sinclair A, Won CW, Beard J, Vellas B: Frailty: an emerging public health priority. J Am Med Dir Assoc 2016;17:188-192.

4. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, Seeman T, Tracy R, Kop WJ, Mary GB, McBurnie A: Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56:M146-M157.

5. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, Martin FC, Michel JP, Rolland Y, Schneider SM, Topinková E, Vandewoude M, Zamboni M: Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age Ageing 2010;39:412-423.

6. Rodgers BD, Garikipati DK: Clinical, agricultural, and evolutionary biology of myostatin: a comparative review. Endocr Rev 2008;29:513-534.

7. White TA, LeBrasseur NK: Myostatin and sarcopenia: opportunities and challenges-a mini-review. Gerontol 2014;60:289-293.

8. Scharf G, Heineke J: Finding good biomarkers for sarcopenia. J Cachexia Sarcopenia Muscle 2012;3:145-148.

9. Calvani R, Marini F, Cesari M, Tosato M, Anker SD, Von Haehling S, Miller RR, Bernabei R, Landi F, Marzetti E, the SPRINTT consortium: Biomarkers for physical frailty and sarcopenia: state of the science and future developments. J Cachexia Sarcopenia Muscle 2015;6:278-286.

10. Peng LN, Lee WJ, Liu LK, Lin MH, Chen LK: Healthy community-living older men differ from women in associations between myostatin levels and skeletal muscle mass. J Cachexia Sarcopenia Muscle 2018;9:635–642.

11. Yarasheski KE, Bhasin S, Sinha-Hikim I, Pak-Loduca J, Gonzalez-Cadavid NF: Serum myostatin-immunoreactive protein is increased in 60-92 year old women and men with muscle wasting. J Nutr Health Aging 2002;6:343-348.

12. Bergen HR, Farr JN, Vanderboom PM, Atkinson EJ, White TA, Singh RJ, Khosla S, LeBrasseur NK: Myostatin as a mediator of sarcopenia versus homeostatic regulator of muscle mass: insights using a new mass spectrometry-based assay. Skeletal Muscle 2015;5:21.

13. Lakshman KM, Bhasin S, Corcoran C, Collins-Racie LA, Tchistiakova L, Forlow SB, St Ledger K, Burczynski ME, Dorner AJ, Lavallie ER: Measurement of myostatin concentrations in human serum: circulating concentrations in young and older men and effects of testosterone administration. Mol Cell Endocrinol 2009;302:26-32.

14. Schafer MJ, Atkinson EJ, Vanderboom PM, Kotajarvi B, White TA, Moore MM, Bruce CJ, Greason KL, Suri RM, Khosla S, Miller JD, Bergen HR, LeBrasseur NK: Quantification of GDF11 and myostatin in human aging and cardiovascular disease. Cell Metabol 2016;23:1207-1215.

15. Puts MTE, Toubasi S, Andrew MK, Ashe MC, Ploeg J, Atkinson E, Ayala AP, Roy A, Rodríguez Monforte M, Bergman H, McGilton K: Interventions to prevent or reduce the level of frailty in community-dwelling older adults: a scoping review of the literature and international policies. Age Ageing 2017;46:383-392.

16. Trombetti A, Hars M, Hsu FC, Reid KF, Church TS, Gill TM, King AC, Liu CK, Manini TM, McDermott MM, Newman AB, Rejeski WJ, Guralnik JM, Pahor M, Fielding RA: Effect of physical activity on frailty: secondary analysis of a randomized controlled trial. Ann Intern Med 2018:168:309-316.

17. Konopka AR, Douglass MD, Kaminsky LA, Jemiolo B, Trappe TA, Trappe S, Harber MP: Molecular adaptations to aerobic exercise training in skeletal muscle of older women. J Gerontol A Biol Sci Med Sci 2010;65:1201-1207.

18. Hittel DS, Axelson M, Sarna N, Shearer J, Huffman KM, Kraus WE: Myostatin decreases with aerobic exercise and associates with insulin resistance. Med Sci Sports Exerc 2010;42:2023.

19. Boeselt T, Nell C, Lütteken L, Kehr K, Koepke J, Apelt S, Veith M, Beutel B, Spielmanns M, Greulich T, Vogelmeier CF, Kenn K, Janciauskiene S, Alter P, Koczulla AR: Benefits of high-intensity exercise training to patients with chronic obstructive pulmonary disease: a controlled study. Respiration 2017;93:301-310.

20. Rodriguez-Larrad A, Arrieta H, Rezola C, Kortajarena M, Yanguas JJ, Iturburu M, Gil SM, Irazusta J: Effectiveness of a multicomponent exercise program in the attenuation of frailty in long-term nursing home residents: study protocol for a randomized clinical controlled trial. BMC Geriatr 2017;17:60.

21. Wade DT, Collin C: The Barthel ADL Index: a standard measure of physical disability?. Int Disability Studies 1988;10:64-67.

22. Lobo A, Saz P, Marcos G, Día JL, Cámara C, Ventura T, Morales Asín F, Pascual LF, Pascual LF, Montañés JA, Aznar S: Revalidación y normalización del Mini-Examen Cognoscitivo (primera versión en castellano del Mini-Mental Status Examination) en la población general geriátrica. Med Clin (Barc) 1999;112:767-774.

23. Rikli RE, Jones CJ: Senior fitness test. Champaign (IL): Human Kinetics 2001.

24. Freedson PS, Melanson E, Sirard J: Calibration of the Computer Science and Applications, Inc. accelerometer. Med Sci Sports Exerc 1998;30:777-781.

25. Rockwood K, Song X, MacKnight C, Bergman H, Hogan DB, McDowell I, Mitnitski A: A global clinical measure of fitness and frailty in elderly people. Can Med Assoc J 2005;173:489-495.

26. Gobbens RJ, van Assen MA, Luijkx KG, Wijnen-Sponselee MT, Schols JM: The Tilburg frailty indicator: psychometric properties. J Am Med Dir Assoc 2010;11:344-355.

27. Cohen J: Statistical power analysis for the behavioral science. 2. Lawrence Earlbaum Associates: Hilldsdale, 1988.

28. Hopkins W, Marshall S, Batterham A, Hanin J. Progressive statistics for studies in sports medicine and exercise science. Med Sci Sports Exerc 2009;41:3.

29. Bakeman R: Recommended effect size statistics for repeated measures designs. Behav Res Methods 2005;37:379-384.

30. Schulte JN, Yarasheski KE: Effects of resistance training on the rate of muscle protein synthesis in frail elderly people. Int J Sport Nutr Exerc Metab 2001;11:S111-S118.

31. Dubois V, Laurent MR, Sinnesael M, Cielen N, Helsen C, Clinckemalie L, Spans L, Gayan-Ramirez G, Deldicque L, Hespel P, Carmeliet G, Vanderschueren D, Claessens F: A satellite cell-specific knockout of the androgen receptor reveals myostatin as a direct androgen target in skeletal muscle. FASEB J 2014;28:2979-2994.

32. Hofmann M, Schober-Halper B, Oesen S, Franzke B, Tschan H, Bachl N, Strasser EM, Quittan M, Wagner KH, Wessner B: Effects of elastic band resistance training and nutritional supplementation on muscle quality and circulating muscle growth and degradation factors of institutionalized elderly women: the Vienna Active Ageing Study (VAAS). Eur J Appl Physiol 2016;116:885-897.

33. Lee SJ: Regulation of muscle mass by myostatin. Annu Rev Cell Dev Biol 2004;20:61-86.

34. Szulc P, Schoppet M, Goettsch C, Rauner M, Dschietzig T, Chapurlat R, Hofbauer LC: Endocrine and clinical correlates of myostatin serum concentration in men—the STRAMBO study. J Clin Endocrinol Metab 2012;97:3700-3708.

4.1.4. The impact of physical exercise on cognitive and affective functions and BDNF levels in long-term nursing home residents

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Submitted

Abstract

We evaluated the effects of a multicomponent physical exercise program on cognitive and affective functioning as well as serum brain-derived neurotrophic factor (BDNF) levels in long-term nursing home (LTNH) residents. This was a single-blind randomized controlled trial among 10 LTNHs in Gipuzkoa, Spain. The study included 112 men and women living in LTNHs (ACTRN12616001044415). Participants in the control group (CG) participated in routine activities, while the intervention group (IG) participated in a 6-month individualized, progressive, multicomponent physical exercise program at moderate intensity focused on strength, balance, and walking. Cognitive and affective functions were assessed at baseline and at 6 months. Serum BDNF levels were also assessed via ELISA. A significant group x time interaction in favor of the IG was observed for Montreal Cognitive Assessment (MOCA) and symbol search tests ($P < 0.05$). The CG scored significantly poorer results on MOCA, WAIS-IV (coding and symbol search), verbal fluency, and semantic fluency tests after 6 months ($P < 0.05$). The IG showed significantly poorer results on the coding test ($P < 0.05$). Loneliness perception was reduced significantly in the IG ($P < 0.05$). No significant changes in serum levels of BDNF were observed (group x time and within groups, $P > 0.05$). A 6-month individualized, progressive, multicomponent physical exercise intervention at moderate intensity is effective to maintain cognitive function and decrease loneliness perception in LTNH residents. Blood levels of BDNF were not affected by the intervention.

Keywords: exercise training, cognition, loneliness, neurotrophin, aging

Introduction

Cognitive function tends to decrease with aging, a phenomenon referred to as cognitive aging[1]. Cognitive aging involves a lifelong process of gradual, ongoing, and highly variable changes in cognitive function that occur as people get older[1]. In addition, aging is related to deteriorating affective function[2,3].

In addition to the physical benefits of participating in an exercise program, interventional studies demonstrate that physical exercise improves certain domains of cognitive and affective functions in older adults[4,5]. However, these observations have mainly focused on community-dwelling older adults. Physical exercise interventions may be particularly important for older adults who live in long-term nursing homes (LTNHs), as they show worryingly low levels of physical activity compared to current recommendations for community-dwelling older adults[6]. Few interventions implemented in LTNHs have assessed the effects of physical exercise programs on cognitive and affective domains of individuals living in these settings[7,8]. In the majority of studies carried out in LTNHs, the intensity of the intervention was not stated[9-11], but appeared low in most of them. In addition, there was a high variability between the studies regarding the type of intervention, including massage and cognitive tasks[7,8]. Moreover, in many studies, the length of the intervention period was short, limiting the possible impact of the intervention[7-9]. Further, prior studies have not demonstrated clear impacts on affective functions in LTNH residents, with some studies reporting improvements[7,8,10] that were not confirmed in others[11]. Therefore, there is an urgent need for quality research in LTNHs, including longer interventions and larger samples to determine the optimum parameters of physical exercise interventions to improve or maintain cognitive and affective functions[9].

Brain-derived neurotrophic factor (BDNF) promotes growth and differentiation of neurons and synapses while supporting survival of existing neurons, and the protein has emerged as one of the most important molecules involved in cognitive and affective functions[12,13]. BDNF also mediates improvements in executive function following physical exercise[13]. However, the impact of physical exercise on serum concentrations of BDNF are equivocal[14].

While some studies describe increases in this neurotrophic factor, others do not find any changes after physical exercise programs[14].

The aim of the present study was to evaluate the effects of a 6-month individualized, progressive, multicomponent physical exercise (MPE) intervention at moderate intensity on cognitive and affective functions among older adults living in LTNHs. In addition, participants' serum BDNF levels were analyzed before and after the intervention.

Methods

Study design

This study was a six-month multicenter, randomized, controlled, single-blind study among 10 LTNHs in Gipuzkoa, Spain (ACTRN12616001044415)[15]. This article presents the results of a secondary analysis. The intervention was conducted between October 2016 and July 2017. The trial was approved by the Committee on Ethics in Research at the University of the Basque Country, UPV/EHU (Humans Committee Code M10/2016/105; Biological Samples Committee Code M30/2016/106). Written informed consent was provided by each participant.

Participants

The study included 112 men and women living in LTNHs who met the following criteria: ≥ 70 years old, scored ≥ 50 on the Barthel Index (0–100), scored ≥ 20 on the MEC-35 test (0–35) [an adapted and validated version of the Mini Mental State Examination (MMSE) in Spanish], and capable of standing up and walking independently for at least 10 meters (Figure 1)[15]. Participants were randomized in a 1:1 ratio using sealed opaque envelopes to either the control (CG) or intervention group (IG) by coin-tossing sequence generation. Assessments were done in each center by the research team, who were blinded to group allocation.

Control group

Participants assigned to the CG participated in routine activities that LTNHs usually offer to residents: memory workshops, reading, singing, and other similar activities.

Intervention group

In addition to routine activities, the IG performed a previously described individualized and progressive, MPE intervention at moderate intensity[15]. The intervention consisted of a 1-hour supervised group session twice a week, separated by at least 2 days, for a 6-month period. The MPE program included strength, balance, and walking recommendations. Each session began with 5 minutes of warm-up performing range-of-motion exercises. Strength training was individually adapted to each participant and focused on upper and lower extremity strength. Brzycki equation[16] was performed to calculate 1 repetition maximum (1RM) and adapt the adequate load progression of arm-curl, knee flexion, and knee extension exercises for every participant at baseline and every two months. Chair-stand, hip abduction, and hip adduction exercises were performed without external loads, and the intensity was tailored to the capabilities of each participant by adjusting the number of repetitions and the velocity. The intensity ranged from 40% at first to 70% 1-RM in the sixth month of the program. Balance exercises were also individually adapted and included exercises progressing in difficulty, starting by decreasing arm support along with decreasing the base of support to challenge participants' balance as they progressed. Exercises varied through the period: weight transfer from one leg to another, proprioceptive exercises and stepping practice. Sessions ended with 5 minutes of deep-breathing exercises and relaxation. Physical exercise sessions were conducted in the gym of each LTNH or in a room adequate for these activities. All sessions were provided by a professional instructor with a degree in physical activity and sports sciences and trained in providing adapted physical activity in older adults. Walking recommendations were also individually tailored based on participants' performance on a baseline 6-minute walk test and started with paths that lasted 5 minutes per day at the beginning of the intervention, with the goal of completing 20 minutes per day by the end of the 6-month period.

Procedures

All enrolled participants were measured before the intervention period (month 0) and after the 6-month intervention period. All measurements were collected by the same investigators. All outcome measurements were evaluated in the participants' place of residence.

Outcomes

Cognitive function was assessed by the Montreal Cognitive Assessment (MOCA)[17], which included visuospatial/executive function, naming, attention, language, abstraction, delayed recall, orientation, and global measures of cognitive functioning. Total learning measure of the Spanish validated version of the Rey Auditory-Verbal Learning Test (RAVLT-TL)[18] was used to evaluate verbal memory and capacity to recall and accumulate words through learning trials. Trail making test A[19] was administered to evaluate executive function. The Coding and Symbol Search test was used to measure processing speed on the Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV)[20]. Verbal Fluency was measured through the number of words listed beginning with a given letter in 60 seconds[21]. Semantic Fluency was measured through the number of words produced in the restricted "animal" category in 60 seconds[21]. Higher scores on these scales indicate better cognitive functioning, except for the Trail making test A, in which higher scores indicate worse performance.

Anxiety and depression were measured with the Goldberg Anxiety and Depression Scale, in which high scores indicate more symptoms of anxiety and depression[22]. Loneliness was measured with the De Jong-Gierveld Loneliness Scale, where high scores indicate a higher perception of loneliness[23]. Quality of life was measured with the Quality of life in Alzheimer’s disease, where the total score ranges from 13 (worst) to 52 (best) points[24].

Blood samples were collected in the morning after an overnight fast. After collection, tubes were centrifuged at 5,000 rpm for 10 min. Serum obtained for each participant was stored in aliquots at –80ºC until analysis. Serum BDNF (ng/mL) was quantified using a sandwich enzyme-linked immunosorbent assay (ELISA). Human BDNF Quantikine Immunoassay (R&D Systems, MN, USA) was performed according to the manufacturer's instructions. Analyses, blinded for group allocation and in duplicate, were averaged. The manufacturer reports <20 pg/mL of sensitivity, <6.2% intra-assay co-efficient of variability (CV), and <11.3% inter-assay CV. Attendance was determined by participants' presence at physical exercise sessions, whereas compliance with walking recommendations was collected daily by each LTNH principal nurse.

Statistical analyses

A sample size of 114 participants was required to detect minimal significant effects on the Short Physical Performance Battery (SPPB), the main outcome of the approved trial: accepting an alpha risk of 0.05 and a beta risk of 0.20 in a bilateral contrast, assuming a 25% loss of follow-up[15]. Normal distribution of the data was checked using the Kolmogorov-Smirnov test. When not normally distributed, data were square-root transformed. Statistical comparisons at baseline were performed using an unpaired Student's t test. Between-group differences were assessed using mixed design Analysis of Variance (ANOVA; 2 time points x 2 groups) with 2 levels (months 0 and 6). A post-hoc Bonferroni test was used to determine differences within groups. Partial η^2 was calculated to estimate effect size. Analyses were performed by assuming intention-to-treat. Values for η^2 of ≤ 0.02, ≤ 0.13, and ≥ 0.26 were considered small, medium, and large, respectively. The significance level for all tests was set at $P < 0.05$. Statistical analysis was performed using IBM SPSS Statistics 24 statistical software package (SPSS Inc., Chicago, IL).

Results

Mean age of the participants was 84.9 years (age range = 70–102 years), and participants were predominantly women (70.5%). There were no significant differences between baseline values of CG and IG descriptive characteristics (Table 1).

Of the 112 participants who began the study, 88 completed the 6-month assessment (Figure 1). Attendance rates for the physical exercise sessions were 90.8%, and compliance with the walking recommendations was 79.0%. No adverse events associated with the physical exercise program were observed.

After 6 months of MPE intervention, a significant group x time interaction in favor of the IG was observed for MOCA (P = 0.024; η^2 = *small*) and symbol search tests (P = 0.017; η^2 = *small*) (Table 2). When the temporal evolution of each group was analyzed, the CG showed significantly poorer results for MOCA, WAIS-IV (coding and symbol search), verbal fluency, and semantic fluency tests after 6 months ($P < 0.05$). In contrast, the IG did not change the scores significantly during the intervention period, with the exception of the coding test, which decreased after the 6-month of MPE ($P < 0.05$).

Regarding affective function, no statistically significant group x time interaction was found after the intervention (mixed ANOVA for the interaction group x time, $P > 0.05$). Nevertheless, loneliness perception was significantly reduced in the IG after the 6-month period ($P < 0.05$) (Table 2).

After the intervention, no statistically significant changes were detected in serum BDNF levels between groups (mixed ANOVA for the interaction group x time and within groups, $P > 0.05$) (Table 2).

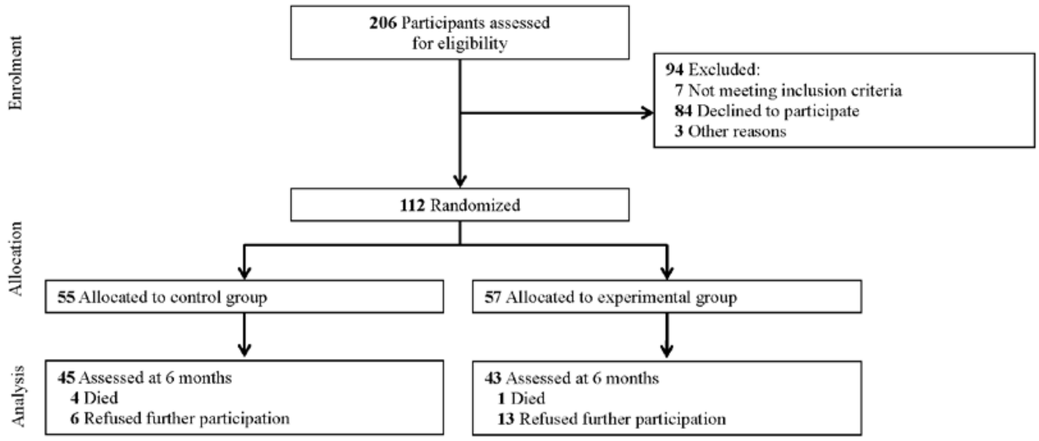

Figure 1. Study flow diagram.

Table 1. Descriptive characteristics of participants at baseline

	Control group (*n* = 55)	**Intervention group (*n* = 57)**	***P* value**
Age (years), mean ± SD	84.7 ± 6.1	85.1 ± 7.6	0.812
Sex, n (%)			
Female	37 (67.3)	42 (73.7)	0.461
Male	18 (32.7)	15 (26.3)	
BMI (kg/m^2), mean ± SD	28.2 ± 5.3	28.2 ± 5.1	0.991
WHR, mean ± SD	0.97 ± 0.08	0.98 ± 0.07	0.697
Barthel Index, mean ± SD	82.8 ± 13.1	79.2 ± 12.9	0.153
MEC-35 test, mean ± SD	28.0 ± 3.5	27.0 ± 4.0	0.157

SD, standard deviation; BMI, body mass index; WHR, waist-to-hip ratio; MEC-35 test, adapted and validated version of the Mini Mental State Examination in Spanish

Table 2. Cognitive and affective function among long-term nursing home residents with and without an exercise intervention program

	Control group (*n* = 45)		**Intervention group (*n* = 43)**			
	Baseline, mean (SD)	**6 months, mean (SD)**	**Baseline, mean (SD)**	**6 months, mean (SD)**	***P*** [a]	**Partial η^2** [b]
Cognitive function						
MOCA (0–30)	14.3 (3.7)	13.0 (5.1)*	14.2 (4.5)	14.9 (5.1)	0.024	0.080
RAVLT (total rep.) (0–75)	19.2 (8.4)	20.7 (11.5)	18.0 (8.7)	19.9 (12.1)	0.691	0.002
TMT-A	124 (54)	136 (72)	120 (45)	107 (40)	0.061	0.097
Coding (WAIS-IV)	13.8 (9.5)	10.9 (8.8)*	11.7 (7.8)	10.1 (8.4)*	0.696	0.003
Symbol search (WAIS-IV)	9.0 (4.4)	6.6 (5.4)*	7.0 (5.3)	6.7 (5.9)	0.017	0.090
Verbal fluency test	7.3 (3.9)	6.5 (4.1)*	6.7 (3.5)	6.4 (3.7)	0.418	0.009
Semantic fluency test	8.7 (3.1)	7.4 (4.2)*	7.9 (3.2)	7.2 (3.3)	0.238	0.018
Affective function						
Goldberg anxiety	1.3 (1.3)	1.4 (1.5)	1.5 (1.8)	1.3 (1.6)	0.662	0.003
Goldberg depression	0.8 (1.8)	1.2 (1.8)	1.0 (2.1)	0.9 (1.8)	0.323	0.013
DJGLS	5.3 (2.8)	4.3 (3.4)	5.8 (3.1)	3.2 (2.6)*	0.088	0.038
QoL-AD	34.1 (4.9)	33.1 (5.3)	34.3 (6.6)	35.4 (7.1)	0.079	0.040
BDNF (ng/mL)	33.6 (14.2)	32.8 (15.7)	34.2 (15.0)	33.5 (13.2)	0.844	0.001

SD, standard deviation; MOCA, Montreal Cognitive Assessment; RAVLT, Rey Auditory-Verbal Learning Test; rep, repetitions; TMT-A, Trail Making Test A; WAIS-IV, Wechsler Adult Intelligence Scale, Fourth Edition; DJGLS, De Jong-Gierveld Loneliness Scale; QoL-AD, quality of life in Alzheimer's disease; BDNF, brain-derived neurotrophic factor

[a] *P* for group x time interaction.

[b] Estimation of effect size for group x time interaction.

* $P < 0.05$, significantly different from baseline.

Discussion

The present study shows that a 6-month individualized and progressive MPE program conducted twice a week at moderate intensity was effective in maintaining certain parameters of cognitive function and reducing loneliness perception among a group of LTNH residents.

The effects of physical exercise training on cognitive performance have not been sufficiently investigated in the LTNH environment[7]. The present study demonstrates that the program is effective to maintain the scores in MOCA (global cognition) and symbol search (processing speed) tests in LTNH residents. While there was a decline in several cognitive tests in the CG, the IG maintained test results with the exception of the coding test. The effects of the intervention on cognitive parameters seem to be likely specific as no changes were observed in the rest of the evaluated cognitive tests. The CG and IG showed a two-point difference in the evolution of MOCA scores, a change that has been considered clinically relevant[25].

Our results agree with a recent systematic review in which the authors conclude that improvements in global cognition and processing speed after physical exercise intervention are the most stable and consistent changes among cognitive parameters in community-dwelling older adults[26]. Importantly, slower processing speed and deteriorating global cognition are associated with increased likelihood of incident dementia[27]. Among studies carried out in LTNHs, there were conflicting results on cognitive function depending on the duration and the type of intervention. One study reported that physical exercise could be beneficial to delay cognitive deterioration[7]. However, the sample size of this study was small and the intervention included cognitive stimulation tasks[7]. Another study failed to demonstrate any benefit after a physical exercise program[11]. Even though the authors did not explain the type and the intensity of the exercises and the duration of the intervention period was short[11]. Thus, these results agree with another report showing that physical exercise interventions are beneficial to delay deterioration in global cognition and processing speed in LTNH residents[7].

The results of the present study are also in line with previous findings of a significant decrease in loneliness among LTNH residents after a physical exercise program[8]. Interestingly, the present study also shows that loneliness levels tended to decrease in the CG. Being part of a research project that included carrying out several measurements and interacting with the research team over 6 months may have influenced this result. Loneliness can be especially relevant because it can be associated with worse health outcomes, such as functional decline, morbidity, and mortality[28].

In other domains of affective function, there were no statistically significant changes. However, it is notable that the differences in quality of life, in favor of the IG, nearly reached statistical significance; therefore, a larger sample size may reveal significant effects. In line with these results, Lok et al[10] reported that physical exercise could be beneficial in improving the quality of life in LTNH residents. There is conflicting evidence on the effectiveness of physical exercise on anxiety and depression when implemented in the LTNH setting. The results of the present study agree with a unique study that measured the impact of physical exercise on anxiety, which showed a reduced anxiety perception in the end of the program, although the differences did not reach statistical significance[29]. With respect to depression, some studies revealed a significant improvement after a physical exercise program[10], while others failed to demonstrate any benefit[11]. The differences found in the current study do not provide sufficient confidence to clarify this controversy.

The effects of physical exercise on serum concentrations of BDNF remain inconclusive[14,30,31]. Some studies show increases in BDNF concentration, while others do not find any changes after a physical exercise program[14]. Results of the present study agree with those reports of no effect of physical exercise on BDNF levels[31]. Although acute bouts of exercise have been reported to increase serum BDNF concentration[13], the short-term response of BDNF that occurs acutely after physical exercise sessions could have been washed out by the time that blood samples were taken[31]. Thus, longer-term physical exercise programs may not demonstrate sustained increases in BDNF levels[14]. In addition, we cannot exclude the possibility of an exercise-induced change in onsite production in the muscle or brain that may not affect serum levels of BDNF[31].

Although it was not the main objective of this research, it is interesting to note that the observed attendance at physical exercise sessions in our study was higher (91%) than that of similar studies[7]. Thus, a longer intervention did not seem to affect adherence rates in our study, in contrast with other studies conducted in the same type of population[7]. Following an initial pilot study to inform both the intervention protocol and procedure in LTNH environments, we met with the directors of each center participating in the main project and emphasized the importance of the centers' staff to encourage participants. This help from the staff may have been key to the high adherence in the present study.

A major strength of the present study is our analysis of the cognitive effects of a physical exercise intervention on LTNH residents. In addition, the study length and sample size, which is one of the largest among studies focused on MPE programs in LTNH residents, are strong points of our research[9]. Most of the studies including physical exercise interventions in LTNH residents lasted between three to five months, with a few longer studies lasting six months or more[9]. Moreover, the present study showed the effects of an individualized and progressive MPE program at moderate intensity, whereas in most studies performed in LTNHs, the intensity of the physical exercise programs was not stated but appeared to be carried out at low intensity[9]. On the other hand, limitations include the need for caution in generalizing our results to cognitively impaired or severe or wholly dependent older adult populations. In consequence, we could not ascertain whether participants who did not meet the inclusion criteria due to their low level of physical fitness and cognitive function would also benefit from this intervention. Attrition bias is a major concern, as those unable to complete the physical exercise program may be those most likely to show cognitive decline. However, the observed attendance at physical exercise sessions in our study (91%) was higher than that of similar studies[29]. Finally, BDNF was measured in serum rather than directly from brain tissue. However, we believe that this is an acceptable limitation given the obvious difficulties of obtaining brain tissue from living human participants.

Perspective

This research demonstrated that a 6-month individualized and progressive MPE intervention performed at moderate intensity is feasible and well tolerated by LTNH residents and induced specific benefits in cognitive function and loneliness. In the absence of a structured training program, LTNH residents are likely to have worse cognitive function. From a practical standpoint, we recommend that individually adjusted and supported progressive MPE programs performed at moderate intensity and focused on strength and balance should be an integral part of daily life in older adults living in LTNHs.

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References

1 Blazer DG, Yaffe K, Karlawish J. Cognitive aging: a report from the Institute of Medicine. *JAMA.* 2015;313(21):2121-2122.

2 Zhao KX, Huang CQ, Xiao Q et al. Age and risk for depression among the elderly: a meta-analysis of the published literature. *CNS Spectr.* 2012;17(3):142-154.

3 Cohen-Mansfield J, Shmotkin D, Goldberg S. Loneliness in old age: longitudinal changes and their determinants in an Israeli sample. *Int Psychogeriatr.* 2009;21(6):1160-1170.

4 Smith PJ, Blumenthal JA, Hoffman BM et al. Aerobic exercise and neurocognitive performance: a meta-analytic review of randomized controlled trials. *Psychosom Med.* 2010;72(3):239-252.

5 McSween M, McMahon K, Coombes J et al. The immediate effects of acute aerobic exercise on cognition in healthy older adults: a systematic review. *J Sci Med Sport.* 2018;21:S95.

6 Arrieta H, Rezola-Pardo C, Zarrazquin I et al. A multicomponent exercise program improves physical function in long-term nursing home residents: a randomized controlled trial. *Exp Gerontol.* 2018;103:94-100.

7 Pereira C, Rosado H, Cruz-Ferreira A et al. Effects of a 10-week multimodal exercise program on physical and cognitive function of nursing home residents: a psychomotor intervention pilot study. *Aging Clin Exp Res.* 2018;30:471-479.

8 Mimi MY, Tang SK, Wan VT et al. The effectiveness of physical exercise training in pain, mobility, and psychological well-being of older persons living in nursing homes. *Pain Manag Nurs.* 2014;15(4):778-788.

9 Brett L, Traynor V, Stapley P. Effects of physical exercise on health and well-being of individuals living with a dementia in nursing homes: A systematic review. *J Am Med Dir Assoc.* 2016;17(2):104-116.

10 Lok N, Lok S, Canbaz M. The effect of physical activity on depressive symptoms and quality of life among elderly nursing home residents: Randomized controlled trial. *Arch Gerontol Geriatr.* 2017;70:92-98.

11 Frändin K, Grönstedt H, Helbostad JL et al. Long-term effects of individually tailored physical training and activity on physical function, well-being and cognition in Scandinavian nursing home residents: a randomized controlled trial. *Gerontol.* 2016;62(6):571-580.

12 Carvalho AL, Caldeira MV, Santos SD et al. Role of the brain-derived neurotrophic factor at glutamatergic synapses. *Br J Pharmacol.* 2008;153(S1):S310-324.

13 Leckie RL, Oberlin LE, Voss MW et al. BDNF mediates improvements in executive function following a 1-year exercise intervention. *Front Hum Neurosci.* 2014;8:985.

14 Ahlskog JE, Geda YE, Graff-Radford NR et al. Physical exercise as a preventive or disease-modifying treatment of dementia and brain aging. *Mayo Clin Proc.* 2011;86(9):876-884.

15 Rodriguez-Larrad A, Arrieta H, Rezola C et al. Effectiveness of a multicomponent exercise program in the attenuation of frailty in long-term nursing home residents: study protocol for a randomized clinical controlled trial. *BMC Geriatr.* 2017(1);17:60.

16 Brzycki M. Strength testing—predicting a one-rep max from reps-to-fatigue. *J Phys Educ Recrea Dance.* 1993;64(1):88–90.

17 Coen RF, Robertson DA, Kenny RA et al. Strengths and limitations of the MoCA for assessing cognitive functioning. Findings from a large representative sample of Irish older adults. *J Geriatr Psychiatry Neurol.* 2015;29(1):18–24.

18 Ponton MO. Research and assessment issues with Hispanic populations, Chapter 3, in *Neuropsychology and the Hispanic patient: A clinical handbook,* Mahwah, NJ: Lawrence Erlbaum Associates 2001:39-58.

19 Reitan RM, Wolfson D. *The Halstead-Reitan neuropsychological test battery: Theory and clinical interpretation* (Vol. 4), Tucson, AZ: Neuropsychology Press, 1985.

20 Wechsler D. *WAIS-IV UK Administration and scoring manual*, London, United Kingdom: Pearson, 2010.

21 Serrani DJL. Spanish translation and validation of an Executive Battery 25 (EB25) and its shortened version (ABE12) for executive dysfunction screening in dementia. *Neurología (English Edition).* 2013;28(8):457-476.

22 Goldberg D, Bridges K, Duncan-Jones P et al. Detecting anxiety and depression in general medical settings. *Br Med J.* 1988;297:897-899.

23 De Jong-Gierveld J, Kamphuls F. The development of a Rasch-type loneliness scale. *Appl Psychol Meas.* 1985;9(3):289-299.

24 Gómez-Gallego M, Gómez-Amor J, Gómez-García J. Validación de la versión española de la escala QoL-AD en pacientes con enfermedad de Alzheimer, cuidadores y profesionales sanitarios. *Neurología.* 2012;27(1):4-10.

25 Wong GKC, Mak JSY, Wong A et al. Minimum clinically important difference of montreal cognitive assessment in aneurysmal subarachnoid hemorrhage patients. *J Clin Neurosci.* 2017;46:41-44.

26 Gomes-Osman J, Cabral DF, Morris TP et al. Exercise for cognitive brain health in aging: A systematic review for an evaluation of dose. *Neurol Clin Pract.* 2018;8(3):1-8.

27 Welmer AK, Rizzuto D, Qiu C et al. Walking speed, processing speed, and dementia: a population-based longitudinal study. *J Gerontol A Biol Sci Med Sci.* 2014;69(12):1503-1510.

28 Perissinotto CM, Cenzer IS, Covinsky KE. Loneliness in older persons: a predictor of functional decline and death. *Ann Intern Med.* 2012;172(14):1078-1084.

29 Dechamps A, Diolez P, Thiaudière E et al. Effects of exercise programs to prevent decline in health-related quality of life in highly deconditioned institutionalized elderly persons: a randomized controlled trial. *Arch Intern Med.* 2010;170(2):162–169.

30 Huang T, Larsen KT, Ried-Larsen M, Møller NC, Andersen LB. The effects of physical activity and exercise on brain-derived neurotrophic factor in healthy humans: A review. *Scand J Med Sci Sports*. 2014;24(1):1-10.

31 Forti LN, Njemini R, Beyer I et al. Strength training reduces circulating interleukin-6 but not brain-derived neurotrophic factor in community-dwelling elderly individuals. *Age.* 2014;36(5):9704.

4.1.5. Effects of multicomponent exercise on frailty in long-term nursing homes: a randomized controlled trial

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Submitted

Abstract

Objectives: To determine the effect of multicomponent exercise on frailty and related adverse outcomes in residents of long-term nursing homes (LTNHs).

Design: A single-blind randomized controlled trial.

Setting: Ten LTNHs in Gipuzkoa, Spain.

Participants: The study sample comprised 112 men and women aged ≥ 70 years who scored ≥ 50 on the Barthel Index, ≥ 20 on the MEC-35 test (an adapted and validated version of Mini Mental State Examination in Spanish), and who were capable of standing up and walking independently for at least 10 m.

Intervention: Subjects in the control group (CG) participated in routine activities. The intervention group (IG) participated in a six-month program of individualized and progressive multicomponent exercise at moderate intensity.

Measurements: Frailty was assessed by four different scales at baseline and at 6 months. Barthel Index was measured at baseline and at 12 months. Frailty-related adverse outcomes were recorded from 12 months before to 12 months after starting the intervention.

Results: A lower prevalence of frailty was observed in the IG compared with the CG according to Fried's frailty phenotype, Short Physical Performance Battery, and Tilburg frailty indicator after 6 months ($p < .05$). There was a decline in the CG on the Barthel Index after 12 months ($p < .05$), whereas score in the IG was maintained. Both groups experienced a similar number of falls before and after the intervention ($p > .05$), but during the 6-month intervention period fewer falls were observed in the IG than CG ($p < .05$). Lower overall mortality was observed 12 months after starting the intervention for the IG than CG (1 vs 6, respectively; $p = .05$).

Conclusion: Individualized and progressive multicomponent exercise at moderate intensity seem to be effective to prevent falls and reduce frailty and mortality.

Key words: frailty; falls; mortality; physical exercise; nursing home

Introduction

Frailty is an age-associated syndrome of increased vulnerability when facing minor stressors, which exposes older adults to a high risk for adverse health-related events, such as falls, disability, hospitalization, institutionalization, and death[1-4]. There is no unique internationally accepted definition of frailty[5], and in the past few years, several indexes and tools have been developed to identify frail subjects in different care settings[5,6]. This variability on the definitions and criteria proposed to operationalize frailty, together with the heterogeneity of characteristics of the older adult population, may explain a lack of consensus on the prevalence of frailty in older people[7]. Compared with other populations, a limited number of studies have analyzed the prevalence of frailty in long-term nursing home (LTNH) settings[8]. A recent systematic review and meta-analysis specifically focused on frailty in LTNHs showed that the prevalence of frailty ranged widely[8].

A growing body of evidence suggests that exercise-based programs may contribute to reduce frailty in community-dwelling older adults[9-11]. However, little is known about the capacity of these interventions to tackle frailty among LTNH residents, a complex population in terms of physical and cognitive functions[12]. Recent studies show that implementation of physical exercise programs in LTNH settings is effective for improving strength, gait ability, and balance[13-15]. Considering that clinical frailty scales include components such as strength and gait ability, exercise programs could also be effective to reduce frailty in this population. Moreover, some recent studies have investigated the topic with promising results[16,17], but further research is needed in this continuously growing population[18].

Exercise programs have been proposed as a strategy to reduce frailty-related adverse outcomes in older adults, which include falls, hospitalizations, and death. However, there is conflicting evidence of the effectiveness of exercise to prevent falls in LTNH settings; while some authors found significant reductions when participants carried out only an exercise program[19,20], others failed to demonstrate any benefit[21-23]. A Cochrane systematic review concluded no reduction in the rate of falls when exercise was carried out as a single intervention[24]. Nevertheless, subgroup analysis suggests that exercise might reduce falls in older adults in intermediate-level facilities, while increasing falls in facilities providing high levels of nursing-care[25]. Further, a recent study found significantly less falls in LTNH residents with dementia when they engaged in an exercise intervention compared to a social activity group[14].

Evidence about whether exercise programs are effective to reduce hospitalization and mortality rates are limited and inconclusive[19,21,22]. More in-depth analysis of those studies highlights that the evaluated interventions are characterized as being generalist, without considering the individual's functional level, and that very few offer objective data on the intensity and volume which they have been carried out. This lack of information is important because it makes it difficult to generate reliable evidence about the role that exercise could have in LTNH settings for the prevention of adverse health outcomes.

Thus, the main goal of the current study was to determine the effect of an individualized and progressive multicomponent exercise intervention comprised of strength, balance, and walking recommendations at moderate intensity on frailty, the ability to perform activities of daily living (ADL), number of falls, visits to emergency departments, hospitalizations, and deaths in residents of LTNHs.

Methods

Study design

This study was a single blind and multicenter randomized controlled trial (ACTRN12616001044415)[26] that took place between October 2016 and July 2017. All participants provided written informed consent and, after baseline measurements, were randomly allocated to a control group (CG) or intervention group (IG). The study was approved by the Committee on Ethics in Research of the University of the Basque Country, UPV/EHU (Humans Committee Code M10/2016/105).

Study participants and selection criteria

We recruited 112 participants (79 women and 33 men) from 10 LTNHs (Gipuzkoa, Basque Country, Spain) (Figure 1). The study sample comprised men and women aged ≥ 70 years who scored ≥ 50 on the Barthel Index[27], ≥ 20 on the MEC-35 test[28] [an adapted and validated version of Mini Mental State Examination (MMSE) in Spanish], and who were capable of standing up and walking independently for at least 10 m. Participants were not eligible for the study if they were clinically unstable under the clinical judgment of the medical professionals of the reference center. Participants were randomized (in a 1:1 ratio) in each center through sealed opaque envelopes to either the CG or IG by coin-tossing sequence generation. Assessments were done in each center by the research team, who were blinded to group allocation.

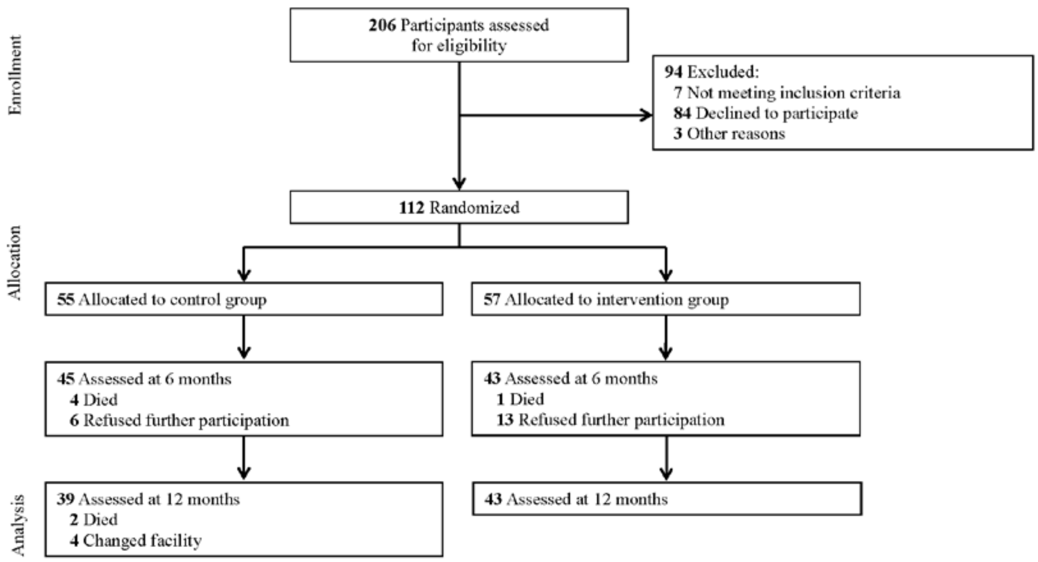

Figure 1. Study flow diagram.

Control group

Subjects in the CG participated in routine low-intensity activities that LTNHs usually offered to residents: memory workshops, reading, singing, soft gymnastics etc.

Intervention group

In addition to routine activities, the IG performed a progressive multicomponent exercise intervention at moderate intensity[26]. The intervention consisted of 1-hour supervised group training sessions twice a week for a 6-month period involving individualized strength and balance exercises. All sessions began with a brief warm-up of range-of-motion exercises. Strength training included upper and lower body exercises individualized according to the Brzycki equation, which was performed to calculate one repetition maximum (1-RM) and adapt the adequate load progression of arm-curl, knee flexion, and knee extension exercises for every participant at baseline and every 2 months. Chair-stand, hip abduction, and hip adduction exercises were performed without external loads, and intensity was tailored to the capabilities of each participant by adjusting the number of repetitions and velocity. Intensity was progressively increased from 40% at the beginning of the intervention to 70% 1-RM in month 6 of the program. Balance training was also individualized and included exercises progressing in difficulty, starting by decreasing arm support along with decreasing the base of support and increasing complexity of movements to challenge participants' balance as they progressed. Exercises varied through the period: weight transfer from one leg to another, proprioceptive exercises, and stepping practice. Sessions finished with 5 min of cooling down by stretching, breathing, and relaxing exercises. All sessions were provided by a professional instructor with a degree in physical activity and sport sciences, specifically trained in guiding adapted physical activity to older adults. In addition, walking recommendations were also individually tailored in duration and intensity based on a baseline 6-min walk test performance. Recommendations started with paths that lasted 5 min per day at the beginning of the intervention, with the goal of completing 140 min per week after the 6-month period.

