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Effects of an individualized and progressive multicomponent exercise program on blood pressure, cardiorespiratory fitness, and body composition in long-term care residents: Randomized controlled trial

Haritz Arrieta, PhD[a,*], Chloe Rezola-Pardo, PhD[b], Javier Gil, PhD[b], Maider Kortajarena, RN PhD[a], Idoia Zarrazquin, PhD[a], Iñaki Echeverria, PhD[b,c], Itxaso Mugica, RN PhD[a], Marta Limousin, RN[d], Ana Rodriguez-Larrad, PhD[b], Jon Irazusta, PhD[b]

[a] *Department of Nursing II, Faculty of Medicine and Nursing, University of the Basque Country (UPV/EHU), Begiristain Doktorea Pasealekua 105, E-20014 Donostia-San Sebastián, Gipuzkoa, Spain.*
[b] *Department of Physiology, Faculty of Medicine and Nursing, University of the Basque Country (UPV/EHU), Barrio Sarriena s/n, E-48940 Leioa, Bizkaia, Spain.*
[c] *Department of Physical Education and Sport, Faculty of Education and Sport, University of the Basque Country (UPV/EHU), Portal de Lasarte 71, E-01007 Vitoria-Gasteiz (Araba), Spain.*
[d] *Uzturre Asistentzia Gunea, San Joan Kalea 4, E-20400 Tolosa (Gipuzkoa), Spain.*

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A B S T R A C T

This study analyzed the effects of an individualized and progressive multicomponent exercise program on blood pressure, cardiorespiratory fitness, and body composition in long-term care residents. This was a single-blind, multicenter, randomized controlled trial performed in 10 long-term care settings and involved 112 participants. Participants were randomly assigned to a control group or an intervention group. The control group participated in routine activities; the intervention group participated in a six-month individualized and progressive multicomponent exercise program focused on strength, balance, and walking recommendations. The intervention group maintained peak VO_2, oxygen saturation, and resting heart rate, while the control group showed a significant decrease in peak VO_2 and oxygen saturation and an increase in resting heart rate throughout the six-month period. Individualized and progressive multicomponent exercise programs comprising strength, balance, and walking recommendations appear to be effective in preventing cardiorespiratory fitness decline in older adults living in long-term care settings.

Introduction

Aging individuals exhibit a progressive decline in cardiorespiratory fitness.[1] This decline results from a combined reduction in muscle oxygen delivery due to reduced cardiac output and reduced oxidative capacity of muscle fibers.[2] Epidemiologic studies indicate that individuals with low cardiorespiratory fitness are more likely to develop hypertension,[3] diabetes,[4,5] and metabolic syndrome[6] and to have higher death rates due to cardiovascular disease,[7] cancer,[8] and all causes.[7] Moreover, higher cardiorespiratory fitness is associated with decreased risk of dependency[2,9] and increased quality of life,[10] and some studies show higher cardiorespiratory fitness is associated with lower healthcare costs.[11,12] These findings support the emerging case for "fitness as a vital sign",[13] by which cardiorespiratory fitness should be routinely determined clinically along with traditional risk factors such as blood pressure, body weight, and lipid levels.[11] Together with cardiorespiratory fitness, blood pressure and body composition parameters are important predictors of cardiovascular events and dependency in community-dwelling older adults.[2,9,14–17] These studies provide an economic-based impetus for healthcare providers and organizations to investigate and implement new interventions to maintain blood pressure, cardiorespiratory fitness, and body composition in older adults.

Older adults living in long-term care (LTC) settings are a diverse and complex population, exhibiting a high prevalence of dependence in activities of daily living, cognitive impairment, depression, falls, multimorbidity, and polymedication.[18,19] Moreover, LTC residents tend to be extremely inactive, engaging in sedentary activities for

Abbreviation: 1-RM, one repetition maximum; ANOVA, analysis of variance; BMI, body mass index; BMR, basal metabolic rate; CG, control group; IG, intervention group; LTC, long-term care; MEC-35 test, adapted and validated version of Mini-Mental State Examination in Spanish; SD, standard deviation

*Corresponding author at: Department of Nursing II, Faculty of Medicine and Nursing, University of the Basque Country (UPV/EHU), Begiristain Doktorea Pasealekua 105, E-20014 Donostia, Gipuzkoa, Spain.
E-mail address: haritz.arrieta@ehu.eus (H. Arrieta).

