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Exercise intensity adherence during aerobic and resistance training in cancer survivors

Abstract

Combined aerobic-resistance training has shown the best benefits for cancer survivors (CS). To understand the adherence to the aerobic training program (in terms of the intensity and duration of the sessions) and the cardiovascular response to the resistance training program, 48 CS were monitored in each training session with a heart rate monitor for two years. During aerobic training, CS had to maintain the intensity in zone 2 (Z2) (*i.e.,* between ventilatory threshold, VT, and respiratory compensation point, RCP). The time spent below Z2 (Z1), in Z2 and above Z2 (Z3) was assessed in both aerobic and resistance training. The adherence to the exercise intensity (aerobic *vs*. resistance training) was: Z1 6.6±12.8% *vs*. 34.3±29.9% ($p<0.001$); Z2 66.6±29.3% *vs*. 54.5±27.6% ($p<0.05$); Z3 26.9±29.9% *vs*. 11.2±20.6% ($p<0.001$). The most deconditioned CS (<4.5 METs) presented the poorest adherence in Z2 and spent the most time in Z3. A significant positive moderate-high correlation was found for the percentage of time in Z3 between resistance and aerobic exercise ($r=0.75$, $p<0.001$). In conclusion, the individualization of exercise intensity resulted in good adherence to the prescribed intensity. Less fit CS need more supervision in their training sessions. Resistance training allowed the CS to train in moderate-vigorous intensities. Resistance training should have more scope in exercise prescriptions, particularly in deconditioned CS and in the first steps of exercise programs.

Keywords: exercise prescription, survivorship, physical activity, oncology.

INTRODUCTION

The evidence of exercise benefits for cancer survivors (CS) has grown and today oncologists recommend avoiding inactivity (24). Compared with healthy people, CS present ~30% lower peak oxygen uptake (VO_{2peak}) values (between 16-25 $mL·kg^{-1}·min^{-1}$) (18, 27). Any activity increment over rest values (~3.5 $mL·kg^{-1}·min^{-1}$ of VO_2) represents a high proportion of VO_{2peak} in CS (24). Intensities above the ventilatory threshold (VT) (*i.e.,* moderate activities) are needed to achieve significant health improvements (7, 23). The combination of aerobic and resistance training presents higher benefits in quality of life, emotional wellbeing, physical fitness and functionality than any one of these activities alone (8).

The American College of Sports Medicine [1] recommend that CS should avoid inactivity and return to the usual activities as early as possible after the cancer diagnosis. At least 150 minutes per week of moderate physical activity are recommended, or 75 minutes per week of vigorous physical activity, in addition to resistance training 2-3 days per week, as well as light intensity activities in everyday life (1, 11, 16, 24, 26). When it is possible to perform a cardiopulmonary exercise test (CPET), individualized exercise should be prescribed based on individualized thresholds, rather than using relative intensities (4, 10, 22). If a CPET is not possible, the moderate intensity in CS is considered an activity between 2.5-4 METs, 8-14 points on the Borg RPE scale, 23-48% of heart rate reserve (HR_{res}), 55-70% of maximum heart rate (HR_{max}) or 41-64% of maximum oxygen consumption (VO_{2max}) (10).

Once the exercise has been prescribed, it is important to assess the adherence to the program, not only the attendance to sessions but also the compliance regarding the intensity and duration of the training sessions (13). Intensity of the exercise programs for CS is not detailed in 75% of the studies (29). Proper exercise intensity prescription and adherence are needed in order to maximize the physiological and psychological effects of exercise and to improve the quality of life (14, 21).

Therefore, the purpose of the current study was to assess the adherence to the prescribed individualized intensity during aerobic training sessions and to understand the distribution of the training time spent in each individualized intensity zone of aerobic and resistance training in CS. The secondary aim was to understand the influence of VO_{2peak} of CS on cardiac responses during aerobic and resistance training.