Outcomes

We previously described the effects of the intervention on anthropometric, physical fitness, habitual physical activity parameters, and myostatin levels in LTNH residents[13,26,29]. Frailty was assessed at baseline and at 6 months through the Fried's frailty phenotype[1], Short Physical Performance Battery[30] (SPPB), Study of Osteoporotic Fractures frailty (SOF) index[31], and Tilburg frailty indicator[32]. Frailty defined by the Fried's frailty phenotype was identified by the presence of ≥3 of the following signs/symptoms: unintended weight loss, exhaustion, weakness, slow gait speed, and low physical activity[1]. SPPB consists of balance, gait ability, and leg strength tests,[30] and participants with a score of ≤9 were considered frail[33]. Frailty defined by the SOF index was identified by the presence of ≥2 of the following components: inability to rise from a chair five times, self-reported reduced energy level, and unintended weight loss[31]. The Tilburg frailty indicator contains 15 questions on components of frailty (physical, psychological, and social)[32]. Participants with a score of ≥5 were considered frail[32]. ADL was assessed at baseline and at 12 months by the Barthel Index, which measures patient performance on 10 items of ADL functions[27]. Number of falls was recorded in six months periods: retrospectively before the baseline assessment, and prospectively during the intervention and 6 months after it was finished. Visits to emergency departments, hospitalizations, and deaths from 12 months before to 12 months after starting the intervention were extracted by a blinded physician from each LTNH database. Attendance was determined by participants' presence at physical exercise sessions, whereas compliance with walking recommendations was collected daily the last week of each month by each LTNH principal nurse.

Statistical analysis

A sample size of 114 participants was required to detect minimal significant effects on the SPPB[30], the main outcome of the approved trial: accepting an alpha risk of 0.05 and a beta risk of 0.20 in a bilateral contrast, assuming a 25% loss of follow-up[26]. Normal distribution of the data was checked through the Kolmogorov-Smirnov test. For parametric tests, when data were not normally distributed values were square-root transformed. Baseline comparisons were performed using an unpaired t-test and chi-square test. Between-group differences for the effects of exercise intervention were assessed using the chi-square test for categorical data and two-way mixed design analysis of variance (ANOVA; two time points × two groups) with two levels (baseline and 6 months) for continuous data. Post-hoc Bonferroni test was used to assess changes within groups. Partial η^2 was calculated to estimate effect size with 95% confidence intervals. Values for η^2 of ≤ .02, ≤ .13, and ≥ .26 were considered *small*, *medium*, and *large*, respectively[34]. Inferential statistics by McNemar's test were also used to compare fall rate, visits to the emergency service, and hospital admissions of both groups between different periods. Survival analysis (Kaplan-Meier) was used to assess the effects of physical exercise training on mortality. Kaplan Meier survival curves were compared using log-rank test. All analyses were tested with a significance level of $p < .05$. Statistical analysis was done using the IBM SPSS Statistics 24 statistical software package (SPSS Inc., Chicago, IL).

Results

Baseline characteristics were not significantly different between CG and IG (Table 1). The mean age was 84.9 years (age range = 70–102 years), and 70.5% of participants were women.

Table 1. Characteristics of subjects at baseline

	Control group (n = 55)	Intervention group (n = 57)	*p*
Age (years), mean ± SD	84.7 ± 6.1	85.1 ± 7.6	.812
Sex, n (%)			
Female	37 (67.3)	42 (73.7)	.461
Male	18 (32.7)	15 (26.3)	
BMI (kg/m^2), mean ± SD	28.2 ± 5.3	28.2 ± 5.1	.991
WHR, mean ± SD	0.97 ± 0.08	0.98 ± 0.07	.697
Barthel Index, mean ± SD (range 0-100)	82.8 ± 13.1	79.2 ± 12.9	.153
MEC-35 test, mean ± SD (range 0-35)	28.0 ± 3.5	27.0 ± 4.0	.157
Comorbidities, n (%)[a]			
1	17 (30.9)	13 (22.8)	.333
2	16 (29.1)	13 (22.8)	.448
≥3	15 (27.3)	21 (36.8)	.278

SD, standard deviation; BMI, body mass index; WHR, waist-to-hip ratio; MEC-35 test, adapted and validated version of mini mental state examination in Spanish

[a] Hypertension, diabetes mellitus, dyslipidemia, chronic obstructive pulmonary disease, coronary heart disease, peripheral vascular disease, cancer, and depression (following Rolland et al., 2007[22]).

Adherence to the exercise program and adverse events

Attendance rates for the exercise sessions were 90.8%, and compliance for the walking recommendations was 79.0%. No adverse effects of exercise occurred.

Frailty and Barthel Index

Fried's frailty phenotype, SPPB, SOF index, and Tilburg frailty indicator showed no significantly different rates of frailty between CG and IG before the intervention ($p > .05$). However, there was a lower prevalence of frailty in the IG compared with the CG according to Fried's frailty phenotype (54% vs 76%; $p <$ .05), SPPB (67% vs 93%; $p < .05$), and Tilburg frailty indicator (42% vs 66%; $p <$

.05) after the 6-month intervention period. In addition, there was a significant group–time interaction, in favor of the IG, reducing frailty indexes assessed by Fried's frailty phenotype (p = .05; η^2 = *small*, 95% confidence interval 0-.171) and SPPB (p < .05; η^2 = *large*, 95% confidence interval .233-.518). Regarding changes within groups, Fried's frailty phenotype and SOF index tended to improve in the IG (p > .05) and decrease in the CG (p > .05) after the 6-month intervention period. SPPB score after 6 months significantly declined in the CG (p < .05) and improved in the IG (p < .05). Tilburg frailty indicator significantly improved after the exercise intervention in the IG (p < .05), while the CG tended to improve but did not reach statistical significance (p > .05; Table 2).

After the intervention, no statistically significant group–time interaction in Barthel Index was observed (mixed ANOVA for the interaction group × time and within groups, p > .05). However, there was a significant decline in the CG on the Barthel Index after 12 months (p < .05), whereas score in the IG was maintained (Table 2).

Frailty-related adverse outcomes

Figure 2 shows the fall rates of CG and IG, analyzed in 6-month intervals, from 12 months before to 12 months after baseline assessment. Similar number of falls were observed in both groups before baseline assessment. In contrast, the distribution of falls during the 6-month intervention significantly differed between the CG and IG (p < .005). During the intervention, CG showed an increase in incidence rate of falls, while the IG remained stable. 6 months after the intervention was finished, an increase in the number of falls was observed in the IG. However, in the CG a similar number of falls was observed in both periods. Therefore, the distribution of falls between groups during and 6 months after the intervention was also significantly different (p < .05).

Results for visits to the emergency service and hospital admissions did not significantly differ between CG and IG participants after 12 months (p > .05; Table 2). Seven deaths occurred during the study: 6 in the CG and 1 in the IG. Kaplan–Meier analysis revealed significantly lower overall mortality for the IG compared to the CG (p = .05; Figure 3).

Table 2. Exercise intervention effects on physical function, frailty status, basic activities of daily living and cognitive function among long-term nursing home residents.

	Control group (n = 45)		Intervention group (n = 43)			
	Baseline	**End point**	**Baseline**	**End point**	***p***	**Partial *η*² (95% CI)**
Frailty status						
FFP, mean ± SD (range 0-5)	2.8±1.1	3.0±1.2	2.8±0.9	2.6±0.9	.05[d]	.049 (0-.171)
frail, %	60.6	75.8	61.0	53.7[c]		
SPPB score, mean ± SD (range 0-12)	5.8±2.7	4.9±2.8[b]	6.1±3.1	7.9±3.1[b]	<.001[d]	.369 (.233-.518)
frail, %	90.7	93.0	81.4	67.4[c]		
SOF index, mean ± SD (range 0-3)	0.6±0.7	0.9±0.8	0.7± 0.7	0.5±0.7	.08[d]	.040 (0-.156)
frail, %	5.9	17.6	16.7	11.9		
TFI, mean ± SD (range 0-15)	5.9±2.7	5.4±3.1	5.8±3.0	4.3±2.9[b]	.08[d]	.039 (0-.152)
frail, %	71.4	65.7	58.1	41.9[c]		
Barthel Index, mean ± SD (range 0-100)	82.3±12.0	72.7±23.8[b]	80.7±13.0	74.7±18.8	.43[d]	.008 (0-.085)
Visits to the emergency services, n[a]	10	11	15	8	.55[e]	
Hospital admissions, n[a]	11	7	12	5	.35[e]	

FFP, Fried's frailty phenotype; SD, standard deviation; SPPB, Short Physical Performance Battery; SOF, Study of Osteoporotic Fractures; TFI, Tilburg frailty indicator; CI, confidence interval

[a] Number of events 12 months before and after baseline assessment.

[b] $p < .05$, significantly different from baseline assessment.

[c] $p < .05$, prevalence of frailty was measured with χ^2 test to measure differences between groups.

[d] *p*-value for the group × time interaction, measured with two-way mixed design analysis of variance.

[e] *p*-value for the group × time interaction, measured with McNemar's test.

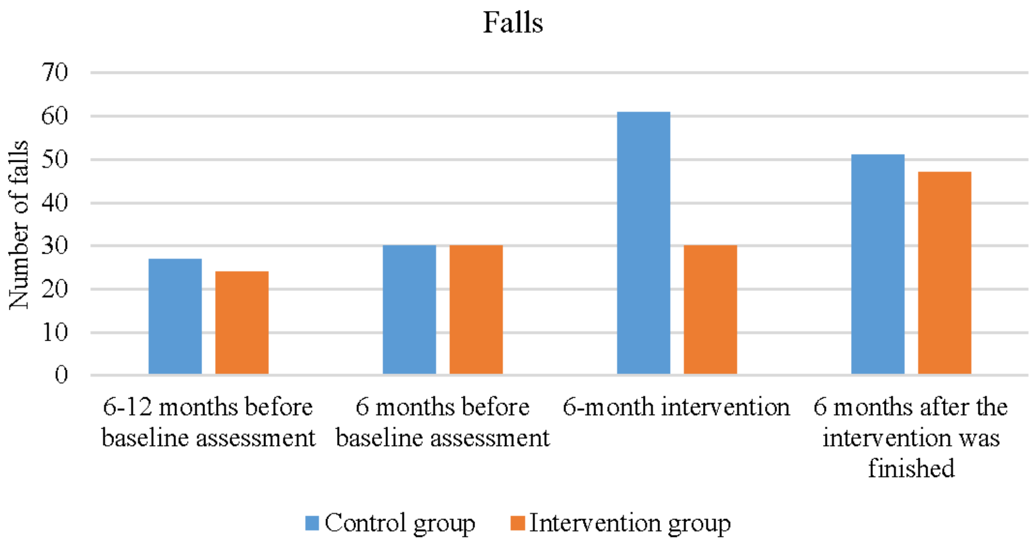

Figure 2. Number of falls in the control and intervention groups, 6 and 12 months before and after baseline assessment. Distribution of falls differed for both the CG and IG, comparing those observed 6 months before and 6 months after baseline assessment ($p < .005$) and those observed at 6 and 12 months after baseline assessment ($p < .05$).

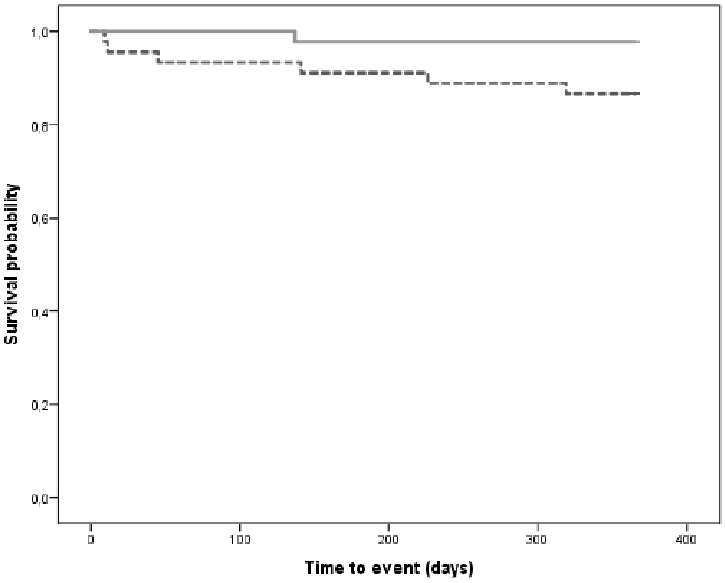

Figure 3. Kaplan-Meyer survival curves for 12 months mortality follow-up of study participants showing cumulative survival proportion of the control group and intervention group (*p* = .05). Dashed line represents CG and continuous line, IG.

Discussion

The primary finding in this study was that 6 months of individualized and progressive multicomponent exercise at moderate intensity comprised of strength, balance, and walking recommendations in LTNH residents was effective to prevent falls and reduce frailty and mortality.

Because the prevalence of frailty varies widely depending on the test used[8], this study used four different tools to assess frailty. The results agree with a previous study that showed a lower prevalence of frailty according to Fried's frailty phenotype after an exercise program in older adults in a long-term care facility in Brazil[16]. Further, the significant increase in the IG and decrease in the CG of SPPB score that we report in this study is in concordance with another study that performed resistance training in LTNHs[17]. In the same vein, our intervention was effective in reducing the prevalence of frailty according to SPPB in the IG.

To the knowledge of the authors, this is the first study to assess the effects of a physical exercise program on SOF index and Tilburg frailty indicator. According to the Tilburg frailty indicator, the prevalence of frailty was significantly lower in the IG compared with the CG after the 6-month intervention period. According to the SOF index, the prevalence of frailty tended to be lower in the IG, but the differences were not significant. Therefore, these results are consistent with results published in recent studies that seem to indicate that physical exercise could play an important role in reducing frailty[16,17]. However, there is a need for more research to determine an optimum program to tackle frailty in LTNHs. Regarding the ability to perform ADL, these results agree with other studies showing a significant decline on the Barthel Index in the CG, but not in those who performed an exercise program in an LTNH setting[20]. The 10-point decrease of the CG reported this study has been considered a relevant functional decline[20].

While both groups experienced similar number of falls before baseline and after the exercise was finished, the number of falls during the 6-month intervention period was significantly higher in the CG than IG. Although evidence regarding the benefit of physical exercise in preventing falls may be inconsistent to date, the results of this study agree with previous results showing the effectiveness of exercise to prevent falls in LTNH residents[14,19] and an increased number of falls after the exercise ends[35]. These results reinforce the need for LTNH residents to be involved in long-term exercise programs without interruption to reduce the risk of falls. These results are also clinically relevant because falls and fall-related injuries are highly prevalent in older adults[36]. Although not all falls lead to injuries, approximately 20% require medical attention, 5% result in a fracture, and 5%–10% cause other serious injuries[37]. It should be noted that injuries resulting from falls are one of the most common causes of pain, functional impairment, disability, and death in older populations[37]. Therefore, the results of this study confirm that exercise programs are an important tool for preventing the increase in the number of falls in the LTNHs.

Similar to other studies performed in LTNH residents, this study failed to report a significant reduction of visits to the emergency service and number of hospital admissions[14,38]. However, the number of deaths was lower in the IG than in the CG at 12 months after beginning the intervention. Epidemiological studies performed in community-dwelling older adults show a strong inverse relationship between physical activity, health, and all-cause mortality[39]. However, less is known about people who live in LTNH settings. This study agrees with previous studies that report lower death rates after physical exercise interventions in LTNHs[40-42]. In line with these results, higher physical function has been associated with a lower risk of mortality in community-dwelling older adults[43]. Further studies are needed to analyze the impact of exercise programs on the number of participants requiring medical attention, fractures, other serious injuries or deaths without going to the hospital.

A major strength of this study is the analysis of progression of frailty with four different tools after an exercise intervention in LTNH residents. Our results agree with those studies that show positive effects of physical exercise interventions on frailty in this population[16,17]. In addition, the study length and sample size, which is one of the largest among studies focused on multicomponent exercise programs in LTNH residents, are strong points of our research. It is interesting to remark also that the observed attendance to exercise sessions in our study was higher (91%) than that found in similar studies[41,44]. On the other hand, we also note some limitations: this study is a post-hoc analysis which encompasses the limitations of this kind of design. Moreover, these results cannot be directly applied to all LTNH residents. In consequence, we could not ascertain whether participants who did not meet the inclusion criteria due to their low level of physical fitness and cognitive function would also benefit from this intervention. There is a need to include longer interventions and larger samples to determine optimum parameters of physical exercise interventions in LTNH residents.

In conclusion, the findings of the current study show that 6 months of individualized and progressive multicomponent exercise at moderate intensity comprised of strength, balance, and walking recommendations seem to be effective to prevent falls and reduce frailty and mortality in LTNH residents. Further research is needed to ascertain whether those who engage in this kind of individualized program ultimately die with better function and lower dependency.

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Conflict of Interest

The authors report no conflict of interest.

Author Contributions

HA, CRP, SMG, MI, JI, and ARL participated in the design of the study. HA, CRP, JV, MI, IA, VGT, and ARL participated in the recruitment process of participants. HA and CRP were responsible for data collection. HA, JI, and ARL performed statistical analyses. HA, CRP, SMG, JV, MI, IA, VGT, JI, and ARL drafted the manuscript. All authors read and approved the final version of the manuscript.

Sponsor's Role

The sponsors had no role in the design, methods, subject recruitment, data collection, analysis, or preparation of the manuscript.

References

1. Fried LP, Tangen CM, Walston J et al. Cardiovascular Health Study Collaborative Research Group. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56:M146-M156.

2. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. Lancet 2013;381:752-762.

3. Cesari M, Prince M, Thiyagarajan JA et al. Frailty: an emerging public health priority. J Am Med Dir Assoc 2016;17:188-192.

4. Sacha J, Sacha M, Soboń J, Borysiuk Z, Feusette P. Is it time to begin a public campaign concerning frailty and pre-frailty? A review article. Front Physiol 2017;8:484.

5. Rodríguez-Mañas L, Féart C, Mann G et al. Searching for an operational definition of frailty: a Delphi method based consensus statement. The frailty operative definition-consensus conference project. J Gerontol A Biol Sci Med Sci 2012;68:62-67.

6. Pialoux T, Goyard J, Lesourd B. Screening tools for frailty in primary health care: a systematic review. Geriatr Gerontol Int 2012;12:189-197.

7. Collard RM, Boter H, Schoevers RA, Voshaar RCO. Prevalence of frailty in community-dwelling older persons: a systematic review. J Am Geriatr Soc 2012;60:1487-1492.

8. Kojima G. Prevalence of frailty in nursing homes: a systematic review and meta-analysis. J Am Med Dir Assoc 2015;16:940-945.

9. Nagai K, Miyamato T, Okamae A et al. Physical activity combined with resistance training reduces symptoms of frailty in older adults: A randomized controlled trial. Arch Gerontol Geriatr 2018;76:41-47.

10. Tarazona-Santabalbina FJ, Gómez-Cabrera MC, Pérez-Ros P et al. A multicomponent exercise intervention that reverses frailty and improves cognition, emotion, and social networking in the community-dwelling frail elderly: a randomized clinical trial. J Am Med Dir Assoc 2016;17:426-433.

11. Ng TP, Feng L, Nyunt MSZ et al. Nutritional, physical, cognitive, and combination interventions and frailty reversal among older adults: a randomized controlled trial. Am J Med 2015;128:1225-1236.

12. De Souto Barreto P, Morley JE, Chodzko-Zajko W et al. Recommendations on physical activity and exercise for older adults living in long-term care facilities: A taskforce report. J Am Med Dir Assoc 2016;17:381-392.

13. Arrieta H, Rezola-Pardo C, Zarrazquin I et al. A multicomponent exercise program improves physical function in long-term nursing home residents: a randomized controlled trial. Exp Gerontol 2018;103:94-100.

14. De Souto Barreto P, Cesari M, Denormandie P et al. Exercise or social intervention for nursing home residents with dementia: a pilot randomized, controlled trial. J Am Geriatr Soc 2017;65:E123-E129.

15. Arrieta H, Rezola-Pardo C, Gil SM et al. Physical training maintains or improves gait ability in long-term nursing home residents: A systematic review of randomized controlled trials. Maturitas 2018;109:45-52.

16. Ferreira CB, Teixeira PDS, Alves Dos Santos G et al. Effects of a 12-week exercise training program on physical function in institutionalized frail elderly. J Aging Res 2018. Doi: 10.1155/2018/7218102.

17. Sahin UK, Kirdi N, Bozoglu E et al. Effect of low-intensity versus high-intensity resistance training on the functioning of the institutionalized frail elderly. Int J Rehabil Res 2018;41:211-217.

18. Pickard L, Comas-Herrera A, Costa-Font J et al. Modelling an entitlement to longterm care services for older people in Europe: Projections for longterm care expenditure to 2050. J Eur Soc Policy 2007;17:33–48.

19. Serra-Rexach JA, Bustamante-Ara N, Hierro Villarán M et al. Short-term, light-to moderate-intensity exercise training improves leg muscle strength in the oldest old: a randomized controlled trial. J Am Geriatr Soc 2011;59:594-602.

20. Cadore EL, Casas-Herrero A, Zambom-Ferraresi F et al. Multicomponent exercises including muscle power training enhance muscle mass, power output, and functional outcomes in institutionalized frail nonagenarians. Age 2014;36:773-785.

21. Bösner S, Keller H, Wöhner A et al. Prevention of falls by outdoor-walking in elderly persons at risk (“power”)–a pilot study. Eur Geriatr Med 2012;3:28-32.

22. Rolland Y, Pillard F, Klapouszczak A et al. Exercise program for nursing home residents with Alzheimer's disease: A 1-year randomized, controlled trial. J Am Geriatr Soc 2007;55:158-165.

23. Mulrow CD, Gerety MB, Kanten D et al. A randomized trial of physical rehabilitation for very frail nursing home residents. JAMA 1994;271:519-524.

24. Cameron IDGL, Gillespie L, Robertson C et al. Interventions for preventing falls in older people in care facilities and hospitals. Cochrane Database Syst Rev 2012;12.

25. Shi C. Interventions for preventing falls in older people in care facilities and hospitals. Orthop Nurs 2014;33:48-49.

26. Rodriguez-Larrad A, Arrieta H, Rezola C et al. Effectiveness of a multicomponent exercise program in the attenuation of frailty in long-term nursing home residents: study protocol for a randomized clinical controlled trial. BMC Geriatr 2017;17:60.

27. Wade DT, Collin C. The Barthel ADL Index: A standard measure of physical disability? Int Disabil Stud 1988;10:64-67.

28. Lobo A, Saz P, Marcos G et al. Revalidación y normalización del Mini-Examen Cognoscitivo (primera version en castellano del Mini-Mental Status Examination) en la población general geriátrica. Med Clin (Barc) 1999;112:767-774.

29. Arrieta H, Hervás G, Rezola-Pardo C et al. Serum myostatin levels are higher in fitter, more active, and non-frail long-term nursing home residents and increase after a physical exercise intervention. Gerontol 2018. Doi: 10.1159/000494137.

30. Guralnik JM, Ferrucci L, Pieper CF et al. Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. J Gerontol A Biol Sci Med Sci 2000;55:M221-M231.

31. Ensrud KE, Ewing SK, Taylor BC et al. Comparison of 2 frailty indexes for prediction of falls, disability, fractures, and death in older women. Arch Intern Med 2008;168:382-389.

32. Gobbens RJ, Van Assen MA, Luijkx KG, Wijnen-Sponselee MT, Schols JM. The Tilburg frailty indicator: psychometric properties. J Am Med Dir Assoc 2010;11:344-355.

33. Da Câmara SM, Alvarado BE, Guralnik JM, Guerra RO, Maciel AC. Using the short physical performance battery to screen for frailty in young-old adults with distinct socioeconomic conditions. Geriatr Gerontol Int 2013;13:421-428.

34. Bakeman R. Recommended effect size statistics for repeated measures designs. Behav Res Methods 2005;37:379-384.

35. Kato M, Izumi K, Hiramatsu T, Shogenji M. Development of an exercise program for fall prevention for elderly persons in a long-term care facility. Jpn J Nurs Sci 2006;3:107-117.

36. Rubenstein LZ, Josephson KR, Osterweil D. Falls and fall prevention in the nursing home. Clin Geriatr Med 1996;12:881.

37. Kannus P, Sievänen H, Palvanen M, Järvinen T, Parkkari J. Prevention of falls and consequent injuries in elderly people. Lancet 2005;366:1885-1893.

38. Dechamps A, Diolez P, Thiaudière E et al. Effects of exercise programs to prevent decline in health-related quality of life in highly deconditioned institutionalized elderly persons: a randomized controlled trial. Arch Intern Med 2010;170:162-169.

39. Taylor D. Physical activity is medicine for older adults. Postgrad Med J 2014;90:26-32.

40. Grönstedt H, Frändin K, Bergland A et al. Effects of individually tailored physical and daily activities in nursing home residents on activities of daily living, physical performance and physical activity level: a randomized controlled trial. Gerontology 2013;59:220-229.

41. Cichocki M, Quehenberger V, Zeiler M et al. Effectiveness of a low-threshold physical activity intervention in residential aged care–results of a randomized controlled trial. Clin Interv Aging 2015;10:885.

42. Kovacs E, Sztruhar Jonasne I, Karoczi CK, Korpos A, Gondos T. Effects of a multimodal exercise program on balance, functional mobility and fall risk in older adults with cognitive impairment: a randomized controlled single-blind study. Eur J Phys Rehabil Med 2013;49:639-648.

43. Guralnik JM, Simonsick EM, Ferrucci L et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. J Gerontol 1994;49:M85-M94.

44. Pereira C, Rosado H, Cruz-Ferreira A, Marmeleira J. Effects of a 10-week multimodal exercise program on physical and cognitive function of nursing home residents: a psychomotor intervention pilot study. Aging Clin Exp Res 2018;30:471.

4.1.6. Are short-term physical exercise interventions in nursing homes effective in the long-term?

Ready to submit

One of the most important worries for health and social staff of nursing homes (NHs) is to avoid physical and cognitive decline and to improve quality of life of people living in these institutions (De Souto Barreto et al., 2016). Physical exercise has been proved to be effective to attenuate physical and cognitive deterioration of older adults and also to improve quality of life in community-dwelling older adults (Oh, Kim, Lee, Jung, & Lee, 2017).

People living in NHs spent most of their time in sedentary activities and they are not use to perform physical activity/exercise (Volkers & Scherder, 2011). Frequently, the environment and the organization of the NHs do not facilitate physical activity among residents (Król-Zielińska, Kusy, Zieliński, & Osiński, 2011). As a consequence, they do not take advantage of being physically active. Acknowledging their clear benefits, many institutions include physical exercise sessions among their offer of activities. However, very often there is a lack of control of the individualization and progression of the sessions and they are performed usually at low intensity (Brett, Traynor, & Stapley, 2016). This model of sessions does not agree with recent scientific evidence about the most effective programs in this population (De Souto Barreto et al., 2016).

Recently, we have developed a randomized controlled trial with a multicomponent (including balance, strength and endurance), individualized and progressive physical exercise program at moderate intensity which was able to improve physical capacities in older people living in NHs (Arrieta, et al., 2018). Aiming to ascertain whether this program could be effective in the long-term, after finishing the program we did a six-month follow-up to both groups, control and intervention, to assess their evolution during detraining.

As we can see in Table 1, after the program there is more than 2 point improvement in Short Physical Performance Battery (Minimum Clinically Important Difference:1 point) (Perera, Mody, Woodman, & Studenski, 2017) and 3 point improvement in Montreal Cognitive Assessment (Minimum Clinically Important Difference: 2 point) test (Wong, et al., 2017). However, the number of steps given by the participants of the intervention group did not increase after the program. In addition, the values of both tests decreased practically to the figures measured before the intervention. The control group had a slow decline in Short Physical Performance Battery and Montreal Cognitive Assessment in the same period. These results indicate that, this kind of short-term programs are not able to increase daily physical activity of older people living in NHs. Therefore, the sedentary behavior of the population causes a decline in physical and cognitive functions which could lead to disability and dependence (Pereira, Rosado, Cruz-Ferreira, & Marmeleira, 2018).

After seeing these results, we feel that physical exercise should be an essential component of the routine activities of NHs and it should be maintained thorough live of NH residents without interruption, unless there is a medical recommendation against the engagement in these type of activities. The sessions should include exercises of balance, strength and endurance and should be performed at moderate intensity, emphasizing individualization and progression. At the same time, the setting and schedule of the NHs should facilitate that the improvements in physical and cognitive functions caused by physical exercise be reflected in the activities of daily living, increasing the time residents are physically active.

In our opinion, the staff of the NHs and the politician responsible for health should be aware of these results to implement/support effective physical exercise programs in these institutions.

Table 1. Exercise intervention effects in nursing home residents

	Control Group (*n* = 15)			Intervention Group (*n* = 16)				
	Baseline, mean (SD)	6 months, mean (SD)	12 months, mean (SD)	Baseline, mean (SD)	6 months, mean (SD)	12 months, mean (SD)	*p* ‡	Partial η^2
SPPB Score	5.8 (2.5)	5.7 (2.2)	5.6 (2.5)	6.6 (2.5)	8.9 (2.4)*	6.9 (2.9)†	<.001	.550
MOCA	14.8 (3.3)	14.4 (4.8)	14.1 (3.8)	14.4 (4.4)	17.1 (5.4)*	15.1 (6.0)	.054	.224
Steps (n of steps/day)	845 (541)	765 (512)	871 (510)	1324 (840)	1594 (1156)	1372 (1198)	.180	.138

SD, standard deviation; SPPB, Short Physical Performance Battery; MOCA, Montreal Cognitive Assessment.

* $p < .05$, significantly different from baseline.

† $p < .05$, significantly different from 6 months after baseline.

‡ *p* value for the group-by-time interaction.

References

Arrieta, H., Rezola-Pardo, C., Zarrazquin, I., Echeverria, I., Yanguas, J. J., Iturburu, M., ... & Irazusta, J. (2018). A multicomponent exercise program improves physical function in long-term nursing home residents: a randomized controlled trial. *Experimental gerontology*, *103*, 94-100.

Brett, L., Traynor, V., & Stapley, P. (2016). Effects of physical exercise on health and well-being of individuals living with a dementia in nursing homes: a systematic review. *Journal of the american medical directors association*, *17*(2), 104-116.

De Souto Barreto, P., Morley, J. E., Chodzko-Zajko, W., Pitkala, K. H., Weening-Djiksterhuis, E., Rodríguez-Mañas, L., ... & Izquierdo, M. (2016). Recommendations on physical activity and exercise for older adults living in long-term care facilities: a taskforce report. *Journal of the american medical directors association*, 17(5), 381-392.

Król-Zielińska, M., Kusy, K., Zieliński, J., & Osiński, W. (2011). Physical activity and functional fitness in institutionalized vs. independently living elderly: A comparison of 70–80-year-old city-dwellers. *Archives of gerontology and geriatrics*, *53*(1), e10-e16.

Oh, S. H., Kim, D. K., Lee, S. U., Jung, S. H., & Lee, S. Y. (2017). Association between exercise type and quality of life in a community-dwelling older people: a cross-sectional study. *PloS one*, *12*(12), e0188335.

Pereira, C., Rosado, H., Cruz-Ferreira, A., & Marmeleira, J. (2018). Effects of a 10-week multimodal exercise program on physical and cognitive function of nursing home residents: a psychomotor intervention pilot study. *Aging clinical and experimental research, 30*(5), 471-479.

Perera, S., Mody, S. H., Woodman, R. C., & Studenski, S. A. (2006). Meaningful change and responsiveness in common physical performance measures in older adults. *Journal of the american geriatrics society*, *54*(5), 743-749.

Volkers, K. M., & Scherder, E. J. (2011). Impoverished environment, cognition, aging and dementia. *Reviews in the neurosciences*, *22*(3), 259-266.

Wong, G. K. C., Mak, J. S. Y., Wong, A., Zheng, V. Z. Y., Poon, W. S., Abrigo, J., & Mok, V. C. T. (2017). Minimum clinically important difference of montreal cognitive assessment in aneurysmal subarachnoid hemorrhage patients. *Journal of clinical neuroscience*, *46*, 41-44.

4.2. Jarduera fisikoaren eragina minbizia duten hirugarren adineko pertsonetan

4.2.1. Effects of a physical activity program to prevent physical performance decline in onco-geriatric patients: a randomized multicenter trial

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Abstract

Background: Older adults with cancer experience negative long-term functional effects of both cancer and treatments. Exercise may minimize their age- and cancer-related functional decline.

Methods: We conducted a multicenter open-label 12-month randomized clinical trial with two parallel arms including participants aged ≥ 70 years with lymphoma or carcinoma requiring curative treatment. The study started at the beginning of any phase of cancer treatment (surgery, chemotherapy or radiotherapy). The usual care group (UCG) received the current national recommendations in physical activity (a guideline without specific counselling). The intervention group (IG) received one-year phoned physical activity advice individually adapted to physical assessment (twice a month during the first six months and then monthly). The primary outcome was the proportion of subjects with a one-year decreased SPPB (Short Physical Performance Battery) score of one point or more. Physical, cognitive and clinical secondary outcomes were also investigated.

Results: We allocated 301 participants (age 76.7 ± 5.0, female 60.6%) to each group. At baseline, the median SPPB was 10/12 in both groups. Breast was the most frequent tumor site (35.7%). After one year, 14.0% of participants in the UCG and 18.7% in the IG had a decrease in SPPB score of one point or more (P = 0.772). At two years, there was no difference in SPPB, gait speed, International Physical Activity Questionnaire score and verbal fluency. Subgroup analyses after two years showed a decline in SPPB for 29.8% of UCG and 5.0% of IG breast cancer participants (P = 0.006), in 21.7% of UCG and 6.2% of IG female participants (P = 0.019) and in 24.5% of UCG and 11.1% of IG normal nutritional status participants (P = 0.009). Falls, hospitalization, institutionalization and death rates were similar in both groups.

Conclusions: Personalized phoned physical activity advice had not reduced functional decline at one year but provide preliminary evidence that may prevent physical performance decline at two years in older adults with breast cancer.

Key words: adapted physical activity; onco-geriatrics; nutrition; breast cancer; frailty

Introduction

Cancer is frequent in older adults. By 2040, nearly three out of four cancer survivors will be 65 years and older [1]. Cancer survivors are known to experience long-term negative effects of treatment such as fatigue, pain, cognitive disturbance, depression, anxiety and reduced health-related quality of life [2, 3]. Compared with other older adults, they are at greater risk of other cancers, cardiovascular disease, osteoporosis, diabetes and accelerated functional decline [4]. However, most survivorship studies have focused on childhood cancer or cancer in young adults but not in older adults [5].

The long-term outcome of successfully treated cancer patients is relatively unknown except for their vital prognosis [6, 7]. Furthermore, the functional consequences of cancer may be greater in elderly than in younger adults [6]. It is important to encourage older cancer survivors to adopt a healthy life style with physical activity together with a health care plan that includes a dynamic conversation focused on education and motivation between patients and their health care providers [8].

Frailty is associated with a high risk of dependency, falls, cognitive decline, infections, hospitalization, disability, institutionalization and death [9, 10, 11]. The most frequently used criteria to define frailty is the set proposed by Fried and coll. that includes five conditions: exhaustion, slowness, weight loss, low physical activity and muscle weakness [12]. A growing body of evidence indicates that frailty is a dynamic syndrome characterized by frequent transitional stages that can be modified [11, 13]. Thus, an intervention that could prevent frailty or reduce its severity would be of great interest for older patients with cancer.

The National Cancer Institute and the National Academy of Medicine of the U.S. have highlighted the need to address functional outcomes during and after oncology interventions more robustly [14]. Physical performance measures can predict onset of disability, and gait speed alone [15] or in combination with other measures like the Short Physical Performance Battery (SPPB) is a strong predictor of adverse outcomes like mortality, hospitalization or disability [16]. Nevertheless, few studies have established standardized and objective measures of physical function that are highly associated with an increased risk of disability, nursing home admission and mortality [16].

Older cancer survivors report low physical activity levels, and few meet recommended health promotion guidelines [17]. Successfully engaging older adults in a regular and consistent physical activity program can be challenging. The latter may face obstacles that make participation less likely: inability to travel to centers with supervised programs, health concerns related to unsupervised physical activity and lack of knowledge regarding appropriate exercise activities [18]. Although home-based programs are associated with reduced effects on change in health-related quality of life and physical function outcomes relative to center-based initiatives, home-based programs have the potential to reach a broader segment of the population at considerably lower cost [18]. Furthermore, reference centers for cancer treatment may be far from older patients' homes, making participation in supervised programs even more difficult. Thus, physical activity programs that offer advice and support at regular intervals by phone may provide a necessary bridge for successful home-based exercise in older adults with cancer. Telephone-based physical activity interventions have been proposed to allow for greater outreach to patients and minimize the high number of participants who refuse to attend supervised exercise sessions after cancer diagnosis due to the lack of interest in exercise, living too far away to travel or because they are too busy [19].

The aim of this study was to compare individualized adapted phone advice for one year to usual care in patients aged 70 and older with good-prognosis cancer and undergoing curative treatment. We tested the hypothesis that providing phone advice on exercising including strength, balance, proprioception, flexibility and aerobic training for one year could prevent physical performance loss at one year as compared to a control arm. The prevention of physical performance loss at two years and better evolution of gait speed, physical activity level and cognition (verbal fluency) at one and two years after the start of cancer treatment were analyzed as secondary outcomes.

Methods

Study design

CAPADOGE (Conseils en Activité physique pour la Prévention de la perte d'Autonomie Des patients d'Onco-GEriatrie) was a multicenter open-label 12-month randomized clinical trial with two parallel arms conducted in 12 recruiting centers in France. The intervention took place between October 2011 and May 2016. The university hospital of Bordeaux coordinated the study and performed data management, analysis and quality control. The subjects received the intervention from the start of any phase of their cancer treatment that was surgery, chemotherapy or radiotherapy.

Patient population

Details of the methods were published previously [20]. Briefly, the population consisted of men and women aged ≥ 70 years with histological confirmation of lymphoma or carcinoma requiring treatment by surgery, chemotherapy, hormonotherapy, radiotherapy or targeted therapy with a curative intention as estimated by oncologists. The locations included colon, rectum, anal canal, breast, esophagus, ear, nose and throat, kidney, prostate, bladder, lung, stomach, biliary ducts, ovary, womb, endometrium and pancreas (Supplementary Table 1). Were also included hepato-cellular carcinomas, all large diffused B cell lymphomas, all T peripheral lymphomas, all low-grade lymphomas: lymphocytic, lymphoplasmacytic, follicular, mantle, marginal zone (Mucosa-Associated Lymphoid Tissue and others) and primary unknown adenocarcinomas. Exclusion criteria were: Eastern Cooperative Oncology Group (ECOG) test score > 2, serious psychiatric or cognitive problems, no basic fluency in the French language and functional disability leading to a total inability to walk. Finally, patients participating in concurrent studies containing physical activity, those in palliative care and those under legal protection were also ineligible. The trial was approved by the institute and ethical committees.

Supplemental file 1. Cancer origin of the participants.

	No. (%)	
Cancer origin	**Usual care group (*n*=150)**	**Intervention group (*n*=150)**
Colon	20 (13.3)	15 (10.0)
Rectum, anal canal	13 (8.7)	13 (8.7)
Breast	47 (31.3)	60 (40.0)
Esophagus	4 (2.7)	8 (5.3)
ORL	.	3 (2.0)
Kidney	2 (1.3)	1 (0.7)
Prostate	12 (8.0)	6 (4.0)
Bladder	5 (3.3)	3 (2.0)
Lung	4 (2.7)	3 (2.0)
Stomach	6 (4.0)	3 (2.0)
Biliary ducts	1 (0.7)	.
Ovary	5 (3.3)	1 (0.7)
Hepato-cellular carcinoma	6 (4.0)	10 (6.7)
Lymphoma	10 (6.7)	7 (4.7)
Womb	2 (1.3)	.
Endometrium	2 (1.3)	4 (2.7)
Pancreas	11 (7.3)	12 (8.0)

Recruitment and randomization

All potentially eligible patients were selected and included before starting treatment in the oncology department. If the patient agreed orally to participate, (s)he was subsequently randomized to the UCG or IG and centralized via internet. Randomization was stratified on the centers and used allocation by random blocks of four or six. Patients were equally randomized to the UCG or the IG (Fig 1). The allocation sequence was centralized via internet and concealed from the project team. Only the oncology team was aware of the group allocation of each patient via internet and was able to deliver the CAPADOGE booklet to the patients in the IG at V1. Thus, no double or simple blind was possible.

Usual care group (UCG)

The UCG received without comments the “PNNS booklet" (French National Nutrition Health Program), which provides the current national recommendations for physical activity for people of this age group, i.e. half an hour a day of any type of physical activity.

Intervention group (IG)

The physical activity intervention involved strength, balance, proprioception, flexibility and aerobic training [20]. The aim of the program was to maintain fitness. Exercise sessions were conducted twice a week at the beginning of the intervention, but more were proposed according to the patients’ motivation and capabilities. Strength training comprised upper and lower body exercises: arm-curl, squats, hip abduction, hip adduction and more. First instruction was to perform 10 repetitions of each exercise without load to ensure an appropriate adaptation to resistance exercise. Thereafter, if they were well tolerated, loads were included and number of repetitions was increased for additional benefit. The CAPADOGE booklet (which included images of different strength, balance, proprioception, flexibility and aerobic exercises) was used so that the patients, apart from the advice they received over the phone, had a visual aid to be able to correctly carry out the exercises. The intensities that were proposed to the patients ranged from low to high and focused on avoiding pain and exhaustion. The instructor received patients’ previous SPPB and IPAQ assessment results to know their functional performance and habitual physical activity level. Then, the choice of intensity was based on the patient’s feedback at each phone call to reach the highest intensity possible for each subject. Balance and proprioception training included exercises difficulty progression starting in sitting position or standing with two arms support. Then patients were invited to increase the complexity of movements according to their feedback: with one hand and finally without hands support if possible. Sessions finished with stretching exercises.

In addition to the exercise sessions, aerobic training was implemented through individualized recommendations regarding time and intensity to perform on their own. At first phone call, the instructor asked the patients about their daily physical activity (e.g., walking, shopping, stair climbing…). The instructor took this information into account together with the SPPB and IPAQ scores to encourage them to increase their daily amount of physical activity.

Advice was given by the same professional instructor with a degree in physical activity and sport sciences and trained in providing adapted physical activity to older adults. Phone calls were made twice a month during the first six months and then monthly until one year. The instructor reported all the exercises that the patients said that they had performed from the last phone call, in order to review each exercise and suggest individualized physical activity advice until the next phone call.

Study design and measurements

Participants were assessed immediately before the cancer treatment (visit 1, V1) and at 3 (V2), 6 (V3), 12 (V4), 18 (V5), and 24 (V6) months. Assessments were done in each center by clinical research assistants blind for group allocation. Data were anonymized by use of an identification code. Outcome measures were keyed in by data managers. The main baseline assessment included body mass index, Mini-Mental State Examination (MMSE) [21], nutritional status (Mini Nutritional Assessment - Short Form; MNA) [22], hand grip strength, SPPB [16], ECOG performance status, level of physical activity measured using the self-reported International Physical Activity Questionnaire (IPAQ) [23], Quality of Life Questionnaire (QLQ-C30) [24], verbal fluency [25], Cumulative Index Rating Scale–Geriatric (CIRS-G) [26], and c-reactive protein dosage (mg/l). Frailty status was measured with a slightly modified version of the Fried criteria [12] (Supplementary Table 2). We used a hand-held dynamometer (Micro-FET-2®) to assess the grip strength criterion, the QLQ-C30 fatigue symptom subscore [24, 27] for the self-reported exhaustion criterion, the MNA [22] weight loss item for the weight loss criterion and the IPAQ score for the decreased physical activity criterion [23].