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most of the day.[20] Considering that LTC residents often have high blood pressure and low fat-free mass,[21,22] and that cardiorespiratory fitness declines with aging,[23] exercise interventions that improve blood pressure, cardiorespiratory fitness, and body composition could hold particular relevance for LTC settings. In this regard, aerobic training can minimize cardiorespiratory fitness decline during aging.[2] To date, aerobic training is the most studied exercise program to improve cardiorespiratory fitness.[24] However, recent trials show that individualized and progressive multicomponent (aerobic, strength, and balance training) exercise programs at moderate intensity also improve cardiorespiratory fitness and decrease blood pressure in community-dwelling older adults.[25,26] Notably, individualized and progressive multicomponent exercise programs at moderate intensity seem to be more efficient than aerobic training to improve body composition[27] and are the most recommended exercise programs to reduce frailty in community-dwelling older adults.[28]

However, currently there are few studies focused specifically on body composition, cardiorespiratory fitness, and blood pressure parameters among LTC residents. Maltais et al.[29] showed no significant effect on body composition after a multicomponent exercise program in LTC residents. In contrast, Coswig et al.[30] showed significant improvement in cardiorespiratory fitness and reduction in body mass but did not observe significant changes in blood pressure after aerobic training performed at moderate intensity in LTC residents. However, neither Maltais et al. nor Coswig et al. included an usual care group for comparison.[29,30] On the other hand, Pepera et al. found a significant decrease in blood pressure after a multicomponent exercise program in LTC residents.[31] However, since this study was of short duration and enrolled few individuals, the authors encouraged future studies of longer duration and larger sample sizes.[31] Considering these mixed results, the aim of the present study was to analyze the effects of an individualized and progressive multicomponent exercise program on blood pressure, cardiorespiratory fitness, and body composition among LTC residents.

Methods

Study design

Here we present the results of an exploratory secondary analysis of a single-blind, multicenter, randomized controlled trial (ACTRN12616001044415)[32] that took place in October 2016–July 2017 and whose primary outcomes were previously published.[33] After baseline assessments, participants within each LTC center were randomly allocated (in a 1:1 ratio) by coin-tossing sequence generation to a control group (CG) or intervention group (IG). This study was developed based on extension of the CONSORT statement (guidelines for reporting randomized controlled trials (Supplementary File 1)). The study was conducted in agreement with the Helsinki Declaration and approved by the Committee on Ethics in Research of the University of the Basque Country, UPV/EHU (Humans Committee Code M10/2016/105).

Participants

We recruited 112 participants from 10 LTC settings (Gipuzkoa, Basque Country, Spain) (Figure 1). The main recruitment strategy was information provided to potential participants by the nursing and medical professionals at each facility. Identification of individuals who met the inclusion criteria was facilitated by the databases of the included LTC centers. All volunteers received detailed study information at 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. The inclusion criteria were as follows: 1) aged ≥70 years, 2) residents who scored ≥50 on the Barthel Index,[34] 3) residents who scored ≥20 on the MEC-35 test[35] (an adapted and validated version of the Mini-Mental State Examination in Spanish), and 4) residents who were capable of standing up from a chair and walking independently for at least 10 meters. Participants were not eligible if they were judged clinically unstable by the medical staff based on absolute contraindications to exercise testing from the American College of Sports Medicine, such as unstable angina, acute pulmonary infarction or embolus, and acute myocarditis or pericarditis.[36] All participants provided written informed consent.

Control group

Subjects in the CG participated in routine low-intensity activities that LTC settings offer to attendees as usual care: memory workshops, reading, singing, and soft gymnastics.

Intervention group

In addition to routine activities, IG participants performed a previously described individualized and progressive multicomponent exercise program at moderate intensity.[32] The intervention consisted of one-hour supervised group training sessions twice per week for a six-month period involving individualized strength and balance exercises and walking recommendations. The intervention took place in the gym or a room equipped to perform group-based activities in each LTC center.