METHODS

Experimental Approach to the Problem

To examine the aim of the current study recruited CS performed a CPET and were classified into three groups according to their cardiorespiratory fitness (in METs). During the individualized exercise program (three sessions per week of 90 minutes each combining aerobic and resistance exercise) participants were monitored in each training session with a heart rate monitor. This study design enabled us to examine: 1) the adherence to the prescribed individualized intensity during aerobic training, 2) the distribution of the training time spent in each individualized intensity zone and 3) the influence of CSs' VO_{2peak} on cardiac responses during training. Conclusions will help cancer exercise specialists to provide appropriate individualized exercise interventions for CS.

Participants

One hundred and fifty two CS were recruited from the oncology department of the ……. Inclusion criteria: 1) cancer survivor, 2) Eastern Cooperative Oncology Group (ECOG) scale = 0, 3) physical activity ≤90 min/week. Exclusion criteria: 1) heart disease (≥ New York Heart Association II), 2) uncontrolled hypertension (blood pressure>160/90 mmHg), 3) uncontrolled pain or 4) any other contraindication to start an exercise program such as high risk of bone fractures, severe anemia (<8g/dL), or $<50\cdot10^9/\mu L$ of platelet count). Participants were informed about the study. Each participant obtained the consent of the oncologist and a written informed consent was obtained before participating in the study. The study received ethical approval from The Clinical Research Ethics Board of ……………. After obtaining peak and submaximal cardiorespiratory variables in the CPET, participants were offered an individualized exercise program (three sessions per week of 90 minutes each combining aerobic and resistance exercise).

Procedures

Sample Procedures

Forty eight of the recruited participants who started the exercise program were randomly selected to analyze the intensity of their exercise sessions (Random Number Generator Pro v 1.72.© de Segobit Software©).

The flow diagram in Figure 1 shows the recruitment process. The participants' characteristics are displayed in Table 1.

Testing Procedures

Each participant performed a CPET in the Sports Medicine Center (…..) at the same time (10:00 am – 02:00 pm) and in similar environmental conditions (temperature 20-22°C, relative humidity 45-55%, barometric pressure 720 mmHg). The test was performed on an electric braking cycle-ergometer (Variobike 600, Marquette Hellige, Freiburg, Germany). Participants were not involved in any exercise the previous 24 h before the test. After an unloaded five-minute warm-up, the load was increased by 8-10W per minute with an initial load of 20W. The participants were informed to maintain the cadence between 60-70 rpm. Gas exchange was measured breath by breath using an open spirometer circuit (MasterScreen CPX, Jaeger, Viasys

Healthcare, Hoechberg, Germany). The test was performed until volitional fatigue, when the cadence could not be maintained above 60 rpm or with confirmation of a maximal effort (meeting three out of the following criteria: 1) no increase in VO_2 with increased workload, 2) HR values ≥ 85% estimated maximum HR (HR_{maxT}) (9), 3) RER ≥ 1.10, and 4) Rating of perceived exertion (RPE) = 20 (Borg 6-20) (1, 3, 15, 17)). Regardless of achieving maximal criteria, the maximum values achieved during the CPET are referenced as "peak" and expressed in $mL·kg^{-1}·min^{-1}$ (17, 27). Heart rate was monitored using a 12-lead electrocardiogram. At the end of each stage (1 min) RPE was evaluated and blood pressure every 2 min. Oxyten consumption, ventilation, ventilatory equivalents (for oxygen and carbon dioxide) and respiratory quotient for peak and submaximal values (VT and RCP) were also evaluated. The VT was defined as the first exponential increase in the O_2 ventilatory equivalent (V_E/VO_2) without a concomitant increase in the CO_2 ventilatory equivalent was considered. The RCP was determined using the ventilatory equivalent method (the first exponential increase in the CO_2 ventilatory equivalent alongside an increase in the ventilatory equivalent for O_2). Two experienced researchers detected these points individually and in the case of disagreement, the opinion of a third researcher was obtained. Heart rate at VT and RCP determined three intensity exercise zones: Heart rates below VT as light intensity zone (Z1), between VT and RCP as moderate intensity (Z2) and above the RCP determined the high-intensity zone (Z3) (7, 23). During the exercise program, eventually, the CS were subjected to the CPET in order to understand their evolution, modify their exercise prescription and readjust the intensity zones. The physiological values of the CS obtained in the CPET are listed in Table 2.