Outcomes

The primary outcome was the proportion of subjects with a one-year decreased SPPB [16] score of one point or more as compared to baseline. A one-point change in total SPPB score has been demonstrated to be of clinical relevance and to represent a substantial meaningful change [28]. It was reported that one-point change can identify changes in the ability to walk one block, ability to climb one flight of stairs, or any self-perceived change in mobility [28]. The SPPB includes tests of gait speed, standing balance and rising from a chair. For tests of standing balance, participants attempted to maintain the side-by-side, semi-tandem and tandem positions for 10 seconds. Usual pace during a 4-meter walk was timed from a standing start and participants were scored according to the time taken. Lastly, the third SPPB test consists of the time to rise from a chair as quickly as possible five times. Overall, the maximal SPPB score is 12 (4 points in each test). The secondary outcomes included the proportion of subjects with a two-year decreased SPPB score of one point or more, self-reported physical activity, cognitive assessments (verbal fluency), and evolution during the two-year follow-up, and the occurrence of clinical outcomes: hospitalization, institutionalization, number of self-reported falls since the previous visit, and mortality.

Statistical analyses

Considering the recruitment capacity of the study, a sample size of 300 patients was required to provide 80% statistical power and a two-sided type I error rate of 5% to detect a minimal difference in the proportion of patients with a lower SPPB, assuming less than 15% in the IG compared to 30% in the UCG and a 10% loss of follow-up.

Analysis was performed on an intention-to-treat basis in a conventional manner: the patients were allocated to their randomization group whatever the intervention they actually received in order to keep the benefits of the randomization. For the main outcome, a missing=failure strategy was used: missing data were replaced by failure value, i.e. loss of 1 SPPB point, being in the least favorable situation for the innovative intervention. The maximal bias strategy completed the sensitivity analysis.

Categorical variables such as one-year or two-year one point SPPB decrease and clinical outcomes were analyzed with logistic regression with adjustment for center, gender, age (> 80 years or not) and chemotherapy (yes/no). Some models for secondary outcomes could not be fully adjusted owing to convergence issues (see footnotes in Tables). Continuous variables were described as mean, median, standard deviation, minimum, maximum and interquartile range (IQR) values when appropriate. Linear mixed models were used to estimate between-group differences accounting for repeated measurements during the two-year follow-up, with subject-specific random intercept. All analyses for secondary criteria were done with available data. Subgroup analyses were specified a priori by gender and breast cancer. A *P* value less than 0.05 was considered statistically significant. The data were analyzed with SAS® base 9.3 (SAS Institute, Cary, NC, USA). Compliance was assessed by dividing the number of phone calls made by the number of planned phone calls for people with a complete follow-up. Efficiency of advice was measured by dividing the number of items of physical activity advice declared as effectively performed by the number of phone calls made.

Supplemental file 2. Modified version of the Fried criteria.

	Fried	Capadoge
Exhaustion	"Exhaustion" (self-report)	Score of fatigue subdivision of the QLQ-C30 ≥ 39 (out of 100)
Slowness	4.72 m gait speed: Men: Height ≤ 1.73m; ≥ 7s Height > 1.73m; ≥ 6s Women: Height ≤ 1.59m; ≥ 7s Height > 1.59m; ≥ 6s	4 m gait speed: Men: Height ≤ 1.73m; ≥ 5.9s Height > 1.73m; ≥ 5.1s Women: Height ≤ 1.59m; ≥ 5.9s Height > 1.59m; ≥ 5.1s
Weight loss	> 4.5kg lost unintentionally in prior year	Self-reported unintentional ≥ 3 kg weight loss since the previous doctor's appointment
Low physical activity	Kcals/week: Men < 383 Kcals/week Women < 270 Kcals/week	Score of the total MET/week of the IPAQ test to Kcal (Kcal = METmin*weight/60): Men < 383 Kcal/week Women < 270 Kcal/week
Muscle weakness	Grip strength: Men BMI ≤ 24; strength ≤ 29kg BMI 24.1-26; strength ≤ 30 kg BMI 26.1-28; strength ≤ 30 kg BMI > 28; strength ≤ 32 kg Women BMI ≤ 23; strength ≤ 17kg BMI 23.1-26; strength ≤ 17.3 kg BMI 26.1-29; strength ≤ 18 kg BMI > 29; strength ≤ 21 kg	Microfet hand grip strength (Newton = kg * 9.81): Men < 30 kg Women < 20 kg

BMI, body mass index; QLQ-C30, Quality of Life Questionnaire.

Results

Study participants

From October 2011 to May 2014, we screened 452 participants. Of these, 301 were eligible, agreed to participate and were allocated to either the UCG or the IG (Fig 1). The mean age was 76.7 years and 60.0% were women (Table 1). Of 300 individuals analyzed, 249 (83%) completed the 12-month follow-up. Attrition was higher than the projected rate (17% at one year) used for sample size calculations. Dropout reasons are listed in Figure 1. Among the 300 participants who began the study, 186 (62%) completed the 24-month assessment (Fig 1). Breast was the most frequent tumor site (Table 1). Chemotherapy was used alone or in association in 91 (60.7%) subjects from the IG and 89 (59.3%) in the UCG (Table 1).

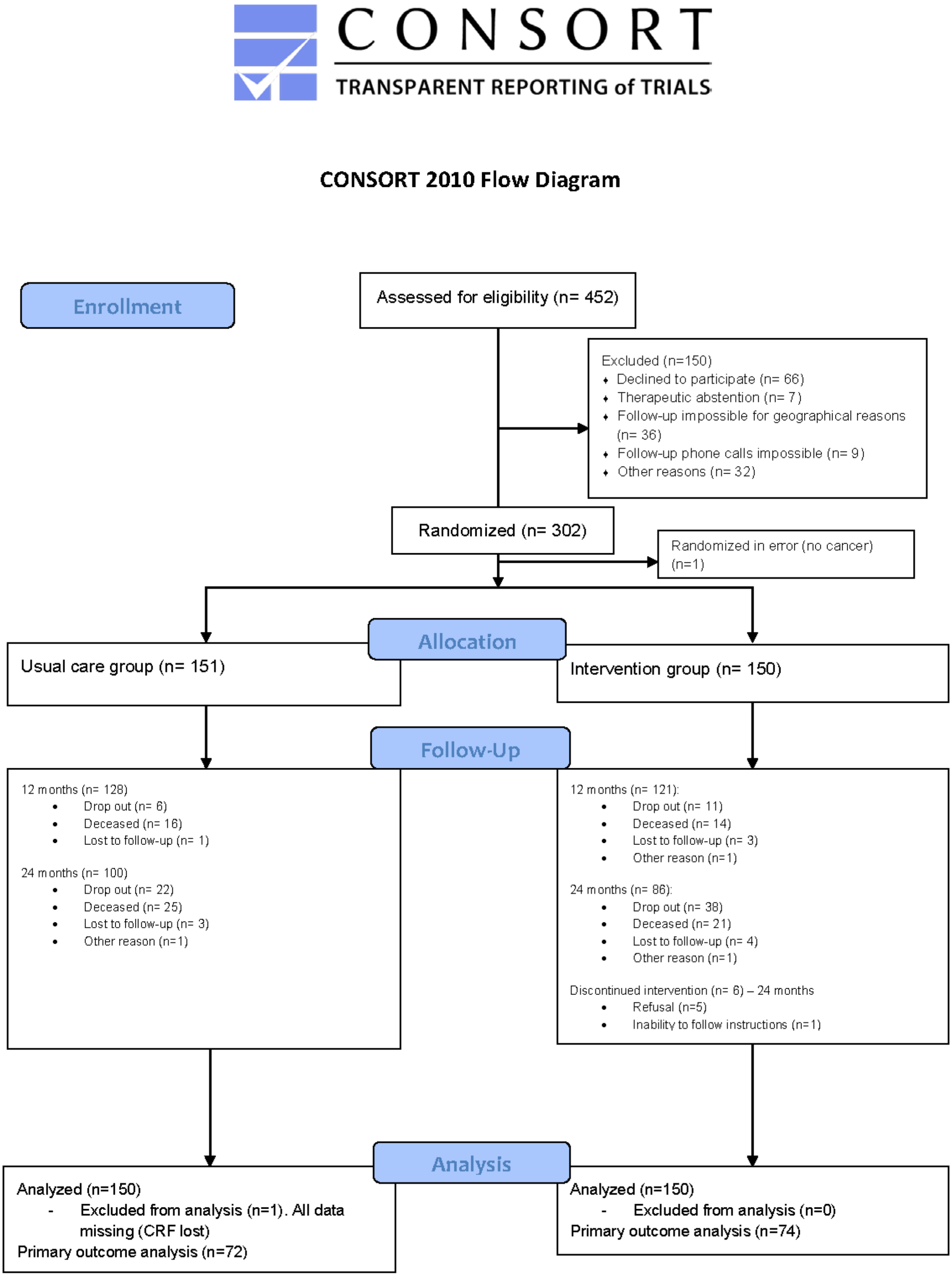

Figure 1. Study flow diagram.

Table 1. Baseline characteristics of patients

	Usual care group (*n*=150)		Intervention group (*n*=150)	
Characteristics	***n***	**%**	***n***	**%**
Age, years				
Mean	76.6		76.8	
SD	5.0		5.1	
Female gender	83	55.3	97	64.7
Body mass index, kg/m^2				
Mean	26.1		26.2	
SD	4.6		4.4	
MMSE, 0-30				
Mean	26.8		26.8	
SD	2.9		2.9	
MNA Questionnaire, 0-14				
Good nutrition, score > 11	49	33.8	54	38.6
At risk/poor nutrition, score ≤ 11	96	66.2	86	61.4
SPPB, 0-12				
Mean	9.2		8.9	
SD	2.3		2.6	
ECOG performance status, No. (%)				
0	86	65.6	74	56.9
1	40	30.5	49	37.7
2	5	3.8	7	5.4
IPAQ, No. (%)				
< 600 MET	29	20.1	26	19.1
600-2999 MET	52	36.1	47	34.6
≥ 3000 MET	63	43.8	63	46.3
Fatigue (QLQ-C30) (0-100)				
Mean	30.5		26.6	
SD	28.9		27.1	

Table 1 (Continued)

	Usual care group (*n*=150)		Intervention group (*n*=150)	
Characteristics	***n***	**%**	***n***	**%**
Physical activity (QLQ-C30) (0-100)				
Mean	23.3		16.7	
SD	23.1		19.0	
Frailty status, No. (%)				
Not frail	90	74.4	83	72.8
Frail	31	25.6	31	27.2
Verbal fluency, 15s				
Mean	6.6		6.8	
SD	2.3		2.2	
Verbal fluency, 15-60s				
Mean	9.3		9.2	
SD	6.6		4.1	
Comorbidity, CIRS-G				
Normal, no grade 3-4 comorbidities	115	76.7	121	80.7
1 comorbidity grade 3-4	28	18.7	24	16.0
≥ 2 comorbidities grade 3-4	7	4.7	5	3.3
C-reactive protein, mg/l				
Median	3		4	
IQR	1-9		2-8	
Cancer origin				
Breast	47	31.3	60	40.0
Colon	20	13.3	15	10.0
Other	83	55.3	75	50.0
Treatment				
Surgery	45	30.0	53	35.3
Chemotherapy	90	60.0	91	60.7
Radiation	58	38.7	59	39.3

Table 1 (Continued)

Characteristics	Usual care group (*n*=150)		Intervention group (*n*=150)	
	n	**%**	***n***	**%**
Treatment				
Hormone therapy	32	21.3	29	19.3
Targeted therapy	2	1.3	3	2.0

SD, standard deviation; MMSE, Mini-Mental State Examination; MNA-SF, Mini Nutritional Assessment - Short Form; SPPB, Short Physical Performance Battery; ECOG, Eastern Cooperative Oncology Group; IPAQ, International Physical Activity Questionnaire; QLQ-C30, Quality of Life Questionnaire; CIRS-G, Cumulative Index Rating Scale–Geriatric; IQR, interquartile range

Intervention adherence

The compliance and efficiency rates for the 12-month period were as follows: 81.1% of the 18 planned phone calls were actually made, and 70.1% of physical activity advice was declared as effectively performed by participants with a complete follow-up.

Functional outcomes

After one year, a decline of one point or more on the SPPB was experienced by 14.0% of participants in the UCG and 18.7% in the IG (P = 0.772; Table 2). Robustness analysis with the maximal bias strategy was also performed but given the proportion of missing data, the results were hardly interpretable. The OR varied from 0.1 to 16.6 according to the orientation of the bias. At two years, 18.0% of UCG participants and 9.3% of IG participants had declined on the SPPB (P = 0.057; Table 2). Linear mixed models showed a similar evolution of both the UCG and IG for SPPB, gait speed, IPAQ score and verbal fluency after 3, 6, 12, 18 and 24 months (NS; Table 3; Supplementary Table 3).

In subgroup analyses, proportions of decline of one or more points on the SPPB did not significantly differ after one year when participants were categorized by breast cancer (P = 0.119; Table 2) and gender (P = 0.068; Table 2). However, after two years, 29.8% of UCG and 5.0% of IG breast cancer participants (*P* = 0.006; Table 2) had declined on the SPPB. In females, 21.7% of UCG and 6.2% of IG participants (*P* = 0.019; Table 2) had declined on the SPPB. The differences between both groups were not significant in males at one (*P* = 0.622; Table 2) and two years (*P* = 0.943; Table 2). We performed additional analyses to explore the role of nutritional status according to MNA categories. At the two-year visit, among participants with a normal nutritional status, 24.5% of UCG and 11.1% of IG participants (*P* = 0.009; Table 2) had declined on the SPPB. There were no differences in SPPB decline for other MNA categories.

Clinical outcomes

Incidence of falls (UCG: 7% and IG: 7%), hospitalization (UCG: 16% and IG: 18%), institutionalization (UCG: 4% and IG: 9%) and death (UCG: 11% and IG: 10%) did not differ significantly between UCG and IG participants at one year. At two years, results for falls (UCG: 11% and IG: 10%), hospitalization (UCG: 29% and IG: 25%), institutionalization (UCG: 6% and IG: 9%) and death (UCG: 20% and IG: 20%) were also similar in both groups.

Table 2. Short Physical Performance Battery change from baseline.

	***n* (%)**					
	Usual care group		**Intervention group**			
	12 months	**24 months**	**12 months**	**24 months**	***P** 12 months**	***P** 24 months**
Main outcome	*n* = 72	*n* = 67	*n* = 74	*n* = 58		
SPPB change vs baseline						
No change or improvement	51 (70.8)	40 (59.7)	46 (62.2)	44 (75.9)		
Decline >= 1 point	21 (29.2)	27 (40.3)	28 (37.8)	14 (24.1)	0.772[a]	0.057[b]
Breast cancer subgroup	*n* = 27	*n* = 31	*n* = 31	*n* = 28		
SPPB change vs baseline						
No change or improvement	20 (74.1)	17 (54.8)	18 (58.1)	25 (89.3)		
Decline >= 1 point	7 (25.9)	14 (45.2)	13 (41.9)	3 (10.7)	0.119[b]	0.006[b]
Males subgroup	*n* = 33	*n* = 23	*n* = 28	*n* = 21		
SPPB change vs baseline						
No change or improvement	22 (66.7)	14 (60.9)	20 (71.4)	13 (61.9)		
Decline >= 1 point	11 (33.3)	9 (39.1)	8 (28.6)	8 (38.1)	0.622[b]	0.943[b]

Table 2 (Continued)

	n (%)					
	Usual care group		**Intervention group**			
	12 months	**24 months**	**12 months**	**24 months**	***P**** **12 months**	***P**** **24 months**
Females subgroup	*n* = 39	*n* = 44	*n* = 46	*n* = 37		
SPPB change vs baseline						
No change or improvement	29 (74.4)	26 (59.1)	26 (56.5)	31 (83.8)		
Decline >= 1 point	10 (25.6)	18 (40.9)	20 (43.5)	6 (16.2)	0.068[b]	0.019[b]
Normal nutritional status subgroup	*n* = 25	*n* = 24	*n* = 34	*n* = 31		
SPPB change vs baseline						
No change or improvement	17 (68.0)	12 (50.0)	22 (64.7)	25 (80.6)		
Decline >= 1 point	8 (32.0)	12 (50.0)	12 (35.3)	6 (19.4)	-	0.009[a]

Abbreviations: SPPB, Short Physical Performance Battery

*P**, *P* for Overall Groupwise Difference

[a] Adjusted for center, gender, age and treatment

[b] Adjusted for center, age and treatment

Table 3. Effects of physical activity program on physical function, physical activity and cognition.

	Usual care group						Intervention group						
	Baseline		12 Months		24 Months		Baseline		12 Months		24 Months		*P**
	n	**Median (IQR)**	***n***	**Median (IQR)**	***n***	**Median (IQR)**	***n***	**Median (IQR)**	***n***	**Median (IQR)**	***n***	**Median (IQR)**	
Physical function													
SPPB score, 0-12	146	10 (8-11)	73	10 (9-11)	69	10 (8-12)	140	10 (8-11)	76	10 (7.5-12)	60	11 (8-12)	0.999[a]
Gait Speed (m/s)	150	0.80	69	0.92	62	0.80	150	0.78	66	0.91	55	0.84	0.171[a]
Physical activity													
IPAQ score (MET)	144	2280	80	2772	76	2946	136	2640	76	2133	64	2369	0.856[a]
Cognition													
Verbal fluency, 15s	132	6 (5-8)	67	7 (6-8)			122	6 (5-8)	66	6 (5-8)			0.920[b]
Verbal fluency, 15-60s	132	9 (6-11)	67	9 (7-12)			122	9 (7-11)	66	9 (7-12)			0.945[b]

Abbreviations: IQR, interquartile range; SPPB, Short Physical Performance Battery; IPAQ, International Physical Activity Questionnaire.

*P**, *P* for Overall Groupwise Difference.

[a] Adjusted for center, gender, age and treatment.

[b] Adjusted for center.

Supplemental file 3. Effects of physical activity program on physical function, physical activity and cognition

	Usual care group (n=150)						Intervention group (n=150)						
	Baseline Median (IQR)	3 months Median (IQR)	6 Months Median (IQR)	12 Months Median (IQR)	18 Months Median (IQR)	24 Months Median (IQR)	Baseline Median (IQR)	3 Months Median (IQR)	6 Months Median (IQR)	12 Months Median (IQR)	18 Months Median (IQR)	24 Months Median (IQR)	*P**
Physical function													
SPPB score, 0-12	10 (8-11)	10 (8-11)	11 (8-11)	10 (9-11)	10 (7-12)	10 (8-12)	10 (8-11)	9 (8-11)	9 (7-11)	10 (7.5-12)	10 (8-11)	11 (8-12)	0.999
Gait Speed (m/s)	0.80	0.80	0.83	0.92	0.93	0.80	0.78	0.82	0.82	0.91	0.84	0.84	0.171
Physical activity													
IPAQ score (MET)	2280	1652	2855	2772	3132	2946	2640	1653	2375	2133	3517	2369	0.856
Cognition													
Verbal fluency, 15s	6 (5-8)			7 (6-8)			6 (5-8)			6 (5-8)			0.920
Verbal fluency, 15-60s	9 (6-11)			9 (7-12)			9 (7-11)			9 (7-12)			

Abbreviations: IQR, interquartile range; SPPB, Short Physical Performance Battery; IPAQ, International Physical Activity Questionnaire.
*P**, *P**for Overall Group-Wise Difference.

Discussion

The CAPADOGE study showed that both personalized physical activity advice given by phone and usual care based on the current national recommendations led to a similar proportion of patients whose SPPB score decreased by ≥ 1 point after one year. Due to the good prognosis with curative intention treatment of the participants included, we expected to recruit participants with a high SPPB score, i.e. little likelihood of improvement but a potential decline. Indeed, this study confirmed our hypothesis of a high proportion of subjects with a one-year decrease of one or more points on the SPPB. The proportion was around 15% at one year as compared to 30% in a geriatric frail population [29].

In women with breast cancer, the intervention had efficiently slowed the functional decline after two years. This was not the case after one year possibly owing to their low muscle mass, strength and physical activity level during and after chemotherapy treatment, and their association with functional decline [30-33]. However, the significant results at two years despite the fact we had 62% participation, and thus a lack of power, strongly suggest the positive effect of physical activity at 2 years. We added a subgroup analysis to explore the role of nutritional status in the response to advice on physical activity. At the two-year visit, only the subgroup of subjects with normal nutritional status had benefited functionally from the intervention. Thus, a multimodal intervention including nutrition, which has been demonstrated to be feasible and safe, should be considered in any future trials with cancer patients [34]. Interestingly, participants with breast cancer, females with any cancer and normal nutritional status showed lower refusal rates compared with males and participants who had other types of cancer (data not shown). Because of the attrition observed at 24 months, this was still the case for participants still followed at that time. Indeed, the effect observed in those with breast cancer was strong enough to remain significant after correction for test multiplicity (e.g. Bonferroni correction). However, the difference by gender in the effect of the intervention may be because breast cancer concerns only females and because the number of patients with breast cancer was large. The low number of patients with other cancer sites did not allow other subgroup analyses to be performed.

Another study in younger participants and after completion of all surgery, chemotherapy and/or radiation therapy showed that phone-based physical activity advice was feasible and effective in improving functional capacity in breast cancer survivors [35], which was the most frequent cancer among females included. Thus, phone-based physical activity interventions might be efficient in improving objectively measured physical functioning among older adults with cancer. As stated above, the phone-based physical activity intervention was carried out to obtain greater outreach to patients, because our hypothesis was that those with lower physical function would not take part in a supervised exercise program. However, in the present study, even though the compliance and the efficiency rates of the program were high, the intensity of the exercises may have been too low, so the advice was not sufficient to prevent functional decline after one year. Therefore, due to the low effect of this intervention at one year, adding a digital virtual supervised session could be a key factor in getting patients to understand that the training program is complementary to medical treatment. In addition, being part of the current study may have increased awareness in the UCG of the health benefits associated with physical activity and may have resulted in maintaining physical function during the program. It is also possible that the effects of cancer treatment were still strong enough at one year to block the benefits of physical activity in older adults with cancer. The anti-anabolic consequences of cancer cachexia may explain this lack of effect at one year. MNA is currently used as a marker of cancer cachexia and has a strong prognostic value, mainly for appetite and sarcopenia [36]. A correlation between the biochemical markers of cachexia and MNA score has been shown in older patients with cancer [37]. In addition, although exercise could be an attractive therapy for cancer cachexia, there is still a lack of studies focusing on the efficacy of exercise programs in older cancer population with regard to functional issues [38].

These findings are consistent with previous reports that did not find any self-reported functional benefits at one year [4]. However, other studies showed slowing down of self-reported functional decline after older adults undergoing and recovering from cancer treatment had received physical activity advice, even though the IG still showed functional decline [17]. Thus, the phone-based physical activity intervention seems to be a suitable solution to prevent or delay physical performance decline in older adults with cancer. Our hypothesis should have concerned functional status two years after the start of the treatment rather than after the first year, since the effects of the treatments that patients have undergone still seemed to be strong enough to mask the beneficial effects of physical activity. However, in the CAPADOGE trial, the assessment schedule was adapted to cancer treatment follow-up visits to minimize loss to follow-up, and we expected high attrition rates in the second year. Even the number of participants who dropped out was slightly higher in the IG, so the number of patients lost to follow-up in both groups is a major limitation of the study. Caution is also required in generalizing our results to patients whose cancer carries a poor prognosis, to the cognitively impaired and to frail older adults. In addition, type of cancer, prognosis and treatment may have influenced participation in the physical activity program and together with the high death rate of the study participants may have confounded our analysis. However, the good prognosis as subjectively assessed by oncologists of all participants included and the adequate randomization in the two groups depending on the type of cancer (Supplementary Table 1) suggest that the aforementioned factors may not have influenced participation in the physical activity program and thus the outcomes. We planned our subgroup analysis according to cancer type but due to the small number in each cancer subgroup, only those with breast cancer were analyzed separately. Indeed, the rate of cachexia may have been different according to cancer type. The subgroup analysis according to the MNA was performed to explore this possibility. Another limitation is that the secondary outcome measure of physical activity together with the measure of compliance with the exercise prescription were not objectively assessed via accelerometers. This point gives less weight and credibility to the physical activity level assessed in this study in comparison with other studies in which accelerometers were used [39]. Responses may have reflected wishful thinking more than the actual level of physical activity. For these reasons, our physical activity data may be inaccurate. However, acceptance of using an accelerometer for such a long duration would probably have been low. The number of clinical trials using objective monitors in cancer patients and survivors is increasing [40] but accelerometers are normally used only for a few days and not in the long-term. Thus, the lack of effect of intervention at one year may have been due to a lack of effect to achieve a sufficient level of physical activity, as advocated over the phone.

The study also has strengths. First, the physical activity intervention was simple to implement, low-cost, practical and broadly applicable to older patients treated for cancer. Second, the findings provide preliminary evidence that physical activity may prevent long-term functional loss in older adults with breast cancer. Third, although poor physical function is known to be a strong predictor of adverse outcomes like disability, hospitalization and mortality [16], this is the first long-term study with a large sample to focus on objectively measured functional decline among older patients treated for cancer, instead of measuring it subjectively [41]. Fourth, compliance was similar to that in other studies focusing on interventions in older participants with cancer [42].

As in other research investigating physical activity in older participants, hospitalization rate and death were similar in both groups [43]. However, given the small number of hospitalizations, these data are inconclusive so further studies are needed to assess the effects of physical activity advice on hospitalization rates in older patients with cancer. To date, the CAPADOGE study is the largest and longest randomized trial assessing the effects of physical activity advice that focused on objectively measured functional decline in older patients treated for cancer. Future studies should focus on digital virtual supervised training in order to design a highly efficient program for the recovery of older patients treated for cancer and designed for a main outcome measured at 2 years.

Conclusions

Compared to usual care given according to the current national recommendations in France, personalized advice on physical activity given over the phone did not reduce functional decline at one year although significant differences were observed after two years in females and in the breast cancer subgroup. Thus, these results highlight the potential for providing efficient personalized physical activity advice over the phone in older adults with cancer. Future work should focus on comparing the effects of digital virtual supervised training and its combination with the currently recommended usual care in older adults with cancer.

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The authors certify that they comply with the ethical guidelines for authorship and publishing of the Journal of Cachexia, Sarcopenia and Muscle [44].

Conflict of interest

All authors declare that they have no conflict of interest.

References

1 Swartz MC, Lewis ZH, Lyons EJ, Jennings K, Middleton A, Deer RR, et al. Effect of home and community-based physical activity interventions on physical function among cancer survivors: a systematic review and meta-analysis. Arch Phys Med Rehabil. 2017;98:1652-65.

2 Huang IC, Hudson MM, Robison LL, Krull KR. Differential impact of symptom prevalence and chronic conditions on quality of life in cancer survivors and non-cancer individuals: a population study. Cancer Epidemiol Biomarkers Prev. 2017;26:1124-32.

3 Agasi-Idenburg SC, Thong MSY, Punt CJA, Stuiver MM, Aaronson NK. Comparison of symptom clusters associated with fatigue in older and younger survivors of colorectal cancer. Support Care Cancer. 2017;25:625-32.

4 Demark-Wahnefried W, Clipp EC, Morey MC, Pieper CF, Sloane R, Snyder DC, et al. Lifestyle intervention development study to improve physical function in older adults with cancer: outcomes from Project LEAD. J Clin Oncol. 2006;24:3465-73.

5 Extermann M, Leeuwenburgh C, Samiian L, Sehovic M, Xu J, Cubitt C, et al. Impact of chemotherapy on medium-term physical function and activity of older breast cancer survivors, and associated biomarkers. J Geriatr Oncol. 2017;8:69-75.

6 Avis NE, Deimling GT. Cancer survivorship and aging. Cancer. 2008;113(S12):3519-29.

7 Halpern MT, Urato MP, Lines LM, Cohen JB, Arora NK, Kent EE. Healthcare experience among older cancer survivors: Analysis of the SEER-CAHPS dataset. J Geriatr Oncol. 2018;9:194-203.

8 Rowland JH, Bellizzi KM. Cancer survivorship issues: life after treatment and implications for an aging population. J Clin Oncol. 2014;32:2662-8.

9 Sacha J, Sacha M, Soboń J, Borysiuk Z, Feusette P. Is it time to begin a public campaign concerning frailty and pre-frailty? A review article. Front Physiol. 2017;8:484.

10 Trevisan C, Veronese N, Maggi S, Baggio G, Toffanello ED, Zambon S, et al. Factors influencing transitions between frailty states in elderly adults: the progetto veneto anziani longitudinal study. J Am Geriatr Soc. 2017;65:179-84.

11 Cesari M, Prince M, Thiyagarajan JA, De Carvalho IA, Bernabei R, Chan P, et al. Frailty: an emerging public health priority. J Am Med Dir Assoc. 2016;17:188-92.

12 Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci. 2001;56:M146-57.

13 Freiberger E, Kemmler W, Siegrist M, Sieber C. Frailty and exercise interventions. Z Gerontol Geriatr. 2016;49:606-11.

14 Duan-Porter W, Cohen HJ, Demark-Wahnefried W, Sloane R, Pendergast JF, Snyder DC, et al. Physical resilience of older cancer survivors: an emerging concept. J Geriatr Oncol. 2016;7:471-8.

15 Pamoukdjian F, Lévy V, Sebbane G, Boubaya M, Landre T, Bloch-Queyrat C, et al. Slow gait speed is an independent predictor of early death in older cancer outpatients: results from a prospective cohort study. J Nutr Health Aging. 2017;21:202-6.

16 Guralnik JM, Ferrucci L, Pieper CF, Leveille SG, Markides KS, Ostir GV, et al. Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. J Gerontol A Biol Sci Med Sci. 2000;55:M221-31.

17 Morey MC, Snyder DC, Sloane R, Cohen HJ, Peterson B, Hartman TJ, et al. Effects of home-based diet and exercise on functional outcomes among older, overweight long-term cancer survivors: RENEW: a randomized controlled trial. JAMA. 2009;301:1883-91.

18 Cowper PA, Peterson MJ, Pieper CF, Sloane RJ, Hall KS, McConnell ES, et al. Economic Analysis of Primary Care-Based Physical Activity Counseling in Older Men: The VA-LIFE Trial. J Am Geriatr Soc. 2017;65:533-9.

19 Adamsen L, Quist M, Andersen C, Møller T, Herrstedt J, Kronborg D, et al. Effect of a multimodal high intensity exercise intervention in cancer patients undergoing chemotherapy: randomised controlled trial. BMJ. 2009;339:b3410.

20 Durrieu J, Doussau A, Rieger A, Terrebonne E, Bouabdallah K, Zwolakowski MD, et al. Design of a physical activity program to prevent functional decline in onco-geriatric patients (CAPADOGE): A randomized multicenter trial. J Frailty Aging. 2012;1:138-43.

21 Derouesne C, Poitreneau J, Hugonot L, Kalafat M, Dubois B, Laurent B, et al. [Mini-mental state examination:a useful method for the evaluation of the cognitive status of patients by the clinician. Consensual French version]. Presse Med. 1999;28:1141-8.

22 Kaiser M, Bauer JM, Ramsch C, Uter W, Guigoz Y, Cederholm T, et al. Validation of the Mini Nutritional Assessment Short-Form (MNA®-SF): A practical tool for identification of nutritional status. J Nutr Health Aging. 2009;13:782-8.

23 Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc. 2003;35:1381-95.

24 Aaronson NK, Ahmedzai S, Bergman B, Bullinger M, Cull A, Duez NJ, et al. The European organization for research and treatment of cancer QLQ-C30: A quality-of-life instrument for use in international clinical trials in oncology. J Natl Cancer Inst. 1993;85:365-76.

25 Raoux N, Le Goff M, Auriacombe S, Dartigues JF, Amieva H. Semantic and letter fluency tasks: normative data in an elderly population of 70 years old and over from the PAQUID cohort. Rev Neurol. 2010;166:594-605.

26 Miller MD, Paradis CF, Houck PR, Mazumdar S, Stack JA, Rifai AH, et al. Rating chronic medical illness burden in geropsychiatric practice and research: application of the cumulative illness rating scale. Psychiatry Res. 1992;41:237-48.

27 Giesinger JM, Kuijpers W, Young T, Tomaszewski KA, Friend E, Zabernigg A, et al. Thresholds for clinical importance for four key domains of the EORTC QLQ-C30: physical functioning, emotional functioning, fatigue and pain. Health Qual Life Outcomes. 2016;14:87.

28 Perera S, Mody SH, Woodman RC, Studenski SA. Meaningful change and responsiveness in common physical performance measures in older adults. J Am Geriatr Soc. 2006;54:743-9.

29 Pahor M, Blair SN, Espeland M, Fielding R, Gill TM, Guralnik JM, et al. Effects of a physical activity intervention on measures of physical performance: results of the Lifestyle Interventions and Independence for Elders Pilot (LIFE-P) study. J Gerontol A Biol Sci Med Sci. 2006;61:1157.

30 Klassen O, Schmidt ME, Ulrich CM, Schneeweiss A, Potthoff K, Steindorf K, et al. Muscle strength in breast cancer patients receiving different treatment regimes. J Cachexia Sarcopenia Muscle. 2017;8:305-16.

31 Demark-Wahnefried W, Peterson BL, Winer EP, Marks L, Aziz N, Marcom PK, et al. Changes in weight, body composition, and factors influencing energy balance among premenopausal breast cancer patients receiving adjuvant chemotherapy. J Clin Oncol. 2001;19:2381-9.

32 Huy C, Schmidt ME, Vrieling A, Chang-Claude J, Steindorf K, et al. Physical activity in a German breast cancer patient cohort: one-year trends and characteristics associated with change in activity level. Eur J Cancer. 2012;48:297-304.

33 Bye A, Sjøblom B, Wentzel-Larsen T, Grønberg BH, Baracos VE, Hjermstad MJ, et al. Muscle mass and association to quality of life in non-small cell lung cancer patients. J Cachexia Sarcopenia Muscle. 2017;8:759-67.

34 Solheim TS, Laird BJA, Balstad TR, Stene GB, Bye A, Johns N, et al. A randomized phase II feasibility trial of a multimodal intervention for the management of cachexia in lung and pancreatic cancer. J Cachexia Sarcopenia Muscle. 2017;8:778-88.

35 Ligibel JA, Meyerhardt J, Pierce JP, Najita J, Shockro L, Campbell N, et al. Impact of a telephone-based physical activity intervention upon exercise behaviors and fitness in cancer survivors enrolled in a cooperative group setting. Breast Cancer Res Treat. 2012;132:205-13.

36 Bourdel-Marchasson I, Diallo A, Bellera C, Blanc-Bisson C, Durrieu J, Germain C, et al. One-year mortality in older patients with cancer: development and external validation of an MNA-based prognostic score. PLoS One. 2016;11:e0148523.

37 Gioulbasanis I, Georgoulias P, Vlachostergios PJ, Baracos V, Ghosh S, Giannousi Z, et al. Mini Nutritional Assessment (MNA) and biochemical markers of cachexia in metastatic lung cancer patients: interrelations and associations with prognosis. Lung Cancer. 2011;74:516-20.

38 Fearon K, Strasser F, Anker SD, Bosaeus I, Bruera E, Fainsinger RL, et al. Definition and classification of cancer cachexia: an international consensus. Lancet Oncol. 2011;12:489-95.

39 Rogers LQ. Objective monitoring of physical activity after a cancer diagnosis: challenges and opportunities for enhancing cancer control. Phys Ther Rev. 2010;15:224-37.

40 Schrack JA, Gresham G, Wanigatunga AA. Understanding physical activity in cancer patients and survivors: new methodology, new challenges, and new opportunities. Cold Spring Harb Mol Case Stud. 2017;3:a001933.

41 Kenzik KM, Morey MC, Cohen HJ, Sloane R, Demark-Wahnefried W. Symptoms, weight loss, and physical function in a lifestyle intervention study of older cancer survivors. J Geriatr Oncol. 2015;6:424-32.

42 Goodwin PJ, Segal RJ, Vallis M, Ligibel JA, Pond GR, Robidoux A, et al. Randomized trial of a telephone-based weight loss intervention in postmenopausal women with breast cancer receiving letrozole: the LISA trial. J Clin Oncol. 2014;32:2231-9.

43 Pahor M, Guralnik JM, Ambrosius WT, Blair S, Bonds DE, Church TS, et al. Effect of structured physical activity on prevention of major mobility disability in older adults: the LIFE study randomized clinical trial. JAMA. 2014;311:2387-96.

44 Von Haehling S, Morley JE, Coats AJS, Anker SD. Ethical guidelines for publishing in the journal of cachexia, sarcopenia and muscle: update 2017. J Cachexia Sarcopenia Muscle. 2017;8:1081-3.

5. EMAITZEN EZTABAIDA OROKORRA

5. EMAITZEN EZTABAIDA OROKORRA

Ikerketa proiektu honetan, jarduera fisikoak pertsona nagusien bi talde zaurgarrietan onurak dituela frogatu dugu. Batetik, intentsitate moderatuan eta norbanakoari egokitutako ariketa fisikoko programa progresiboak hirugarren adineko egoitzetako pertsonen egoera fisiko, kognitibo, afektibitate-egoera eta hauskortasunean onurak eragin zituela eta ondorio kaltegarriak murrizteko eraginkorra dela behatu genuen. Gainera, hirugarren adineko egoitzetako pertsonetan indar gehiago eta jarduera fisiko gehiago burutzen zutenek, funtzio kognitibo eta afektibitate-egoera hobea zutela behatu genuen. Biomarkatzaileei dagokienez, serum-eko miostatina kontzentrazioa eta gorputz-osaera, egoera fisikoa, ohiko jarduera fisikoa eta hauskortasuna lotuta daudela behatu genuen. Horrez gain, gizonetan ariketa fisikoko programak miostatina kontzentrazioa igotzea eragin zuen, eta egoera fisikoan izandako hobekuntzak miostatina kontzentrazioaren igoerarekin lotuta zeudela behatu genuen. Bestetik, bularreko minbizia zuten emakumeetan telefonoz helarazi ziren eta norbanakoan oinarrituriko jarduera fisikoko gomendioek ez zuten gaitasun funtzionalaren galera murriztu urte baten ondoren, baina bi urteren ondoren programak gaitasun funtzionalaren galera murriztea eragin zuen.

Hiru hilabete nahikoak izan ziren talde esperimentalaren eta kontrol taldearen artean gerriaren perimetroan, goiko eta beheko gorputz-adarren indarran, ibilera abiaduran eta oreka estatiko zein dinamikoan ezberdintasunak behatzeko hirugarren adineko egoitzetako pertsonetan. Izan ere, epe labur baten ondoren, talde esperimentalean hobekuntza adierazgarriak behatu genituen, eta kontrol taldeak gainbehera nabarmena izan zuen. Gure ikerketa proiektuan ariketa fisikoaren eraginkortasuna aztertzeko, lagina bi azpi-taldetan banatu genuen gaitasun funtzionalaren arabera. Programak funtzionaltasun urriko taldean hobekuntza adierazgarriak eragin ditu parametro fisiko gehienetan. Ordea, hobekuntza adierazgarri gutxiago lortu ditugu SPPB-ko puntuazio altua duten pertsonetan. Beraz, ariketa fisikoaren eskakizuna txikiegia izan zitekeen gaitasun funtzional hobea zuten pertsonentzat. Zenbait ikerketek egoitzetako pertsonen ibilera zein gaitasun funtzionalean ariketa fisikoak duen eragina aztertu dute (Rolland et al., 2007; Cadore et al., 2014). Hala ere, gehienek ez dute parte hartzaileen gaitasun funtzionala kontuan hartu ariketa fisikoko programa egoiliarrei egokitzeko. Egoitzetako parte hartzaileek gaitasun funtzional altua zein baxua izan dezaketenez, zenbait ikerketek interbentzio programa parte hartzaileen gaitasunei egokitu beharko litzaiokela proposatu dute, ariketa fisikoaren estimulua optimoa izateko helburuarekin (Frändin et al., 2016). Gure ustez, ikerketa hau izan da ariketa fisikoko programa baten eraginkortasuna hirugarren adineko egoitzetako pertsonetan aztertzerakoan, gaitasun funtzionalean oinarritu den lehen ikerketa, bi azpi-talderen arteko konparaketa egiteko, eta funtzionaltasun altua zutenengan ez da oso eraginkorra izan. Hau guztiagatik, etorkizunean burutuko diren ikerketek gaitasun funtzional hobea dutenentzat eskakizun altuagoa duen ariketa fisikoko programa baten eraginkortasuna aztertu beharko lukete.

Gure ikerketa proiektuan, lehen hiru hilabeteetan egoera fisikoan lortutako hobekuntzak mantentzeko eraginkorra izateaz gain, hirugarren hilabetetik seigarrenera interbentzio taldeak indarra, oreka dinamikoa eta gaitasun aerobikoa oraindik ere gehiago hobetu zituen. Emaitzak hauek ez datoz guztiz bat beste ikerketetako emaitzekin, hirugarren eta seigarren hilabeteen artean ez bait zituzten ezberdintasunak behatu (Dechamps et al., 2010). Ikerketa proiektu honetan norbanakoan eta intentsitate moderatuan buruturiko indar eta oreka ariketak bi hilabetero doitu ziren, RM1-ean eta oreka ariketetan izandako hobekuntzak kontutan hartuta. Programari dagokionez, azpimarragarria da gure ikerketa proiektuan behatu dugun bertaratzea (%91), antzeko ezaugarriak zituzten parte hartzaileekin buruturiko ikerketa laburragoetan izandakoa baino altuagoa izan bait zen (Cichocki et al., 2015; Toots et al., 2016). Beraz, badirudi ariketa fisikoko programa luzatzeak ez duela bertaratzean eragiten.

Ariketa fisikoko interbentzioen ariketa mota eta iraupenari dagokionez, aurretik hirugarren adineko egoitzetako pertsonekin burutu diren ikerketetan emaitza kontraesankorrak azaleratu dituzte (Serra-Rexach et al., 2011; Cadore et al., 2014). Gure proiektuko lagina hirugarren adineko egoitzetako pertsonekin egin diren ausazko entsegu klinikoetatik handienetarikoa da, eta epe luzeko interbentzio bateko emaitzak argitaratu ditugu, laburragoak diren ikerketa batzuek lortutako emaitzekin bat etorri direnak (Cadore, Rodríguez-Mañas, Sinclair & Izquierdo, 2013). Ariketa fisikoko programak egoera fisikoan eragin dituen hobekuntzak oso garrantzitsuak izan dira, arlo fisikoan gertatzen den gainbehera oso lotuta dagoelako ondorio kaltegarriekin. Ibilera abiadura, indarra eta oreka dinamikoak hirugarren adineko pertsonen gaitasun funtzionalen gainbehera azkarra, eguneroko jarduerak burutzeko zailtasuna, erorketak, desgaitasuna eta hilkortasuna iragarri ditzakela frogatu da (McGough et al., 2011; Viccaro, Perera & Studenski, 2011; Pavasini et al., 2016).

Bestetik CAPADOGE ikerketan, telefonoz helarazitako eta norbanakoan oinarrituriko jarduera fisikoko gomendioen programa jarraitu duen taldearen eta gaur egun Frantzian helarazten diren jarduera fisikoko gomendioak jaso dituzten taldearen arteko konparaketa burutu da. Bertan, bi taldeek urtebetera SPPB testean puntu bat galdu duten parte hartzaileen proportzioa berdintsua izan dela behatu dugu. Hala ere, emaitza hauek bat datoz urtebetera emaitza adierazgarriak topatu ez zituzten beste ikerketa batzuekin (Demark-Wahnefried et al., 2006). Urtebetera emaitza adierazgarriak ez izatearen arrazoia minbiziaren tratamendua izan daiteke, agian gogorregia izan daitekeelako eta jarduera fisikoaren onurak geldiarazi ditzakeelako.