All sessions began with a brief five-minute warm-up consisting of range-of-motion exercises for the neck, wrists, shoulders, hip, knees, and ankles. Strength training comprised upper and lower body exercises individualized according to the Brzycki equation[37] that were performed for the estimation of one repetition maximum (1-RM) and tailored to the adequate load progression of knee extension, knee flexion, and arm-curl exercises for each participant at baseline and every two months. Hip abduction, hip adduction, and chair-stand exercises were performed without external weights, and intensity was adapted to the capabilities of each participant by adjusting the number of repetitions and velocity. The exercise program was designed and adapted according to FITT training principles, in which both the volume and intensity of the strength exercises were progressively increased. Residents started by performing one set of 8–12 repetitions at 40% of 1-RM and finished the program by performing two sets of 7–8 repetitions at 70% of 1-RM in each strength exercise performed in the program. Balance training was also individually tailored and included exercises progressing in difficulty, starting with the greatest 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 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 five minutes of cooling down with stretching, breathing, and relaxing exercises. All sessions were conducted by professional exercise instructors who graduated with degrees in physical activity and sports sciences and had broad experience performing exercise sessions with older adults. A total of three exercise instructors supervised all exercise sessions performed in this study. Of note, the instructors conducted a pilot study before starting this study. In this pilot study they designed and tested both the types of exercise and the volume and intensity of each exercise in the program. In each center, the same instructor was responsible for conducting all exercise sessions. The three instructors relied on the experience gained in the pilot study and the meetings they held during design of the exercise program to carry out the