The CS were classified into three groups according to their cardiorespiratory fitness: the most deconditioned CS with a VO_{2peak} < 4.5 METs; the second group of CS were between 4.5 and 6 METs and the third group corresponded to CS with > 6 METs.

Training Procedures

The exercise program consisted of three weekly sessions of 90 minutes each (aerobic + resistance exercises). All training sessions were performed at the same fitness club (….) and supervised by the same exercise instructor. Each training session started and finished with 10 minutes of warm-up and cool-down (light intensity activities such as joint mobility, stretching, walking or cycling). The aerobic exercise consisted of one or two exercises (cycle-ergometer, rowing-ergometer, treadmill walking or running or elliptical trainer) of 20-30 minutes (continuous or in series of 10 minutes). Participants had to maintain the individualized moderate intensity zone (Z2) for as long as possible (the CS had a digital screen available showing their heart rate). The resistance training included 11 exercises engaging the major muscle groups (chest press, shoulder press, leg extension, leg curl, leg press, leg calf rise, abdominal crunch, low back extension, arm curl, arm extension and lateral pull-down). The resistance was individually adjusted to allow 12-15 repetitions for three sets of the large muscle group exercises and two sets of the small muscle group exercises. The resistance was increased by 5-10% when the individual was able to perform the prescribed maximum repetitions per set. After an increase in resistance, the repetitions per set were decreased to the low end of the prescribed repetition range. Abdominal and lower back exercises were performed with 15-20 repetitions in the maximum zone.

The participants were monitored in each training session with a HR monitor (Suunto Dual Confort Belt). All data were transferred to the program "Suunto Team Monitor" and analyzed with the program "Suunto Team Manager". Two years of data on cardiorespiratory and resistance exercise were collected (from 2010, November 29th to 2012, December 19th): 2862 sessions of aerobic training and 2974 of resistance training. The erroneous files were removed. The time spent in each intensity zone was assessed (7, 23) by the same researcher.

Statistical analysis

Descriptive statistics were calculated for the continuous variables (mean±SD) and frequencies for the non-continuous variables. The normality criterion was verified for each variable (Kolmogorov-Smirnov test) and for the groups that would be compared to different variables (Kolmogorov-Smirnov or Shapiro-Wilk). To verify the variance homogeneity, Levene's test was performed. To assess the differences in the time percentage spent in each zone between aerobic and resistance exercise and the differences in the time percentage spent among the three intensity zones in each exercise type, the paired t-test was performed for the parametric variables and the Wilcoxon signed rank test for the non-parametric variables. One-way ANOVA was used for the parametric samples and Kruskal-Wallis H test was used for the non-parametric samples to compare the time percentage spent in each intensity zone among the aerobic fitness groups (<4.5 METs, 4.5-6 METs and >6 METs). Bonferroni posthoc test was applied to understand which groups had statistical differences and the Mann-Whitney U test was used for non-parametric variables. Paired *t* test and Wilcoxon signed rank test were used to assess the differences between the intensity zones in each group. To assess the association between VO_{2peak} and the time percentage spent in each intensity zone during aerobic and resistance training, Pearson´s correlation coefficient was used. Statistical significance was set at $p<0.05$. Statistical analyses were performed using SPSS statistical software (version 20.0, IBM SPSS Statistics, Chicago, IL).