Hala ere, bularreko minbizia zuten emakumeetan, talde esperimentalaren interbentzioa gaitasun funtzionalaren galera lausotzeko eraginkorra dela behatu dugu bi urteren ondoren. Aldiz, interbentzioa ez zen eraginkorra izan urtebetera. Litekeena da kimioterapia tratamenduak eragin ohi duen gihar masa, indar eta jarduera fisiko galerarekin lotura zuzena izatea (Demark-Wahnefried et al., 2001; Huy et al., 2012; Bye et al., 2017; Klassen et al., 2017). Hala ere, bi urtetara izandako emaitza adierazgarriak direla eta, norbanakoan oinarrituriko jarduera fisikoko programaren eragin positiboa azpimarratu nahi dugu.

Honez gain, nutrizio egoera normala zutenen eta ez zutenen artean interbentzioak zuen eragina ere aztertu genuen. Bertan ere, bi urteren ondoren SPPB testean ezberdintasun adierazgarriak behatu genituen, nutrizio egoera normala zutenen alde. Beraz, etorkizuneko interbentzioek nutrizioa ere kontutan hartu beharko luketela ondorioztatu genuen (Solheim et al., 2017).

Telefono bitartez helarazitako jarduera fisikoko gomendioak bularreko minbizia zuten gazteen gaitasun funtzionala hobetzeko eraginkorrak zirela frogatu zen (Ligibel et al., 2012). Horregatik, telefonoz helarazitako jarduera fisikoko programa hirugarren adineko pertsonetan gaitasun funtzionalaren galera murrizteko eraginkorra izan zitekeela pentsatu genuen. Jarduera fisikoko programa telefono bitartez burutzea erabaki zen, parte hartzaile gehiagok burutu ahal izateko helburuarekin, batik bat gaitasun funtzional baxua zutenek gainbegiratutako jarduera fisikoko programa batean ez zutela parte hartuko pentsatzen genuelako. Hala ere, nahiz eta talde esperimentalak programarekiko atxikimendu handia izan, litekeena da ariketen intentsitatea baxuegia izatea, eta beraz nahikoa ez izatea urtebetera gaitasun funtzionalaren galera ekiditeko. Horregatik, etorkizuneko proiektuetan gainbegiratutako saio birtualen eragina aztertzea oso interesgarria izan daiteke.

Bestetik, egoitzetan bizi diren hirugarren adineko pertsonek burutzen duten jarduera fisikoa ikerketa oso gutxik azaleratu dute (Ikezoe, Asakawa, Shima, Kishibuchi & Ichihashi, 2013). Gure ikerketako emaitzak bat datoz hirugarren adineko egoitzetako pertsonek jarduera fisiko gutxi burutzen dutela diotenekin (Lobo et al., 2008). Egoitzetan bizi diren adinduek egunaren %65,5a jarduera geldoak burutzeko erabili ohi dute (eserita egonda) eta %0,9a bakarrik ibiltzeko (Ice, 2002). Lobo eta lankideak (2008) izan dira egoitzetan bizi diren hirugarren adineko pertsonen jarduera fisikoa burutzeko ohiturak objektiboki Actigraph azelerometroen bitartez neurtu duten ikertzaile bakarrak, eta hirugarren adineko pertsonen gomendio orokorrak baino askoz ere jarduera fisiko gutxiago burutzen dutela behatu zuten. Ariketa fisikoko programa baten ondoren, gure proiektuan talde esperimentalak proiektu hasieran baino pauso gehiago burutu zituen eta kontrol taldeak pauso gutxiago. Hala ere, ezberdintasun hauek ez ziren adierazgarriak izan. Agian ibiltzeko gomendioak laburregiak izan ziren (20 min eguneko); edo agian egoitzaren egitura edota ingurune fisiko desegokia izan da ibiltzeko gomendioak guztiz ez betetzea eragin duten arrazoietariko bat (egituraren estetika, baliabideak, egoitzaren tamaina, egoitzatik kanpo ibiltzeko aukera…) (Król-Zielińska, Kusy, Zieliński & Osiński, 2011).

Minbizia zuten hirugarren adineko pertsonekin buruturiko ikerketan aldiz, galdeketa bat erabili zen ohiko jarduera fisikoa ezagutzeko. Ohiko jarduera fisikoa neurtzeko gailu objektiboen erabilera areagotzen ari da populazio honetan

(Schrack, Gresham & Wanigatunga, 2017). Ikerketa proiektu honetako pertsonen ohiko jarduera fisikoan ere ez zen ezberdintasun adierazgarririk behatu kontrol taldearen eta talde esperimentalaren artean.

Bestalde, hirugarren adineko egoitzetako ariketa fisikoko programa eraginkorra izan zen bertako pertsonen funtzio kognitiboa mantendu eta depresio pertzepzioa murrizteko. Ariketa fisikoak hirugarren adineko egoitzetako pertsonen kognizioan duen eragina aztertu duten ikerketa oso gutxi daude (Pereira et al., 2018). Gure ikerketa proiektuan ikusi ahal izan dugunez, ariketa fisikoa zenbait funtzio kognitibo mantentzeko eraginkorra dela frogatu genuen (Montreal kognizio azterketa eta ikurren bilaketa testa). Kontrol taldeak zenbait kognizio testetan gainbehera izan zuen bitartean, talde esperimentalak test horietan emaitza mantentzea lortu zuen, zenbakien kodea testean izan ezik, talde esperimentalak ere okertu bait zuen sei hilabeteren ondoren. Minbizia zuten hirugarren adineko pertsonetan, jarduera fisikoko programaren ondoren ez zen hobekuntzarik behatu Animaliak testean, hirugarren adineko egoitzetako pertsonetan bezala. Beraz, kognizioan eragin dituen onurak espezifikoak izan direla esan dezakegu, hobekuntzak bakarrik bi testetan frogatu direlako eta beste test guztietan emaitzak mantendu egin direlako.

Montreal kognizio azterketa testari dagokionez, bi puntuko ezberdintasuna behatu zen sei hilabeteren ondoren kontrol taldearen eta talde esperimentalaren artean. Bi puntuko ezberdintasun hau klinikoki adierazgarria da beste zenbait ikerketen arabera (Wong et al., 2017). Beraz, eta berriki hirugarren adineko pertsonen inguruan argitaratutako errebisio batekin bat etorrita, badirudi kognizio orokorra eta informazioa prozesatzeko abiadura direla ariketa fisikoak hobetzen dituen aldagai egonkor eta iraunkorrenak (Gomes-Osman et al., 2018). Gainera, azpimarratu beharra dago kognizio orokor okerragoa eta informazioa prozesatzeko abiadura mantsoagoa dementzia izateko arrisku handiagoarekin lotuta dagoela (Welmer, Rizzuto, Qiu, Caracciolo & Laukka, 2014). Beraz, proiektu honetako emaitzak bat datoz hirugarren adineko egoitzetako pertsonekin ariketa fisikoko programa baten eragina aztertu duten beste ikerketa batekin, kognizio orokorra eta informazioa prozesatzeko abiaduraren gainbehera atzeratzea lortu bait zuten (Pereira et al., 2018).

Hirugarren adineko egoitzetako pertsonetan, sei hilabetetako interbentzioaren ondoren talde esperimentalak gaitasun funtzionalean (SPPB) eta funtzio kognitiboan (Montreal kognizio testa) izandako hobekuntzak, hurrengo 6 hilabeteetan galdu egin zituztela frogatu genuen, interbentzio programa hasi zuten egoera berdinera bueltatuz. Bitartean, kontrol taldeak bi aldagai hauetan okertzen jarraitu zuen 6 eta 12 hilabeteetara. Ohiko jarduera fisikoari dagokionez, ez genituen ezberdintasun adierazgarririk behatu 6 eta 12 hilabeteetara kontrol taldearen eta talde esperimentalaren artean. Beraz, 6 hilabetetako ariketa fisikoko programa ez zen eraginkorra izan ohiko jarduera fisikoan hobekuntzak eragiteko. Ondorioz, egoitzetan bizi diren adineko pertsonen jarrera sedentarioak gaitasun fisiko zein kognitiboen gainbehera eragin dezake, desgaitasuna eta mendekotasuna izateko arriskua areagotuz (Pereira et al., 2018). Beraz, hau guztia ikusita, hirugarren adineko egoitzetan ariketa fisikoko programek ez dutela geldiunerik izan behar ondorioztatu genuen.

Afektibitate-egoerari dagokionez, ikerketa proiektu honetako emaitzak bat datoz ariketa fisikoko programa baten eraginez hirugarren adineko egoitzetako pertsonen bakardade pertzepzioa murriztea lortu zuten beste ikerketa batekin (Mimi et al., 2014). Gainera, gure proiektuan kontrol taldearen bakardade pertzepzioa ere murriztu egin zen sei hilabeteren ondoren. Honen arrazoia izan daiteke, ikerketa proiektu baten parte hartzaile izatea eta zenbait proba burutzerakoan ikertzaile ezberdinekin sei hilabetetan zehar harremanak izateak eragina izan zuela. Parte hartzaileek bakardade pertzepzioan izan zuten aldaketa oso garrantzitsua izan daiteke, bakardadea gaitasun funtzionalaren gainbeherarekin, morbilitatearekin eta heriotzarekin lotu izan delako (Perissinotto, Cenzer & Covinsky, 2012). Ikerketa proiektu honetan afektibitate-egoera aztertzeko erabili ziren beste aldagaietan ez genituen ezberdintasun adierazgarriak behatu. Hala ere, kontrol taldeak depresio pertzepzioa handitu eta bizi-kalitatea okertu zuen bitartean, sei hilabeteko interbentzioaren ondoren talde esperimentalak depresio pertzepzioa jaitsi eta bizi-kalitatea hobetu zuela behatu genuen. Beste ikerketetan lortu diren emaitzei dagokienez, zenbait ikerketek ariketa fisikoko programa bat burutu ondoren hobekuntza adierazgarriak topatu dituzte depresioan (De Carvalho Bastone & Filho, 2004; Dechamps et al., 2010;

Mimi et al., 2014; Lok, Lok & Canbaz, 2017) eta bizi-kalitatean (Cichocki et al., 2015; Lok, Lok & Canbaz, 2017), baina beste zenbaitek ez du inolako hobekuntzarik behatu (Rolland et al., 2007; Ouyang et al., 2009; Telenius et al., 2015; Frändin et al., 2016). Beraz, ikerketa proiektu honetan ikusi ditugun hobekuntzak, adierazgarriak ez izanik, ez dute emaitza kontraesankor hau guztiz argitu.

Guk dakigula, hau da higurarren adineko egoitzetako pertsonetan egoera fisikoaren, funtzio kognitiboaren eta afektibitate-egoeraren arteko lotura aztertu duen lehen ikerketa proiektua. Proiektu honetan azaldu ditugun emaitzak bat datoz komunitatean bizi direnekin burutu diren beste ikerketa batzuetako emaitzekin, non arlo fisikoa eta kongnitiboa lotuta daudela adierazi duten (Colcombe & Kramer, 2003; Angevaren et al., 2007; Angevaren et al., 2008; Liu-Ambrose et al., 2010; Vidoni et al., 2015). Gainera, gure ikerketa proiektuan behatu ditugun loturak, ibiltzeko laguntza aparatua behar dutenen eta ez dutenen artean ezberdinak izan dira. Ibiltzeko laguntza aparatua behar dutenetan, goiko gorputz-adarretako indarra hitzezko oroimenarekin eta bizi-kalitatearekin lotuta dagoela behatu da. Ibiltzeko laguntza aparatua behar ez dutenetan, beheko gorputz-adarretako indarra hitzezko oroimenarekin lotuta dagoela behatu dugu, jarduera fisiko arina bizi-kalitatearekin, eta eguneko pauso kopurua depresioarekin negatiboki lotuta dagoela behatu dugu. Beraz, badirudi eguneroko jarduerak burutzeko goiko edo beheko gorputz-adarren erabilerak zerikusia izan dezakeela ikerketa proiektu honetan behatu ditugun emaitzekin. Adibidez, ibiltzeko, oreka mantentzeko edo aulkitik altxatzeko goiko gorputz-adarren erabilera behar izaten dutenek, zenbait egokitzapen fisiologiko izango dituzte muskuluan, aurretik aipaturiko loturetan eragina izan dezaketenak. Bestalde, bizi-kalitate hobea duten pertsonek bizi ohitura aktiboagoak dituztela uste dugu, eta honek azal dezake indar gehiago izatearen zergatia (baina lotura honen arrazoia, alderantziz gerta daitekeela ere pentsa daiteke). Bizi ohitura aktiboagoak dituzten pertsonek indar gehiago izan dezaketela ere pentsa daiteke, eta ondorioz bizi-kalitate hobea (eta alderantziz).

Gure ikerketa proiektuan ere ohiko jarduera fisikoa bizi-kalitate hobearekin eta depresioa izateko arrisku baxuagoarekin lotuta dagoela frogatu dugu. Emaitza hauek bat datoz egoitzetan bizi ziren pertsonekin burutu zuten beste ikerketa bateko emaitzekin, egoitzatik kanpo egin ohi zituzten jarduerak eta depresioa izateko arriskua lotuta daudela frogatu bait zuten (Patra et al., 2017). Hau guztiagatik, jarduera fisikoa burutzean depresioa izateko arriskua jaitsi daitekeela pentsa genezake. Jarduera fisiko gehiago burutzean, egoiliarrek leku gehiagotan egoteko aukera izaten dute, eta hortaz pertsona gehiagorekin harremanak izateko aukera izan ohi dute. Izan ere, egoiliarrek oso jarduera fisiko gutxi burutu ohi dute, eta hortaz oso bizi-espazio txikia izan ohi dute (Tsai et al., 2015; Jansen, Diegelmann, Schnabel, Wahl & Hauer, 2017).

Gure ikerketako ariketa fisikoko programa eraginkorra izan zen ere hauskortasunaren garapena lausotu eta erorketa eta heriotza kopurua murrizteko. Hauskortasuna neurtzeko erabili izan diren testen arabera pertsona hauskorren prebalentzia asko aldatzen denez (Kojima, 2015), ikerketa proiektu honetan lau test ezberdin erabili ziren hauskortasuna baloratzeko. Proiektu honetako emaitzak bat datoz ariketa fisikoaren bitartez Fried-en hauskortasun irizpidean oinarrituta hauskortasun prebalentzia murriztea lortu zuen beste ikerketa batekin (Ferreira et al., 2018). SPPB testeko emaitzei dagokienez, gure proiektuko emaitzak bat datoz indar ariketen eragina aztertu zuten beste ikerketa batekin; talde esperimentalak hobekuntza adierazgarria izan zuen, kontrol taldeak gainbehera adierazgarria izan zuen bitartean (Sahin et al., 2018). Ildo berean, gure interbentzioa eraginkorra izan zen talde esperimentalean SPPB-n oinarritutako hauskorren prebalentzia murrizteko.

Gure ustez, ikerketa proiektu hau da ariketa fisikoak Tilburg-en hauskortasun indizea eta osteoporosi hausturen ikerketako hauskortasun indizea testetan duen eragina aztertu duen lehen ikerketa. Tilburg-en hauskortasun indizeari dagokionez, pertsona hauskorren kopurua txikiagoa izan zen sei hilabeteko interbentzio epearen ondoren talde esperimentalean, kontrol taldean baino. Osteoporosi hausturen ikerketako hauskortasun indizeari dagokionez, pertsona hauskorren kopurua txikiagoa izan zen talde esperimentalean kontrol taldean baino, baina taldeen arteko ezberdintasunak ez ziren adierazgarriak izan.

Hortaz, emaitza hauek bat datoz aurretik argitaratutako artikuluekin, eta badirudi ariketa fisikoak eginkizun garrantzitsua izan dezakeela hauskortasunaren garapena lausotzeko (Ferreira et al., 2018; Sahin et al., 2018). Hala ere, ikerketa gehiago behar dira hirugarren adineko egoitzetako pertsonen hauskortasunari aurre egiteko egokiena izan daitekeen ariketa fisikoko programa zehazteko.

Eguneroko jarduerak burutzeko gaitasunari dagokionez, gure proiektuan gainbehera adierazgarria behatu zen Barthel eskalan kontrol taldean, baina ez ariketa fisikoa burutu zuen taldean, beste ikertzaileek adierazi zituzten datuekin bat etorriz (Cadore et al., 2014). Gainera, Barthel eskalan kontrol taldeak 10 puntu galdu zituen, eta aldaketa hau gainbehera adierazgarria dela adierazi dute beste ikerketa batzuek (Cadore et al., 2014).

Azpimarratu beharra dago ere gure proiektuko bi taldeek erorketa kopuru berdinak izan zituztela interbentzioaren aurretik eta interbentzioa amaitu ondorengo sei hilabeteetan, baina interbentzioan zehar talde esperimentalaren erorketa kopurua kontrol taldearena baino txikiagoa izan zela. Ariketa fisikoak hirugarren adineko egoitzetako pertsonen erorketen zenbatekoa ez igotzeko duen eraginaren ebidentzia ez da trinkoa gaur egun. Hala ere, gure proiektuko emaitzak bat datoz hirugarren adineko egoitzetako pertsonetan ariketa fisikoaren bitartez erorketen zenbatekoa igotzea ekidin dutenekin (Serra-Rexach et al., 2011; De Souto Barreto et al., 2017). Gainera, gure proiektuko emaitzak ere bat datoz ariketa fisikoko programa bukatu zenean talde esperimentalaren erorketa kopurua igo zela adierazi zuten beste ikerketa batzuekin (Kato et al., 2006). Horregatik, erortzeko arriskua murrizteko argi geratu da ariketa fisikoko programak luzea eta geldiunerik gabekoa izan behar duela. Emaitza hauek klinikoki garrantzitsuak dira, erorketak eta erorketen ondorioz izaten diren lesioak oso ohikoak direlako hirugarren adineko pertsonetan (Rubenstein, Josephson & Osterweil, 1996). Hirugarren adineko egoitzetako pertsonen %50 baino gehiago behin edo gehiagotan erortzen dira, eta erortzen direnen erdiak gutxi gorabehera, behin baino gehiagotan erortzen dira (Kannus, Sievänen, Palvanen, Järvinen & Parkkari, 2005). Erorketa kopurua areagotu egin ohi da zahartzen goazen heinean, narriadura funtzionalarekin eta desgaitasunarekin batera (Kannus et al., 2005). Gainera, erorketen %20 inguruk arreta medikoa behar izaten du, %5ak hausturaren bat izan ohi du, eta %5-10ek beste zenbait lesio larri izan ohi dituzte (Kannus et al., 2005).

Hirugarren adineko egoitzetako pertsonekin eta minbizia duten pertsonekin burutu diren beste ikerketa batzuen antzera, ospitalizazioen zein larrialdietara eginiko deien zenbatekoetan ez genituen bi taldeen artean ezberdintasun adierazgarririk behatu (Dechamps et al., 2010; Pahor et al., 2014; De Souto Barreto et al., 2017). Gure proiektuko emaitzak bat datoz hirugarren adineko egoitzetan ariketa fisikoko programa baten ondoren heriotza tasa baxuagoa adierazi zuten beste ikerketa batzuekin (Grönstedt et al., 2013; Kovacs, Sztruhar Jonasne, Karoczi, Korpos & Gondos, 2013; Cichocki et al., 2015). Aldiz, minbizia zuten hirugarren adineko pertsonetan heriotza kopurua berdintsua izan zen kontrol taldean eta talde esperimentalean. Beraz gakoa, ariketa fisikoko programa gainbegiratua burutzea izan daiteke. Hala ere, bi proiektuetako gertaera kopurua oso txikia izan zenez, ikerketa gehiagoren beharra dago populazio hauetan ariketa fisikoak ospitalizazio, larrialdietara eginiko deien eta heriotza kopuruan duen eragina ezagutzeko.

Hauskortasunaren balizko biomarkatzaileei dagokienez, gure ikerketa proiektua izan da hirugarren adineko pertsonetan serum-eko miostatina kontzentrazioaren eta antropometriaren, gaitasun fisikoen, ohiko jarduera fisikoaren eta hauskortasuna neurtzeko eskala ezberdinen arteko lotura aztertu duen lehen ikerketa. Serum-eko miostatina kontzentrazio altuagoak behatu ziren gaitasun fisiko hobea eta hauskortasun maila baxuagoa zuten pertsonetan eta gantz-masaren ehuneko baxuagoa, gihar-masaren ehuneko altuagoa eta jarduera fisiko gehiago burutzen zuten emakumeetan.

Serum-eko miostatina kontzentrazioaren eta adinaren zein hauskortasunarekin lotutako beste parametroen arteko lotura ez dago oraindik guztiz egonkortuta. Zeharkako azterketa batean hirugarren adineko gizon eta emakumeetan miostatina kontzentrazio altuagoak behatu zituzten (Yarasheski et al., 2002). Ildo berean, serum-eko miostatina kontzentrazioaren eta muskulu masaren arteko korrelazio negatiboa behatu zen (Yarasheski et al., 2002). Hala ere, beste zenbait ikerketek miostatina kontzentrazioa zahartzen goazen heinean jaitsi egin ohi dela adierazi zuten (Lakshman et al., 2009; Bergen et al., 2015).

Ikerketa gutxi daude gaur egun serum-eko miostatina kontzentrazioaren eta hauskortasunaren arteko lotura aztertu dutenak. Ikerketa batzuek miostatina kontzentrazio altuagoak behatu dituzte fisikoki hauskorrak ziren emakumeetan, hauskorrak ez zirenekin alderatzerakoan (Schulte & Yarasheski, 2001; Yarasheski et al., 2002). Gure proiektuko emaitzak ez datoz bat aurretik aipaturiko emaitzekin, gure ikerketan hauskorrak ez ziren pertsonetan serum-eko miostatina kontzentrazio altuagoak behatu ditugulako, hauskorrak zirenekin alderatzerakoan. Hala ere, esan beharra dago gure proiektuko lagina beste ikerketetakoekin alderatzerakoan, zaharragoa eta hauskorragoa zela. Gainera, miostatina muskuluan jariatzen denez, zentzuzkoa da muskulu masa gutxiago duten parte hartzaileek miostatina gutxiago jariatzen dutela esatea (Bergen et al., 2015).

Bestetik, gure ikerketa proiektuan miostatina eta gaitasun fisikoaren eta ohiko jarduera fisikoaren artean korrelazio positiboak behatu dira. Emaitza hauek neurri-batean bat datoz Bergen eta lankideek (2015) adierazitako emaitzekin; miostatinaren kontzentrazio altuagoa indar handiagoarekin lotuta dagoela adierazi zuten, baina jarduera fisikoarekin ez duela loturarik adierazi zuten ere. Hala ere, aipatutako ikerketa honetan jarduera fisikoa galdeketen bitartez neurtu zuten, eta ez objektiboki azelerometroen bitartez, gure ikerketa proiektuan bezala.

Gure ariketa fisikoko programak hirugarren adineko egoitzetako gizonen miostatina kontzentrazioa igotzea eragin zuen. Igoera hau bat etorri zen ere interbentzioak gizonen gaitasun fisikoetan eragin zituen hobekuntzekin. Orohar, ariketa fisikoak miostatina kontzentrazioan duen eragina aztertu duten ikerketa gutxi dago, eta emaitzak kontraesankorrak dira. Zenbait ikerketek ariketa fisikoak miostatina kontzentrazioa jaitsi edota ez duela inolako eraginik adierazi dute (Hittel et al., 2010; Konopka et al., 2010; Boeselt et al., 2017). Hortaz, gure emaitzak ez datoz bat aurretik argitaratutako emaitzekin, ariketa fisikoak gizonetan miostatina kontzentrazioa igotzea eragin zuelako. Hala ere, gure emaitzak bat datoz testosteronaren eragina aztertu duten beste ikerketa batzuekin, muskulu masa eta miostatina areagotzen zituela behatu bait zuten gizon adinduetan (Lakshman et al., 2009).

Miostatina kontzentrazioan gure ariketa fisikoko programaren eragina ezberdina izan da gizon eta emakumeetan. Nahiz eta bi generoetan gaitasun fisikoen hobekuntzak behatu diren, gizonek hobekuntza funtzional nabariagoak izan zituzten eta miostatina kontzentrazioa bakarrik gizonetan igo zen. Ildo berean, zenbait ikerketek ariketa fisikoko programa baten ondoren gizonen miostatina kontzentrazioa igo zela behatu zuten (Lakshman et al., 2009), baina ez emakumeena (Hofmann et al., 2016). Gainera, gaitasun fisikoetako onurak miostatina kontzentrazioan izandako aldaketekin gizonetan bakarrik lotu dira. Bi generoen artean miostatina kontzentrazioan izan diren ezbedintasunak androgenoen eraginaren ondorioz gertatu izan daiteke, androgenoak miostatinaren ekintza anabolikoa geldiarazi dezakeelako (Dubois et al., 2014). Beraz, miostatinak gehiegizko muskulu hipertrofiaren erregulatzaile homeostatikoa izan dezake, eta horregatik, muskulu masa eta indar handiagoarekin lotura izan dezake (Bergen et al., 2015). Hala ere, kontuz ibili behar gara emaitza hauek beste populazioetara zabaltzerako orduan, ikerketa proiektu honetan parte hartu duten parte hartzaileak orohar beste ikerketetakoak baino zaharragoak direlako eta emaitzak ezberdinak izan direlako generoari dagokionez.

Bestetik, ariketa fisikoak BDNF-ren kontzentrazioan duen eragina aztertu duten ikerketen emaitzak kontraesankorrak dira (Ahlskog, Geda, Graff-Radford & Petersen, 2011; Forti et al., 2014). Zenbait ikerketek ariketa fisikoko programa baten ondoren BDNF-ren kontzentrazioa igo dela behatu zuten (Ahlskog et al., 2011). Gure ikerketa proiektuko emaitzak bat datoz ariketa fisikoko programa baten ondoren BDNF-ren kontzentrazioan aldaketarik behatu ez zuten ikerketekin (Forti et al., 2014). Ikertzaile batzuk diotenez, ariketa fisikoa burutzerakoan BDNF jariatzen da (Knaepen et al., 2010). Hala ere, gure proiektuan odol laginak ariketa fisikoa burutu bezain laister jaso ez zirenez, balitekeena da ariketa fisikoa burutzen ari ziren bitartean BDNF-ren kontzentrazio igoera ez somatzea, odolean garbitu egin zelako eta berriz ere kontzentrazio berdina izatera bueltatu zelako (Forti et al., 2014). Horregatik, epe luzeko ariketa fisikoko programek ez dute BDNF-ren kontzentrazio igoerarik frogatu (Ahlskog et al., 2011). Gainera, gure ikerketa proiektuan ezin dugu baztertu ariketa fisikoak muskulu zein garun barneko BDNF-ren kontzentrazioan eraginik izan zuenik (Forti et al., 2014).

Nahiz eta ikerketa proiektu honen helburu nagusienetariko bat ez izan, garrantzitsua da ariketa fisikoko saioetako bertaratzea beste ikerketetakoa baino altuagoa izan zela (%91) azpimarratzea (Cichocki et al., 2015; Pereira et al., 2018). Hortaz, nahiz eta hirugarren adineko egoitzetan burutu diren proiektuekin alderatuz gero gure interbentzioa besteak baino luzeagoa izan, badirudi honek ez duela bertaratzean okerrera eragin. Aipagarria da proiektu honen aurretik proba pilotu bat ere burutu zela esatea, eta prozedura asko erraztu zuela proiektuan burutu behar genituen neurketa zein ariketa fisikoko programaren prozedura diseinatzeko. Proba pilotua amaitu ondoren, ikerketa proiektuan parte hartuko zuten egoitza guztietako zuzendariekin bilera egin genuen, eta egoitzetako langileen laguntza ezinbestekoa zela azpimarratu genien. Beraz, bertaratze altua izateko langileek proiektuan emandako laguntza azpimarragarria dela iruditzen zaigu. Minbizia zuten hirugarren adineko pertsonetan telefonoz jarduera fisikoari emandako jarraipena, antzeko ezaugarriak zituzten beste ikerketetan behatu den antzekoa izan zen (Goodwin et al., 2014).

Ikerketa proiektu hauen indarguneei dagokionez, batetik esatea laginaren tamaina hirugarren adineko egoitzetan bizi diren pertsonetan ariketa fisikoaren eraginkortasuna aztertu dutenetan handienetarikoa dela. Bestalde, ikerketa hau izan da ariketa fisikoaren eragina aztertzerako orduan parte hartzaileak bi azpi-taldetan banatu dituen lehen ikerketa. Gainera, jarduera fisikoa burutzeko ohitura objektiboki neurtu zen azelerometroen bitartez. Azelerometroen erabilerak sinesgarritasun handiagoa ematen diote emaitzei, aurretik burututako ikerketetan galdeketen bitartez burutu zutelako neurketa hau, eta galdeketa hauetan ohikoa delako parte hartzaileen nahia neurtzea, benetan egin ohi duten jarduera fisikoa zehazki neurtu beharrean. Behatu diren hobekuntza fisikoak miostatinan izandako aldaketekin lotu dira eta aztertutako ia aldagai guztietan behatu ditugun korrelazioak trinkoak eta koherenteak izan dira. Gainera, hirugarren adineko egoitzetako pertsonetan miostatina zein BDNF-n ariketa fisikoak duen eragina aztertu duen lehenengo ikerketa izan da. Bestetik, ariketa fisikoak hirugarren adineko egoitzetako pertsonen funtzio kognitiboa mantendu dezakeela frogatu duen lehenengoetariko ikerketa izan da. Ariketa fisikoak hauskortasunean duen eragina aztertzeko lau tresna ezberdin erabili dira. Azpimarragarria iruditzen zaigu sei hilabetetako ariketa fisikoko programan zehar ez dugula interbentzioari lotutako ondorio kaltegarririk behatu. Horregatik, proposatzen dugun ariketa fisikoaren protokoloa, aurretik aipatu ditugun barneratze irizpideak betetzen dituzten hirugarren adineko egoitzetako pertsonek segurtasunez burutu dezaketen interbentzio bat dela iruditzen zaigu. Hau dela eta, proiektu honetan parte hartu duten egoitza guztiei, Gipuzkoako Foru Aldundiari eta Eusko Jaurlaritzari, proiektu honetako emaitzak bidaliko dizkiegu, pixkanaka horrelako interbentzioak hirugarren adineko egoitzetan martxan jarri eta egonkortzeko helburuarekin. Bestetik, minbizia zuten hirugarren adineko pertsonekin buruturiko ikerketari dagokionez, azpimarratzekoa da jarduera fisikoko programa martxan jartzea erraza izan zela, merkea, praktikoa eta ospitaletik urrun bizi ziren hirugarren adineko pertsonek ere burutzeko aukera ahalbidetzen zuela. Hau izan da epe-luzean lagin handi batekin minbizia duten hirugarren adineko pertsonetan objektiboki gaitasun funtzionalaren galera neurtu duen lehen ikerketa, subjektiboki neurtu beharrean (Kenzik, Morey, Cohen, Sloane & Demark-Wahnefried, 2015). Talde esperimentalean telefonoz jarduera fisikoari emandako jarraipena beste ikerketetan behatu denaren antzekoa izan zen (Goodwin et al., 2014). Etorkizunean burutuko diren ikerketek minbizia duten hirugarren adineko pertsonen indarberritzean gainbegiratutako saio birtualen eragina aztertu beharko lukete, aldagai nagusia bi urtetara neurtuta. Proiektu honetan lortutako emaitzak eta esperientzia oso baliagarria izan daiteke minbizia duten hirugarren adineko euskaldunek jarduera fisikoko programa bat eskuragarri izateko.

Hala ere, ikerketa proiektu hauek ere zenbait muga izan dituzte. Batetik, programa hauek ezin dira egoitzetan bizi diren hirugarren adineko pertsona guztiei zuzenean aplikatu. Ikerketa honetan barneratze irizpide jakin batzuk erabili ziren, eta gaitasun funtzional oso baxua zutenek, ibiltzeko gai ez zirenek zein narriadura kognitibo altua zutenek ez zuten parte hartu. Neurketei dagokienez, gorputz-osaera aztertzeko bioinpedantzia erabili genuen erresonantzia magnetikoa edo hezur-dentsitometria proba erabili beharrean, eta azken hauek dira gorputz-osaera aztertzeko metodorik fidagarrienak (Cruz-Jentoft et al., 2010). Bestetik, bai miostatina zein BDNF-ren kontzentrazioak ELISA kit-en bitartez aztertu ziren, teknika sentikorrago bat erabili beharrean (adibidez, masen espektrometroa). Gainera, ez ziren muskulu biopsiak jaso. Nahiz eta hirugarren adineko pertsonetan biopsia laginak jasotzea etikoki eztabaidagarria izan daitekeen. Testosterona, estrogenoak, D bitamina edota hantura markatzaileak ez ziren aztertu, eta informazio interesgarria gehitu zezaketen hauskortasunaren osotasuna eta ariketa fisikoaren eragina hobeto ulertzeko. Minbizia zuten hirugarren adineko pertsonetan buruturiko ikerketari dagokionez, muga nagusiena bi taldeetan proiektuari uko egin dioten parte hartzaile kopuru altua da. Gainera, ikerketa proiektu honetan barneratze irizpide jakin batzuk erabili ziren, eta minbiziaren pronostiko larria zutenak edo narriadura kognitiboa zuten hirugarren adineko pertsonek ez zuten parte hartu eta programa hau ezaugarri horiek zituztenentzat ere eraginkorra izan liteke. Gainera, hainbat izan dira parte hartu dutenen tumorearen kokalekuak eta jarraitu dituzten tratamenduak, eta jarduera fisikoko programaren eragina ezberdina izan liteke azpi-talde bakoitzarentzat. Hala ere, bi taldeetan minbizi motan oinarrituriko ausaz egindako banaketa orekatuak, aurretik aipaturiko arrazoiak ez lukeela eragin behar ondorioztatu dezakegu. Minbizi motaren arabera azpi-taldeen analisia burutzea pentsatu genuen, baina oso lagin txikia geratu zitzaigun minbizi mota bakoitzarekin sorturiko azpi-taldeekin. Horregatik, analisia bakarrik bular minbizia zuten azpi-taldearekin burutu genuen. Ohiko jarduera fisikoa galdeketa baten bitartez neurtzea, objektiboki azelerometroen bitartez neurtu beharrean, ikerketa honen beste muga bat da. Azelerometroek ohiko jarduera fisikoaren neurketa sinesgarriagoa egiten dute eta beste ikerketetako emaitzekin alderatzeko aukera ematen dute (Rogers, 2010).

6. ONDORIOAK

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- **Ariketa fisikoaren eragina hirugarren adineko egoitzetako pertsonetan**
    - Ikerketa proiektu honetan hirugarren adineko egoitzetako pertsonen egoera fisiko, kognitibo eta afektibitate-egoeraren arteko loturak aztertu ditugu. Indarra eta ohiko jarduera fisikoa, hitzezko memoria eta bizi-kalitate hobearekin eta depresioa izateko arrisku baxuagoarekin lotuta dagoela frogatu dugu. Lotura hauek ibiltzeko behar duten laguntzaren arabera ezberdinak direla ere behatu dugu.
    - Proiektu honetako ausazko entsegu kliniko honetan, hirugarren adineko egoitzetako pertsonetan ariketa fisikoko programa egingarria eta ondo toleratua izan dela frogatu da. Gure proiektuko parte hartzaileak ariketa fisikoko saioetan izan zuten bertaratzea altua izan zen.
    - Interbentzio programak hobekuntzak eragin ditu hiru hilabeteren ondoren gorputz osaeran eta egoera fisikoan. Gaitasun funtzional baxua zuten pertsonek ariketa fisikoko programa ondo toleratu zuten, eta gainera, interbentzio honetako emaitzak hobeak izan dira gaitasun funtzional baxua zuten pertsonetan.
    - Egoera fisiko hobea zuten pertsonetan serum-eko miostatina kontzentrazio altuagoak behatu ditugu. Ariketa fisikoko programak eragin dituen onura fisikoak gizonen serum-eko miostatina kontzentrazioan behatu dugun igoerarekin lotuta daudela behatu dugu. Ariketa fisikoko programak ezberdintasun adierazgarriak eragin ditu, talde esperimentalaren alde, gantz eta gihar masaren ehuneko, goiko eta beheko gorputz-adarren indarra eta oreka dinamikoan emakumeetan eta goiko eta beheko gorputz-adarren indarra, oreka dinamikoa, gaitasun aerobikoa eta miostatina kontzentrazioan gizonetan.

- Ikerketa proiektu honetan, hirugarren adineko egoitzetako pertsonetan norbanakoan oinarrituriko eta intentsitate moderatuan sei hilabetetan zehar buruturiko ariketa fisikoko programa progresiboa egingarria dela eta ondo toleratu zutela frogatu dugu, eta hobekuntza espezifikoak eragin ditu funtzio kognitiboan eta bakardade pertzepzioan. Ariketa fisikoko programa burutu ez zutenek, funtzio kognitiboa okertu egin zuten sei hilabeteren ondoren.
- Ikerketa proiektu honetan norbanakoan oinarrituriko eta intentsitate moderatuan buruturiko ariketa fisikoko programa progresiboa (indarra, oreka eta ibilera lantzeko helburu dituena) eraginkorra da hirugarren adineko egoitzetako pertsonen hauskortasuna lausotu eta erorketak eta heriotza kopurua murrizteko.
- Emaitza hauek ikusita, ariketa fisikoko programak hirugarren adineko egoitzetako pertsonen egunerokotasunaren parte izan behar duela iruditzen zaigu. Gainera, programa hauek denboran zehar mantendu beharko lirateke, geldiunerik gabe, sendagileak kontrakoa ez dioen bitartean. Beraz, garrantzitsua iruditzen zaigu hirugarren adineko egoitzetako zuzendariak eta osasunari lotutako arduradun politikoak emaitza hauen jakitun izatea.

- **Jarduera fisikoaren eragina minbizia zuten hirugarren adineko pertsonetan**
    - Gaur egun Frantzian helarazten diren gomendioak jaso dituen kontrol talde batekin alderatuta, telefonoz helarazi diren eta norbanakoan oinarrituriko jarduera fisikoko gomendioek ez dute gaitasun funtzionalaren galera murriztu urte batera, baina ezberdintasun adierazgarriak lortu dira talde esperimentalaren alde emakumeetan eta bularreko minbizia zuten azpi-taldeetan bi urteren ondoren. Horregatik, emaitza hauek minbizia duten hirugarren adineko pertsonetan norbanakoan oinarritu diren eta telefonoz helarazi diren jarduera fisikoko gomendioek duten garrantzia azpimarratzen dute. Etorkizunean burutuko diren ikerketek gainbegiratutako saio birtualen eragina aztertu beharko lukete, aldagai nagusia bi urtetara neurtuta.

7. ARGITALPENAK

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1- **Arrieta, H.,** Rezola-Pardo, C., Gil, S. M., Irazusta, J., & Rodriguez-Larrad, A. (2018). Physical training maintains or improves gait ability in long-term nursing home residents: A systematic review of randomized controlled trials. *Maturitas*, *109*, 45-52.

2- Rodriguez-Larrad, A., **Arrieta, H.,** Rezola, C., Kortajarena, M., Yanguas, J. J., Iturburu, M., ... & Irazusta, J. (2017). Effectiveness of a multicomponent exercise program in the attenuation of frailty in long-term nursing home residents: study protocol for a randomized clinical controlled trial. *BMC geriatrics*, *17*(1), 60.

3- **Arrieta, H.,** Rezola-Pardo, C., Echeverria, I., Iturburu, M., Gil, S. M., Yanguas, J. J., ... & Rodriguez-Larrad, A. (2018). Physical activity and fitness are associated with verbal memory, quality of life and depression among nursing home residents: preliminary data of a randomized controlled trial. *BMC geriatrics*, *18*(1), 80.

4- **Arrieta, H.,** Rezola-Pardo, C., Zarrazquin, I., Echeverria, I., Yanguas, J. J., Iturburu, M., ... & Irazusta, J. (2018). A multicomponent exercise program improves physical function in long-term nursing home residents: a randomized controlled trial. *Experimental gerontology*, *103*, 94-100.

5- **Arrieta, H**., Hervás, G., Rezola-Pardo, C., Ruiz-Litago, F., Iturburu, M., Yanguas, J. J., ... & Irazusta, J. (2018). Serum Myostatin Levels Are Higher in Fitter, More Active, and Non-Frail Long-Term Nursing Home Residents and Increase after a Physical Exercise Intervention. *Gerontology*, DOI: 10.1159/000494137.

6- **Arrieta, H**., Astrugue, C., Regueme, S., Durrieu J., Maillard, A., Rieger, A., … & Bourdel-Marchasson, I. (2018). Effects of a physical activity programme to prevent physical performance decline in onco-geriatric patients: a randomized multicentre trial. *Journal of Cachexia, Sarcopenia and Muscle,* DOI: 10.1002/jcsm.12382.

8. BIBLIOGRAFIA

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Aaronson, N. K., Ahmedzai, S., Bergman, B., Bullinger, M., Cull, A., Duez, N. J., ... & Kaasa, S. (1993). The european organization for research and treatment of cancer QLQ-C30: a quality-of-life instrument for use in international clinical trials in oncology. *Journal of the national cancer institute, 85*(5), 365-376.

Abizanda, P., Romero, L., Sanchez-Jurado, P. M., Atienzar-Nunez, P., Esquinas-Requena, J. L., & García-Nogueras, I. (2012). Association between functional assessment instruments and frailty in older adults: The FRADEA study. *The journal of frailty & aging, 1*(4), 162-168.

Abizanda, P., Romero, L., Sanchez-Jurado, P. M., Martinez-Reig, M., Alfonso-Silguero, S. A., & Rodríguez-Mañas, L. (2014). Age, frailty, disability, institutionalization, multimorbidity or comorbidity. Which are the main targets in older adults?. *The journal of nutrition, health & aging, 18*(6), 622-627.

ACSM: American College of Sports Medicine. (2009). American college of sports medicine position stand. Progression models in resistance training for healthy adults. *Medicine and science in sports and exercise*, *41*(3), 687.

ACSM: American College of Sports Medicine. (2013). *ACSM's guidelines for exercise testing and prescription*. Baltimore, USA: Lippincott Williams & Wilkins.

Adamsen, L., Quist, M., Andersen, C., Møller, T., Herrstedt, J., Kronborg, D., ... & Stage, M. (2009). Effect of a multimodal high intensity exercise intervention in cancer patients undergoing chemotherapy: randomised controlled trial. *Bmj, 339*, b3410.

Agasi-Idenburg, S. C., Thong, M. S. Y., Punt, C. J. A., Stuiver, M. M., & Aaronson, N. K. (2017). Comparison of symptom clusters associated with fatigue in older and younger survivors of colorectal cancer. *Supportive care in cancer*, *25*(2), 625-632.

Aguiñaga, S., Ehlers, D. K., Salerno, E. A., Fanning, J., Motl, R. W., & McAuley, E. (2018). Home-based physical activity program improves depression and anxiety in older adults. *Journal of physical activity and health, 15*(9), 692-696.

Ahlskog, J. E., Geda, Y. E., Graff-Radford, N. R., & Petersen, R. C. (2011). Physical exercise as a preventive or disease-modifying treatment of dementia and brain aging. *Mayo clinic proceedings, 86*(9), 876-884.

Alcalá, M. V. C., Puime, Á. O., Santos, M. T. S., Barral, A. G., Montalvo, J. I. G., & Zunzunegui, M. V. (2010). Prevalencia de fragilidad en una población urbana de mayores de 65 años y su relación con comorbilidad y discapacidad. *Atención primaria*, *42*(10), 520-527.

Amador, J. A. (2013). *Escala de inteligencia de Wechsler para adultos-IV (WAIS-IV)*. Barcelona, España.