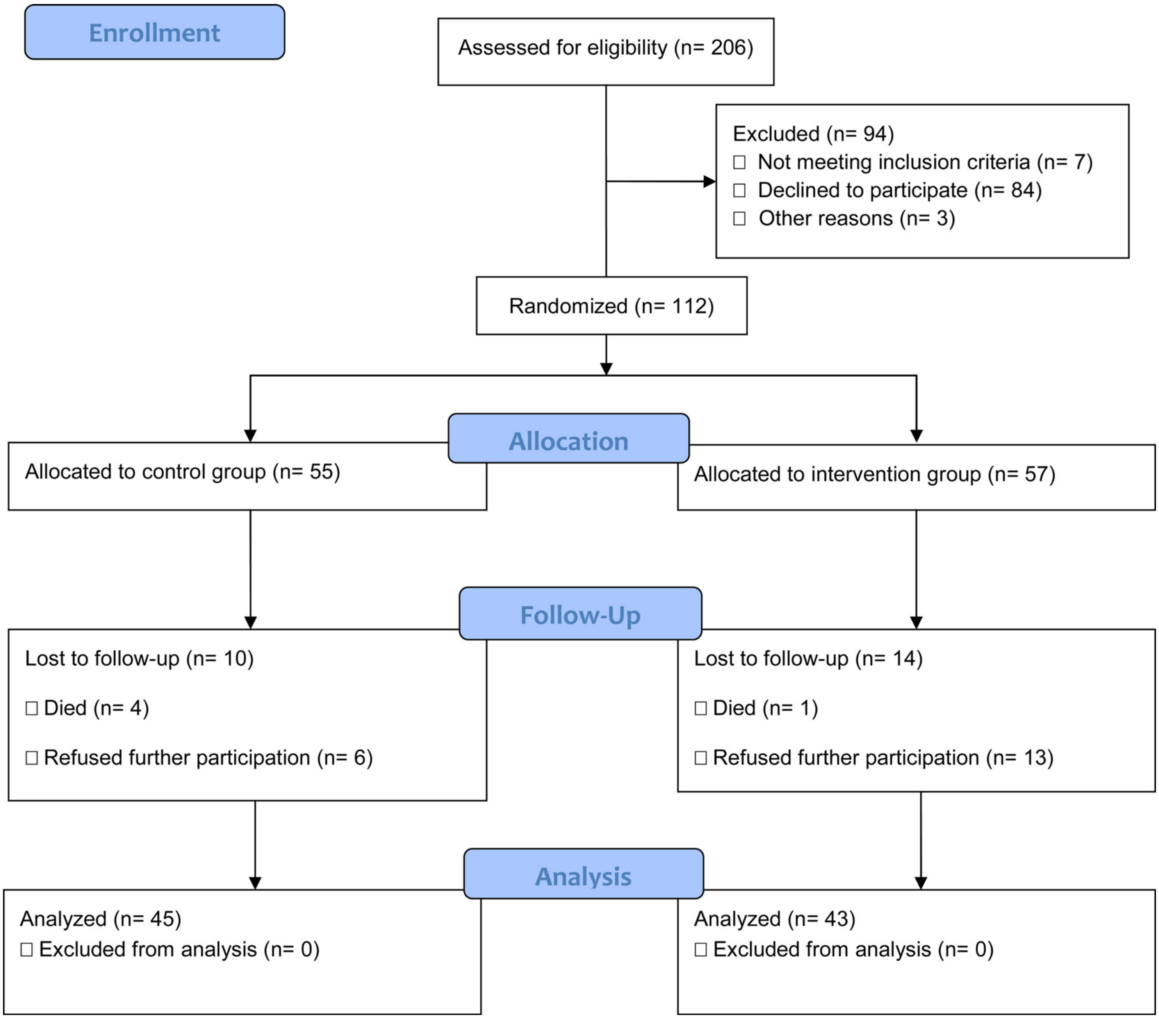

Fig. 1. CONSORT 2010 Flow Diagram

sessions using the same methodology. In addition, they maintained close and daily contact throughout the intervention to resolve any doubts that arose during the program. No adaptations were made according to the center in which participants resided. The exercise instructor together with the LTC center staff, which included nurses, auxiliary nurses, and medical doctors, encouraged and helped gather residents in the room where the sessions were conducted.

Walking recommendations were individualized based on each participant's baseline six-minute walk test performance. Walking recommendations started with paths that lasted 5 minutes per day at the beginning of the intervention, then progressed to 10 minutes, 15 minutes, and finally 20 minutes per day, with the goal of completing 140 minutes per week after the six-month period. The objective proposed in the walking program was to get all residents to approach 150 minutes of aerobic physical activity at moderate intensity per week, as currently recommended for older adults by the World Health Organization.[38] Recommendations were based on a specific number of laps on a track (based on aerobic capacity of each participant as measured by the six-minute walk test). Residents took the walks alone, with their family members, or with the help of LTC center staff. LTC center staff encouraged residents to comply with the walking recommendations daily. Residents also were encouraged by the exercise instructor during each exercise session to continue complying with the walking recommendations. The number of laps completed by each participant each day was registered during the last week of the second, fourth, and sixth months by the chief nurse of each LTC setting. Chief nurses monitored completion of the recommendations, checking performance themselves and asking assistant nurses or study participants according to the internal organization from each center. The chief nurse of each LTC setting received specific training to assess residents' adherence to the walking recommendations.

Measurements

Measurements were taken at baseline and at six months. Assessments were conducted in each center by the same clinical research assistants who were blinded to group allocation. Clinical research assistants were investigators from the research team and included nurses as well as other health professionals with special training in geriatric assessments.

Outcome measures

Adherence to the exercise program and adverse events

Adherence was determined by participants' presence at exercise sessions. Compliance of walking recommendations was collected daily during the last week of the second, fourth, and sixth month by the chief nurse of each LTC setting.

Blood pressure

Systolic and diastolic blood pressures were assessed using a clinically validated automatic blood pressure monitor (Omron M6AC) before breakfast in each resident's room. Participants were asked to remain in the supine decubitus position with their arms resting on their sides. The cuff was placed on their unclothed right arm, 1–2 cm above the elbow joint, with the cable on the brachial artery. Blood pressure was measured twice, leaving a rest period between measurements, and both measurements were noted.

Cardiorespiratory fitness

Resting heart rate was assessed using an automatic blood pressure monitor (Omron M6AC) and the procedure detailed above. Peak VO_2 and heart rate recovery were estimated with the six-minute walk test.[39] Heart rate recovery was calculated from the difference between heart rate at the end of the six-minute walk test and 1 minute into recovery. The heart rates of residents during the six-minute walk test were objectively measured using Polar heart rate monitors (Polar ft4, Polar, Finland). The six-minute walk test is part of the Senior Fitness Test and is used to evaluate endurance capacity in older adults.[40] This test consists of walking as quickly as the participant can for six minutes to cover as much distance as possible.[40] Testing areas for the walking test included garages, terraces, or large spaces used for group activities in the LTC itself. We used the same testing area in each LTC setting to perform the walking test at baseline and at six months. Oxygen saturation was measured using a pulse oximeter after blood pressure measurement using the procedure detailed above.