RESULTS

The adherence to the prescribed aerobic exercise intensity (Z2) was 66.6±29.3% of the total time (Table 3) (significant differences with the other two intensity zones $p<0.001$) (Figure 2). Of all participants, 35.6% presented a good adherence (>80% of the time in Z2) (Table 3). The

6.6±12.8% of the aerobic exercise time was performed in Z1, whereas the time spent in Z3 was significantly higher ($p<0.001$) (26.9±29.9% of the time) (Figure 2).

Most of the resistance exercise time was spent at moderate intensities (54.5±27.6%). However, compared to aerobic exercise, more time was spent at light intensities (34.3±29.9% in Z1) and less time at higher intensities (11.2±20.6% in Z3). Statistically significant differences were found in each intensity zone between aerobic and resistance exercises. (Figure 2).

When CS were divided into groups according to their peak cardiorespiratory capacity, the fittet CS (>6 METs) showed the greatest adherence to the prescribed intensity in aerobic exercise (74.8±24.3% of the time in Z2). On the contrary, the most deconditioned CS (<4.5 METs) presented the poorest adherence (49.5±33.1% of the time in Z2), but these differences were not statistically significant. The <4.5 METs CS group exercised 43.9±36.8% of the time in Z3 and showed statistically significant differences with the >6 METs CS group ($p<0.05$) (Figure 3). In resistance training (Figure 4), the 4.5-6 METs group was the group that exercised the most time at moderate intensity (67.8±25.8% of the time in Z2), showing significant differences with the <4.5 METs CS group ($p<0.05$). The < 4.5 METs CS group exercised 33.8±31.8% of the time in Z1, 40.1±24.4% of the time in Z2 and 26.4±33.5% in Z3, showing significant differences at the vigorous intensity with the other two groups ($p<0.05$ with 4.5-6 METs and $p<0.01$ with >6 METs).

Significant positive correlations were found between VO_{2peak} and the time percentage in prescribed Z2 in aerobic exercise ($r=0.35$, $p<0.05$) (Figure 5c), although the association was moderate-low. VO_{2peak} and time percentage in Z3 during both aerobic and resistance exercise presented a negative significant correlation ($r = -0.31$, $p <0.05$ and $r = -0.4$, $p < 0.01$, respectively (Figure 5a and b). There was a significant positive moderate-high correlation for the time percentage spent in Z3 between resistance and aerobic exercise ($r = 0.75$, $p < 0.001$) (Figure 5d).

DISCUSSION

The CS spent most of the aerobic training time (66.6±29.3%) in the prescribed zone (Z2). The adherence to the prescribed intensity was good. In exercise programs for CS, it is necessary to provide detailed information about the exercise prescription, mainly in terms of exercise intensity. This allows the objective interpretation of the results, and it can provide information about the tolerability and the safety of the prescription (29). A study with breast CS found similar results (65% of the time, the workouts were performed in the prescribed heart rate range) (6). In our study 26.9±29.9% of the training time was performed in Z3 and CS spent 6% of the time in Z1. These results suggest that the intensity of VT is easily surpassed, but also the intensity of RCP. In the present study, 22.2% of the participants showed low adherence (<40% of the time at Z2). These CS would surely need more supervision in their training sessions. When exercise intensity is not controlled, the cardiovascular response in this group could be different to from required.