American Geriatrics Society, Geriatrics Society & American Academy Of Orthopaedic Surgeons Panel On Falls Prevention. (2001). Guideline for the prevention of falls in older persons. *Journal of the american geriatrics society*, *49*(5), 664-672.

Angevaren, M., Aufdemkampe, G., Verhaar, H. J., Aleman, A., & Vanhees, L. (2008). Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment. *Cochrane database of systematic reviews*, *3*(3), 1-73.

Angevaren, M., Vanhees, L., Wendel-Vos, W., Verhaar, H. J., Aufdemkampe, G., Aleman, A., & Verschuren, W. M. (2007). Intensity, but not duration, of physical activities is related to cognitive function. *European journal of cardiovascular prevention & rehabilitation*, *14*(6), 825-830.

Arrieta, H., Hervás, G., Rezola-Pardo, C., Ruiz-Litago, F., Iturburu, M., Yanguas, J. J., ... & Irazusta, J. (2018). Serum myostatin levels are higher in fitter, more active, and non-frail long-term nursing home residents and increase after a physical exercise intervention. *Gerontology*. Doi: 10.1159/000494137

Arrieta, H., Rezola, C., Gil, S. M., Irazusta, J., & Rodriguez-Larrad, A. (2018). Physical training maintains or improves gait ability in long-term nursing home residents: a systematic review of randomized controlled trials. *Maturitas, 109,* 45-52.

Arrieta, H., Rezola-Pardo, C., Zarrazquin, I., Echeverria, I., Yanguas, J. J., Iturburu, M., ... & Irazusta, J. (2018). A multicomponent exercise program improves physical function in long-term nursing home residents: a randomized controlled trial. *Experimental gerontology*, *103*, 94-100.

Ávila-Funes, J. A., Pina-Escudero, S. D., Aguilar-Navarro, S., Gutierrez-Robledo, L. M., Ruiz-Arregui, L., & Amieva, H. (2011). Cognitive impairment and low physical activity are the components of frailty more strongly associated with disability. *The journal of nutrition, health & aging*, *15*(8), 683-689.

Avis, N. E., & Deimling, G. T. (2008). Cancer survivorship and aging. *Cancer: interdisciplinary international journal of the american cancer society*, *113*(S12), 3519-3529.

Bakeman, R. (2005). Recommended effect size statistics for repeated measures designs. *Behavior research methods*, *37*(3), 379-384.

Baker, L. D., Frank, L. L., Foster-Schubert, K., Green, P. S., Wilkinson, C. W., McTiernan, A., ... & Duncan, G. E. (2010). Effects of aerobic exercise on mild cognitive impairment: a controlled trial. *Archives of neurology*, *67*(1), 71-79.

Balboa-Castillo, T., León-Muñoz, L. M., Graciani, A., Rodríguez-Artalejo, F., & Guallar-Castillón, P. (2011). Longitudinal association of physical activity and sedentary behavior during leisure time with health-related quality of life in community-dwelling older adults. *Health and quality of life outcomes*, *9*(1), 47.

Bates-Jensen, B. M., Alessi, C. A., Cadogan, M., Levy-Storms, L., Jorge, J., Yoshii, J., ... & Schnelle, J. F. (2004). The minimum data set bedfast quality indicator: differences among nursing homes. *Nursing research*, *53*(4), 260-272.

Beauchet, O., Fantino, B., Allali, G., Muir, S. W., Montero-Odasso, M., & Annweiler, C. (2011). Timed Up and Go test and risk of falls in older adults: a systematic review. *The journal of nutrition, health & aging*, *15*(10), 933-938.

Bekinschtein, P., Cammarota, M., & Medina, J. H. (2014). BDNF and memory processing. *Neuropharmacology*, *76*, 677-683.

Berg, K. O., Wood-Dauphinee, S. L., Williams, J. I., & Maki, B. (1992). Measuring balance in the elderly: validation of an instrument. *Canadian journal of public health= Revue canadienne de sante publique*, *83*, S7-11.

Bergen, H. R., Farr, J. N., Vanderboom, P. M., Atkinson, E. J., White, T. A., Singh, R. J., ... & LeBrasseur, N. K. (2015). Myostatin as a mediator of sarcopenia versus homeostatic regulator of muscle mass: insights using a new mass spectrometry-based assay. *Skeletal muscle*, *5*(1), 21.

Bernal-López, C., Potvin, O., & Ávila-Funes, J. A. (2012). Frailty is associated with anxiety in community-dwelling elderly adults. *Journal of the american geriatrics society*, *60*(12), 2373-2374.

Bernard, P., Doré, I., Romain, A. J., Hains-Monfette, G., Kingsbury, C., & Sabiston, C. (2018). Dose response association of objective physical activity with mental health in a representative national sample of adults: A cross-sectional study. *PloS one*, *13*(10), e0204682.

Berryman, N., Bherer, L., Nadeau, S., Lauzière, S., Lehr, L., Bobeuf, F., ... & Bosquet, L. (2013). Executive functions, physical fitness and mobility in well-functioning older adults. *Experimental gerontology*, *48*(12), 1402-1409.

Bezdicek, O., Stepankova, H., Moták, L., Axelrod, B. N., Woodard, J. L., Preiss, M., ... & Poreh, A. (2014). Czech version of rey auditory verbal learning test: normative data. *Aging, neuropsychology, and cognition*, *21*(6), 693-721.

Bilgili, N., & Arpacı, F. (2014). Quality of life of older adults in Turkey. *Archives of gerontology and geriatrics*, *59*(2), 415-421.

Billinger, S. A., Vidoni, E. D., Morris, J. K., Thyfault, J. P., & Burns, J. M. (2017). Exercise test performance reveals evidence of the cardiorespiratory fitness hypothesis. *Journal of aging and physical activity*, *25*(2), 240-246.

Birch, K., Ten Hope, M., Malek-Ahmadi, M., O'Connor, K., Schofield, S., Coon, D., & Nieri, W. (2016). Cognitive function as a mediator in the relationship between physical activity and depression status in older adults. *Journal of aging and physical activity*, *24*(4), 540-546.

Bischoff, H. A., Stähelin, H. B., Monsch, A. U., Iversen, M. D., Weyh, A., Von Dechend, M., ... & Theiler, R. (2003). Identifying a cut-off point for normal mobility: a comparison of the timed 'up and go'test in community-dwelling and institutionalised elderly women. *Age and ageing*, *32*(3), 315-320.

Blazer, D. G., Yaffe, K., & Karlawish, J. (2015). Cognitive aging: a report from the institute of medicine. *Journal of the american medical association*, *313*(21), 2121-2122.

Bocchio-Chiavetto, L., Bagnardi, V., Zanardini, R., Molteni, R., Gabriela Nielsen, M., Placentino, A., ... & Gennarelli, M. (2010). Serum and plasma BDNF levels in major depression: a replication study and meta-analyses. *The world journal of biological psychiatry*, *11*(6), 763-773.

Boeselt, T., Nell, C., Lütteken, L., Kehr, K., Koepke, J., Apelt, S., ... & Vogelmeier, C. F. (2017). Benefits of high-intensity exercise training to patients with chronic obstructive pulmonary disease: a controlled study. *Respiration*, *93*(5), 301-310.

Bogle-Thorbahn, L. D., & Newton, R. A. (1996). Use of the berg balance test to predict falls in elderly persons. *Physical therapy*, *76*(6), 576-583.

Bohannon, R. W. (2006). Reference values for the timed up and go test: a descriptive meta-analysis. *Journal of geriatric physical therapy*, *29*(2), 64-68.

Bohannon, R. W., Andrews, A. W., & Thomas, M. W. (1996). Walking speed: reference values and correlates for older adults. *Journal of orthopaedic & sports physical therapy*, *24*(2), 86-90.

Bösner, S., Keller, H., Wöhner, A., Wöhner, C., Sönnichsen, A., Baum, E., & Donner-Banzhoff, N. (2012). Prevention of falls by outdoor-walking in elderly persons at risk ("power")–a pilot study. *European geriatric medicine*, *3*(1), 28-32.

Bouillon, K., Kivimaki, M., Hamer, M., Sabia, S., Fransson, E. I., Singh-Manoux, A., ... & Batty, G. D. (2013). Measures of frailty in population-based studies: an overview. *BMC geriatrics*, *13*(1), 64.

Bourdel-Marchasson, I., Diallo, A., Bellera, C., Blanc-Bisson, C., Durrieu, J., Germain, C., ... & Doussau, A. (2016). One-year mortality in older patients with cancer: development and external validation of an MNA-based prognostic score. *PLoS One*, *11*(2), e0148523.

Boyle, P. A., Buchman, A. S., Wilson, R. S., Leurgans, S. E., & Bennett, D. A. (2009). Association of muscle strength with the risk of Alzheimer disease and the rate of cognitive decline in community-dwelling older persons. *Archives of neurology*, *66*(11), 1339-1344.

Boyle, P. A., Buchman, A. S., Wilson, R. S., Leurgans, S. E., & Bennett, D. A. (2010). Physical frailty is associated with incident mild cognitive impairment in community-based older persons. *Journal of the american geriatrics society*, *58*(2), 248-255.

Brett, L., Traynor, V., & Stapley, P. (2016). Effects of physical exercise on health and well-being of individuals living with a dementia in nursing homes: a systematic review. *Journal of the american medical directors association*, *17*(2), 104-116.

Briel, M., Ferreira-Gonzalez, I., You, J. J., Karanicolas, P. J., Akl, E. A., Wu, P., ... & Whitt, I. (2009). Association between change in high density lipoprotein cholesterol and cardiovascular disease morbidity and mortality: systematic review and meta-regression analysis. *Bmj*, *338*, b92.

Brisswalter, J., Collardeau, M., & Arcelin R. (2002). Effects of acute physical exercise characteristics on cognitive performance. *Sports medicine*, *32*(9), 555-566.

Brzycki, M. (1993). Strength testing—predicting a one-rep max from reps-to-fatigue. *Journal of physical education, recreation & dance*, *64*(1), 88-90.

Buchman, A. S., Boyle, P. A., Wilson, R. S., Tang, Y., & Bennett, D. A. (2007). Frailty is associated with incident Alzheimer's disease and cognitive decline in the elderly. *Psychosomatic medicine*, *69*(5), 483-489.

Buchman, A. S., Schneider, J. A., Leurgans, S., & Bennett, D. A. (2008). Physical frailty in older persons is associated with Alzheimer disease pathology. *Neurology*, *71*(7), 499-504.

Buchman, A. S., Wilson, R. S., Bienias, J. L., Shah, R. C., Evans, D. A., & Bennett, D. A. (2005). Change in body mass index and risk of incident Alzheimer disease. *Neurology*, *65*(6), 892-897.

Buchman, A. S., Wilson, R. S., Boyle, P. A., Bienias, J. L., & Bennett, D. A. (2007). Grip strength and the risk of incident Alzheimer's disease. *Neuroepidemiology*, *29*(1-2), 66-73.

Buchman, A. S., Yu, L., Boyle, P. A., Schneider, J. A., De Jager, P. L., & Bennett, D. A. (2016). Higher brain BDNF gene expression is associated with slower cognitive decline in older adults. *Neurology*, 10-1212.

Buracchio, T., Dodge, H. H., Howieson, D., Wasserman, D., & Kaye, J. (2010). The trajectory of gait speed preceding mild cognitive impairment. *Archives of neurology*, *67*(8), 980-986.

Butman, J., Allegri, R. F., Harris, P., & Drake, M. (2000). Fluencia verbal en español. Datos normativos en Argentina. *Medicina*, *60*(5/1), 561-4.

Bye, A., Sjøblom, B., Wentzel-Larsen, T., Grønberg, B. H., Baracos, V. E., Hjermstad, M. J., ... & Jordhøy, M. (2017). Muscle mass and association to quality of life in non-small cell lung cancer patients. *Journal of cachexia, sarcopenia and muscle*, *8*(5), 759-767.

Cadore, E. L., Casas-Herrero, A., Zambom-Ferraresi, F., Idoate, F., Millor, N., Gómez, M., ... & Izquierdo, M. (2014). Multicomponent exercises including muscle power training enhance muscle mass, power output, and functional outcomes in institutionalized frail nonagenarians. *Age*, *36*(2), 773-785.

Cadore, E. L., Rodríguez-Mañas, L., Sinclair, A., & Izquierdo, M. (2013). Effects of different exercise interventions on risk of falls, gait ability, and balance in physically frail older adults: a systematic review. *Rejuvenation research*, *16*(2), 105-114.

Calvani, R., Marini, F., Cesari, M., Tosato, M., Anker, S. D., Von Haehling, S., ... & SPRINTT consortium. (2015). Biomarkers for physical frailty and sarcopenia: state of the science and future developments. *Journal of cachexia, sarcopenia and muscle*, *6*(4), 278-286.

Cameron, I. D. G. L., Gillespie, L., Robertson, C., Murray, G., Hill, K., Cumming, R., & Kerse, N. (2012). Interventions for preventing falls in older people in care facilities and hospitals. *Cochrane database of systematic reviews*, *12*, CD005465-1.

Cardoso, A. L., Fernandes, A., Aguilar-Pimentel, J. A., de Angelis, M. H., Guedes, J. R., Brito, M. A., ... & Schosserer, M. (2018). Towards frailty biomarkers: candidates from genes and pathways regulated in aging and age-related diseases. *Ageing research reviews, 47*, 214-277.

Carone, G. (2005). *Long-term labour force projections for the 25 EU member states: A set of data for assessing the economic impact of ageing.* Brussels, Belgium.

Carvalho, A. L., Caldeira, M. V., Santos, S. D., & Duarte, C. B. (2008). Role of the brain-derived neurotrophic factor at glutamatergic synapses. *British journal of pharmacology*, *153*(S1), S310-S324.

Castle, N. G., & Ferguson, J. C. (2010). What is nursing home quality and how is it measured?. *The gerontologist*, *50*(4), 426-442.

Cesari, M., Kritchevsky, S. B., Newman, A. B., Simonsick, E. M., Harris, T. B., Penninx, B. W., ... & Rubin, S. M. (2009). Added value of physical performance measures in predicting adverse health-related events: results from the health, aging and body composition study. *Journal of the american geriatrics society*, *57*(2), 251-259.

Cesari, M., Kritchevsky, S. B., Penninx, B. W., Nicklas, B. J., Simonsick, E. M., Newman, A. B., ... & Visser, M. (2005). Prognostic value of usual gait speed in well-functioning older people—results from the health, aging and body composition study. *Journal of the american geriatrics society*, *53*(10), 1675-1680.

Cesari, M., Onder, G., Zamboni, V., Manini, T., Shorr, R. I., Russo, A., ... & Landi, F. (2008). Physical function and self-rated health status as predictors of mortality: results from longitudinal analysis in the ilSIRENTE study. *BMC geriatrics*, *8*(1), 34.

Cesari, M., Prince, M., Thiyagarajan, J. A., De Carvalho, I. A., Bernabei, R., Chan, P., ... & Manas, L. R. (2016). Frailty: an emerging public health priority. *Journal of the american medical directors association*, *17*(3), 188-192.

Cesari, M., Vellas, B., Hsu, F. C., Newman, A. B., Doss, H., King, A. C., ... & Pahor, M. (2014). A physical activity intervention to treat the frailty syndrome in older persons—results from the LIFE-P study. *Journals of gerontology series a: biomedical sciences and medical sciences*, *70*(2), 216-222.

Chang, Y. K., Pan, C. Y., Chen, F. T., Tsai, C. L., & Huang, C. C. (2012). Effect of resistance-exercise training on cognitive function in healthy older adults: a review. *Journal of aging and physical activity*, *20*(4), 497-517.

Chekroud, S. R., Gueorguieva, R., Zheutlin, A. B., Paulus, M., Krumholz, H. M., Krystal, J. H., & Chekroud, A. M. (2018). Association between physical exercise and mental health in 1.2 million individuals in the USA between 2011 and 2015: a cross-sectional study. *The lancet psychiatry*, *5*(9), 739-746.

Cichocki, M., Quehenberger, V., Zeiler, M., Adamcik, T., Manousek, M., Stamm, T., & Krajic, K. (2015). Effectiveness of a low-threshold physical activity intervention in residential aged care–results of a randomized controlled trial. *Clinical interventions in aging*, *10*, 885-895.

Clegg, A., Young, J., Iliffe, S., Rikkert, M. O., & Rockwood, K. (2013). Frailty in elderly people. *The lancet*, *381*(9868), 752-762.

Coen, R. F., Robertson, D. A., Kenny, R. A., & King-Kallimanis, B. L. (2015). Strengths and limitations of the MoCA for assessing cognitive functioning: Findings from a large representative sample of Irish older adults. *Journal of geriatric psychiatry and neurology*, *29*(1), 18-24.

Cohen, J. (1988). *Statistical power analysis for the behavioral science*. 2nd edn. Lawrence earlbaum associates: Hilldsdale, NJ.

Cohen-Mansfield, J., Shmotkin, D., & Goldberg, S. (2009). Loneliness in old age: longitudinal changes and their determinants in an israeli sample. *International psychogeriatrics*, *21*(6), 1160-1170.

Colcombe, S., & Kramer, A. F. (2003). Fitness effects on the cognitive function of older adults: a meta-analytic study. *Psychological science*, *14*(2), 125-130.

Collard, R. M., Boter, H., Schoevers, R. A., & Voshaar, R. C. O. (2012). Prevalence of frailty in community-dwelling older persons: a systematic review. *Journal of the american geriatrics society*, *60*(8), 1487-1492.

Cowper, P. A., Peterson, M. J., Pieper, C. F., Sloane, R. J., Hall, K. S., McConnell, E. S., ... & Morey, M. C. (2017). Economic analysis of primary care-based physical activity counseling in older men: The VA-LIFE Trial. *Journal of the american geriatrics society*, *65*(3), 533-539.

Craig, C. L., Marshall, A. L., Sjorstrom, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., ... & Oja, P. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine and science in sports and exercise*, *35*(8), 1381-1395.

Crimmins, E. M., & Beltrán-Sánchez, H. (2011). Mortality and morbidity trends: is there compression of morbidity?. *The journals of gerontology: series b*, *66*(1), 75-86.

Cruz-Jentoft, A. J., Baeyens, J. P., Bauer, J. M., Boirie, Y., Cederholm, T., Landi, F., ... & Topinková, E. (2010). Sarcopenia: European consensus on definition and diagnosis: report of the european working group on sarcopenia in older people. *Age and ageing*, *39*(4), 412-423.

Da Câmara, S. M. A., Alvarado, B. E., Guralnik, J. M., Guerra, R. O., & Maciel, Á. C. C. (2013). Using the Short Physical Performance Battery to screen for frailty in young-old adults with distinct socioeconomic conditions. *Geriatrics & gerontology international*, *13*(2), 421-428.

Davis, M. G., Fox, K. R., Stathi, A., Trayers, T., Thompson, J. L., & Cooper, A. R. (2014). Objectively measured sedentary time and its association with physical function in older adults. *Journal of aging and physical activity*, *22*(4), 474-481.

De Carvalho Bastone, A., & Filho, W. J. (2004). Effect of an exercise program on functional performance of institutionalized elderly. *Journal of rehabilitation research & development*, *41*(5), 659-668.

De Jong-Gierveld, J., & Kamphuls, F. (1985). The development of a Rasch-type loneliness scale. *Applied psychological measurement*, *9*(3), 289-299.

De Rezende, L. F. M., Rey-López, J. P., Matsudo, V. K. R., & do Carmo Luiz, O. (2014). Sedentary behavior and health outcomes among older adults: a systematic review. *BMC public health*, *14*(1), 333.

De Souto Barreto, P., Cesari, M., Denormandie, P., Armaingaud, D., Vellas, B., & Rolland, Y. (2017). Exercise or social intervention for nursing home residents with dementia: a pilot randomized, controlled trial. *Journal of the american geriatrics society*, *65*(9), E123-E129.

De Souto Barreto, P., Morley, J. E., Chodzko-Zajko, W., Pitkala, K. H., Weening-Djiksterhuis, E., Rodríguez-Mañas, L., ... & Izquierdo, M. (2016). Recommendations on physical activity and exercise for older adults living in long-term care facilities: a taskforce report. *Journal of the american medical directors association*, *17*(5), 381-392.

Dechamps, A., Diolez, P., Thiaudière, E., Tulon, A., Onifade, C., Vuong, T., ... & Bourdel-Marchasson, I. (2010). Effects of exercise programs to prevent decline in health-related quality of life in highly deconditioned institutionalized elderly persons: a randomized controlled trial. *Archives of internal medicine*, *170*(2), 162-169.

Delbaere, K., Crombez, G., Vanderstraeten, G., Willems, T., & Cambier, D. (2004). Fear-related avoidance of activities, falls and physical frailty. A prospective community-based cohort study. *Age and ageing*, *33*(4), 368-373.

Demark-Wahnefried, W., Clipp, E. C., Morey, M. C., Pieper, C. F., Sloane, R., Snyder, D. C., & Cohen, H. J. (2006). Lifestyle intervention development study to improve physical function in older adults with cancer: outcomes from project LEAD. *Journal of clinical oncology: official journal of the american society of clinical oncology*, *24*(21), 3465-3473.

Demark-Wahnefried, W., Peterson, B. L., Winer, E. P., Marks, L., Aziz, N., Marcom, P. K., ... & Rimer, B. K. (2001). Changes in weight, body composition, and factors influencing energy balance among premenopausal breast cancer patients receiving adjuvant chemotherapy. *Journal of clinical oncology*, *19*(9), 2381-2389.

Den Ouden, M., Bleijlevens, M. H., Meijers, J. M., Zwakhalen, S. M., Braun, S. M., Tan, F. E., & Hamers, J. P. (2015). Daily (in) activities of nursing home residents in their wards: an observation study. *Journal of the american medical directors association*, *16*(11), 963-968.

Derouesne, C., Poitreneau, J., Hugonot, L., Kalafat, M., Dubois, B., & Laurent, B. (1999). Mini-mental state examination: a useful method for the evaluation of the cognitive status of patients by the clinician. Consensual french version. *Presse medicale*, *28*(21), 1141-1148.

Diaz, K. M., & Shimbo, D. (2013). Physical activity and the prevention of hypertension. *Current hypertension reports*, *15*(6), 659-668.

Doerflinger, D. M. C. (2012). Mental status assessment in older adults: Montreal cognitive assessment: MoCA Version 7.1 (original version). *The clinical neuropsychologist*, *25*(1), 119-126.

Dong, X., Milholland, B., & Vijg, J. (2016). Evidence for a limit to human lifespan. *Nature*, *538*(7624), 257-259.

Duan-Porter, W., Cohen, H. J., Demark-Wahnefried, W., Sloane, R., Pendergast, J. F., Snyder, D. C., & Morey, M. C. (2016). Physical resilience of older cancer survivors: an emerging concept. *Journal of geriatric oncology*, *7*(6), 471-478.

Dubois, V., Laurent, M. R., Sinnesael, M., Cielen, N., Helsen, C., Clinckemalie, L., ... & Carmeliet, G. (2014). A satellite cell-specific knockout of the androgen receptor reveals myostatin as a direct androgen target in skeletal muscle. *The FASEB journal*, *28*(7), 2979-2994.

Dunlop, D. D., Song, J., Arntson, E. K., Semanik, P. A., Lee, J., Chang, R. W., & Hootman, J. M. (2015). Sedentary time in US older adults associated with disability in activities of daily living independent of physical activity. *Journal of physical activity and health*, *12*(1), 93-101.

Durrieu, J., Doussau, A., Rieger, A., Terrebonne, E., Bouabdallah, K., Zwolakowski, M. D., ... & Bourdel-Marchasson, I. (2012). Design of a physical activity program to prevent functional decline in onco-geriatric patients (CAPADOGE): A randomized multicenter trial. *The journal of frailty & aging*, *1*(3), 138-143.

Ensrud, K. E., Ewing, S. K., Taylor, B. C., Fink, H. A., Cawthon, P. M., Stone, K. L., ... & Tracy, J. K. (2008). Comparison of 2 frailty indexes for prediction of falls, disability, fractures, and death in older women. *Archives of internal medicine*, *168*(4), 382-389.

Erickson, K. I., Voss, M. W., Prakash, R. S., Basak, C., Szabo, A., Chaddock, L., ... & Wojcicki, T. R. (2011). Exercise training increases size of hippocampus and improves memory. *Proceedings of the national academy of sciences*, *108*(7), 3017-3022.

Esbrí-Víctor, M., Huedo-Rodenas, I., López-Utiel, M., Navarro-López, J. L., Martínez-Reig, M., Serra-Rexach, J. A., ... & Abizanda, P. (2017). Frailty and fear of falling: The FISTAC dtudy. *Journal of frailty and aging*, *6*(3), 136-140.

Eustat. (2014). *Euskal I+G+b Europan koaderno estrategikoa 2014-2020.* Retrieved from: http://www.eustat.eus/elementos/ele0012300/Panorama_de_la_salud_2014_35MB/inf0012374_c.pdf

Eustat. (2018a). *Euskal AEko emakumeen bizi-itxaropena (86,2 urte) altuena da 28-EB osoan*. Retrieved from: http://eu.eustat.eus/elementos/ele0015400/Euskal_AEko_emakumeen_bizi-itxaropena_862_urte_altuena_da_28-EB_osoan/not0015471_e.html

Eustat. (2018b). *Euskal AEko jaiotza-tasa 28-EBko batez bestekoaren oso azpitik da*. Retrieved from: http://eu.eustat.eus/elementos/ele0014300/Euskal_AEko_jaiotza-tasa_28-EBko_batez_bestekoaren_oso_azpitik_da/not0014325_e.html

Eustat. (2018c). *Piramide interaktiboak*. Retrieved from: http://eu.eustat.eus/indic/indicadoresgraficosvistapir.aspx?idgraf=522

Extermann, M., Leeuwenburgh, C., Samiian, L., Sehovic, M., Xu, J., Cubitt, C., ... & Manini, T. M. (2017). Impact of chemotherapy on medium-term physical function and activity of older breast cancer survivors, and associated biomarkers. *Journal of geriatric oncology*, *8*(1), 69-75.

Falck, R. S., Davis, J. C., & Liu-Ambrose, T. (2017). What is the association between sedentary behaviour and cognitive function? A systematic review. *British journal of sports medicine*, *51*(10), 800-811.

Farlie, M. K., Robins, L., Keating, J. L., Molloy, E., & Haines, T. P. (2013). Intensity of challenge to the balance system is not reported in the prescription of balance exercises in randomised trials: a systematic review. *Journal of physiotherapy*, *59*(4), 227-235.

Fearon, K., Strasser, F., Anker, S. D., Bosaeus, I., Bruera, E., Fainsinger, R. L., ... & Davis, M. (2011). Definition and classification of cancer cachexia: an international consensus. *The lancet oncology*, *12*(5), 489-495.

Ferreira, C. B., Teixeira, P. D. S., Alves dos Santos, G., Maya, D., Teles, A., Americano do Brasil, P., ... & Nóbrega, O. D. T. (2018). Effects of a 12-week exercise training program on physical function in institutionalized frail elderly. *Journal of aging research*, 7218102.

Ferrer, A., Formiga, F., Almeda, J., Alonso, J., Brotons, C., & Pujol, R. (2010). Calidad de vida en nonagenarios: género, funcionalidad y riesgo nutricional como factores asociados. *Medicina clínica*, *134*(7), 303-306.

Fess, E. (1992). *Clinical assessment recommendations. Grip strength.* Chicago, USA: american society of hand therapists.

Figueira, H. A., Figueira, A. A., Cader, S. A., Guimarães, A. C., De Oliveira, R. J., Figueira, J. A., ... & Dantas, E. H. (2012). Effects of a physical activity governmental health programme on the quality of life of elderly people. *Scandinavian journal of public health*, *40*(5), 418-422.

Forti, L. N., Njemini, R., Beyer, I., Eelbode, E., Meeusen, R., Mets, T., & Bautmans, I. (2014). Strength training reduces circulating interleukin-6 but not brain-derived neurotrophic factor in community-dwelling elderly individuals. *Age*, *36*(5), 9704.

Frändin, K., Grönstedt, H., Helbostad, J. L., Bergland, A., Andresen, M., Puggaard, L., ... & Hellström, K. (2016). Long-term effects of individually tailored physical training and activity on physical function, well-being and cognition in scandinavian nursing home residents: a randomized controlled trial. *Gerontology*, *62*(6), 571-580.

Freedson, P. S., Melanson, E., & Sirard, J. (1998). Calibration of the computer science and applications, Inc. accelerometer. *Medicine and science in sports and exercise*, *30*(5), 777-781.

Freiberger, E., Kemmler, W., Siegrist, M., & Sieber, C. (2016). Frailty and exercise interventions. *Zeitschrift für gerontologie und geriatrie*, *49*(7), 606-611.

Fried, L. P., Tangen, C. M., Walston, J., Newman, A. B., Hirsch, C., Gottdiener, J., ... & McBurnie, M. A. (2001). Frailty in older adults: evidence for a phenotype. *The journals of gerontology series a: biological sciences and medical sciences*, *56*(3), M146-M157.

Gale, C. R., Cooper, C., Deary, I. J., & Sayer, A. A. (2014). Psychological well-being and incident frailty in men and women: the english longitudinal study of ageing. *Psychological medicine*, *44*(4), 697-706.

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I. M., ... & Swain, D. P. (2011). Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Medicine & science in sports & exercise*, *43*(7), 1334-1359.

Garcia-Garcia, F. J., Avila, G. G., Alfaro-Acha, A., Andres, M. A., Aparicio, M. E., Aparicio, S. H., ... & Rodríguez-Mañas, L. (2011). The prevalence of frailty syndrome in an older population from Spain. The Toledo study for healthy aging. *The journal of nutrition, health & aging*, *15*(10), 852-856.

Giesinger, J. M., Kuijpers, W., Young, T., Tomaszewski, K. A., Friend, E., Zabernigg, A., ... & Aaronson, N. K. (2016). Thresholds for clinical importance for four key domains of the EORTC QLQ-C30: physical functioning, emotional functioning, fatigue and pain. *Health and quality of life outcomes*, *14*(1), 87.

Giné-Garriga, M., Roqué-Fíguls, M., Coll-Planas, L., Sitja-Rabert, M., & Salvà, A. (2014). Physical exercise interventions for improving performance-based measures of physical function in community-dwelling, frail older adults: a systematic review and meta-analysis. *Archives of physical medicine and rehabilitation*, *95*(4), 753-769.

Gioulbasanis, I., Georgoulias, P., Vlachostergios, P. J., Baracos, V., Ghosh, S., Giannousi, Z., ... & Georgoulias, V. (2011). Mini nutritional assessment (MNA) and biochemical markers of cachexia in metastatic lung cancer patients: interrelations and associations with prognosis. *Lung cancer*, *74*(3), 516-520.

Gobbens, R. J., Van Assen, M. A., Luijkx, K. G., Wijnen-Sponselee, M. T., & Schols, J. M. (2010). The Tilburg frailty indicator: psychometric properties. *Journal of the american medical directors association*, *11*(5), 344-355.

Gobierno de España. (2013). *Estrategia española de ciencia y tecnología y de innovación 2013-2020*. Retrieved from: http://www.ciencia.gob.es/stfls/MICINN/Investigacion/FICHEROS/Estrategia_espanola_ciencia_tecnologia_Innovacion.pdf

Goldberg, D., Bridges, K., Duncan-Jones, P., & Grayson, D. (1988). Detecting anxiety and depression in general medical settings. *Bmj*, *297*(6653), 897-899.

Gomes-Osman, J., Cabral, D. F., Morris, T. P., McInerney, K., Cahalin, L. P., Rundek, T., ... & Pascual-Leone, A. (2018). Exercise for cognitive brain health in aging: a systematic review for an evaluation of dose. *Neurology: clinical practice*, *8*(3), 257-265.

Gómez-Gallego, M., Gómez-Amor, J., & Gómez-García, J. (2012). Validación de la versión española de la escala QoL-AD en pacientes con enfermedad de Alzheimer, cuidadores y profesionales sanitarios. *Neurología*, *27*(1), 4-10.

Goodpaster, B. H., Park, S. W., Harris, T. B., Kritchevsky, S. B., Nevitt, M., Schwartz, A. V., ... & Newman, A. B. (2006). The loss of skeletal muscle strength, mass, and quality in older adults: the health, aging and body composition study. *The journals of gerontology series a: biological sciences and medical sciences*, *61*(10), 1059-1064.

Goodwin, P. J., Segal, R. J., Vallis, M., Ligibel, J. A., Pond, G. R., Robidoux, A., ... & Levine, M. (2014). Randomized trial of a telephone-based weight loss intervention in postmenopausal women with breast cancer receiving letrozole: the LISA trial. *Journal of clinical oncology*, *32*(21), 2231-2239.

Gourovitch, M. L., Goldberg, T. E., & Weinberger, D. R. (1996). Verbal fluency deficits in patients with schizophrenia: semantic fluency is differentially impaired as compared with phonologic fluency. *Neuropsychology*, *10*(4), 573-577.

Grönstedt, H., Frändin, K., Bergland, A., Helbostad, J. L., Granbo, R., Puggaard, L., ... & Hellström, K. (2013). Effects of individually tailored physical and daily activities in nursing home residents on activities of daily living, physical performance and physical activity level: a randomized controlled trial. *Gerontology*, *59*(3), 220-229.

Guralnik, J. M., Ferrucci, L., Pieper, C. F., Leveille, S. G., Markides, K. S., Ostir, G. V., ... & Wallace, R. B. (2000). Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. *The journals of gerontology series a: biological sciences and medical sciences*, *55*(4), M221-M231.

Guralnik, J. M., Simonsick, E. M., Ferrucci, L., Glynn, R. J., Berkman, L. F., Blazer, D. G., ... & Wallace, R. B. (1994). A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *Journal of gerontology*, *49*(2), M85-M94.

Hagen, S. A. (2013). *Rising demand for long-term services and supports for elderly people*. Retrieved from: https://www.cbo.gov/publication/44363

Halpern, M. T., Urato, M. P., Lines, L. M., Cohen, J. B., Arora, N. K., & Kent, E. E. (2018). Healthcare experience among older cancer survivors: Analysis of the SEER-CAHPS dataset. *Journal of geriatric oncology*, *9*(3), 194-203.

Hart, T. L., Swartz, A. M., Cashin, S. E., & Strath, S. J. (2011). How many days of monitoring predict physical activity and sedentary behaviour in older adults?. *International journal of behavioral nutrition and physical activity*, *8*, 62.

Hittel, D. S., Axelson, M., Sarna, N., Shearer, J., Huffman, K. M., & Kraus, W. E. (2010). Myostatin decreases with aerobic exercise and associates with insulin resistance. *Medicine and science in sports and exercise*, *42*(11), 2023-2029.

Hofmann, M., Schober-Halper, B., Oesen, S., Franzke, B., Tschan, H., Bachl, N., ... & Wessner, B. (2016). Effects of elastic band resistance training and nutritional supplementation on muscle quality and circulating muscle growth and degradation factors of institutionalized elderly women: the Vienna active ageing study (VAAS). *European journal of applied physiology*, *116*(5), 885-897.

Hopkins, W., Marshall, S., Batterham, A., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine & science in sports & exercise*, *41*(1), 3-13.

Hsu, C. L., Best, J. R., Wang, S., Voss, M. W., Hsiung, R. G., Munkacsy, M., ... & Liu-Ambrose, T. (2017). The impact of aerobic exercise on Fronto-parietal network connectivity and its relation to mobility: an exploratory analysis of a 6-month randomized controlled trial. *Frontiers in human neuroscience*, *11*, 344.

Huang, I. C., Hudson, M. M., Robison, L. L., & Krull, K. R. (2017). Differential impact of symptom prevalence and chronic conditions on quality of life in cancer survivors and non-cancer individuals: a population study. *Cancer epidemiology and prevention biomarkers, 26*(7), 1124-1132.

Huang, T., Larsen, K. T., Ried-Larsen, M., Møller, N. C., & Andersen, L. B. (2014). The effects of physical activity and exercise on brain-derived neurotrophic factor in healthy humans: a review. *Scandinavian journal of medicine and science in sports, 24*(1), 1-10.

Huy, C., Schmidt, M. E., Vrieling, A., Chang-Claude, J., & Steindorf, K. (2012). Physical activity in a german breast cancer patient cohort: one-year trends and characteristics associated with change in activity level. *European journal of cancer*, *48*(3), 297-304.

Hvid, L. G., Nielsen, M. K., Simonsen, C., Andersen, M., & Caserotti, P. (2017). Brain-derived neurotrophic factor (BDNF) serum basal levels is not affected by power training in mobility-limited older adults—a randomized controlled trial. *Experimental gerontology*, *93*, 29-35.

Ice, G. H. (2002). Daily life in a nursing home: Has it changed in 25 years?. *Journal of aging studies*, *16*(4), 345-359.

Ikezoe, T., Asakawa, Y., Shima, H., Kishibuchi, K., & Ichihashi, N. (2013). Daytime physical activity patterns and physical fitness in institutionalized elderly women: an exploratory study. *Archives of gerontology and geriatrics*, *57*(2), 221-225.

INE: Instituto Nacional de Estadística. (2018). *Gasto total y gastos medios de los hogares*. Retrieved from: http://www.ine.es/jaxiT3/Tabla.htm?t=10670&L=0

Ivnik, R. J., Malec, J. F., Tangalos, E. G., Petersen, R. C., Kokmen, E., & Kurland, L. T. (1990). The auditory-verbal learning test (AVLT): norms for ages 55 years and older. *Psychological assessment: a journal of consulting and clinical psychology*, *2*(3), 304-312.

Jansen, C. P., Diegelmann, M., Schnabel, E. L., Wahl, H. W., & Hauer, K. (2017). Life-space and movement behavior in nursing home residents: results of a new sensor-based assessment and associated factors. *BMC geriatrics*, *17*(1), 36.

Janssen, I., Heymsfield, S. B., Baumgartner, R. N., & Ross, R. (2000). Estimation of skeletal muscle mass by bioelectrical impedance analysis. *Journal of applied physiology*, *89*(2), 465-471.

Jerez-Roig, J., Ferreira, L. M. D. B. M., de Araújo, J. R. T., & Lima, K. C. (2017). Functional decline in nursing home residents: A prognostic study. *PloS one*, *12*(5), e0177353.

John, A., Patel, U., Rusted, J., Richards, M., & Gaysina, D. (2018). Affective problems and decline in cognitive state in older adults: a systematic review and meta-analysis. *Psychological medicine*, 1-13.

Jones, A. L., Dwyer, L. L., Bercovitz, A. R., & Strahan, G. W. (2009). The national nursing home survey: 2004 overview. *Vital and health statistics. Series 13, data from the national health survey*, 167, 1-155.

Kaiser, M., Bauer, J. M., Ramsch, C., Uter, W., Guigoz, Y., Cederholm, T., ... & Tsai, A. C. (2009). Validation of the mini nutritional assessment short-form (MNA®-SF): a practical tool for identification of nutritional status. *The journal of nutrition, health and aging*, *13*(9), 782-788.

Kannus, P., Sievänen, H., Palvanen, M., Järvinen, T., & Parkkari, J. (2005). Prevention of falls and consequent injuries in elderly people. *The lancet*, *366*(9500), 1885-1893.

Kato, M., Izumi, K., Hiramatsu, T., & Shogenji, M. (2006). Development of an exercise program for fall prevention for elderly persons in a long-term care facility. *Japan journal of nursing science*, *3*(2), 107-117.

Keeler, E., Guralnik, J. M., Tian, H., Wallace, R. B., & Reuben, D. B. (2010). The impact of functional status on life expectancy in older persons. *Journals of gerontology series a: biomedical sciences and medical sciences*, *65*(7), 727-733.

Kenzik, K. M., Morey, M. C., Cohen, H. J., Sloane, R., & Demark-Wahnefried, W. (2015). Symptoms, weight loss, and physical function in a lifestyle intervention study of older cancer survivors. *Journal of geriatric oncology*, *6*(6), 424-432.

Klassen, O., Schmidt, M. E., Ulrich, C. M., Schneeweiss, A., Potthoff, K., Steindorf, K., & Wiskemann, J. (2017). Muscle strength in breast cancer patients receiving different treatment regimes. *Journal of cachexia, sarcopenia and muscle*, *8*(2), 305-316.

Knaepen, K., Goekint, M., Heyman, E. M., & Meeusen, R. (2010). Neuroplasticity—exercise-induced response of peripheral brain-derived neurotrophic factor. *Sports medicine*, *40*(9), 765-801.

Kohanpour, M. A., Peeri, M., & Azarbayjani, M. A. (2017). The effects of aerobic exercise with lavender essence use on cognitive state and serum brain-derived neurotrophic factor levels in elderly with mild cognitive impairment. *Journal of herbmed pharmacology*, *6*(2), 80-84.

Kojima, G. (2015). Prevalence of frailty in nursing homes: a systematic review and meta-analysis. *Journal of the american medical directors association*, *16*(11), 940-945.

Konopka, A. R., Douglass, M. D., Kaminsky, L. A., Jemiolo, B., Trappe, T. A., Trappe, S., & Harber, M. P. (2010). Molecular adaptations to aerobic exercise training in skeletal muscle of older women. *Journals of gerontology series a: biomedical sciences and medical sciences*, *65*(11), 1201-1207.

Kovacs, E., Sztruhar Jonasne, I., Karoczi, C. K., Korpos, A., & Gondos, T. (2013). Effects of a multimodal exercise program on balance, functional mobility and fall risk in older adults with cognitive impairment: a randomized controlled single-blind study. *European journal of physical and rehabilitation medicine, 49*(5), 639-648.

Kraft, E. (2012). Cognitive function, physical activity, and aging: possible biological links and implications for multimodal interventions. *Aging, neuropsychology, and cognition*, *19*(1-2), 248-263.

Kress, J. P., & Herridge, M. S. (2012). Medical and economic implications of physical disability of survivorship. *Seminars in respiratory and critical care medicine, 33*(4), 339-347.

Król-Zielińska, M., Kusy, K., Zieliński, J., & Osiński, W. (2011). Physical activity and functional fitness in institutionalized vs. independently living elderly: A comparison of 70–80-year-old city-dwellers. *Archives of gerontology and geriatrics*, *53*(1), e10-e16.

Kuys, S. S., Peel, N. M., Klein, K., Slater, A., & Hubbard, R. E. (2014). Gait speed in ambulant older people in long term care: a systematic review and meta-analysis. *Journal of the american medical directors association*, *15*(3), 194-200.

Kwon, S., Perera, S., Pahor, M., Katula, J. A., King, A. C., Groessl, E. J., & Studenski, S. A. (2009). What is a meaningful change in physical performance? Findings from a clinical trial in older adults (the LIFE-P study). *The journal of nutrition, health and aging*, *13*(6), 538-544.

Laffon de Mazières, C. L., Morley, J. E., Levy, C., Agenes, F., Barbagallo, M., Cesari, M., ... & Izquierdo, M. (2017). Prevention of functional decline by reframing the role of nursing homes?. *Journal of the american medical directors association*, *18*(2), 105-110.

Lakshman, K. M., Bhasin, S., Corcoran, C., Collins-Racie, L. A., Tchistiakova, L., Forlow, S. B., ... & LaVallie, E. R. (2009). Measurement of myostatin concentrations in human serum: circulating concentrations in young and older men and effects of testosterone administration. *Molecular and cellular endocrinology*, *302*(1), 26-32.

Large, J., Gan, N., Basic, D., & Jennings, N. (2006). Using the timed up and go test to stratify elderly inpatients at risk of falls. *Clinical rehabilitation*, *20*(5), 421-428.

Leckie, R. L., Oberlin, L. E., Voss, M. W., Prakash, R. S., Szabo-Reed, A., Chaddock-Heyman, L., ... & Martin, S. A. (2014). BDNF mediates improvements in executive function following a 1-year exercise intervention. *Frontiers in human neuroscience*, *8*, 985.

Lee, I. M., & Shiroma, E. J. (2014). Using accelerometers to measure physical activity in large-scale epidemiological studies: issues and challenges. *British journal of sports medicine*, *48*(3), 197-201.