Body composition

Height was measured with a Holtain stadiometer with an accuracy of 0.1 cm, and body mass was assessed with an Omron digital scale with an accuracy of 0.1 kg. Body mass index (BMI) was calculated based on body height and mass. Total body water, basal metabolic rate (BMR), and BMR/body weight were measured with the QuadScan 4000 bioelectrical impedance unit (Bodystat Ltd., Isle of Man, UK). All body composition measures were taken by the same investigator, who was internationally accredited in anthropometric testing (ISAK level 1).

Statistical analyses

Normal distribution of data was checked using the Kolmogorov-Smirnov test, and non-normally distributed variables were square-root-transformed. Categorical variables are presented as frequencies and percentages, and continuous variables as means and standard deviation. Statistical comparisons at baseline were performed using unpaired student's t-tests and chi-squared tests. Between-group differences for effects of the exercise intervention on systolic and diastolic blood pressure, peak VO_2, oxygen saturation, resting heart rate, heart rate recovery, BMI, total body water, BMR, and BMR/body weight were assessed using mixed-design analysis of variance (ANOVA; two time points × two groups). Partial η^2 was calculated to estimate the effect size; η^2 values of $\leq$0.02, $\leq$0.13, and $\geq$0.26 were considered small, medium, and large, respectively.[41] Post-hoc Bonferroni test was used to assess changes within groups. All analyses were tested with a significance level of $p < 0.05$. Statistical analysis was performed using the IBM SPSS Statistics v.24 software package (SPSS, Inc., Chicago, IL, USA).

Results

We assessed 206 participants for eligibility, and 112 consented to participate and were randomized into the CG or IG. Of these 112 participants, 5 died and 19 refused further participation during the six-month follow-up, so the study included 88 participants. There were no differences between baseline values of CG and IG in any of the study variables ($p > 0.05$). The mean participant age was 84.9 years (range: 70–102 years), and participants were predominantly women (70.5%) (Table 1).

Table 1
Descriptive characteristics of participants at baseline.

	Control group		Intervention group		*p*
		n		*n*	
Age in years, mean (SD)	84.7 (6.1)	55	85.1 (7.6)	57	0.812
Females, n (%)	37 (67.3)		42 (73.7)		0.457
Barthel Index score, mean (SD)	82.8 (13.1)	55	79.2 (12.9)	57	0.153
MEC-35 test score, mean (SD)	28.0 (3.5)	55	27.0 (4.0)	57	0.157
Comorbidities, n (%)[a]					
1	17 (30.9)		13 (22.8)		0.333
2	16 (29.1)		13 (22.8)		0.448
≥3	15 (27.3)		21 (36.8)		0.278
Blood pressure					
Systolic blood pressure in mm Hg, mean (SD)	153 (21.3)	52	148 (21.1)	57	0.200
Diastolic blood pressure in mm Hg, mean (SD)	81.5 (9.9)	52	78.6 (12.0)	57	0.176
Cardiorespiratory fitness					
Peak VO_2 in mL/kg/min, mean (SD)	10.0 (2.2)	54	10.3 (2.2)	56	0.413
Oxygen saturation in percentage, mean (SD)	95.2 (3.1)	52	95.3 (2.3)	57	0.795
Resting heart rate in beats/minute, mean (SD)	69.4 (11.7)	52	70.0 (10.3)	57	0.798
Heart rate recovery in beats, mean (SD)	18.9 (16.9)	54	17.58 (12.4)	53	0.665
Body composition					
Body mass index in kg/m^2, mean (SD)	28.2 (5.3)	52	28.2 (5.1)	57	0.991
Total body water percentage, mean (SD)	49.6 (6.5)	52	48.7 (6.1)	57	0.459
Basal metabolic rate in kcal/day, mean (SD)	1216 (248)	52	1196 (220)	57	0.665
Basal metabolic rate/body weight in kcal/day/kg, mean (SD)	18.5 (2.0)	52	18.3 (2.0)	57	0.739

SD, standard deviation; MEC-35 test, adapted and validated version of Mini-Mental State Examination in Spanish.
[a] Comorbidities include hypertension, diabetes mellitus, dyslipidaemia, chronic obstructive pulmonary disease, coronary heart disease, peripheral vascular disease, cancer, and depression.[33,61]

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 events associated with the exercise program were observed.