From the total work time of resistance training 54.5±27.6% was performed at moderate intensity or Z2, significantly lower ($p<0.05$) than the time in Z2 doing aerobic exercise. Resistance exercise provided enough stimulus to work at moderate intensities or higher (Z2 + Z3) 65% of the time. Time percentage in Z1 is significantly higher. However, during resistance exercise, recovery between sets and exercises is done in Z1, thus, bloating the amount of time at light intensities. These results suggest that resistance training can provide high-intensity cardiac stimul for CS that could lead to large increases in VO_{2peak} (12). This training mode can induce peripheral changes that enhance the capacity of the muscle to use oxygen; increase the number of blood vessels and capillaries, in addition to the increase in muscle mass and strength (20). Knowing the actual intensity performed during resistance exercise by CS enables the modification of the exercise prescription. By modifying the resistance exercise components (number of exercises, sets, repetitions, intensity, recovery time, execution speed), we could expect different cardiovascular responses and this would enable us to design the exercise according to the needs of each CS (25). Cancer is accompanied with muscle mass loss and with a decline in physical function (8, 19, 30). In these situations, resistance training is the best way to increase this physical function and muscle mass (2, 6, 11, 14, 19).- This type of exercise should be offered to all CS. In postmenopausal women or in the elderly, in whom sarcopenia is one of the main limiting factors of oxygen uptake, or in prostate CS with androgen deprivation therapy, who present a significant loss of muscle mass, resistance exercise should be one of the main portions of their exercise program (5). When it is combined with aerobic training, even greater improvement in VO_{2peak} and in the quality of life could be obtained [5, 14, 20].

When the CS were divided into groups according to their cardiorespiratory capacity, large differences were observed in the distribution of exercise intensity. In aerobic exercise, the groups with higher physical fitness (the 4.5-6 METs and >6 METs groups) presented the best adherence to prescribed intensity (72.3% and 74.8% of the time respectively), whereas the most deconditioned group (<4.5 METs) exhibited the poorest adherence (49.5±33.1% of the time at Z2), spending a large part at high intensities. A minimum effort for a healthy person means an intense effort for this group of CS. Deconditioned CS needs more supervised and controlled exercise sessions in order to improve the adherence to the prescribed intensity. In resistance training the most deconditioned CS (<4.5 METs) spent more time at a vigorous intensity (26.4±33.5% of the time in Z3), than the other groups. 4,5-6 METs group train 67.8±25.8% of the time in Z2, showing similar cardiovascular response to aerobic exercise (72.3±26.4% of the time), suggesting that for this group of 4.5-6 METs resistance exercise could offer the intended cardiovascular response at moderate intensity, in addition to peripheral and muscle improvements. Modifying resistance exercise components we could increase the time spent at moderate intensity (Z2), especially in most deconditioned CS. As in this group the percentage of time in Z1 (low intensity) is high, reduction of the recovery time between sets and/or the increase in the number or repetitions per set could be a strategy to increase the time spent in Z2 and therefore to obtain an improvement in their cardiorespiratory fitness.

Those CS who trained more time at high intensity in the aerobic exercise were also who trained more time at high intensity in resistance exercise ($r=0.75$, $p<0.001$). This suggests that exercise intensity is dependent on the individual CS characteristics (mainly of their cardiorespiratory fitness) rather than influenced by the type of exercise.

In conclusion, the individualization of exercise intensity resulted in good adherence to the prescribed intensity. Less fit CS (<4.5METs) needs more attention in their exercise sessions due to the low adherence to the prescribed target. Resistance training allowed the CS to train at moderate-vigorous intensities for a large part of the training, showing sufficient cardiac response to achieve an improvement in VO_{2peak}. Less fit CS were able to obtain the most benefit from resistance training because they spent significantly more time at vigorous intensity than the others CS. Thus, resistance training should be considered an important element in exercise programs for CS.

Practical Applications

Once the exercise intensity has been prescribed in CS (with a CPET or with specific intensity guidelines for CS (10)), proper exercise intensity adherence (Good >80% of training time in Z2) is needed in order to maximize the physiological and psychological effects of exercise and to improve the quality of life (10, 13, 14, 21).

In aerobic exercise programs for CS, it is necessary to provide detailed information about the exercise workout assignment, mainly in terms of exercise intensity. Less fit CS (<4 METs) need more control (HR monitor) or supervision of their cancer exercise specialist in training sessions.

Our results suggest that resistance training can provide high-intensity cardiac stimuli for CS and should be considered an important element in individualization of CS exercise programs (particularly in deconditioned CS, during the first steps of the exercise programs and during adjuvant cancer therapy).

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