Lee, I. M., Shiroma, E. J., Evenson, K. R., Kamada, M., LaCroix, A. Z., & Buring, J. E. (2018). Using devices to assess physical activity and sedentary behavior in a large cohort study: the women’s health study. *Journal for the measurement of physical behaviour*, *1*(2), 60-69.

Lee, S. J. (2004). Regulation of muscle mass by myostatin. *Annual review of cell and developmental biology. 20*, 61-86.

Leong, D. P., Teo, K. K., Rangarajan, S., Lopez-Jaramillo, P., Avezum Jr, A., Orlandini, A., ... & Rahman, O. (2015). Prognostic value of grip strength: findings from the prospective urban rural epidemiology (PURE) study. *The lancet*, *386*(9990), 266-273.

Lewington, S., Whitlock, G., Clarke, R., Sherliker, P., Emberson, J., Halsey, J., ... & Collins, R. (2007). Blood cholesterol and vascular mortality by age, sex, and blood pressure: a meta-analysis of individual data from 61 prospective studies with 55000 vascular deaths. *The lancet, 372*(9635), 292-292.

Ligibel, J. A., Meyerhardt, J., Pierce, J. P., Najita, J., Shockro, L., Campbell, N., ... & Marshall, J. (2012). Impact of a telephone-based physical activity intervention upon exercise behaviors and fitness in cancer survivors enrolled in a cooperative group setting. *Breast cancer research and treatment*, *132*(1), 205-213.

Liu, C. J., & Latham, N. K. (2009). Progressive resistance strength training for improving physical function in older adults. *The cochrane database of systematic reviews*, (3), CD002759.

Liu-Ambrose, T., Nagamatsu, L. S., Graf, P., Beattie, B. L., Ashe, M. C., & Handy, T. C. (2010). Resistance training and executive functions: a 12-month randomized controlled trial. *Archives of internal medicine*, *170*(2), 170-178.

Lobo, A., Santos, P., Carvalho, J., & Mota, J. (2008). Relationship between intensity of physical activity and health-related quality of life in portuguese institutionalized elderly. *Geriatrics & gerontology international*, *8*(4), 284-290.

Lobo, A., Saz, P., Marcos, G., Día, J. L., de la Cámara, C., Ventura, T., ... & Aznar, S. (1999). Revalidación y normalización del mini-examen cognoscitivo (primera versión en castellano del mini-mental status examination) en la población general geriátrica. *Medicina Clínica (Barcelona)*, *112*(20), 767-74.

Lok, N., Lok, S., & Canbaz, M. (2017). The effect of physical activity on depressive symptoms and quality of life among elderly nursing home residents: Randomized controlled trial. *Archives of gerontology and geriatrics*, *70*, 92-98.

Marfell-Jones, M. J., Stewart, A. D., & de Ridder, J. H. (2012). *International standards for anthropometric assessment*. Wellington, New Zealand: International society for the advancement of kinanthropometry.

Martín, I. S. M., Barato, V. P., Oliva, S. L., Rodríguez, M., Yurrita, L. C., Cabañas, M. J. C., ... & Pascual, P. E. (2018). Body composition, dietary, and gustatory function assessment in people with Alzheimer's disease. *American journal of Alzheimer's disease & other dementias®, 33*(8), 508-515.

Mather, A. S., Rodriguez, C., Guthrie, M. F., McHarg, A. M., Reid, I. C., & McMurdo, M. E. (2002). Effects of exercise on depressive symptoms in older adults with poorly responsive depressive disorder: randomised controlled trial. *The british journal of psychiatry*, *180*(5), 411-415.

Matthews, V., Åström, M. B., Chan, M. H. S., Bruce, C. R., Krabbe, K. S., Prelovsek, O., ... & Penkowa, M. (2009). Brain-derived neurotrophic factor is produced by skeletal muscle cells in response to contraction and enhances fat oxidation via activation of AMP-activated protein kinase. *Diabetologia*, *52*(7), 1409-1418.

Mavros, Y., Gates, N., Wilson, G. C., Jain, N., Meiklejohn, J., Brodaty, H., ... & Baker, M. K. (2017). Mediation of cognitive function improvements by strength gains after resistance training in older adults with mild cognitive impairment: outcomes of the study of mental and resistance training. *Journal of the american geriatrics society*, *65*(3), 550-559.

McGough, E. L., Kelly, V. E., Logsdon, R. G., McCurry, S. M., Cochrane, B. B., Engel, J. M., & Teri, L. (2011). Associations between physical performance and executive function in older adults with mild cognitive impairment: gait speed and the timed "up & go" test. *Physical therapy*, *91*(8), 1198-1207.

McSween, M., McMahon, K., Coombes, J., MacKay, C., Rodriguez, A., Erickson, K., & Copland, D. (2018). The immediate effects of acute aerobic exercise on cognition in healthy older adults: a systematic review. *Journal of science and medicine in sport*, *21*, S95.

Meng, S. J., & Yu, L. J. (2010). Oxidative stress, molecular inflammation and sarcopenia. *International journal of molecular sciences*, *11*(4), 1509-1526.

Mhaoláin, A. M. N., Gallagher, D., Crosby, L., Ryan, D., Lacey, L., Coen, R. F., ... & Lawlor, B. (2012). Frailty and quality of life for people with Alzheimer's dementia and mild cognitive impairment. *American journal of Alzheimer's disease & other dementias®*, *27*(1), 48-54.

Migueles, J. H., Cadenas-Sanchez, C., Ekelund, U., Nyström, C. D., Mora-Gonzalez, J., Löf, M., ... & Ortega, F. B. (2017). Accelerometer data collection and processing criteria to assess physical activity and other outcomes: a systematic review and practical considerations. *Sports medicine*, *47*(9), 1821-1845.

Milanović, Z., Pantelić, S., Trajković, N., Sporiš, G., Kostić, R., & James, N. (2013). Age-related decrease in physical activity and functional fitness among elderly men and women. *Clinical interventions in aging*, *8*, 549-556.

Miljkovic, N., Lim, J. Y., Miljkovic, I., & Frontera, W. R. (2015). Aging of skeletal muscle fibers. *Annals of rehabilitation medicine*, *39*(2), 155-162.

Miller, M. D., Paradis, C. F., Houck, P. R., Mazumdar, S., Stack, J. A., Rifai, A. H., ... & Reynolds III, C. F. (1992). Rating chronic medical illness burden in geropsychiatric practice and research: application of the cumulative illness rating scale. *Psychiatry research*, *41*(3), 237-248.

Mimi, M. Y., Tang, S. K., Wan, V. T., & Vong, S. K. (2014). The effectiveness of physical exercise training in pain, mobility, and psychological well-being of older persons living in nursing homes. *Pain management nursing*, *15*(4), 778-788.

Miranda, M. (2011). *Análisis dinamométrico de la mano: valores normativos en la población española* (Tesis doctoral). Universidad Complutense de Madrid, facultad de medicina, Madrid, España.

Miskelly, F. (2005). Electronic tracking of patients with dementia and wandering using mobile phone technology. *Age and ageing*, *34*(5), 497-499.

Montero-Fernandez, N., & Serra-Rexach, J. A. (2013). Role of exercise on sarcopenia in the elderly. *European journal of physical and rehabilitation medicine*, *49*(1), 131-143.

Morey, M. C., Snyder, D. C., Sloane, R., Cohen, H. J., Peterson, B., Hartman, T. J., ... & Demark-Wahnefried, W. (2009). Effects of home-based diet and exercise on functional outcomes among older, overweight long-term cancer survivors: RENEW: a randomized controlled trial. *Journal of the american medical association*, *301*(18), 1883-1891.

Morley, J. E., Vellas, B., Van Kan, G. A., Anker, S. D., Bauer, J. M., Bernabei, R., ... & Fried, L. P. (2013). Frailty consensus: a call to action. *Journal of the american medical directors association*, *14*(6), 392-397.

Mulrow, C. D., Gerety, M. B., Kanten, D., Cornell, J. E., DeNino, L. A., Chiodo, L., ... & Solis, R. M. (1994). A randomized trial of physical rehabilitation for very frail nursing home residents. *Journal of the american medical association*, *271*(7), 519-524.

Nagai, K., Miyamato, T., Okamae, A., Tamaki, A., Fujioka, H., Wada, Y., ... & Domen, K. (2018). Physical activity combined with resistance training reduces symptoms of frailty in older adults: a randomized controlled trial. *Archives of gerontology and geriatrics*, *76*, 41-47.

Nelson, M. E., Rejeski, W. J., Blair, S. N., Duncan, P. W., Judge, J. O., King, A. C., ... & Castaneda-Sceppa, C. (2007). Physical activity and public health in older adults: recommendation from the american college of sports medicine and the american heart association. *Circulation*, *116*(9), 1094-1105.

Ng, T. P., Feng, L., Nyunt, M. S. Z., Feng, L., Niti, M., Tan, B. Y., ... & Yap, K. B. (2015). Nutritional, physical, cognitive, and combination interventions and frailty reversal among older adults: a randomized controlled trial. *The american journal of medicine*, *128*(11), 1225-1236.

Norris, M. P., Blankenship-Reuter, L., Snow-Turek, A. L., & Finch, J. (1995). Influence of depression on verbal fluency performance. *Aging, neuropsychology, and cognition*, *2*(3), 206-215.

Oh, S. H., Kim, D. K., Lee, S. U., Jung, S. H., & Lee, S. Y. (2017). Association between exercise type and quality of life in a community-dwelling older people: a cross-sectional study. *PloS one*, *12*(12), e0188335.

Olabarrieta-Landa, L., Caracuel, A., Pérez-García, M., Panyavin, I., Morlett-Paredes, A., & Arango-Lasprilla, J. C. (2016). The profession of neuropsychology in Spain: Results of a national survey. *The clinical neuropsychologist*, *30*(8), 1335-1355.

Ouyang, P., Yatsuya, H., Toyoshima, H., Otsuka, R., Wada, K., Matsushita, K., ... & Muramatsu, T. (2009). Changes in activities of daily living, physical fitness, and depressive symptoms after six-month periodic well-rounded exercise programs for older adults living in nursing homes or special nursing facilities. *Nagoya journal of medical science*, *71*(3-4), 115-126.

Pachana, N. A., Boone, K. B., Miller, B. L., Cummings, J. L., & Berman, N. (1996). Comparison of neuropsychological functioning in Alzheimer's disease and frontotemporal dementia. *Journal of the international neuropsychological society*, *2*(6), 505-510.

Pahor, M., Blair, S.N., Espeland, M., Fielding, R., Gill, T.M., Guralnik, J.M., … & Miller, M. E. (2006). Effects of a physical activity intervention on measures of physical performance: Results of the lifestyle interventions and independence for Elders Pilot (LIFE-P) study. *The journals of gerontology series a: biological sciences and medical sciences*, *61*(11), 1157-1165.

Pahor, M., Guralnik, J. M., Ambrosius, W. T., Blair, S., Bonds, D. E., Church, T. S., ... & King, A. C. (2014). Effect of structured physical activity on prevention of major mobility disability in older adults: the LIFE study randomized clinical trial. *Journal of the american medical association*, *311*(23), 2387-2396.

Pamoukdjian, F., Lévy, V., Sebbane, G., Boubaya, M., Landre, T., Bloch-Queyrat, C., ... & Zelek, L. (2017). Slow gait speed is an independent predictor of early death in older cancer outpatients: results from a prospective cohort study. *The journal of nutrition, health & aging*, *21*(2), 202-206.

Park, H., Kim, K. J., Komatsu, T., Park, S. K., & Mutoh, Y. (2008). Effect of combined exercise training on bone, body balance, and gait ability: a randomized controlled study in community-dwelling elderly women. *Journal of bone and mineral metabolism*, *26*(3), 254-259.

Parkin, A. J., Belinchón, M., & Vargas, J. R. (1999). *Exploraciones en neuropsicología cognitiva*. Madrid, España: Médica panamericana.

Patra, P., Alikari, V., Fradelos, E. C., Sachlas, A., Kourakos, M., Rojas, G. A., ... & Zyga, S. (2017). Assessment of depression in elderly. Is perceived social support related? A nursing home study: depression and social support in elderly. *Advances in experimental medicine and biology*, *987*, 139-150.

Pavasini, R., Guralnik, J., Brown, J. C., Di Bari, M., Cesari, M., Landi, F., ... & Stenholm, S. (2016). Short physical performance battery and all-cause mortality: systematic review and meta-analysis. *BMC medicine*, *14*(1), 215.

Paw, M. J. C. A., Van Poppel, M. N., Twisk, J. W., & Van Mechelen, W. (2006). Once a week not enough, twice a week not feasible?: A randomised controlled exercise trial in long-term care facilities [ISRCTN87177281]. *Patient education and counseling*, *63*(1-2), 205-214.

Penedo, F. J., & Dahn, J. R. (2005). Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Current opinion in psychiatry*, *18*(2), 189-193.

Peng, L. N., Lee, W. J., Liu, L. K., Lin, M. H., & Chen, L. K. (2018). Healthy community-living older men differ from women in associations between myostatin levels and skeletal muscle mass. *Journal of cachexia, sarcopenia and muscle, 9*(4), 635-642.

Pereira, C., Fernandes, J., Raimundo, A., Biehl-Printes, C., Marmeleira, J., & Tomas-Carus, P. (2016). Increased physical activity and fitness above the 50th percentile avoid the threat of older adults becoming institutionalized: a cross-sectional pilot study. *Rejuvenation research*, *19*(1), 13-20.

Pereira, C., Rosado, H., Cruz-Ferreira, A., & Marmeleira, J. (2018). Effects of a 10-week multimodal exercise program on physical and cognitive function of nursing home residents: a psychomotor intervention pilot study. *Aging clinical and experimental research, 30*(5), 471-479.

Perera, S., Mody, S. H., Woodman, R. C., & Studenski, S. A. (2006). Meaningful change and responsiveness in common physical performance measures in older adults. *Journal of the american geriatrics society*, *54*(5), 743-749.

Perissinotto, C. M., Cenzer, I. S., & Covinsky, K. E. (2012). Loneliness in older persons: a predictor of functional decline and death. *Archives of internal medicine*, *172*(14), 1078-1084.

Phillips, C. B., Edwards, J. D., Andel, R., & Kilpatrick, M. (2016). Daily physical activity and cognitive function variability in older adults. *Journal of aging and physical activity*, *24*(2), 256-267.

Pialoux, T., Goyard, J., & Lesourd, B. (2012). Screening tools for frailty in primary health care: a systematic review. *Geriatrics & gerontology international*, *12*(2), 189-197.

Pickard, L., Comas-Herrera, A., Costa-Font, J., Gori, C., di Maio, A., Patxot, C., ... & Wittenberg, R. (2007). Modelling an entitlement to long-term care services for older people in Europe: projections for long-term care expenditure to 2050. *Journal of european social policy*, *17*(1), 33-48.

Podsiadlo, D., & Richardson, S. (1991). The timed “up & go”: a test of basic functional mobility for frail elderly persons. *Journal of the american geriatrics society*, *39*(2), 142-148.

Ponton, M. O. (2001). Research and assessment issues with hispanic populations. In *neuropsychology and the hispanic patient* (pp. 51-70). Mahwah, USA: Lawrence erlbaum associates, publishers.

Portegijs, E., Rantakokko, M., Viljanen, A., Sipilä, S., & Rantanen, T. (2016). Is frailty associated with life-space mobility and perceived autonomy in participation outdoors? A longitudinal study. *Age and ageing*, *45*(4), 550-553.

Pratesi, A., Tarantini, F., & Di Bari, M. (2013). Skeletal muscle: an endocrine organ. *Clinical cases in mineral and bone metabolism*, *10*(1), 11-14.

Prince, M., Prina, M., & Guerchet, M. (2013). *World Alzheimer report 2013. Journey of caring. An analysis of long-term care for dementia*. London, England: Alzheimer's disease International.

Puthoff, M. L. (2008). Outcome measures in cardiopulmonary physical therapy: short physical performance battery. *Cardiopulmonary physical therapy journal*, *19*(1), 17-22.

Puts, M. T. E., Toubasi, S., Andrew, M. K., Ashe, M. C., Ploeg, J., Atkinson, E., ... & McGilton, K. (2017). Interventions to prevent or reduce the level of frailty in community-dwelling older adults: a scoping review of the literature and international policies. *Age and ageing*, *46*(3), 383-392.

Raoux, N., Le, M. G., Auriacombe, S., Dartigues, J. F., & Amieva, H. (2010). Semantic and letter fluency tasks: normative data in an elderly population of 70 years old and over from the PAQUID cohort. *Revue neurologique*, *166*(6-7), 594-605.

Rasmussen, P., Brassard, P., Adser, H., Pedersen, M. V., Leick, L., Hart, E., ... & Pilegaard, H. (2009). Evidence for a release of brain-derived neurotrophic factor from the brain during exercise. *Experimental physiology*, *94*(10), 1062-1069.

Reid, K. F., Naumova, E. N., Carabello, R. J., Phillips, E. M., & Fielding, R. A. (2008). Lower extremity muscle mass predicts functional performance in mobility-limited elders. *The journal of nutrition health and aging*, *12*(7), 493-498.

Reitan, R. M., & Wolfson, D. (1985). The Halstead-Reitan neuropsychological test battery. In *contemporary approaches to neuropsychological assessment.* Boston, USA: Springer.

Rikli, R. E., & Jones, C. J. (2001). *Senior fitness test manual*. Champaign, USA: Human kinetics.

Rizzoli, R., Reginster, J. Y., Arnal, J. F., Bautmans, I., Beaudart, C., Bischoff-Ferrari, H., ... & Cooper, C. (2013). Quality of life in sarcopenia and frailty. *Calcified tissue international*, *93*(2), 101-120.

Robertson, D. A., Savva, G. M., & Kenny, R. A. (2013). Frailty and cognitive impairment—a review of the evidence and causal mechanisms. *Ageing research reviews*, *12*(4), 840-851.

Robinovitch, S. N., Feldman, F., Yang, Y., Schonnop, R., Leung, P. M., Sarraf, T., ... & Loughin, M. (2013). Video capture of the circumstances of falls in elderly people residing in long-term care: an observational study. *The lancet*, *381*(9860), 47-54.

Rockwood, K., Song, X., MacKnight, C., Bergman, H., Hogan, D. B., McDowell, I., & Mitnitski, A. (2005). A global clinical measure of fitness and frailty in elderly people. *Canadian medical association journal*, *173*(5), 489-495.

Rodgers, B. D., & Garikipati, D. K. (2008). Clinical, agricultural, and evolutionary biology of myostatin: a comparative review. *Endocrine reviews*, *29*(5), 513-534.

Rodriguez-Larrad, A., Arrieta, H., Rezola, C., Kortajarena, M., Yanguas, J. J., Iturburu, M., ... & Irazusta, J. (2017). Effectiveness of a multicomponent exercise program in the attenuation of frailty in long-term nursing home residents: study protocol for a randomized clinical controlled trial. *BMC geriatrics*, *17*(1), 60.

Rodríguez-López, S., Montero, P., Carmenate, M., & Avendano, M. (2014). Functional decline over 2 years in older spanish adults: Evidence from the survey of health, ageing and retirement in Europe. *Geriatrics & gerontology international*, *14*(2), 403-412.

Rodríguez-Mañas, L., Féart, C., Mann, G., Viña, J., Chatterji, S., Chodzko-Zajko, W., ... & Scuteri, A. (2012). Searching for an operational definition of frailty: a Delphi method based consensus statement. The frailty operative definition-consensus conference project. *Journals of gerontology series a: biomedical sciences and medical sciences*, *68*(1), 62-67.

Rodríguez-Mañas, L., & Fried, L. P. (2015). Frailty in the clinical scenario. *The lancet*, *385*(9968), e7-e9.

Rodríguez-Rodríguez, V., Rodríguez-Mañas, L., Sancho-Castiello, M., & Díaz-Martín, R. (2012). Envejecimiento. La investigación en España y Europa. *Revista española de geriatría y gerontología*, *47*(4), 174-179.

Rogers, L. Q. (2010). Objective monitoring of physical activity after a cancer diagnosis: challenges and opportunities for enhancing cancer control. *Physical therapy reviews*, *15*(3), 224-237.

Rolland, Y., Pillard, F., Klapouszczak, A., Reynish, E., Thomas, D., Andrieu, S., ... & Vellas, B. (2007). Exercise program for nursing home residents with Alzheimer's disease: a 1-year randomized, controlled trial. *Journal of the american geriatrics society*, *55*(2), 158-165.

Rosano, C., Newman, A. B., Katz, R., Hirsch, C. H., & Kuller, L. H. (2008). Association between lower digit symbol substitution test score and slower gait and greater risk of mortality and of developing incident disability in well-functioning older adults. *Journal of the american geriatrics society*, *56*(9), 1618-1625.

Rosenberg, D. E., Bellettiere, J., Gardiner, P. A., Villarreal, V. N., Crist, K., & Kerr, J. (2015). Independent associations between sedentary behaviors and mental, cognitive, physical, and functional health among older adults in retirement communities. *Journals of gerontology series a: Biomedical sciences and medical sciences*, *71*(1), 78-83.

Rosendahl, E., Gustafson, Y., Nordin, E., Lundin-Olsson, L., & Nyberg, L. (2008). A randomized controlled trial of fall prevention by a high-intensity functional exercise program for older people living in residential care facilities. *Aging clinical and experimental research*, *20*(1), 67-75.

Rowland, J. H., & Bellizzi, K. M. (2014). Cancer survivorship issues: life after treatment and implications for an aging population. *Journal of clinical oncology*, *32*(24), 2662-2668.

Rubenstein, L. Z., Josephson, K. R., & Osterweil, D. (1996). Falls and fall prevention in the nursing home. *Clinics in geriatric medicine*, *12*(4), 881-902.

Ruscheweyh, R., Willemer, C., Krüger, K., Duning, T., Warnecke, T., Sommer, J., ... & Flöel, A. (2011). Physical activity and memory functions: an interventional study. *Neurobiology of aging*, *32*(7), 1304-1319.

Sacha, J., Sacha, M., Soboń, J., Borysiuk, Z., & Feusette, P. (2017). Is it time to begin a public campaign concerning frailty and pre-frailty? A review article. *Frontiers in physiology*, *8*, 484.

Sahin, U. K., Kirdi, N., Bozoglu, E., Meric, A., Buyukturan, G., Ozturk, A., & Doruk, H. (2018). Effect of low-intensity versus high-intensity resistance training on the functioning of the institutionalized frail elderly. *International journal of rehabilitation research*, *41*(3), 211-217.

Santos-Eggimann, B., Cuénoud, P., Spagnoli, J., & Junod, J. (2009). Prevalence of frailty in middle-aged and older community-dwelling europeans living in 10 countries. *The journals of gerontology series a: biological sciences and medical sciences*, *64*(6), 675-681.

Sayer, A. A., & Kirkwood, T. B. (2015). Grip strength and mortality: a biomarker of ageing?. *The lancet*, *386*(9990), 226-227.

Scaccianoce, S., Del Bianco, P., Paolone, G., Caprioli, D., Modafferi, A. M., Nencini, P., & Badiani, A. (2006). Social isolation selectively reduces hippocampal brain-derived neurotrophic factor without altering plasma corticosterone. *Behavioural brain research*, *168*(2), 323-325.

Schafer, M. J., Atkinson, E. J., Vanderboom, P. M., Kotajarvi, B., White, T. A., Moore, M. M., ... & Miller, J. D. (2016). Quantification of GDF11 and myostatin in human aging and cardiovascular disease. *Cell metabolism*, *23*(6), 1207-1215.

Scharf, G., & Heineke, J. (2012). Finding good biomarkers for sarcopenia. *Journal of cachexia, sarcopenia and muscle*, *3*(3), 145-148.

Schrack, J. A., Gresham, G., & Wanigatunga, A. A. (2017). Understanding physical activity in cancer patients and survivors: new methodology, new challenges, and new opportunities. *Cold spring harbor molecular case studies*, *3*(4).

Schulte, J. N., & Yarasheski, K. E. (2001). Effects of resistance training on the rate of muscle protein synthesis in frail elderly people. *International journal of sport nutrition and exercise metabolism*, *11*(s1), S111-S118.

Schulz, C., Lindlbauer, I., Rapp, K., Becker, C., & König, H. H. (2017). Long-term effectiveness of a multifactorial fall and fracture prevention program in bavarian nursing homes: an analysis based on health insurance claims data. *Journal of the american medical directors association*, *18*(6), 552.e7-552.e17.

Scully, T. (2012). To the limit: more people are surviving to older ages than ever before, pushing life expectancy from birth to unprecedented highs. Further gains will require tackling age-related conditions, across the world, with ramifications for society as a whole. *Nature*, *492*(7427), S2-S2.

Serrani, D. J. L. (2013). Spanish translation and validation of an executive battery 25 (EB25) and its shortened version (ABE12) for executive dysfunction screening in dementia. *Neurología (english edition)*, *28*(8), 457-476.

Serra-Rexach, J. A., Bustamante-Ara, N., Hierro Villarán, M., González Gil, P., Sanz Ibáñez, M. J., Blanco Sanz, N., ... & Rodríguez Romo, G. (2011). Short-term, light-to moderate-intensity exercise training improves leg muscle strength in the oldest old: a randomized controlled trial. *Journal of the american geriatrics society*, *59*(4), 594-602.

Shega, J. W., Andrew, M., Hemmerich, J., Cagney, K. A., Ersek, M., Weiner, D. K., & Dale, W. (2012). The relationship of pain and cognitive impairment with social vulnerability—an analysis of the canadian study of health and aging. *Pain medicine*, *13*(2), 190-197.

Shi, C. (2014). Interventions for preventing falls in older people in care facilities and hospitals. *Orthopaedic nursing*, *33*(1), 48-49.

Shiroma, E. J., Freedson, P. S., Trost, S. G., & Lee, I. M. (2013). Patterns of accelerometer-assessed sedentary behavior in older women. *Journal of the american medical association*, *310*(23), 2562-2563.

Shumway-Cook, A., Baldwin, M., Polissar, N. L., & Gruber, W. (1997). Predicting the probability for falls in community-dwelling older adults. *Physical therapy*, *77*(8), 812-819.

Smith, G. L., Banting, L., Eime, R., O'Sullivan, G., & Van Uffelen, J. G. (2017). The association between social support and physical activity in older adults: a systematic review. *International journal of behavioral nutrition and physical activity*, *14*(1), 56.

Smith, P. J., Blumenthal, J. A., Hoffman, B. M., Cooper, H., Strauman, T. A., Welsh-Bohmer, K., ... & Sherwood, A. (2010). Aerobic exercise and neurocognitive performance: a meta-analytic review of randomized controlled trials. *Psychosomatic medicine*, *72*(3), 239-252.

Solheim, T. S., Laird, B. J., Balstad, T. R., Stene, G. B., Bye, A., Johns, N., ... & Kaasa, S. (2017). A randomized phase II feasibility trial of a multimodal intervention for the management of cachexia in lung and pancreatic cancer. *Journal of cachexia, sarcopenia and muscle*, *8*(5), 778-788.

Stigger, F. S., Zago-Marcolino, M. A., Portela, K. M., & Plentz, R. D. M. (2018). Effects of exercise on inflammatory, oxidative, and neurotrophic biomarkers on cognitively impaired individuals diagnosed with dementia or mild cognitive impairment: A systematic review and meta-analysis. *The journals of gerontology series a: biological sciences and medical sciences.* Doi: 10.1093/gerona/gly173.

St. John, P. D., Tyas, S. L., & Montgomery, P. R. (2013). Depressive symptoms and frailty. *International journal of geriatric psychiatry*, *28*(6), 607-614.

Ströhle, A., Stoy, M., Graetz, B., Scheel, M., Wittmann, A., Gallinat, J., ... & Hellweg, R. (2010). Acute exercise ameliorates reduced brain-derived neurotrophic factor in patients with panic disorder. *Psychoneuroendocrinology*, *35*(3), 364-368.

Studenski, S., Perera, S., Patel, K., Rosano, C., Faulkner, K., Inzitari, M., ... & Nevitt, M. (2011). Gait speed and survival in older adults. *Journal of the american medical association*, *305*(1), 50-58.

Sturnieks, D. L., St George, R., & Lord, S. R. (2008). Balance disorders in the elderly. *Neurophysiologie clinique/Clinical neurophysiology*, *38*(6), 467-478.

Swartz, M. C., Lewis, Z. H., Lyons, E. J., Jennings, K., Middleton, A., Deer, R. R., ... & Goodwin, J. S. (2017). Effect of home-and community-based physical activity interventions on physical function among cancer survivors: a systematic review and meta-analysis. *Archives of physical medicine and rehabilitation*, *98*(8), 1652-1665.

Swift, D. L., Johannsen, N. M., Lavie, C. J., Earnest, C. P., & Church, T. S. (2014). The role of exercise and physical activity in weight loss and maintenance. *Progress in cardiovascular diseases*, *56*(4), 441-447.

Szulc, P., Schoppet, M., Goettsch, C., Rauner, M., Dschietzig, T., Chapurlat, R., & Hofbauer, L. C. (2012). Endocrine and clinical correlates of myostatin serum concentration in men—the STRAMBO study. *The journal of clinical endocrinology & metabolism*, *97*(10), 3700-3708.

Tarazona-Santabalbina, F. J., Gómez-Cabrera, M. C., Pérez-Ros, P., Martínez-Arnau, F. M., Cabo, H., Tsaparas, K., ... & Viña, J. (2016). A multicomponent exercise intervention that reverses frailty and improves cognition, emotion, and social networking in the community-dwelling frail elderly: a randomized clinical trial. *Journal of the american medical directors association*, *17*(5), 426-433.

Taylor, D. (2014). Physical activity is medicine for older adults. *Postgraduate medical journal*, *90*(1059), 26-32.

Telenius, E. W., Engedal, K., & Bergland, A. (2015). Long-term effects of a 12 weeks high-intensity functional exercise program on physical function and mental health in nursing home residents with dementia: a single blinded randomized controlled trial. *BMC geriatrics*, *15*(1), 158.

The, L. P. H. (2017). Ageing: a 21st century public health challenge?. *The lancet. Public health*, *2*(7), e297.

Tintle, N., Bacon, B., Kostyuchenko, S., Gutkovich, Z., & Bromet, E. J. (2011). Depression and its correlates in older adults in Ukraine. *International journal of geriatric psychiatry*, *26*(12), 1292-1299.

Tolea, M. I., & Galvin, J. E. (2015). Sarcopenia and impairment in cognitive and physical performance. *Clinical interventions in aging*, *10*, 663-671.

Toots, A., Littbrand, H., Lindelöf, N., Wiklund, R., Holmberg, H., Nordström, P., ... & Rosendahl, E. (2016). Effects of a high-intensity functional exercise program on dependence in activities of daily living and balance in older adults with dementia. *Journal of the american geriatrics society*, *64*(1), 55-64.

Trevisan, C., Veronese, N., Maggi, S., Baggio, G., Toffanello, E. D., Zambon, S., ... & Manzato, E. (2017). Factors influencing transitions between frailty states in elderly adults: the progetto veneto anziani longitudinal study. *Journal of the american geriatrics society*, *65*(1), 179-184.

Troiano, R. P., Berrigan, D., Dodd, K. W., Masse, L. C., Tilert, T., & McDowell, M. (2008). Physical activity in the United States measured by accelerometer. *Medicine and science in sports and exercise*, *40*(1), 181-188.

Trombetti, A., Hars, M., Hsu, F. C., Reid, K. F., Church, T. S., Gill, T. M., ... & Newman, A. B. (2018). Effect of physical activity on frailty: secondary analysis of a randomized controlled trial. *Annals of internal medicine*, *168*(5), 309-316.

Tsai, L. T., Portegijs, E., Rantakokko, M., Viljanen, A., Saajanaho, M., Eronen, J., & Rantanen, T. (2015). The association between objectively measured physical activity and life-space mobility among older people. *Scandinavian journal of medicine & science in sports*, *25*(4), e368-e373.

Vagetti, G. C., Barbosa Filho, V. C., Moreira, N. B., Oliveira, V. D., Mazzardo, O., & Campos, W. D. (2014). Association between physical activity and quality of life in the elderly: a systematic review, 2000-2012. *Revista brasileira de psiquiatria*, *36*(1), 76-88.

Viccaro, L. J., Perera, S., & Studenski, S. A. (2011). Is timed up and go better than gait speed in predicting health, function, and falls in older adults?. *Journal of the american geriatrics society*, *59*(5), 887-892.

Vidoni, E. D., Johnson, D. K., Morris, J. K., Van Sciver, A., Greer, C. S., Billinger, S. A., ... & Burns, J. M. (2015). Dose-response of aerobic exercise on cognition: a community-based, pilot randomized controlled trial. *PLoS one*, *10*(7), e0131647.

Volkers, K. M., & Scherder, E. J. (2011). Impoverished environment, cognition, aging and dementia. *Reviews in the neurosciences*, *22*(3), 259-266.

Volpato, S., Cavalieri, M., Sioulis, F., Guerra, G., Maraldi, C., Zuliani, G., ... & Guralnik, J. M. (2010). Predictive value of the short physical performance battery following hospitalization in older patients. *Journals of gerontology series a: biomedical sciences and medical sciences*, *66*(1), 89-96.

Von Haehling, S., Morley, J. E., Coats, A. J., & Anker, S. D. (2017). Ethical guidelines for publishing in the journal of cachexia, sarcopenia and muscle: update 2017. *Journal of cachexia, sarcopenia and muscle*, *8*(6), 1081-1083.

Voss, M. W., Vivar, C., Kramer, A. F., & van Praag, H. (2013). Bridging animal and human models of exercise-induced brain plasticity. *Trends in cognitive sciences*, *17*(10), 525-544.

Wade, D. T., & Collin, C. (1988). The Barthel ADL Index: a standard measure of physical disability?. *International disability studies*, *10*(2), 64-67.

Wagner, K. H., Cameron-Smith, D., Wessner, B., & Franzke, B. (2016). Biomarkers of aging: from function to molecular biology. *Nutrients*, *8*(6), 338.

Wechsler, D. (2010). *WAIS–IV UK administrative and scoring manual*. Harlow, England: Pearson.

Welmer, A. K., Rizzuto, D., Qiu, C., Caracciolo, B., & Laukka, E. J. (2014). Walking speed, processing speed, and dementia: a population-based longitudinal study. *Journals of gerontology series a: biomedical sciences and medical sciences*, *69*(12), 1503-1510.

Wetherell, J. L., Reynolds, C. A., Gatz, M., & Pedersen, N. L. (2002). Anxiety, cognitive performance, and cognitive decline in normal aging. *The journals of gerontology series b: psychological sciences and social sciences*, *57*(3), P246-P255.

White, T. A., & LeBrasseur, N. K. (2014). Myostatin and sarcopenia: opportunities and challenges-a mini-review. *Gerontology*, *60*(4), 289-293.

WHO: World Health Organization. (2007). *Global age-friendly cities.* Retrieved from: https://www.who.int/ageing/publications/Global_age_friendly_cities_Guide_English.pdf

WHO: World Health Organization. (2012). Good health adds life to years. Retrieved from: http://apps.who.int/iris/bitstream/handle/10665/70853/WHO_DCO_WHD_2012.2_eng.pdf;jsessionid=34CAE8ADC36821FFE938B64FB98BEABF?sequence=1

WHO: World Health Organization. (2015). *World report on ageing and health.* Retrieved from: *http://apps.who.int/iris/bitstream/handle/10665/186463/9789240694811_eng.pdf?sequence=1*

WHO: World Health Organization. (2016). Action plan for the prevention and control of noncommunicable diseases in the WHO European Region. Retrieved from: https://nutrimento.pt/activeapp/wp-content/uploads/2016/09/NCDActionPlan.pdf

Wiener, J. M. (2003). An assessment of strategies for improving quality of care in nursing homes. *The gerontologist*, *43*(suppl_2), 19-27.

Wong, G. K. C., Mak, J. S. Y., Wong, A., Zheng, V. Z. Y., Poon, W. S., Abrigo, J., & Mok, V. C. T. (2017). Minimum clinically important difference of montreal cognitive assessment in aneurysmal subarachnoid hemorrhage patients. *Journal of clinical neuroscience*, *46*, 41-44.

Yanovski, S. Z., Hubbard, V. S., Heymsfield, S. B., & Lukashi, H. C. (1996). Bioelectrical impedance analysis in body composition measurement: National institutes of health technology assessment conference statement. *The american journal of clinical nutrition*, *64*(3), 524S-532S.

Yarasheski, K. E., Bhasin, S., Sinha-Hikim, I., Pak-Loduca, J., & Gonzalez-Cadavid, N. F. (2002). Serum myostatin-immunoreactive protein is increased in 60-92 year old women and men with muscle wasting. *Journal of nutrition health and aging*, *6*(5), 343-348.

Zaslavsky, O., Rillamas-Sun, E., Li, W., Going, S., Datta, M., Snetselaar, L., & Zelber-Sagi, S. (2017). Association of dynamics in lean and fat mass measures with mortality in frail older women. *The journal of nutrition, health & aging*, *21*(1), 112-119.

Zhao, K. X., Huang, C. Q., Xiao, Q., Gao, Y., Liu, Q. X., Wang, Z. R., ... & Xie, Y. Z. (2012). Age and risk for depression among the elderly: a meta-analysis of the published literature. *CNS spectrums*, *17*(3), 142-154.

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Physical training maintains or improves gait ability in long-term nursing home residents: A systematic review of randomized controlled trials

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ABSTRACT

Numerous studies have reported the benefits of physical exercise in older adults. However, studies performed in long-term nursing home (LTNH) residents are scarce. A literature search was conducted to identify physical exercise intervention studies that were randomized and controlled and that assessed gait ability in older LTNH residents using both walking speed and timed up-and-go (TUG) tests simultaneously. Together, these tests have been defined under the term "gait ability"; they are widely used to screen for impaired physical function, and can predict accelerated functional decline, difficulty with activities of daily living (ADL), falls, and disability in older adults. Multicomponent physical exercise programs are effective in improving or maintaining gait ability in older LTNH residents. The studies included in this review show substantial heterogeneity in terms of participant characteristics (age, baseline TUG performance, and walking speed), types of evaluated intervention (multicomponent and gait retraining programs), duration of the intervention (ranging from four weeks to 12 months), duration of physical exercise sessions (ranging from 30 min to 1 h), and exercise intensity (from 40% to 60–70% RM). Due to this heterogeneity, no firm conclusions can be drawn regarding the impact of exercise programs on gait ability in LTNH residents. However, the results of this review should encourage the gathering of additional evidence to support the use of multicomponent exercise programs by older individuals.

1. Introduction

The World Health Organization (WHO) recently published an Action Plan for the Prevention and Control of Non-Communicable Diseases in the WHO European Region from 2016 to 2025 [1]. This action plan highlights the importance of encouraging musculoskeletal health programs for older individuals. Worldwide projections predict that the number of dependent older adults will increase from 350 million in 2010 to 488 million in 2030 [2]. The dependency on the activities of daily living (ADL) leads individuals to move to long-term nursing homes (LTNH), so this growth will directly influence the percentage of older adults residing in LTNHs in the coming years [3]. Because walking is possible for a certain proportion of LTNH residents, proactive prevention programs encompassing musculoskeletal health may be particularly relevant to preserve walking ability in those individuals.

Physical exercise programs are interventions meant to prevent or slow the functional decline of older adults living in LTNHs [4]. In community dwelling older adults, exercise has been found to reduce all-cause mortality as well as the risk of falls and fractures as a result of falling [5,6]. Nevertheless, substantial evidence supporting the efficacy and feasibility of these programs in LTNH settings is scarce. Further, people residing in LTNHs spend most of the day time taking part in sedentary activities. Bates-Jensen et al. [7] studied the amount of time that 451 residents of 15 LTNHs spent in bed and found that most of the residents spent at least 17 h a day in bed. Although the efficacy of physical exercise programs has been demonstrated for community dwelling older adults, few studies have analyzed the relevance of these programs in LTNHs.

Functional decline in older adults is driven mainly by impairments to gait ability. In particular, walking speed [8–11] and timed up-and-go (TUG) [12,13] are two bedside tests that screen for impaired functionality in older adults. In fact, the capacity for walking and for standing from a chair are key factors for identifying functional decline in older adults; thus, it seems particularly relevant to assess these capacities together. Indeed, walking speed and TUG tests together have been defined under the term "gait ability", and are found to predict accelerated functional decline, ADL difficulty, falls, and disability in older adults [14,15]. A usual walking speed of less than 1 m/s seems to identify people at risk of health-related outcomes in well-functioning

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older people [9]. However, older adults living in long-term care settings show slower performance in gait speed: a recent systematic review [16] found that usual pace gait speed in ambulant older people remained functional at 0.47 m/s. A recognized fall prevention guideline recommends the TUG test to screen for the presence of gait and balance disorders in older adults [17]. In fact, retrospective studies showed a significant positive association between the time taken to perform the TUG and a history of falls, where the cut-off time separating non-fallers and fallers varies from 10 to 32.6 s [18]. Unfortunately, the predictive ability of the TUG test for future falls remains limited [19].

Exercise interventions can be beneficial for frail older adults. However, there is no clear guidance regarding the most effective program indications for LTNH residents. Due to their sedentary behavior, this population stands to be positively affected by physical exercise. The objective of this study was to systematically review the impact of physical exercise interventions performed by residents of LTNHs in terms of gait ability parameters, interpreted as a result of assessing both TUG test and walking speed simultaneously. We have included the TUG test and walking speed as outcome measures because they are two of the most frequent parameters used to assess functional decline, and they have been previously analyzed together to measure the gait ability performance of older adults [20]. To the best of our knowledge, this is the first systematic review of randomized controlled trials (RCT) investigating the efficacy of exercise interventions and focused on gait ability in older adults who live in LTNHs.

2. Materials and methods

2.1. Literature search and study selection

This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [21,22]. Relevant peer-reviewed literature was obtained by searching four electronic databases until 28 April 2017: MEDLINE (Medical Literature Analysis and Retrieval System on-line), PubMed, Cochrane, PEDro and Web of Science. The search strategy is shown in Table 1.

Articles fulfilling the following criteria were included: (1) randomized controlled trials (RCT); (2) peer-reviewed articles that were published in English, French, or Spanish; (3) interventions carried out in LTNH settings; (4) two or more physical exercise interventions were compared or one intervention was compared to a control group that continued usual care or low intensity Range Of Motion exercises (ROM); and (5) gait speed and TUG tests were assessed together as outcome variables. The “Get Up and Go” test [23] was also accepted as equivalent to the TUG test, as both involve performing the same procedure, standing from a chair, walking three meters, turning, going back, and sitting down on the same chair. The TUG test measures the performance by timing the task, while the “Get Up and Go” test scores the result subjectively as a function of instability from 1 to 5 (1 = no instability; 5 = very abnormal). Both gait speed and TUG tests were selected as endpoint measurements of results based on their capacity to measure physical impairment in the studied population. No limits were applied concerning the type, duration, or frequency of the physical exercise interventions.

Table 1
Search strategy performed by the authors in *MEDLINE (Pubmed)*.

#1 “institutionalized” [All Fields]
#2 “nursing home” [Mesh]
#3 “long-term care” [Mesh]
#4 (#1 OR #2 OR #3)
#5 “exercis*” [All Fields]
#6 “physical performance” [All Fields]
#7 “training” [All Fields]
#8 (#5 OR #6 OR #7)
#9 “ability to walk” [All Fields]
#10 “ambulation” [All Fields]
#11 “walking” [Mesh]
#12 (#9 OR #10 OR #11)
#13 (#4 AND #8)
#14 (#4 AND #12)
#15 (#4 AND #8 AND #12)

Articles were excluded if: (1) the physical exercise intervention was rehabilitation or treatment focused; (2) they were abstracts, dissertations, conference proceedings, pilot studies, reviews, or meta-analyses; (3) the study combined physical exercise intervention with nutritional supplementation.