Blood pressure

When differences were measured within groups, neither the CG nor IG showed significant changes in diastolic or systolic blood pressure throughout the six-month period ($p > 0.05$). The group-by-time interaction in mixed-design ANOVA was not significant for either diastolic or systolic blood pressure ($p > 0.05$) (Table 2).

Cardiorespiratory fitness

When differences were measured within groups, the IG maintained peak VO_2, oxygen saturation, and resting heart rate ($p > 0.05$), while the CG showed a significant decrease in peak VO_2 (F = 14.918; $p < 0.05$) and oxygen saturation (F = 6.093; $p < 0.05$) and an increase in resting heart rate (F = 6.369; $p < 0.05$) throughout the six-month period. The group-by-time interaction in mixed-design ANOVA was significant for peak VO_2 (F = 6.571; $p < 0.05$; ES^2 = *small*), oxygen saturation (F = 3.996; $p < 0.05$; ES^2 = *small*), and resting heart rate (F = 4.375; $p < 0.05$; ES^2 = *small*). Heart rate recovery did not significantly change throughout the six-month period in either group ($p > 0.05$) (Table 2).

Body composition

When differences were measured within groups, the CG and IG showed no significant changes in any body composition-related study variable throughout the six-month period ($p > 0.05$). The group-by-time interaction in mixed-design ANOVA was not significant for any study variable related to body composition ($p > 0.05$) (Table 2).

Discussion

This study demonstrates that a six-month, individualized, and progressive multicomponent exercise program performed at moderate intensity and encompassing strength, balance, and walking recommendations is effective to avoid decline in peak VO_2 and oxygen saturation and increase in resting heart rate that usually occurs among LTC residents in a cohort of participants with a mean age of 84.9 years. Similarly, aerobic training and multicomponent exercise programs are reported to be beneficial by increasing peak VO_2 in community-dwelling older adults aged <80 years.[42,43] However, to our knowledge, no studies have evaluated the effects of multicomponent exercise programs on peak VO_2 in people >80 years of age residing in LTC settings. Here, we observed a significant group-by-time interaction on peak VO_2 in favor of the IG after the six-month multicomponent exercise program among LTC residents. The IG maintained peak VO_2 after the exercise program, while the CG showed a significant decline. Aging is characterized by progressive decline of peak VO_2.[1] LTC residents spend most of the day engaged in sedentary activities,[44] which may further increase the speed of age-related reductions in aerobic capacity. Therefore, the fast decline of peak VO_2 in only 6 months is not surprising. Lower peak VO_2 is associated with cardiovascular events and dependence,[2,9,14] so multicomponent exercise programs are especially relevant among LTC residents.

We also showed a significant group-by-time interaction on oxygen saturation in favor of the IG after six months. The IG maintained oxygen saturation, while the CG had decreased oxygen saturation after the six-month study period. These results are in line with those of Bichay et al.[45] in community-dwelling older adults, with higher oxygen saturation in participants who performed aerobic exercise training at moderate intensity compared to a control group. Low oxygen saturation or hypoxemia is defined when oxygen saturation is <95%, and it is associated with increased all-cause mortality.[46] After the six-month period in our study, the CG had a mean oxygen saturation value of <95%, while the IG had a mean value of >95%.

We also observed a group-by-time interaction on resting heart rate, with a lower resting heart rate in the IG than CG after the exercise program. These results are in line with those of Coswig et al.,[30] which showed a significant decrease in resting heart rate after four weeks of aerobic training at moderate intensity among LTC residents. Several studies have demonstrated an association between elevated resting heart rate and increased incidence of cardiovascular disease.[47] An elevated resting heart rate could increase hemodynamic stress and shorten the diastolic phase, leading to increased mechanical load, stress, blood pressure, and cardiac work, thus enhancing oxygen consumption[48] and increasing the risk of cardiovascular disease such as coronary atherosclerosis and myocardial ischemia.[49]

The reported effectiveness of exercise programs in increasing heart rate recovery after physical activity is variable. Tsarouhas et al.[50] showed that aerobic training at moderate intensity is effective at increasing heart rate recovery in patients with chronic heart failure. On the other hand, Matsuo et al.[51] showed no significant change in heart rate recovery in sedentary adults at 1 minute after

Table 2
Effects of multicomponent exercise intervention on cardiovascular parameters in long-term care residents.