Thereafter, a backward search was performed, reviewing reference lists of included articles in search of further relevant citations. After removal of duplicates, the titles and abstracts of all references obtained in the search were screened. The full text of those that were eligible was assessed against the inclusion and exclusion criteria by two authors (H.A., C.R.). Disagreements were resolved by consensus with a third author (A.R-L.).

2.2. Risk of bias assessment and data analysis

The Cochrane Handbook for Systematic Reviews criteria [24] was used for rating the risk of bias of the included studies, independently assessed by three reviewers (H.A., C.R., and A.R-L.). Unpublished data were requested when necessary from the authors of the original studies. Disagreements were resolved by consensus. In this analysis, the maximum possible score was 10, given that it was not possible to blind the participants and the professionals administering the intervention; accordingly, results should be considered cautiously. These two items were marked as “not applicable”. Studies that met ≥5 of the 10 identified criteria were considered to have a low risk of bias.

The heterogeneity of the interventions across the studies did not allow for a meta-analysis. Therefore, a qualitative analysis was carried out, critically assessing the methodological quality of the included studies and the consistency of their findings.

3. Results

A final sample of seven studies [25–31] met the inclusion criteria for this systematic review. A flow diagram of the selection process is presented in Fig. 1. Details of the participants and the interventions are summarized in Table 2.

3.1. Description of the population

Baseline functional characteristics of participants varied across studies. The mean average age ranged between 78.4 and 92.0 years for the control group and 75.4–93.4 years for the intervention group. Participant gait speed was higher than 0.47 m/s in four of the seven studies [25–28], and participants needed as little as 15.7s ± 4.4 s to perform the TUG test in the study by Au-Yeung et al. [25] as opposed to 131.3 s ± 85.4 s in the study by Tsaih et al. [31] (Table 2).

3.2. Type of activities of control groups

Participants in the control groups mostly performed ROM exercises [25,26,28,30,31], while others continued with their routine medical care [27,29].

3.3. Description of the evolution of control groups

All the studies included in this review reported worse results for the control groups in the TUG test after the intervention period [25–31]. Regarding gait speed, five studies reported worse results for the control groups [25–27,30,31] and two reported an improvement [28,29]. Three studies analyzed differences within the control group, and

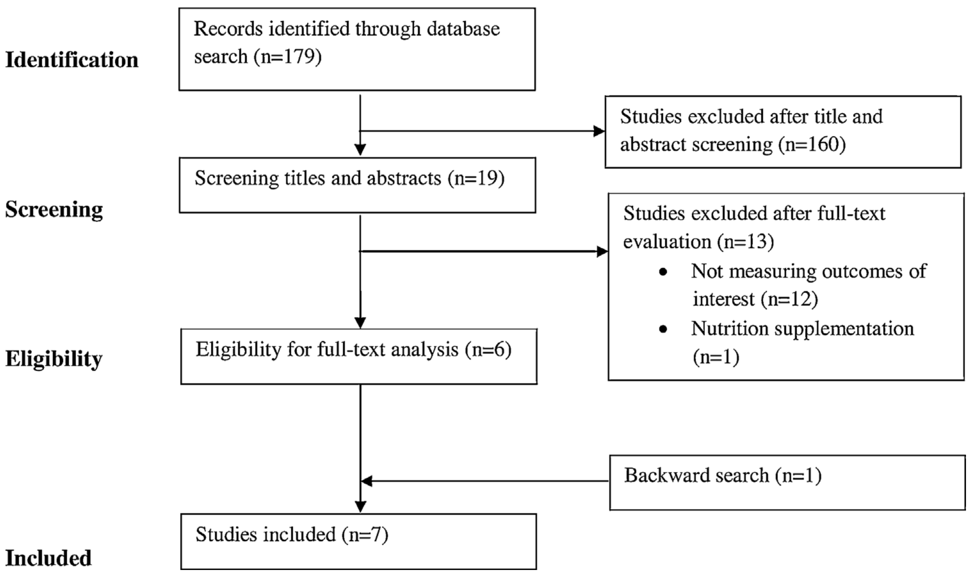

Fig. 1. Flow diagram of the systematic review.

significant differences were reported in two studies [26,27].

3.4. Type of activities of exercise interventions

Six studies assessed multicomponent programs [25–30], focusing the core of the exercises on resistance and balance training, and the remaining study investigated a gait retraining program [31].

The programs assessed low [31] or low-to-moderate (40% and up to 60–70% RM) exercise intensities [25–30], with different findings in the outcomes of interest, as described earlier. None of the studies assessed moderate-to-vigorous exercise programs.

The duration of the interventions included in this review range from four weeks [31] up to 12 months [29]. With the exception of the Tsaih et al. [31] study, only multicomponent exercise interventions that lasted at least three months obtained significant differences between the intervention and control groups in the TUG and/or gait speed tests [26,28,29]. However, taking into account the heterogeneity of the participants and interventions analyzed in this review, more studies are needed to reach stronger conclusions.

Two studies stated that the interventions utilized did not cause any adverse effects and are feasible to carry out in older adults that live in LTNHs [28,30]. Rolland et al. [29] reported five falls during the exercise sessions, one of which resulted in a scalp wound; even so, the authors concluded that the program was safe. Serra-Rexach et al. [30] described a mild muscle pain after a strengthening exercise. However, the rest of the studies did not report any concern regarding exercise safety [25,26,31].

3.5. Description of the evolution of exercise interventions

Three studies including multicomponent [26,28], and gait retraining [31], reported an improvement of the TUG test after the intervention, while other multicomponent studies showed similar [25] or worse results [27,29,30]. Regarding gait speed, five multicomponent [25,26,28–30] and gait retraining [31] programs showed an improvement after the intervention, while another multicomponent program showed similar results [27]. Three studies analyzed differences within the intervention group, and only a multicomponent program was associated with significant improvements [26].

3.6. Comparison of control and intervention groups

For multicomponent exercise programs, two studies [26,28] showed significant differences between the intervention and the control groups in the TUG test after the program, whereas the rest of studies did not find statistically significant differences [25,27,29,30]. Two studies [26,29] that included walking or gait retraining programs combined with resistance and balance exercises found significant group versus time interaction improvements in walking speed.

A gait retraining program showed significant differences with the control group in the TUG test and walking speed [31]. Note that the results of this study on the TUG and gait speed tests at baseline were noticeably worse compared with the results of the rest of the studies included in this review.

3.7. Methodological quality

The assessment of the methodological quality of the included studies is shown in Table 3. Three studies achieved a score of 10 out of 10 [26,30,31], another study scored 9 points [25], and three studies scored 8 points [27–29]. All studies described the randomization and allocation procedure and were single-blinded. Likewise, all of them performed intention-to-treat analysis. Small sample sizes were analyzed in most studies, which may lead to inaccurate statistical results (three studies with $n < 50$, two with n between 50 and 100, and only two with $n > 100$). Dropout rates were adequately described and considered between normal ranges except in one study [25], where the loss to follow up rose to 42%. It is remarkable also that even if the rate of dropouts in the study by Lazowski et al. [28] was similar to other studies (29%), it was double (67%) for the intervention group compared to the control group (33%). Importantly, the studies included in the present systematic review have a low risk of bias that was independently agreed upon by the authors.

4. Discussion

The studies included in this review show substantial heterogeneity in terms of participant characteristics (age, baseline TUG performance, and walking speed), types of evaluated intervention (multicomponent interventions, and gait retraining interventions), duration of the interventions (ranging from four weeks to 12 months), and the duration of physical exercise-based sessions (ranging from 30 min to 1 h). On this basis alone, even without analyzing the results, the conclusions should be considered with caution.

None of the included studies described any serious accidents or injuries sustained during the program. These results agree with a previous systematic review that evaluated whether progressive resistance training improves strength and functional performance in older adults

Table 2
Characteristics of the studies included.

Study	Subjects	CG		IG			Outcomes	
			Type[a]	Dose	Frequency/duration	TUG	Gait Speed	Balance
Au-Yeung et al., 2002 (Hong Kong) [25]	$n = 31$	ROM	Type 2, 3	45 min per session	3/week × 2 months	CG mean: 15.67 ± 4.40 s to 16.01 ± 6.05s; $p > 0.05$	CG mean: 0.69m/s to 0.61m/s; $p > 0.05$	CG mean in BBS: 47.3 ± 5.6Pts to 51.6 ± 3.9Pts; $p < 0.05$
	13 dropped out (42%)					IG mean: 16.47 ± 7.63 s to 16.42 ± 6.09s; $p > 0.05$	IG mean: 0.67m/s to 0.70m/s; $p > 0.05$	IG mean changed in BBS from 50.8 ± 3.29Pts to 49.8 ± 4.21Pts; $p > 0.05$
	Mean age: CG:81.0; IG:79.1; $p > 0.05$ 75% in the CG and 70% in the IG were able to walk independently and unaided Inclusion criteria: able to understand and follow verbal instructions, ambulate independently with or without walking aids, and tolerate standing and walking for at least 5 min					Group interaction; $p > 0.05$	Group interaction; $p > 0.05$	Group interaction in BBS; $p < 0.05$
Cadore et al., 2014 (Spain) [26]	$n = 32$	ROM	Type 1,2,3	40 min per session	2/week × 3 months	CG mean: 18.4 ± 5.1 s to 21.8 ± 6.3s; $p > 0.05$	CG mean: 0.68 ± 0.1 m/s to 0.60 ± 0.1m/s; $p < 0.05$	CG mean in FICSIT-4: 0.36 ± 0.5Pts to 0.3 ± 0.5Pts; $p > 0.05$
	8 dropped out (25%)					IG mean: 19.9 ± 8.0 s to 18.8 ± 7.9s; $p < 0.05$	IG mean: 0.76 ± 0.1 m/s to 0.80 ± 0.1m/s; $p > 0.05$	IG mean in FICSIT-4: 0.44 ± 0.5Pts to 0.66 ± 0.5Pts; $p > 0.05$
	Mean age: CG:90.1; IG:93.4; $p > 0.05$ Barthel Index was > 60 for all participants and they were able to walk independently without help of another person Inclusion criteria: > 85 years and met Fried's criteria for frailty					Group interaction; $p < 0.01$	Group interaction; $p < 0.05$	Group interaction; $p < 0.05$
Dechamps et al., 2010 (France) [27]	$n = 160$	Routine medical care	Type 8 (AT Group) and type 2,3,4 (CA Group)	30 min (Group 1) and 30–40 min (Group 2)	4/week (Group 1) and 2/week (Group 2) × 6 months	CG mean: 12.3 ± 6.4Pts CB +2.5Pts; $p < 0.005$	CG mean: 0.53 ± 0.36m/s CB −0.16m/s; $p < 0.001$	
	14 dropped out (9%)					AT mean: 11.6 ± 6.6Pts CB +0.9Pts; $p > 0.05$	AT mean: 0.58 ± 0.29m/s CB −0.02m/s; $p > 0.05$	
	Mean age: CG:80.9; AT:83.0; CA:83.2; $p > 0.05$					CA mean: 11.9 ± 6.3Pts CB +0.5Pts; $p > 0.05$	CA mean: 0.52 ± 0.36m/s CB −0.00m/s; $p > 0.05$	

(*continued on next page*)

Table 2 (*continued*)

Study	Subjects	CG	IG			Outcomes		
			Type[a]	Dose	Frequency/duration	TUG	Gait Speed	Balance
	ADL: CG:5.3; AT:3.4; CA:4.7 Inclusion criteria: ≥65 years, living in an institution for more than 6 months, have the ability to get up alone or with technical or human help if necessary, and able to understand basic motor commands							
Lazowski et al., 1999 (Canada) [28]	$n = 96$ 28 dropped out (29%) Mean age: CG:80.4; IG:79.7; $p > 0.05$ FIM: CG:110.4; IG:114.7 Inclusion criteria: able to stand with minimal assistance (e.g. cueing, supervision) and follow simple instructions/demonstrations or mimic the actions of the instructor	ROM	Type 2,3,4,5	45 min per session	3/week × 4 months	CG mean: 26.8 ± 17.4 s to 33.0 ± 35.1s IG mean: 22.0 ± 15.2 s to 18.3 ± 11,9s Group interaction; $p < 0.05$	CG mean: 0.57 ± 0.27 m/s to 0.61 ± 0.31m/s IG mean: 0.69 ± 0.28 m/s to 0.73 ± 0.33m/s Group interaction; $p > 0.05$	CG mean in BBS: 35.9 ± 13.1Pts to 35.4 ± 12.0Pts IG mean in BBS: 43.7 ± 10.6Pts to 47.6 ± 8.4Pts Group interaction; $p < 0.005$
Rolland et al., 2007 (France) [29]	$n = 134$ 17 dropped out (13%) Mean age: CG:83.1; IG:82.8; $p > 0.05$ ADL: CG:3.1; IG:3.2 Inclusion criteria: Diagnosis of AD or a Mini-Mental State Examination (MMSE) score of less than 25, have lived in the nursing home for at least 2 months, and be able to transfer from a chair and walk at least 6 m without human assistance	Routine medical care	Type 2,3,4,5	60 min per session	2/week × 12 months	CG mean in get-up-and-go test: 2.7 ± 0.8Pts to 3.0 ± 1.0Pts IG mean in get-up-and-go test: 2.7 ± 0.8Pts to 3.0 ± 1.1Pts Group interaction; $p > 0.05$	CG mean: 0.33 ± 0.14 m/s to 0.37 ± 0.17m/s IG mean: 0.33 ± 0.14 m/s to 0.41 ± 0.17m/s; $p < 0.001$ Group interaction; $p < 0.05$	
Serra-Resach et al., 2011 (Spain) [30]	$n = 43$	ROM	Type 2,4,6,7	45–50 min/session (type 2,4,6) and 40–45 min/session (type 7)	3/week (type 2,4,6) and 2/week (type 7) × 8 weeks	CG mean: 22.8 ± 8.0 s to 23.7 ± 6.1s	CG mean: 0.41 ± 0.25 m/s to 0.34 ± 0.20m/s	

(*continued on next page*)

Table 2 (*continued*)

Study	Subjects	CG	IG			Outcomes	
			Type[a]	Dose	Frequency/duration	TUG	Gait Speed	Balance
	5 dropped out (12%) Mean age: CG:92; IG:92; $p > 0.05$ 40% in the CG and 45% in the IG were able to walk independently and unaided Inclusion criteria: ≥90 years old, planning to stay in the same nursing home during the study, able to ambulate, able to communicate					IG mean: 24.0 ± 9.4 s to 28.5 ± 21.7s Group interaction; $p > 0.05$	IG mean: 0.38 ± 0.29 m/s to 0.42 ± 0.28m/s Group interaction; $p > 0.05$	
Tsaih et al., 2012 (Taiwan) [31]	$n = 59$ 9 dropped out (15% completed) Mean age: CG:78.4; IG:75.4; $p > 0.05$ Barthel Index: CG:9.9; IG:11.4 Inclusion criteria: ambulation challenged, able to regain walking function after 4-wk intervention	ROM	Type 1	30–45 min per session	3/week × 4 weeks	CG mean: 142.6 ± 101.8 s to 143.1 ± 101.3s IG mean: 131.3 ± 85.4 s to 98.5 ± 60.8s Group interaction; $p < 0.01$	CG mean: 0.15 ± 0.15 m/s to 0.12 ± 0.13m/s IG mean: 0.14 ± 0.15 m/s to 0.20 ± 0.17m/s Group interaction; $p < 0.001$	CG mean in BBS: 20.7 ± 14.0Pts to 20.2 ± 15.1Pts IG mean in BBS: 23.5 ± 13.9Pts to 29.1 ± 13.4Pts Group interaction in BBS; $p < 0.005$

Note. CG = Control Group; IG = Intervention Group; AD = Alzheimer's disease; CA = Cognition-Action; AT = Adapted Tai Chi; ADL = Activity of Daily Living score; FIM = Functional Independence Measure; ROM = Range of Motion; TUG = Timed-Up & Go test; CB = Change from Baseline; Pts = Points; BBS = Berg Balance Scale.

[a] Intervention – Type 1) Gait Retraining 2) Resistance training 3) Balance training, 4) Flexibility training 5) Walking program 6) Mobility exercises 7) Cycling 8) Adapted Tai Chi.

Table 3
Risk of bias of the studies included.

Source of risk of bias	Lazowski et al. [28]	Au-Yeung et al. [25]	Rolland et al. [29]	Dechamps et al. [27]	Serra-Rexach et al. [30]	Tsaih et al. [31]	Cadore et al. [26]
1. Was the method of randomization adequate?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Was treatment allocation concealed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was knowledge of allocated interventions adequately prevented during the study?							
3. Were participants blinded to the intervention?	NA	NA	NA	NA	NA	NA	NA
4. Was the care provider blinded to the intervention?	NA	NA	NA	NA	NA	NA	NA
5. Was the outcome assessor blinded to the intervention?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were incomplete outcome data adequately addressed?							
6. Was the dropout rate described and acceptable?	No	No	Yes	Yes	Yes	Yes	Yes
7. Were all randomized participants analyzed in the group to which they were allocated?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8. Are reports of the study free of suggestion of selective outcome reporting?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other sources of potential bias:							
9. Were the groups similar at baseline regarding the most important prognostic indicators?	No	Yes	No	No	Yes	Yes	Yes
10. Were co-interventions avoided or comparable?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11. Was the compliance acceptable in all groups?	Yes	Yes	No	No	Yes	Yes	Yes
12. Was the timing of the outcome assessment in all groups similar?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TOTAL SCORE	**8**	**9**	**8**	**8**	**10**	**10**	**10**

NA: not applicable.

living in LTNHs [32]. Thus, there is a considerable body of evidence to support the safety of engaging with exercise programs in this older adult population.

The studies that evaluated a multicomponent intervention reported significant improvements [26,28,29] or positive trends [25,30] in gait ability (TUG performance or walking speed) compared to control groups with the exception of one study in which the performance of the participants in the control group significantly worsened while the intervention groups showed no improvement or worsening conditions [27]. These results coincide with the findings of previous studies [33,34] in which the authors concluded that physical exercise, especially when multiple conditioning components are included (i.e. strength, endurance, and balance), is a key factor for the maintenance of the functionality of older adults living in LTNHs. Emerging evidence indicates that multicomponent interventions seem to be the most beneficial for the prevention of functional decline in people who live in LTNHs, and particularly, for the maintenance or improvement of gait ability. In addition, all the included studies have evaluated exercise programs at low to moderate training intensities, showing that it could be enough to maintain or improve the gait ability in older adults living in LTNHs. However, the dose-response relationship between the intensity of training and functional performance was not taken into account in any of the studies [35]; it is possible that high-intensity progressive training performed by frail older adults could result in greater functional improvements than low to moderate programs. Even so, further research is needed to determine the optimum intensity for the physical exercise programs that focus more on safety and feasibility of these kinds of programs in LTNH environment.

It should also be noted that control group participants in all the included studies showed a decline in gait ability parameters throughout the intervention period. These results agree with those reported in the IQUARE study by de Souto et al. [36], where data from 175 LTNHs were analyzed. A period of 18 months living in a LTNH was found to be enough to reduce the functionality of the residents in the activities of daily living (assessed with an ADL score), when compared to the level reported at baseline. This could be explained to a great extent by the partial or completely sedentary environment in which institutionalized people coexist. It has been reported that LTNH residents spend 65.5% of their day in passive activities conducted in a seated position and only walk for 0.9% of the daytime [37]. In fact, in a study by Lobo, Santos, Carvalho, and Mota [38] that aimed to explore the relationship between health related quality of life and objectively measured intensity of physical activity, the authors observed that the levels of physical activity were much lower than those recommended, even taking into account the fact that the study only included participants that were independent or moderately dependent in daily life activities. Therefore, in agreement with the conclusions arrived at by the Task Force of Experts in LTNH care and research [4], the results of the present review support the urgent need for cultural change to incorporate physical activity to prevent or slow the functional decline in people living in LTNHs.

To the best of our knowledge, this is the first systematic review investigating the efficacy of physical exercise interventions directed to improve or maintain gait ability in older adults living in LTNHs. Previous reviews have focused on the effects of exercise on health and well-being or in physical functioning of individuals living with dementia [33,39], or have limited their analysis to a progressive resistance training intervention [32]. Despite these differences, our findings agree with what has been previously reported. However, there are some methodological issues relating to the present review that need to be addressed. On the one hand, there is a remarkable heterogeneity in the characteristics of the participants, type of interventions, and training protocols among the studies. For this reason, it was not possible to perform a meta-analysis. On the other hand, the included studies have all shown a low risk of bias.

The most relevant finding of this systematic review is that physical exercise programs based on multicomponent interventions are effective, safe, and significantly improve or maintain gait ability in older adults living in LTNHs. Older adults who practice healthy lifestyles and participate in physical exercise are more likely to remain healthy, live independently, and incur fewer health-related costs [40]. This report should encourage the development of recommendations for implementing exercise programs in LTNHs and other geriatric care facilities. Further research is needed to specifically determine which are the most effective and feasible physical exercise protocols (in terms of intensity, frequency, and duration) for maintaining gait ability and slowing functional decline and disability in older adults.

Contributors

Haritz Arrieta participated in the study concept and design, data extraction (abstracts and full texts), independent review of full articles, data analysis and interpretation and drafting of the manuscript.

Chloe Rezola participated in the study concept and design, data extraction (abstracts and full texts), independent review of full articles, quality review and interpretation and drafting of the manuscript.

Susana María Gil participated in the study concept and design, and editing and reviewing of the manuscript.

Jon Irazusta participated in the study concept and design, and editing and reviewing of the manuscript.

Ana Rodriguez-Larrad participated in the study concept and design, independent review of full articles, and drafting of the manuscript.

All authors saw and approved the final version.

Conflict of interest

The authors report no conflict of interest.

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Provenance and peer review

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References

[1] World Health Organisation, Regional committee for Europe 66th session, Action Plan for the Prevention and Control of Noncommunicable Diseases in the WHO European Region, WHO, Copenhagen, 2016 Retrieved March 3rd, 2017, from http://www.euro.who.int/_data/assets/pdf_file/0011/315398/66wd11e_NCDActionPlan_160522.pdf?ua=1.

[2] M. Prince, M. Prina, M. Guerchet, Journey of Caring, An Analysis of Long-term Care for Dementia. World Alzheimer Report 2013, Alzheimer's Disease International, London, 2013 http://www.alz.co.uk/research/WorldAlzheimerReport2013.pdf.

[3] S. Hagen, Rising Demand for Long-Term Services and Supports for Elderly People, (2013) https://www.cbo.gov/sites/default/files/113th-congress-2013-2014/reports/44363-ltc.pdf.

[4] C. Laffon de Mazières, J.E. Morley, C. Levy, et al., Prevention of functional decline by reframing the role of nursing homes? J. Am. Med. Dir. Assoc. 18 (2017) 105–110.

[5] G.L. Smith, L. Banting, R. Eime, G. O'Sullivan, J.G. van Uffelen, The association between social support and physical activity in older adults: a systematic review, Int. J. Behav. Nutr. Phys. Act. 14 (2017) 56.

[6] H. Park, K.J. Kim, T. Komatsu, S.K. Park, Y. Mutoh, Effect of combined exercise training on bone, body balance, and gait ability: a randomized controlled study in community-dwelling elderly women, J. Bone Miner. Metab. 26 (2008) 254–259.

[7] B.M. Bates-Jensen, C.A. Alessi, M. Cadogan, et al., The Minimum Data Set bedfast quality indicator: differences among nursing homes, Nurs. Res. 53 (2004) 260–272.

[8] M. Cesari, S.B. Kritchevsky, A.B. Newman, et al., Added value of physical performance measures in predicting adverse health-related events: results from the health, aging and body composition study, J. Am. Geriatr. Soc. 57 (2009) 251–259.

[9] M. Cesari, S.B. Kritchevsky, B.W.H.J. Penninx, et al., Prognostic value of usual gait speed in well-functioning older people – results from the health, aging and body composition study, J. Am. Geriatr. Soc. 53 (2005) 1675–1680.

[10] C. Rosano, A.B. Newman, R. Katz, C.H. Hirsch, L.H. Kuller, Association between lower digit symbol substitution test score and slower gait and greater risk of mortality and of developing incident disability in well-functioning older adults, J. Am. Geriatr. Soc. 56 (2008) 1618–1625.

[11] S. Studenski, S. Perera, K. Patel, et al., Gait speed and survival in older adults, JAMA 305 (2011) 50–58.

[12] H.A. Bischoff, H.B. Stähelin, A.U. Monsch, et al., Identifying a cut-off point for normal mobility: a comparison of the timed 'up and go' test in community-dwelling and institutionalised elderly women, Age Ageing 32 (2003) 315–320.

[13] R.W. Bohannon, Reference values for the timed up and go test: a descriptive meta-analysis, J. Geriatr. Phys. Ther. 29 (2006) 64–68.

[14] L.J. Viccaro, S. Perera, S.A. Studenski, Is timed up and go better than gait speed in predicting health function, and falls in older adults? J. Am. Geriatr. Soc. 59 (2011) 887–892.

[15] E.L. McGough, V.E. Kelly, R.G. Logsdon, S.M. McCurry, B.B. Cochrane, J.M. Engel, L. Teri, Associations between physical performance and executive function in older adults with mild cognitive impairment: gait speed and the timed up & go test, Phys. Ther. 91 (8) (2011) 1198–1207.

[16] S.S. Kuys, N.M. Peel, K. Klein, A. Slater, R.E. Hubbard, Gait speed in ambulant older people in long term care: a systematic review and meta-analysis, J. Am. Med. Dir. Assoc. 15 (2014) 194–200.

[17] N. Lundebjerg, Guideline for the prevention of falls in older persons, J. Am. Geriatr. Soc. 49 (2001) 664–672.

[18] O. Beauchet, B. Fantino, G. Allali, S.W. Muir, M. Montero-Odasso, C. Annweiler, Timed Up and Go test and risk of falls in older adults: a systematic review, J. Nutr. Health Aging 15 (2011) 933–938.

[19] J. Large, N. Gan, D. Basic, N. Jennings, Using the Timed Up and Go Test to stratify elderly inpatients at risk of falls, Clin. Rehabil. 20 (2006) 421–428.

[20] E.L. Cadore, L. Rodríguez-Mañas, A. Sinclair, M. Izquierdo, Effects of different exercise interventions on risk of falls, gait ability, and balance in physically frail older adults: a systematic review, Rejuvenation Res. 16 (2013) 105–114.

[21] A. Liberati, D.G. Altman, J. Tetzlaff, et al., The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration, PLoS Med. 6 (2009) e1000100.

[22] D. Moher, A. Liberati, J. Tetzlaff, D.G. Altman, The PRISMA Group, Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement, PLoS Med. 6 (2009) e1000097.

[23] S. Mathias, U.S. Nayak, B. Isaacs, Balance in elderly patients: the get-up and go test, Arch. Phys. Med. Rehabil. 67 (1986) 387–389.

[24] J.P. Higgins, S. Green, Cochrane Handbook for Systematic Reviews of Interventions, (2011) Retrieved January 3rd, 2017, from http://handbook.cochrane.org/.

[25] S.S.Y. Au-Yeung, H.P.Y. Ho, J.W.C. Lai, R.W.K. Lau, A.Y.L. Wong, S.K. Lau, Did mobility and balance of residents living in private old age homes improve after a mobility exercise programme? A pilot study, Hong Kong Physiother. J. 20 (2002) 16–21.

[26] E.L. Cadore, A. Casas-Herrero, F. Zambom-Ferraresi, et al., Multicomponent exercises including muscle power training enhance muscle mass, power output, and functional outcomes in institutionalized frail nonagenarians, AGE 36 (2014) 773–785.

[27] A. Dechamps, P. Diolez, E. Thiaudière, et al., Effects of exercise programs to prevent decline in health-related quality of life in highly deconditioned institutionalized elderly persons: a randomized controlled trial, Arch. Intern. Med. 170 (2010) 162–169.

[28] D.A. Lazowski, N.A. Ecclestone, A.M. Myers, et al., A randomized outcome evaluation of group exercise programs in long-term care institutions, J. Gerontol. A Biol. Sci. Med. Sci. 54 (1999) M621–M628.

[29] Y. Rolland, F. Pillard, A. Klapouszczak, et al., Exercise program for nursing home residents with Alzheimer's disease: a 1-year randomized, controlled trial, J. Am. Geriatr. Soc. 55 (2007) 158–165.

[30] J.A. Serra-Rexach, N. Bustamante-Ara, M. Hierro Villarán, et al., Short-term, light-to moderate-intensity exercise training improves leg muscle strength in the oldest old: a randomized controlled trial, J. Am. Geriatr. Soc. 59 (2011) 594–602.

[31] P.L. Tsaih, Y.L. Shih, M.H. Hu, Low-intensity task-oriented exercise for ambulation-challenged residents in long-term care facilities, Am. J. Phys. Med. Rehabil. 91 (2012) 616–624.

[32] T. Valenzuela, Efficacy of progressive resistance training interventions in older adults in nursing homes: a systematic review, J. Am. Med. Dir. Assoc. 13 (2012) 418–428.

[33] L. Brett, V. Traynor, P. Stapley, Effects of physical exercise on health and well-being of individuals living with a dementia in nursing homes: a systematic review, J. Am. Med. Dir. Assoc. 17 (2016) 104–116.

[34] K.V. Hruda, A.L. Hicks, N. McCartney, Training for muscle power in older adults: effects on functional abilities, Can. J. Appl. Physiol. 28 (2003) 178–189.

[35] O. Seynnes, M.A. Fiatarone Singh, O. Hue, P. Pras, P. Legros, P.L. Bernard, Physiological and functional responses to low-moderate versus high-intensity progressive resistance training in frail elders, J. Gerontol. A Biol. Sci. Med. Sci. 59 (2004) M503–M509.

[36] P. de Souto Barreto, M. Lapeyre-Mestre, C. Mathieu, et al., A multicentric individually-tailored controlled trial of education and professional support to nursing home staff: research protocol and baseline data of the IQUARE study, J. Nutr. Health Aging 17 (2013) 173–178.

[37] G.H. Ice, Daily life in a nursing home: has it changed in 25 years? J. Aging Stud. 16 (2002) 345–359.

[38] A. Lobo, P. Santos, J. Carvalho, J. Mota, Relationship between intensity of physical activity and health-related quality of life in Portuguese institutionalized elderly, Geriatr. Gerontol. Int. 8 (2008) 284–290.

[39] K. Pitkälä, N. Savikko, M. Poysti, T. Strandberg, M.L. Laakkonen, Efficacy of physical exercise intervention on mobility and physical functioning in older people with dementia: a systematic review, Exp. Gerontol. 48 (2013) 85–93.

[40] M. Yamada, H. Arai, T. Sonoda, T. Aoyama, Community-based exercise program is cost-effective by preventing care and disability in Japanese frail older adults, J. Am. Med. Dir. Assoc. 13 (2012) 507–511.

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STUDY PROTOCOL **Open Access**

Effectiveness of a multicomponent exercise program in the attenuation of frailty in long-term nursing home residents: study protocol for a randomized clinical controlled trial

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Abstract

Background: There is increasing evidence suggesting that cognition and physical frailty interact within a cycle of decline associated with aging which has been called cognitive frailty. Exercise programs have demonstrated to be an effective tool to prevent functional and cognitive decline during aging, but little is known about their potential to restore or maintain functionality in individuals that require long-term nursing care. Besides, WHO has recently highlighted the importance of introducing systematic musculoskeletal health programs for older people living in residential care, as they represent a particularly vulnerable group for the development of noncommunicable diseases.

Methods: This is a multicentre randomized controlled trial. 114 participants will be randomly allocated to a usual care group or to an intervention group. Inclusion criteria are as follows: ≥ 70 years, ≥ 50 on the Barthel Index, ≥ 20 on MEC-35 who are capable to stand up and walk independently for 10 m. Subjects in the intervention group will add to the activities scheduled for the control group the participation in a 6 months long multicomponent exercise program designed to improve strength, balance and walking retraining. Study assessments will be conducted at baseline and at 3 and 6 months. The primary outcome is change in function assessed by Short Physical Performance Battery and secondary outcomes include other measurements to assess all together the condition of frailty, which includes functionality, sedentary behaviors, cognitive and emotional status and biological markers. The present study has been approved by the Committee on Ethics in Research of the University of the Basque Country (Humans Committee Code M10/2016/105; Biological Samples Committee Code M30/2016/106).

Discussion: Results from this research will show if ageing related functional and cognitive deterioration can be effectively prevented by physical exercise in institutionalized elders. It is expected that the results of this research will guide clinical practice in nursing home settings, so that clinicians and policymakers can provide more evidence-based practice for the management of institutionalized elder people.

Trial registration: The protocol has been registered under the Australian and New Zealand Clinical Trials Registry (ANZCTR) with the identifier: ACTRN12616001044415.

Keywords: Physical activity, Exercise, Older adults, Aging, Frailty, Cognitive frailty, Nursing-home

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Background

Globally, older adult population is estimated to reach approximately 22% of the world's population by 2050 [1, 2] due to the increase in life expectancy. Those older people are characterized by a particularly higher risk of developing negative health-related events because of an age-associated decline in physical and cognitive functions, leading to a progressive disability status. This condition of risk (generally indicated as "frailty") may support the differentiation of "chronologically" from "biologically" aged individuals in the heterogeneous group of elders [3], and consequently, has emerged as a major clinical and public health priority providing a challenge for health and social care resources development [4].

Otherwise, age-associated frailty is a major concern in geriatrics because of its high prevalence in older persons [5–7] and because it is associated with a greater incidence of disability, hospitalization and death [8]. Although frailty references focus usually on its physical side, there is increasing evidence suggesting that cognition and physical frailty interact within a cycle of decline associated with aging [9]. Actually, affective psychological aspects such as anxiety [10] and depression [11], subjective well-being [12] and quality of life [13, 14] of people are also closely related to frailty.

In this regard, researchers from the International Academy of Nutrition and Aging (IANA) and the International Association of Gerontology and Geriatrics (IAGG) have recently established a definition for "cognitive frailty" in older adults [15]: "an heterogeneous clinical manifestation characterized by the simultaneous presence of physical frailty and cognitive impairment. In particular, the key factors that define such conditions include: 1) the presence of physical frailty and cognitive impairment; and 2) the exclusion of a concurrent clinical diagnosis of Alzheimer disease or other dementias".

Exercise programs have demonstrated to prevent functional and cognitive decline during aging [16–18]. In the last decade, the study of exercise programs exploring its benefits has been mainly focused on community-dwelling older adults [19], when frailty is identified at an early stage. When compared with control interventions, physical exercise programs have shown to reverse frailty and improve cognition, emotional, and social networking in controlled populations of community-dwelling frail older adults [20, 21]. Otherwise, while it is widely accepted that frailty can be considered reversible at early stages, mild to moderate disability has proven to be hardly reversible by interventions at old age [22], when individuals require long-term nursing care.

In spite of the widely known health benefits associated with physical activity, older adults represent a very sedentary behavior cohort [23, 24]. Sedentary behavior refers to any waking activity characterized by low energy expenditure (1.0 to 1.5 basal metabolic rate) and a sitting or reclining posture [25]. There is a new body of evidence centered on the negative impact of sedentary behaviors for health, which links it with a higher risk of cardiovascular disease, metabolic syndrome, obesity, and other negative health outcomes, independent of physical activity levels, among older adults [26, 27]. Furthermore, several studies have demonstrated the association between the sedentary behaviors and the development of functional limitations in older adults [28–35]. Nevertheless, little is known about the associations of sedentary behavior with variables that are important for successful aging including mental [36, 37], cognitive [38], biological markers [39] and quality of life indicators [40–42].

Finally, about 60 different potential biomarkers of frailty have been postulated, most of them involved in inflammation, oxidative stress and metabolism which affect different organ systems [43, 44]. Inflammation appears to play a major role in the pathophysiology of frailty; in fact, a positive relationship between frailty-related indexes and markers of inflammation has been observed [45]. Several studies have also detected higher serum levels of interleukin 6 (IL-6), CRP and IL-1Ra in fragile patients, which have been associated with lower muscle strength and a slower gait [46–48]. On the other hand, brain-derived neural factor (BDNF) which is related to brain plasticity and function, has demonstrated to be influenced by physical exercise [49]. Despite this evidence, nowadays there is no clear consensus about the validity of such biomarkers in primary and hospital care and they are not commonly used for identifying frailty in clinical settings.

Objective

To the knowledge of the authors, no studies have explored the effects of a supervised multicomponent exercise program carried out in long-term nursing care centers from a broad perspective of the condition of frailty, assessing all together functionality, sedentary behaviors, cognitive and emotional status and biological markers. Thus, it has been designed a randomized multicenter study to test the hypothesis that the addition of a multicomponent exercise program to the usual care in institutionalized elders can improve their functionality in 1 point in the Short Physical Performance Battery (SPPB).

The major aim of this study is to ascertain if a supervised multicomponent exercise program carried out in long-term nursing care centers improves or maintains functionality, sedentary behaviors, cognitive and emotional status, health related quality of life and modifies biological markers related to frailty when compared with a control population that received usual care.

The present study is based on a previous pilot study [50] in which we successfully collected preliminary data to accurately demonstrate the feasibility of recruitment, estimate the required sample size for the current trial, confirm the adherence and safety of the intervention, refine the outcome assessments, and optimize the organizational infrastructure.

Methods

Study design and participants

With the above mentioned objective in mind, it has been designed an experimental multicentre simple randomized study, with random allocation to a usual care group or to an intervention group. Each site will enroll on average 15 subjects. Researchers responsible for data gathering will be blinded for this study. Participants will be recruited from Matia and Caser Residential Care Facilities in 7 long-term nursing homes (San Sebastian, Basque Country, Spain). It is expected that the intervention will take place between October 2016 and June 2017. Study assessments will be conducted by blinded research staff during clinic visits at baseline, as well as at 3 and 6 months from the beginning of the intervention. The CONSORT Statement extension for trials of non-pharmacological interventions and pragmatic intervention trials has been used to design the study and will be used to report it (Fig. 1).

Inclusion and exclusion criteria

Subjects will be considered eligible for the study if they fulfill all of the following criteria: aged ≥ 70 years, scored ≥ 50 on the Barthel Index [51], scored ≥ 20 on MEC-35 [52] Test (an adapted and validated version of Mini Mental State Examination (MMSE) in Spanish) who are all capable to stand up and walk independently for at least 10 m.

Participants will not be eligible for the study if they are clinically unstable under the clinical judgment of the medical professionals of the reference center, or in any other condition that means that entering the study would not be in the subject's best interests.

Recruitment and randomization

The listing of individuals that meet inclusion criteria will be obtained from the database of Matia and Caser Residential Care Facilities. The primary recruitment strategy will be information provided to the potential participants by the medical and nursing professionals from each nursing home. All the volunteers will receive detailed study information in their reference sites through the research team: objectives, measurement variables and other details about the interventions will be explained orally and in writing, to both potential participants and their families. Informed consent will be obtained from each participant who will sign it after fully understanding the procedures. Afterwards they will be randomly assigned (1:1 ratio) by center through sealed opaque envelopes to either the control or the intervention group by coin-tossing sequence generation.

Control group

Subjects in the control group will participate in the routine activities that all nursing homes usually offer to the

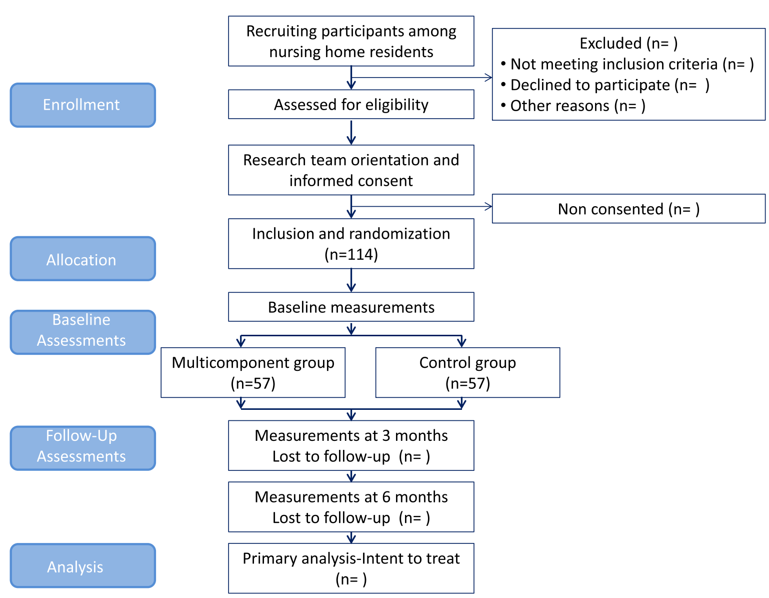

Fig. 1 Study protocol description

attendees: memory workshops, reading, singing, etc. Activities will be low intensity in any case.

Multicomponent exercise program

Subjects in the intervention group will add to the activities scheduled for the control group, the participation in a multicomponent exercise program designed to improve strength, balance and walking retraining conducted by an experienced physical trainer. Strength and balance training will be performed through supervised sessions, while walking retraining will be carried out through individualized recommendations that participants will fulfill on their own. The technical content of the program is based on a specific literature review [17, 53, 54] including authors' expertise and field experience, and it is divided into two sections of 3 months long (Table 1). Each section has specific objectives and a standardized framework (combination and sequence of exercises), but the goals are individualized based on each participants' level of physical fitness. Goals will be adapted in response to illness, injury or physical symptoms. The intervention has been designed to meet the exercise and physical activity guidelines for older adults established by the American College of Sport Medicine (ACSM) and American Heart Association (AHA) [55, 56]. Training attendance will be recorded every session.

Forty-five min supervised sessions directed to improve strength and balance will be conducted twice a week. An interval of at least 48 h between training sessions will be respected (Table 2). All sessions will begin with a brief warm-up of 5 min (range-of-motion exercises for the neck, wrists, shoulders, hip, knees and ankles). Strength training (25 min) will comprise upper and lower body exercises performed with external weights, which will be tailored to the individual's functional capacity through Brzycki equation for the estimation of 1-RM (repetition maximum) at baseline and at the end of every month, to ensure an appropriate training stimulus. In all strength tests subjects will be encouraged verbally to perform each exercise as forcefully as possible in a standardized form. In the three first months exercises will be performed with light loads (40–60% 1-RM) to ensure an appropriate adaption to resistance exercise and thereafter loads, if they are well tolerated, will be increased to 65–70% 1-RM for additional benefits.

Balance training (10 min) will include exercises in progressing difficulty starting by decreasing arm support (with 2 arms at first, with one hand, and finally none if possible) along with decreasing base of support (both feet together, semi-tandem and tandem positions) and increasing complexity of movements as to challenge participants' balance as they progress. Exercises will be varied through the period: weight transfer from one leg to another, walking with small obstacles, proprioceptive exercises and stepping practice. Sessions will finish with 5 min of cooling down by stretching, breathing and relaxing exercises.

Walking retraining will also be implemented through individualized recommendations regarding distance and intensity to perform on their own in addition to the supervised sessions. According to ACSM/AHA guidelines [56], exercise intensity will be monitored using a category-ratio 0–10 scale for physical exertion and breathlessness (Borg CR10 scale) [57]. Participants will be instructed to walk at a moderate intensity, equivalent to a 5–6 on the CR10 scale, with a target goal of achieving at least 22 min/day at the end of the 6 months period. Walking retraining will initially begin with light intensity activity for short periods of time, which gradually will be increased in intensity and duration over the 6 months period.

Finally, attendance to the program may be suspended due to a hospitalization, injury, or any other health events. Evaluation for re-engaging the exercitation will depend on the functional impact of the illness and on any activity limitation prescriptions that may provide the participant's health care team. Irrespective of the week of the intervention that a suspension may occur, all restarts will be conducted in a supervised and progressive way.

Table 1 Multicomponent exercise program's technical content

	3 MONTHS Familiarisation phase Objective: Increase strength			3 MONTHS Development phase Objective: Improve functional capacity		
	1ST MONTH	2ND MONTH	3RD MONTH	4TH MONTH	5TH MONTH	6TH MONTH
Strength	3–4 Ex: 1–2 sets, 8–12 rep at 40% of 1RM	4 Ex: 2 sets, 8–12 rep at 50% of 1RM	4–5 Ex: 2 sets, 8–12 rep at 60% of 1RM	4–5 Ex: 3 sets, 8–12 rep at 60–65% of 1RM	4–5 Ex: 2 sets, 7–8 rep at 70% of 1RM	3 Ex: 1 set,7–8 rep at 70% of 1RM
Balance	2–3 exercises, progressive difficulty in sitting position and decreasing arm support when standing position.			4–5 exercises, progressive difficulty in standing position, decreasing arm support, increasing instability and external perturbations.		
Walking program	5 min WR 5 days (M)	10 min WR 5 days (5′ M and 5′ A)	14 min WR 5 days (7′ M and 7′ A)	18 min WR 5 days (9′ M and 9′ A)	22 min WR 5 days (11′ M and 11′ A)	22 min WR 7 days (11′ M and 11′ A)

Ex exercises, *rep* repetitions, *WR* walking recommendation, *M* morning, *A* afternoon

Table 2 Programation of the intervention for the 13th week

Objective	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Multicomponent exercise program							
Warm-Up 5 min		Range of motion for different joints		Range of motion for different joints			
Strength training 25 min	-	Arm curl 60% 3 sets 8-12rep	-	Arm curl 60% 3 sets 8-12rep	-	-	-
	-	Chair stand 60% 3 sets 8-12rep	-	Chair stand 60% 3 sets 8-12rep	-	-	-
	-	Leg flexion 60% 3 sets 8-12rep	-	Leg flexion 60% 3 sets 8-12rep	-	-	-
	-	Leg abduction 60% 3 sets 8-12rep	-	-	-	-	-
	-	-	-	Hip extensión 60% 3 sets 8-12rep	-	-	-
	-	Standing on tips and heels 3 sets 10 rep	-	Standing on tips and heels 3 sets 10 rep	-	-	-
Balance training 10 min	-	One legged stand 2 sets 10 s	-	One legged stand 2 sets 10 s	-	-	-
	-	Semi-tandem/Tandem exercises 2 sets 10 s	-	Semi-tandem/Tandem exercises 2 sets 10 s	-	-	-
	-	Circuit training 2 sets	-	Circuit training 2 sets	-	-	-
	-	Stepping 2 sets 10 rep	-	Stepping 2 sets 10rep	-	-	-
	-	Ball reaching 2 sets	-	-	-	-	-
Cooling-Down 5 min		Stretching, breathing, relaxing exercises.		Stretching, breathing, relaxing exercises.			
Walking retraining							
	9 min WR M & A	-	9 min WR M & A	-	9 min WR M & A	9 min WR M & A	9 min WR M & A

WR walking recommendation, *M* morning, *A* afternoon

Outcome measures

The primary outcome measure will be the difference in function between intervention and control group assessed by changes in summary ordinal score on the Short Physical Performance Battery [58] (SPPB). SPPB consists of three tests: balance, gait ability and leg strength. The score for each test is given in categorical modality (0–4) based on run time intervals, and the total score will range from 0 (worst) to 12 points (best). The SPPB has been shown to be a valid instrument for screening frailty and predicting disability, institutionalization and mortality. A total score of less than 10 points indicates frailty and a high risk of disability and falls. 1 point change in the total score has demonstrated to be of clinical relevance [59, 60].

The following parameters will be also recorded: age, gender, socioeconomic situation, marital status, Barthel index [51], MEC-35 [52], Lubben Social Network Scale (LSNS-6) [61], Tilburg Frail index [62], Frailty index [63], and Charlson [64] index. Anthropometric data will include body mass index (BMI) and waist-hip ratio; fat mass percentage will be measured using a portable bioelectrical impedance analyzer (Bodystat BIA Quadscan 4000) [65].

Functional examination will include the following (Table 3): Senior Fitness Test [66], instrumented Timed Up and Go test [67] (iTUG; BTS Biomedical G-WALK triaxial accelerometer and gyroscope), comfortable and fast walking speed [68], bilateral handgrip strength test [69] (Jamar dynamometer), Berg balance test [70], static balance and fall-risk by stabilometer [71] (Biodex Balance System SD), as well as active and sedentary periods during everyday life recorded with an accelerometer (Actigraph GT3X model (Actigraph LLC, Pensacola, FL, USA)) that will be worn on the hip with a belt for a 7 day period. The device will be set to quantify the number of steps taken per day. In line with that, active-period intensities will be classified following the criteria developed by Freedson et al. [72] as light, moderate or vigorous intensity and measured in minutes performed in each intensity.

Cognitive and emotional assessment will be determined by the following (Table 4): Clinical Dementia Rating [73] (CDR), Montreal Cognitive Assessment (MoCA) [74], Symbol Digit Modalities Test (SDMT) [75] and Anxiety and Depression Goldberg Scale [76]. Health related quality of life will be assessed by the questionnaire EQ-5D-5 L [77].

Table 3 Functional assessment tests

Test (Reference)	Functions/Parameters	Description
Short Physical Performance Battery (SPPB) [58]	Lower extremity function: static balance, gait speed and getting in and out of a chair	Side-by-side, semi-tandem and tandem stands (10 s); 4 meters walk test at comfortable speed and 5 quickly sit to stand from a chair without upper extremity assistance
Senior Fitness Test [66]	Upper and lower extremity strength and flexibility, static and dynamic balance and aerobic capacity	Chair-stands in 30 s; 6-min walking test; arm curl test (30 s); chair sit and reach; back scratch and 8 foot up and go test
Instrumented Timed Up and Go test (BTS Biomedical G-WALK) [67]	Dynamic balance	Get up from a chair, walk 3 meters at a normal pace, turn and walk back to sit down again
Instrumented walking speed (BTS Biomedical G-WALK) [68]	Standard gait parameters: speed, step frequency, cadence	Walk for 4 and 10 meters at comfortable and fast speed
Bilateral handgrip strength test (Jamar dynamometer) [69]	Hand grip strength	Squeez the dynamometer with maximum isometric effort for about 5 s
Berg balance test [70]	Postural stability	Performance of 14 functional tasks
Stabilometry (Biodex Balance System) [71]	Ability to control balance on an oscillatory platform	Two-legged stance counterbalancing of an standardized oscillatory platform displacements
Accelerometry (Actigraph GT3X model (Actigraph LLC, Pensacola, FL, USA) [72]	Active and sedentary periods during everyday life	7 days period quantification of the number of steps performed per day and minutes completed at light, moderate or vigorous intensity

Blood samples will be obtained and stored at – 80 °C. Biomarkers will be measured according to standard laboratory protocols at the Physiology laboratory in the University of the Basque Country using an ELISA kit (ChemiKine TM; Millipore, Temecula, CA) following the manufacturer's instructions. Thus, myostatin [78], irisin [79], interleukin 6 [46] and BDNF [49] will be measured (Table 5).

Finally, we will also record the number of falls, visits to the emergency service, hospital admissions and length of hospital stay.

Safety assessments

All co-existing diseases or conditions related with the intervention will be treated in accordance with prevailing medical practice and will be reported as an adverse event.

Power and sample size

Sample size has been calculated to detect minimal significant effects on the variable of physical performance (SPPB) [80, 81]: accepting an alpha risk of 0.05 and a beta risk of 0.20 in a bilateral contrast, 86 individuals are required in order to detect a difference equal to or greater than 1 unit in the SPPB (SD = 2.34). It has been increased the sample size in an additional 20% (loses during follow-up) and 5% (mortality). The resultant sample size is determinate in 114 individuals, therefore 57 individuals per group (intervention and control group).

Statistical considerations

The IBM SPSS Statistics 23 statistical software package (SPSS, Inc., Chicago, IL) will be used to analyse the data. Intention to treat analyses will be performed. The

Table 4 Cognitive and Functional assessment tests

Test (Reference)	Functions	Description
Clinical Dementia Rating (CDR) [73]	Cognitive and functional performance	Covered domains: Memory, Orientation, Judgment and Problem Solving, Community Affairs, Home and Hobbies, Personal Care
Montreal Cognitive Assessment (MoCA) [74]	Mild Cognitive Impairment, Early Alzheimer's disease	Covered domains: Attention and Concentration, Executive Functions, Memory, Language, Visuoconstructional Skills, Conceptual Thinking, Calculations, Orientation
Symbol Digit Modalities Test (SDMT) [75]	Cognitive impairment	Covered domains: Attention, Visual Scanning, Motor Speed
Anxiety and Depression Goldberg Scale [76]	Affective state	Includes nine depression and nine anxiety items from the past month
Questionnaire EQ-5D-5 L [77]	Health related quality of life	Self-rated quality of life related to health; included dimensions: Mobility, Self-Care, Usual Activities, Pain/Discomfort, Anxiety/Depression

Table 5 Biomarkers that will be analysed in the study

Biomarker (Reference)	Associated Function
Myostatin [78]	Miokine associated to the muscle gain inhibition
Irisin [79]	Miokine associated to the increase of thermogenesis with physical activity
Interleukin 6 [46]	Inflammatory marker associated to frailty and physical performance
Brain-Derived Neural Factor (BDNF) [49]	Neurotrophic factor associated to cognitive function

normal distribution of the data will be evaluated using the Kolmogorov-Smirnov test. Continuous variables will be expressed as mean (SD) when normally distributed and as median with interquartile range (IQR) when not. Categorical variables will be expressed as frequency counts and percentages. Statistical comparisons at baseline will be performed using appropriate statistical tests according to the type and distribution of the data: t test or Mann–Whitney U-test for continuous variables and Chi-squared test for categorical variables. The intervention-related effects will be performed using appropriate statistical tests according to the type and distribution of the data: an analysis of variance (ANOVA) or Friedman test with repeated measures (0, 3 and 6 months). When a significant F value is obtained, LSD post hoc procedures will be used to evaluate pairwise differences. $p < 0.05$ will be considered to be statistically significant. Furthermore, an analysis of covariance (ANCOVA) will be done to compare the data between intervention and control groups, considering as co-variables baseline measurements, as well as other variables as age or gender.

Trial status

The trial is currently being set up with participant recruitment. Recruitment will cease when 114 participants have been randomized; it is expected this target will be reached by June 2017.

Discussion

This is a multicenter study designed to ascertain if a supervised multicomponent exercise program carried out in long-term nursing care centers improves or maintains functionality, sedentary behaviors, cognitive and emotional status and biological markers related to frailty when compared with a control population that receives usual care. To our knowledge, an exercise program carried out in nursing home elderly population has not been studied before from a so broad perspective, taking into account all together functional, cognitive, emotional and biochemical conditions. The current lack of definitive evidence on whether ageing related functional deterioration can be effectively prevented by physical exercise in institutionalized elders represents a potential obstacle to the development of guidelines for geriatric clinicians and policymakers that would also report in increasing health-related quality of life for a prevalent and clinically-relevant population. Furthermore, the World Health Organization (WHO) has recently published an Action Plan for the Prevention and Control of Noncommunicable Diseases in the WHO European Region 2016–2025, where it is highlighted the importance of introducing systematic musculoskeletal health programs for older people, including those living in residential care [82]. Moreover, long-term nursing home residents have been identified as a particularly vulnerable group where the above mentioned plan should direct its actions through an early intervention to restore and maintain functionality.

The exercise program that is described in this protocol has been designed to be feasible, easy to implement and potentially delivered in any nursing home settings, which may have direct clinical applications. We previous reported [83] that a similar multicomponent exercise program is feasible, well tolerated and pleasantly welcomed by individuals living in long-term care facilities. Furthermore, improvements in functional status were observed in those participants that took part in the program, particularly in gait ability, balance and aerobic capacity. These findings are in line with other studies carried out in nursing homes, indicating that the exercise programs can benefit functional performance, well being and cognition of the residents [84–88]. Nevertheless, to date few randomized clinical trials have been conducted in institutionalized elders, and normally these trials study heterogeneous interventions (sometimes poorly explained), while our study allows the extrapolation of results and the implementation of the program to any other nursing home through a well-defined methodology.

Finally, if the described multicomponent exercise program proves to report benefits in terms of functional, sedentary behavior, cognitive and emotional status, as well as knowledge on the response of biological markers to physical activity, the findings could provide evidence suggesting the need to augment the standard physical practice prescribed at nursing homes in the elder population. Otherwise, failure to reject the null hypothesis would suggest that the progression of the decline associated with the aging process in at-risk persons continues on to disability, despite any potential benefits from physical activity. This would be an important study outcome as well and implies that efforts to hold back the process of disablement in this population should be directed elsewhere.

The study of whether multicomponent exercise program can improve or maintain functionality, sedentary behaviors, cognitive and emotional status and biological markers related with frailty in nursing home elders is nowadays an unanswered question that is of major importance to public health and social policy. It is expected that the results of this research will guide clinical practice in nursing home settings, so that clinicians and policymakers can provide more evidence-based practice for the management of institutionalized elder people.

Abbreviations
ACSM: American College of sport medicine; AHA: American heart association; ANZCTR: Australian and New Zealand clinical trials registry; BDNF: Brain-derived neural factor; BMI: Body mass index; CDR: Clinical dementia rating; CONSORT: Consolidated Standards of reporting trials; CRP: C-Reactive protein; EQ-5D-5 L: EuroQol five-dimensional questionnaire; IAGG: International association of gerontology and geriatrics; IANA: International academy of nutrition and aging; IL-1Ra: Interleukin 1 reception antagonist; IL-6: Interleukin 6; IQR: InterQuartile range; iTUG: Instrumented timed up and go test; LSNS: Lubben social network scale; MEC-35: Cognition mini-exam of lobo; MoCA: Montreal cognitive assessment; RM: Repetition maximum; SDMT: Symbol digit modalities test; SPPB: Short physical performance battery; WHO: World health organisation

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Availability of data and materials
Not applicable.

Authors' contributions
The protocol was developed by AR, JI, SG, HA, CR, MK, JY and MI. AR, JI, SG, HA and CR prepared the initial manuscript. All authors contributed to and reviewed the final manuscript prior to submission. All authors read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

Consent for publication
Not applicable.

Ethics approval and consent to participate
The present study has been approved by the Committee on Ethics in Research of the University of the Basque Country (Humans Committee Code M10/2016/105; Biological Samples Committee Code M30/2016/106) and has also received a letter of support from the senior administrator of Matia and Caser Residential Care Facilities. Furthermore, the study protocol has been registered under the Australian and New Zealand Clinical Trials Registry (ANZCTR) with the identifier: ACTRN12616001044415 and all participants will provide written informed consent based on documents approved by a university Institutional Review Board. The study will be carried out in accordance with Good Clinical Practice, applicable local regulatory requirements, and the guiding principles of the Declaration of Helsinki. Universal Trial Number U1111-1185-6368.

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References
1. Scully T. Demography: to the limit. Nature. 2012;492:2. doi:10.1038/492S2a.
2. World Health Organization. Global Age-friendly Cities: A Guide. Geneva: WHO press; 2007.
3. Cesari M, Vellas B, Gambassi G. The stress of aging. Exp Gerontol. 2013;48: 451–6. doi:10.1016/j.exger.2012.10.004.
4. World Health Organization. Good Health Adds Life to Years: Global Brief for World Health Day 2012. Geneva: WHO press; 2012.
5. Rodriguez-Manas L, Fried LP. Frailty in the clinical scenario. Lancet. 2015; 385(9968):e7–9. http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(14)61595-6/abstract.
6. Collard RM, Boter H, Schoevers RA, et al. Prevalence of frailty in community-dwelling older persons: a systematic review. J Am Geriatr Soc. 2012;60(8): 1487–92. doi:10.1111/j.1532-5415.2012.04054.x.
7. Santos-Eggimann B, Cuénoud P, Spagnoli J, et al. Prevalence of frailty in middle-aged and older community-dwelling Europeans living in 10 countries. J Gerontol A Biol Sci Med Sci. 2009;64(6):675–81. doi:10.1093/gerona/glp012.
8. Rodriguez-Manas L, Feart C, Mann G, et al. Searching for an operational definition of frailty: A Delphi method based consensus statement: The frailty operative definition-consensus conference project. J Gerontol A Biol Sci Med Sci. 2013;68(1):62–7. doi:10.1093/gerona/gls119.
9. Robertson DA, Savva GM, Kenny RA. Frailty and cognitive impairment–a review of the evidence and causal mechanisms. Ageing Res Rev. 2013;12(4): 840–51. doi:10.1016/j.arr.2013.06.004.
10. Bernal-Lopez C, Potvin O, Avila-Funes JA. Frailty is associated with anxiety in community-dwelling elderly adults. J Am Geriatr Soc. 2012;60(12):2373–4. doi:10.1111/jgs.12014.
11. St. John PD, Tyas SL, Montgomery PR. Depressive symptoms and frailty. Int J Geriatr Psychiatry. 2013;28(6):607–14. doi:10.1002/gps.3866.
12. Gale CR, Cooper C, Deary IJ, et al. Psychological well-being and incident frailty in men and women: the English Longitudinal Study of Ageing. Psychol Med. 2014;44(4):697–706. doi:10.1017/S0033291713001384.
13. Mhaolain AM, Gallagher D, Crosby L, et al. Frailty and quality of life for people with Alzheimer's dementia and mild cognitive impairment. Am J Alzheimers Dis Other Demen. 2012;27(1):48–54. doi:10.1177/1533317511435661.
14. Rizzoli R, Reginster JY, Arnal JF, et al. Quality of life in sarcopenia and frailty. Calcif Tissue Int. 2013;93(2):101–20. doi:10.1007/s00223-013-9758-y.
15. Kelaiditi E, Cesari M, Canevelli M, et al. Cognitive frailty: rational and definition from an (I.A.N.A./I.A.G.G.) international consensus group. J Nutr Health Aging. 2013;17(9):726–34. doi:10.1007/s12603-013-0367-2.
16. Theou O, Stathokostas L, Roland KP, et al. The effectiveness of exercise interventions for the management of frailty: a systematic review. J Aging Res. 2011;2011:569194. doi:10.4061/2011/569194.
17. Cadore EL, Rodriguez-Manas L, Sinclair A, et al. Effects of different exercise interventions on risk of falls, gait ability, and balance in physically frail older adults: A systematic review. Rejuvenation Res. 2013;16(2):105–14. doi:10.1089/rej.2012.1397.
18. Buford TW, Anton SD, Clark DJ, et al. Optimizing the benefits of exercise on physical function in older adults. PM R. 2014;6(6):528–43. doi:10.1016/j.pmrj.2013.11.009.
19. Gine-Garriga M, Roque-Figuls M, Coll-Planas L, et al. Physical exercise interventions for improving performance-based measures of physical function in community-dwelling, frail older adults: A systematic review and meta-analysis. Arch Phys Med Rehabil. 2014;95(4):753–69. doi:10.1016/j.apmr.2013.11.007.
20. Tarazona-Santabalbina FJ, Gómez-Cabrera MC, Pérez-Ros P, et al. A multicomponent exercise intervention that reverses frailty and improves cognition, emotion, and social networking in the community-dwelling frail elderly: a randomized clinical trial. J Am Med Dir Assoc. 2016;17(5):426–33. doi:10.1016/j.jamda.2016.01.019.
21. Pahor M, Guralnik JM, Ambrosius WT, et al. Effect of structured physical activity on prevention of major mobility disability in older adults: the LIFE study randomized clinical trial. Jama. 2014;311(23):2387–96. doi:10.1001/jama.2014.5616.
22. Cadore EL, Moneo ABB, Mensat MM, et al. Positive effects of resistance training in frail elderly patients with dementia after long-term physical restraint. AGE. 2014;36(2):801–11. doi:10.1007/s11357-013-9599-7.

23. Colley RC, Garriguet D, Janssen I, et al. Physical activity of Canadian adults: accelerometer results from the 2007–2009 Canadian Health Measures Survey. Health Reports, Statistics Canada. 2011;Catalogue 82-003-XPE. http://www.statcan.gc.ca/pub/82-003-x/2011001/article/11396-eng.pdf. Accessed 21 Feb 2017.
24. Sardinha LB, Santos DA, Silva AM, et al. Breaking-up sedentary time is associated with physical function in older adults. J Gerontol A Biol Sci Med Sci. 2015;70(1):119–24. doi:10.1093/gerona/glu193.
25. Cart LRSM. Letter to the editor: standardized use of the terms "sedentary" and "sedentary behaviours". Appl Physiol Nutr Metab. 2012;37(3):540–2. doi:10.1139/h2012-024.
26. Shiroma EJ, Freedson PS, Trost SG, et al. Patterns of accelerometer-assessed sedentary behavior in older women. JAMA. 2013;310(23):2562–3. doi:10.1001/jama.2013.278896.
27. De Rezende LFM, Rey-Lopez JP, Matsudo VK, et al. Sedentary behavior and health outcomes among older adults: a systematic review. BMC Public Health. 2014;14(1):333. doi:10.1186/1471-2458-14-333.
28. Davis MG, Fox KR, Stathi A, et al. Objectively measured sedentary time and lower extremity function in older adults. J Aging Phys Act. 2014;22(4):474–81. http://dx.doi.Org/10.1123/JAPA.2013-0042.
29. Santos DA, Silva AM, Baptista F, et al. Sedentary behavior and physical activity are independently related to functional fitness in older adults. Exp Gerontol. 2012;47:908–12. doi:10.1016/j.exger.2012.07.011.
30. Chastin SFM, Ferriolli E, Stephens NA, et al. Relationship between sedentary behaviour, physical activity, muscle quality and body composition in healthy older adults. Age Ageing. 2012;41:111–4. doi:10.1093/ageing/afr075.
31. McDermott MM, Liu K, Ferrucci L, et al. Greater sedentary hours and slower walking speed outside the home predict faster declines in functioning and adverse calf muscle changes in peripheral arterial disease. J Am Coll Cardiol. 2011;57(23):2356–64. doi:10.1016/j.jacc.2010.12.038.
32. Cawthon PM, Blackwell TL, Cauley JA, et al. Objective assessment of activity, energy expenditure, and functional limitations in older men: the Osteoporotic Fractures in Men study. J Gerontol A Biol Sci Med Sci. 2013;68(12):1518–24. doi:10.1093/gerona/glt054.
33. Rosenberg DE, Bellettiere J, Gardiner PA, et al. Independent Associations Between Sedentary Behaviors and Mental, Cognitive, Physical, and Functional Health Among Older Adults in Retirement Communities. J Gerontol A Biol Sci Med Sci. 2016;71(1):78–83. doi:10.1093/gerona/glv103.
34. Dunlop DD, Song J, Arntson EK, et al. Sedentary time in U.S. older adults associated with disability in activities of daily living independent of physical activity. J Phys Act Health. 2015;12(1):93–101. doi:10.1123/jpah.2013-0311.
35. Davis MG, Fox KR, Stathi A, et al. Objectively measured sedentary time and its association with physical function in older adults. J Aging Phys Act. 2014;22(4):474–81. doi:10.1123/japa.2013-0042.
36. Lucas M, Mekary R, Pan A, et al. Relation between clinical depression risk and physical activity and time spent watching television in older women: a 10-year prospective follow-up study. Am J Epidemiol. 2011;174(9):1017–27. doi:10.1093/aje/kwr218.
37. Hamer M, Stamatakis E. Prospective study of sedentary behavior, risk of depression, and cognitive impairment. Med Sci Sports Exerc. 2014;46(4):718–23. doi:10.1249/MSS.0000000000000156.
38. Kesse-Guyot E, Charreire H, Andreeva VA, et al. Cross-sectional and longitudinal associations of different sedentary behaviors with cognitive performance in older adults. PLoS One. 2012;7(10), e47831. doi:10.1371/journal.pone.0047831.
39. Fraile-Bermúdez AB, Kortajarena M, Zarrazquin I, et al. Relationship between physical activity and markers of oxidative stress in independent community-living elderly individuals. Exp Gerontol. 2015;70:26–31. doi:10.1016/j.exger.2015.07.005.
40. Vallance JK, Boyle T, Courneya KS, et al. Associations of objectively assessed physical activity and sedentary time with health-related quality of life among colon cancer survivors. Cancer. 2014;120(18):2919–26. doi:10.1002/cncr.28779.
41. George SM, Alfano CM, Groves J, et al. Objectively measured sedentary time is related to quality of life among cancer survivors. PLoS One. 2014;9(2), e87937. doi:10.1371/journal.pone.0087937.
42. Balboa-Castillo T, Leon-Munoz LM, Graciani A, et al. Longitudinal association of physical activity and sedentary behavior during leisure time with health-related quality of life in community-dwelling older adults. Health Qual Life Outcomes. 2011;9(1):47. doi:10.1186/1477-7525-9-47.
43. Berrut G, Andrieu S, De Carvalho IA, et al. Promoting access to innovation for frail old persons. J Nutr Health Aging. 2013;17(8):688–93. doi:10.1007/s12603-013-0039-2.
44. Erusalimsky JD, Grillari J, Grune T, et al. In Search of 'Omics'-Based Biomarkers to Predict Risk of Frailty and Its Consequences in Older Individuals: The FRAILOMIC Initiative. Gerontology. 2015;62(2):182–90. doi:10.1159/000435853.
45. Walston J, McBurnie MA, Newman A, et al. Frailty and activation of the inflammation and coagulation systems with and without clinical comorbidities: results from the Cardiovascular Health Study. Arch Intern Med. 2002;162(20):2333–41. doi:10.1001/archinte.162.20.2333.
46. Cesari M, Penninx BW, Pahor M, et al. Inflammatory markers and physical performance in older persons: the InCHIANTI study. J Gerontol A Biol Sci Med Sci. 2004;59(3):M242–8. doi:10.1093/gerona/59.3.M242.
47. Ferrucci L, Penninx BW, Volpato S, et al. Change in Muscle Strength Explains Accelerated Decline of Physical Function in Older Women With High Interleukin-6 Serum Levels. J Am Geriatr Soc. 2002;50(12):1947–54. doi:10.1046/j.1532-5415.2002.50605.x.
48. Puts MTE, Lips PTAM, Deeg DJH. Static and dynamic measures of frailty predicted decline in performance-based and self-reported physical functioning. J Clin Epidemiol. 2005;58(11):1188–98. doi:10.1016/j.jclinepi.2005.03.008.
49. De Melo Coelho FG, Gobbi S, Andreatto CAA, et al. Physical exercise modulates peripheral levels of brain-derived neurotrophic factor (BDNF): a systematic review of experimental studies in the elderly. Arch Gerontol Geriatr. 2013;56(1):10–5. doi:10.1016/j.archger.2012.06.003.
50. Rodriguez-Larrad A, Arrieta H, Yanguas J, Markotegi M, Irazusta A, Gil SM. Multi-component exercise training in elderly day care centers: a pilot study. 21st Annual Congress of the European College of Sport Science. Book of Abstracts. ISBN 978-3-00-053383-9. 2016. p. 204.
51. Wade DT, Collin C. The Barthel ADL Index: a standard measure of physical disability? Int Disabil Stud. 1988;10(2):64–7. doi:10.3109/09638288809164105.
52. Lobo A, Saz P, Marcos G, et al. Revalidación y normalización del Mini-Examen Cognoscitivo (primera versión en castellano del Mini-Mental Status Examination) en la población general geriátrica. Med Clin (Barc). 1999;112(20):767–74.
53. Binder EF, Schechtman KB, Ehsani AA, et al. Effects of exercise training on frailty in community-dwelling older adults: results of a randomized, controlled trial. J Am Geriatr Soc. 2002;50(12):1921–8. doi:10.1046/j.1532-5415.2002.50601.x.
54. McPhate L, Simek EM, Haines TP. Program-related factors are associated with adherence to group exercise interventions for the prevention of falls: a systematic review. J Physiother. 2013;59(2):81–92. doi:10.1016/S1836-9553(13)70160-7.
55. Chodzko-Zajko WJ, Proctor DN, Fiatarone-Singh MA, for the American College of Sports Medicine Position Stand, et al. Exercise and physical activity for older adults. Med Sci Sports Exerc. 2009;41:1510–30. doi:10.1249/MSS.0b013e3181a0c95c.
56. Nelson ME, Rejeski WJ, Blair SN, et al. Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. Circulation. 2007;116(9):1094–105. doi:10.1161/CIRCULATIONAHA.107.185650.
57. Guralnik JM, Simonsick EM, Ferrucci L, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. J Gerontol. 1994;49(2):M85–94. doi:10.1093/geronj/49.2.M85.
58. Borg G. Perceived exertion and pain scales. Champaign: Human Kinetics; 1988.
59. Guralnik JM, Ferrucci L, Simonsick EM, et al. Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. N Engl J Med. 1995;332(9):556–61. doi:10.1056/NEJM199503023320902.
60. Guralnik JM, Ferrucci L, Pieper CF, Leveille SG, et al. Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. J Gerontol A Biol Sci Med Sci. 2000;55(4):M221–31. doi:10.1093/gerona/55.4.M221.
61. Lubben J, Blozik E, Gillmann G, et al. Performance of an abbreviated version of the Lubben Social Network Scale among three European community-dwelling older adult populations. Gerontologist. 2006;46:503–13. doi:10.1093/geront/46.4.503.
62. Gobbens RJ, Van Assen MA, Luijkx KG, et al. The Tilburg Frailty Indicator: psychometric properties. J Am Med Dir Assoc. 2010;11(5):344–55. doi:10.1016/j.jamda.2009.11.003.
63. Fried LP, Tangen CM, Walston J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci. 2001;56(3):M146–56. doi:10.1093/gerona/56.3.M146.

64. Charlson M, Szatrowski TP, Peterson J, et al. Validation of a combined comorbidity index. J Clin Epidemiol. 1994;47(11):1245–51. doi:10.1016/0895-4356(94)90129-5.
65. Scafoglieri A., Predicting appendicular lean and fat mass with bioelectrical impedance analysis in older adults with physical function decline e The PROVIDE study. Clin Nutrition. 2016;Article in press. doi: http://dx.doi.org/10.1016/j.clnu.2016.04.026.
66. Rikli RE, Jones CJ. Senior fitness test. Champaign: Human Kinetics; 2001. ISBN 0-7360-3356-4.
67. Mathias S, Nayak US, Isaacs B. Balance in elderly patients: the "get-up and go" test. Arch Phys Med Rehabil. 1986;67(6):387–9.
68. Bohannon RW, Andrews AW, Thomas MW. Walking speed: reference values and correlates for older adults. J Orthop Sports Phys Ther. 1996;24(2):86–90. doi:10.2519/jospt.1996.24.2.86.
69. Fess EE. In: Casanova JS, editor. Clinical assessment recommendations. Chicago: American Society of Hand Therapists; 1992. p. 41–5. Grip strength.
70. Berg KO, Wood-Dauphinée SL, Williams JI, et al. Measuring balance in the elderly: validation of an instrument. Can J Publ Health. 1992;83:S7–S11.
71. Gusi N, Adsuar JC, Corzo H, et al. Balance training reduces fear of falling and improves dynamic balance and isometric strength in institutionalised older people: a randomised trial. J Physiother. 2012;58(2):97–104. doi:10.1016/S1836-9553(12)70089-9.
72. Freedson PS, Melanson E, Sirard J. Calibration of the Computer Science and Applications, Inc. accelerometer. Med Sci Sports Exerc. 1998;30(5):777–81. doi:10.1097/00005768-199805000-00021.
73. Morris JC. The clinical dementia rating (CDR): current version and scoring rules. Neurology. 1993;43(11):2412–4.
74. Coen RF, Robertson DA, Kenny RA, et al. Strengths and Limitations of the MoCA for Assessing Cognitive Functioning Findings From a Large Representative Sample of Irish Older Adults. J Geriatr Psychiatry Neurol. 2016;29(1):18–24. doi:10.1177/0891988715598236.
75. Sheridan LK, Fitzgerald HE, Adams KM, et al. Normative Symbol Digit Modalities Test performance in a community-based sample. Arch Clin Neuropsychol. 2006;21(1):23–8. doi:10.1016/j.acn.2005.07.003.
76. Goldberg D, Bridges K, Duncan-Jones P, et al. Detecting anxiety and depression in general medical settings. Br Med J. 1988;297(6653):897–9. doi:10.1136/bmj.297.6653.897.
77. Janssen MF, Pickard AS, Golicki D, et al. Measurement properties of the EQ-5D-5 L compared to the EQ-5D-3 L across eight patient groups: a multi-country study. Qual Life Res. 2013;22(7):1717–27. doi:10.1007/s11136-012-0322-4.
78. Kalinkovich A, Livshits G. Sarcopenia–The search for emerging biomarkers. Ageing Res Rev. 2015;22:58–71.
79. Boström P, Wu J, Jedrychowski MP, et al. A PGC1-[agr]-dependent myokine that drives brown-fat-like development of white fat and thermogenesis. Nature. 2012;481(7382):463–8.
80. Perera S, Mody SH, Woodman RC, et al. Meaningful change and responsiveness in common physical performance measures in older adults. J Am Geriatr Soc. 2006;54(5):743–9. doi:10.1111/j.1532-5415.2006.00701.x.
81. Kwon S, Perera S, Pahor M, et al. What is a meaningful change in physical performance? Findings from a clinical trial in older adults (the LIFE-P study). J Nutr Health Aging. 2009;13:538–44. doi:10.1007/s12603-009-0104-z.
82. World Health Organization. Regional Committee for Europe 66th Session. Action plan for the prevention and control of noncommunicable diseases in the WHO European Region. Copenhagen, Denmark, 12–15 September 2016. http://www.euro.who.int/__data/assets/pdf_file/0011/315398/66wd11e_NCDActionPlan_160522.pdf?ua=1. Accesed 21 Feb 2017.
83. Arrieta H., Rodriguez-Larrad A., Iturburu M., Kortajarena M., Irazusta J. A pilot trial of multi-component exercise training in older residents in long-term residential care facilities. 21st Annual Congress of the European College of Sport Science. Book of Abstracts. ISBN 978-3-00-053383-9. 2016. p. 204.
84. Brett L, Traynor V, Stapley P. Effects of physical exercise on health and well-being of individuals living with a dementia in nursing homes: A systematic review. J Am Med Dir Assoc. 2016;17(2):104–16. doi:10.1016/j.jamda.2015.08.016.
85. De Souto Barreto P, Morley JE, Chodzko-Zajko W, et al. Recommendations on physical activity and exercise for older adults living in long-term care facilities: a taskforce report. J Am Med Dir Assoc. 2016;17(5):381–92. doi:10.1016/j.jamda.2016.01.021.
86. Frändin K., Grönstedt H., Helbostad J.L. et al. Long-Term Effects of Individually Tailored Physical Training and Activity on Physical Function, Well-Being and Cognition in Scandinavian Nursing Home Residents: A Randomized Controlled Trial. Gerontology. 2016. doi:10.1159/000443611.
87. Franzke B, Halper B, Hofmann M, et al. The effect of 6 months of elastic band resistance training, nutritional supplementation or cognitive training on chromosomal damage in institutionalized elderly. Exp Gerontol. 2015;65:16–22. doi:10.1016/j.exger.2015.03.001.
88. Casilda-López J, Torres-Sánchez I, Garzón-Moreno VM, et al. Results of a physical therapy program in nursing home residents: A randomized clinical trial. Rev Esp Geriatr Gerontol. 2014;50(4):174–8. doi:10.1016/j.regg.2014.09.007.

3. Eranskina. Baimen informatua

Estimado participante, somos Haritz Arrieta Etxeberria y Chloe Rezola Pardo, investigadores del Dpto. de Fisiología de la UPV/EHU y esta es una hoja con información sobre un proyecto de investigación titulado: *Efectos del ejercicio físico en la fragilidad y sarcopenia de las personas mayores*, en el que se le invita a participar.

El objetivo general del estudio es conocer los efectos del ejercicio físico frente a la fragilidad y sarcopenia en personas mayores de 70 años y más concretamente, determinar si una intervención de ejercicio físico es efectiva para retrasar los efectos de la edad y si la toma de alguna familia de fármacos impide este beneficio. Su participación en el proyecto será a lo largo de 6 meses.

Si Usted desea participar en el proyecto, será asignado de forma aleatoria al Grupo Control o al Grupo Experimental. Todos los participantes seguirán realizando las sesiones de ejercicio físico habituales programadas por la Institución donde residan durante seis meses. Los participantes que sean asignados al Grupo Experimental realizarán además un programa de 2 sesiones semanales de una hora de actividad física tutelada (que incluye ejercicios de fuerza, equilibrio y flexibilidad) adaptadas a personas de su edad y características físicas. Para dichas sesiones de entrenamiento Usted deberá traer ropa y calzado adecuado, que le resulte confortable para la práctica de ejercicio físico. No se llevarán a cabo actividades a altas intensidades y no se espera que su participación en el estudio le cause ningún tipo de molestia o perjuicio, más allá del tiempo empleado para realizar las sesiones de ejercicio físico y evaluaciones que se detallan a continuación. Como medida de seguridad, en el equipo de trabajo hay personal sanitario.

Todos los participantes, indistintamente del grupo al que hayan sido asignados, serán evaluados física y cognitivamente antes de comenzar el proyecto, a los 3 meses y al finalizar el programa a los 6 meses. Las sesiones se realizarán en una sala del mismo centro, habilitada al efecto.

Si Usted decide participar en el estudio, se le realizarán 3 veces a lo largo del mismo:

* Valoración antropométrica (se tomarán medidas como la altura, el peso, la composición corporal)
* Valoración neuropsicológica mediante la realización de test y entrevistas adecuadas para ello.
* Determinación de su estado físico (capacidad aeróbica, fuerza y equilibrio).
* Valoración sobre hábitos de vida relacionados con la actividad física. Para ello, durante una semana deberá llevar puesto un acelerómetro para recoger y memorizar todos los desplazamientos que realice. Se le facilitará una hoja informativa en la cual se detalla el uso del acelerómetro y se le explicará cómo ponerse en contacto con los responsables en caso de duda. El uso del acelerómetro es inocuo, y consiste en llevar puesto un *cinturón* especial durante estos días.
* Una extracción de 5 ml de sangre, para el análisis de biomarcadores relacionados con el envejecimiento (irisina, miostatina, adiponectina, PCR, IL-6, TNFα y BDNF).
* Un estudio sobre el riesgo de caída, empleando para ello técnicas ampliamente validadas, fiables y seguras.
* Consulta de su historia clínica para el acceso a la información clínica y su evolución (como por ejemplo el número de caídas, hospitalizaciones, visitas a los servicios de urgencias, comorbilidad, nivel de funcionalidad, toma de medicamentos).

Los datos personales que nos faciliten para este proyecto de investigación serán tratados con absoluta confidencialidad de acuerdo a la Ley Orgánica 15/1999 de 13 de diciembre de Protección de Datos de Carácter Personal (LOPD). Se incluirán en el fichero de la UPV/EHU de referencia " INA - EJERCICIO Y ENVEJECIMIENTO " y sólo se utilizarán para los fines del proyecto.

Puede consultar en cualquier momento los datos que nos ha facilitado o solicitarnos que los rectifiquemos o cancelemos o simplemente que no los utilicemos para algún fin concreto. La manera de hacerlo es dirigiéndose al Responsable de Seguridad Ley Orgánica de Protección de Datos de la UPV/EHU, Rectorado, Barrio Sarriena s/n, 48940 Leioa-Bizkaia. Para más información sobre Protección de Datos le recomendamos consultar en Internet nuestra página web www.ehu.es/babestu.

Una vez finalizado el estudio, y si así lo desea, puede Usted solicitar conocer los resultados de la investigación, tanto los globales como los individuales obtenidos a partir de las pruebas que se le han realizado. Los resultados generales serán publicados en revistas científicas.

Yo, D./Dña..., mayor de edad, y con D.N.I. ……………..,

Yo, D./Dña. …………………………………….., mayor de edad y con D.N.I. ………………………, como representante en este acto de D./Dña………………………..……………………... y con D.N.I. ………………………

DECLARO:

Mi consentimiento para participar en este estudio, cuyo objetivo es determinar el efecto del ejercicio físico en la fragilidad y sarcopenia de las personas mayores.

Manifiesto que he tenido la oportunidad de comentar todos los detalles y preguntar todas las dudas que me han surgido sobre el proyecto.

Entiendo que mi participación en el proyecto es voluntaria, y que puedo abandonar el mismo en cualquier momento sin que exista por ello ningún perjuicio o medida en mi contra.

Se me ha informado de que la donación de muestras es altruista y no recibiré remuneración por ello. Marque con una X si consiente el uso de sus datos anonimizados y del remanente de la muestra para posibles proyectos posteriores.

SI ☐ NO ☐

También me han indicado que todos los datos acerca de mi persona son estrictamente confidenciales, que se garantizará el más absoluto respeto a mi intimidad y anonimato y que los datos serán destruidos una vez finalizado el estudio.

Dado que entiendo todo lo anterior, **CONSIENTO** que se me incluya en el citado estudio de investigación.

Firma del participante en el estudio,

Nombre y Firma del representante (en caso de participante dependiente) en este acto de D./Dña.

Firma del investigador,

En………...., a……. de………….. de 201

4. Eranskina. Argazkien eta grabaketen erabilerarako baimena

5. Eranskina. Erregistro orria

1.GO EGUNA

Dinamometroa		
Eskuina	Kg	Kg
Ezkerra	Kg	Kg

SENIOR FITNESS TEST (SFT)					
Testak	**1.go saiakera**		**2. saiakera**		**Oharrak**
1. Aulkitik altxa eta eseri *(errep.)(30”)*			**X**		
2. Beso-flexioa mankuernekin *(errep.)(30”)*			**X**		
3. TUG:Altxa, ibili, eseri NORMAL 3m (sg)					
4. Altxa, ibili eta eseri (AZKAR, 2,44)(sg)					
5. Gorputz enborraren flexioa (cm)					
6. Eskuak bizkarraldean elkartu (cm)					
7. Ibilera abiadura 1. proba (sg)	4m Norm.	8m Norm.	4m Azk.	8m Azk.	
8. Ibilera abiadura 2. proba (sg)					

6 minutu ibiltzen	
Birak (45,7m)	**Denbora**
1	
2	
3	
4	
5	
6	

SPPB	**Denbora**
Altxa-eseri (5 errep. zenbat denbora)	
Oreka oinak elkarrekin (10s)	
Oreka semitandem (10s)	
Oreka tandem (10s)	

Oharrak

7				
8				
9				
10				
BUELTAK GUZT.(M)				
KONOAK (M)		Bm Hasierakoa		
DISTANTZIA (M)		Bm Amaierakoa		
GUZTIRA (M)		Bm Errek. (1')		

2. EGUNA

Dinamometroa		
Eskuina	Kg	Kg
Ezkerra	Kg	Kg

SENIOR FITNESS TEST (SFT)			
Testak	**1.go saiakera**	**2. saiakera**	**Oharrak**
1. Aulkitik altxa eta eseri *(errep.)(30”)*		**x**	
2. Beso-flexioa mankuernekin *(errep.)(30”)*		**x**	
3. TUG:Altxa, ibili, eseri NORMAL <u>3m</u> (sg)			
4. Altxa, ibili eta eseri (AZKAR, 2,44)(sg)			
5. Gorputz enborraren flexioa (cm)			
6. Eskuak bizkarraldean elkartu (cm)			

6 minutu ibiltzen		**Berg oreka testa**	**Puntuazioa**
Birak (45,7m)	**Denbora**	1. Aulkitik altxa	
1		2. Zutik egon	
2		3. Eserita egon	
3		4. Aulkian eseri	
4		5. Transferentziak	
5		6. Begiak itxita	
6		7. Oinak elkartuta	
7		8. Besoa aurreraka luzatu	
8		9. Lurretik objektu bat jaso	
9		10. Atzera begiratu	
10		11. 360º-ko bira ematea	

BUELTAK GUZT.(M)		12. Oinak step edo eskaloi baten gainean jarri		
KONOAK (M)		13. Tandem		
DISTANTZIA (M)		14. Hanka bakarrean		
GUZTIRA (M)		Oharrak	GUZTIRA	
Bm Hasierakoa				
Bm Amaierakoa				
Bm Errek. (1’)				