	Control group			Intervention group					
	Baseline, mean (SD)	6 months, mean (SD)	*n*	Baseline, mean (SD)	6 months, mean (SD)	*n*	*p* [b]	*F*	Partial η^2
Blood pressure									
Systolic blood pressure (mm Hg)	152 (19.5)	148 (20.5)	42	147 (20.7)	149 (23.6)	43	0.118	2.499	0.029
Diastolic blood pressure (mm Hg)	81.1 (10.5)	81.7 (12.1)	42	78.1 (11.5)	77.3 (10.4)	43	0.516	0.425	0.005
Cardiorespiratory fitness									
Peak VO_2 (mL/kg/min)	9.8 (1.9)	9.0 (1.9)[a]	43	10.6 (2.3)	10.6 (2.5)	43	0.012	6.571	0.073
Oxygen saturation (%)	94.8 (3.2)	93.7 (3.4)[a]	42	95.3 (2.1)	95.5 (2.1)	42	0.049	3.996	0.046
Resting heart rate (beats per minute)	69.5 (12.2)	73.2 (11.9)[a]	41	70.3 (11.3)	70.1 (12.3)	43	0.040	4.375	0.051
Heart rate recovery (beats)	18.7 (16.5)	17.5 (14.5)	39	17.7 (10.1)	18.0 (9.9)	40	0.731	0.119	0.002
Body composition									
Body mass index (kg/m^2)	28.9 (5.0)	29.2 (4.9)	41	28.4 (5.0)	28.6 (5.1)	43	0.895	0.018	<0.001
Total body water (%)	48.8 (6.3)	48.5 (6.4)	42	49.2 (6.3)	49.4 (6.2)	43	0.395	0.732	0.009
Basal metabolic rate (kcal/day)	1229 (238)	1234 (233)	42	1243 (226)	1255 (228)	43	0.465	0.540	0.006
Basal metabolic rate/body weight (kcal/day/kg)	18.3 (2.1)	18.2 (2.1)	42	18.5 (2.0)	18.5 (2.0)	43	0.426	0.641	0.008

SD, standard deviation.
[a] $p < 0.05$, significantly different from baseline.
[b] *p*-value for group-by-time interaction.

continuous aerobic training at moderate intensity. Moreover, Matsuo et al.[51] showed significant changes in heart rate recovery at 2 minutes after high-intensity aerobic interval training but not with continuous aerobic training at moderate intensity. In addition, Villelabeitia Jaureguizar et al.[52] showed no significant increase in heart rate recovery after continuous aerobic training but found a significant increase after high-intensity interval aerobic training in patients with coronary artery disease. To date, to our knowledge, no study has evaluated the effects of multicomponent exercise programs on heart rate recovery among LTC residents. Our results are in line with those of Matsuo et al.[51] and Villelabeitia Jaureguizar et al.,[52] as we did not observe a significant group-by-time interaction on heart rate recovery after the individualized and progressive multicomponent exercise program at moderate intensity. Therefore, significant differences in heart rate recovery may be observed with a higher-intensity multicomponent exercise program among LTC residents.

Several studies showed that multicomponent exercise decreases blood pressure in community-dwelling older adults.[53] However, we did not observe significant changes in systolic and diastolic blood pressure after a multicomponent exercise program among LTC residents. These results agree with Coswig et al.,[30] who showed no effects on systolic and diastolic blood pressure among LTC residents after an aerobic training program performed at moderate intensity. The same authors[30] also showed a significant reduction of systolic blood pressure only after high-intensity interval aerobic training. Therefore, significant differences in blood pressure may be observed with a higher-intensity aerobic training program among LTC residents. Hypertension is defined as systolic blood pressure $\geq$140 mm Hg and/or diastolic blood pressure $\geq$90 mm Hg.[54] Because mean systolic blood pressure was $>$140 mm Hg in both the CG and IG, there were likely many patients with hypertension in our study. Hypertension elevates the risk of cardiovascular events, and this risk is lowered by decreasing blood pressure.[53] Therefore, more studies are needed to determine the optimal exercise intensity to reduce systolic and diastolic blood pressure among LTC residents, since this could prevent cardiovascular events in this population.

The present study showed no significant effects of an individualized and progressive multicomponent exercise program on BMI among LTC residents, in line with results from Maltais et al.[29] Although epidemiological studies have observed that higher BMI is associated with increased risk of all-cause mortality,[55] observational studies among LTC residents have shown opposing results. Kimyagarov et al.[56] showed that LTC residents with BMI $>$ 27 have less mortality risk than their counterparts with BMI $<$ 27. Moreover, Beck and Damkjær et al.[57] showed that LTC residents with BMI $>$ 29 have a higher quality of life than their counterparts with BMI $<$ 29, despite an increased prevalence of obesity-related diseases. Therefore, reducing BMI in older adults living in LTC facilities cannot be considered a positive result based on current data.

Further, our study did not show significant group-by-time interactions for total body water, BMR, and BMR/body weight measured with bioelectrical impedance. These results are in line with those of Henwood et al.[58] and Hassan et al.,[59] who showed no significant changes in body composition measured with bioelectrical impedance after a multicomponent exercise program among LTC residents. Thus, although increased muscle strength and physical fitness performance have been consistently reported with multicomponent exercise programs among LTC residents,[60,61] changes in body composition seem to be less common. This finding may suggest that multicomponent exercise programs among LTC residents improve muscle neural and/or metabolic efficiency and muscle quality per unit mass, with little impact on cross-sectional area.[62] Total body water is positively associated with better physical performance.[63] BMR, defined as the energy required to perform essential physical functions at rest,[64] can be used to predict long-term weight gain[65] and development of age-related chronic disease, and is a marker of frailty in older men.[66]

The main strength of our study is that it includes a well-defined sample of LTC residents. This is the first study analyzing the effects of a multicomponent exercise program on blood pressure, peak VO_2, oxygen saturation, resting heart rate, heart rate recovery, total body water, BMR, and BMR/body weight among LTC residents. Moreover, the implemented multicomponent exercise intervention is feasible and includes detailed information about training frequency, volume, intensity, and individualization. This characterization will facilitate straightforward implementation in LTC facilities, as the existing literature on exercise protocols for LTC residents includes few randomized controlled trials, and the methodology tends to be heterogeneous.[67,68] In addition, the methods used are often not sufficiently described to allow replication. Finally, COVID-19 may represent an opportunity to design a new model of LTC settings,[69] and the findings of this study could be used to improve the quality of care among LTC residents through implementation of multicomponent exercise programs.

Despite its strengths, our study has certain limitations. These results cannot be directly applied to all LTC residents, as we do not know if they are applicable to individuals with lower physical and cognitive functions than the participants in our study. Although the sample size is one of the largest among studies focusing on the effects of a multicomponent exercise program on LTC residents, larger trials would be welcome. We also used a generalized equation to estimate peak VO_2 from the 6-minute walk test[39] and did not perform cardiopulmonary exercise testing, which is considered more reliable to measure peak VO_2. Cardiopulmonary exercise testing with measurement of peak VO_2 is the "gold standard" for assessing aerobic capacity. Nevertheless, the safety and feasibility of this test have not been proven among LTC residents. Moreover, this test is restricted by expensive and sophisticated equipment, qualified examiners, and long duration of testing sessions. In addition, LTC residents might not be familiar with the equipment (cyclergometers or tapes), which could potentially pose a challenge. In this regard, walking is a simple, natural, and familiar mode of exercise that is well-tolerated by older adults,[70] even those with higher levels of dependence and cognitive impairment.

Conclusions

These results provide evidence that individualized and progressive multicomponent exercise programs are effective in preventing cardiorespiratory fitness decline among LTC residents. From a practical standpoint, individualized and progressive multicomponent exercise programs encompassing strength, balance, and walking recommendations should be included as standard of care for LTC residents, as in addition to their well-known effects on physical and cognitive function, these programs appear to be effective in preventing cardiorespiratory fitness decline. These results highlight residents' care needs for recreation and exercise. These results are particularly relevant for gerontological nurses, who are often among the main agents promoting physical activity and healthy lifestyles in LTC settings. LTC staff, along with health institutions and funding providers, should be aware of these results when implementing multicomponent exercise programs.

Declaration of Interest

None.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.gerinurse.2022.03.005.

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