Exercise-Intensity Adherence During Aerobic Training and Cardiovascular Response During Resistance Training in Cancer Survivors

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1 GIAFyS Cancer Foundation, Miranda de Ebro, Burgos, Spain; 2Sport Medical Center, City Council of Miranda de Ebro, Castilla y Leon, Burgos, Spain; and 3Department of Physical Education and Sport, Faculty of Education and Sport, Physical Activity and Sport Sciences Section, University of the Basque Country (UPV/EHU), Vitoria-Gasteiz, Araba/Álava, Basque Country, Spain

Abstract
Quevedo-Jerez, K, Gil-Rey, E, Maldonado-Martín, S, and Herrero-Román, F. Exercise-intensity adherence during aerobic training and cardiovascular response during resistance training in cancer survivors. J Strength Cond Res XX(X): 000–000, 2019—Combined aerobic-resistance training has shown the best benefits has proved beneficial for cancer survivors (CS). To understand the adherence to the aerobic training programs (in terms of the intensity and duration of the sessions) and the cardiovascular response to the resistance training program, heart rate (HR) of 48 CS was monitored in each training session with an HR monitor for a 2-year period. During aerobic training, CS had to maintain the intensity in zone 2 (Z2) (between the ventilatory threshold and respiratory compensation point). The time spent below Z2 (Z1), in Z2, and above Z2 (Z3) was assessed in both aerobic and resistance training. The exercise-intensity distribution (aerobic vs. resistance training) was as follows: 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); and Z3 26.9 ± 29.9% vs. 11.2 ± 20.6% (p < 0.001). The most deconditioned CS (≤4.5 metabolic equivalents [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 needed more supervision in their training sessions. Resistance training allowed the CS to train in moderate-vigorous intensities of cardiovascular response. Resistance training should have more scope in exercise prescriptions, particularly in deconditioned CS and in the first steps of exercise programs.

Key Words: exercise prescription, physical activity, oncology

Introduction
The evidence for benefits from exercise in cancer survivors (CS) has grown, and today, oncologists recommend avoiding a sedentary lifestyle (27). Compared with healthy individuals, CS present ~30% lower peak oxygen uptake (V̇O2peak) values (between 16 and 25 ml·kg−1·min−1) (18,20,28). Any activity increase over rest values (~3.5 ml·kg−1·min−1 of V̇O2) represents a high proportion of V̇O2peak in CS (24). Intensities above the ventilatory threshold (VT) (i.e., moderate activities) are needed to achieve significant health improvements (8,24). The combination of aerobic and resistance training yields higher benefits in quality of life, emotional well-being, physical fitness, and functionality than any one of these activities alone (9).

The American College of Sports Medicine (1) recommends CS to avoid a sedentary lifestyle and return to normal activities as soon as possible after the cancer diagnosis. At least 150 minutes per week of moderate physical activity is recommended, or 75 minutes per week of vigorous physical activity along with resistance training 2–3 days per week, as well as light-intensity activities in everyday life (1,12,17,25,27,29). When a cardiopulmonary exercise test (CPET) can be performed, individualized exercise should be prescribed based on individualized thresholds, rather than using relative intensities (5,11,23). If a CPET is not possible, moderate intensity in CS is considered an activity between 2.5 and 4 metabolic equivalents (METs), 8–14 points on the Borg rating of perceived effort (RPE) scale, 23–48% of heart rate (HR) reserve (HRres), 55–70% of maximum HR (HRmax), or 41–64% of maximum oxygen consumption (V̇O2max) (11).

Once the exercise regimen has been established, it is important to monitor adherence to the program, not only in terms of session attendance but also regarding compliance pertaining to the intensity and duration of the training sessions (14). The intensity of the exercise programs for CS is not detailed in 75% of the studies (30). Proper exercise-intensity assignment and adherence are needed to maximize the physiological and psychological effects of exercise and to improve CS’ quality of life (15,22).

Therefore, the purpose of the current study was to assess adherence to the assigned individualized intensity during training sessions and to understand the distribution of the training time spent in each individualized intensity zone. This study design enabled us to examine: (a) the adherence to the assigned individualized intensity during aerobic training, (b) the distribution of the training time spent in each individualized cardiovascular intensity zone during resistance training, and (c) the influence of V̇O2peak of CS on cardiac responses during aerobic and resistance training. It was hypothesized that: (a) CS spend most of the time in
the designated exercise-intensity zone (moderate-intensity zone) during both aerobic and resistance training; (b) CS with better cardiorespiratory fitness show better adherence to the designated intensity and CS with worse cardiorespiratory fitness exercise more than the rest of the groups in the high-intensity zone during both aerobic and resistance training.

Methods

Experimental Approach to the Problem

The current study was an observational investigation designed to examine the HR values of each CS during training sessions. Recruited CS performed a CPET to establish exercise-intensity zones and were classified into 3 groups according to their cardiorespiratory fitness (in METs). During the individualized exercise program (three 90-minute sessions per week each combining aerobic and resistance exercise), participants’ HR was monitored in each training session with an HR monitor. Time in each intensity zone (Z1, Z2, and Z3) was recorded. As a result, the dependent variable of the current study was % of time in each intensity zone, and the independent variables included the type of training (aerobic and resistance) and cardiorespiratory fitness (<4.5 METs; 4.5–6 METs; >6 METs).

Subjects

One hundred fifty-two CS were recruited from the oncology department of the Santiago Apostol Hospital (Miranda de Ebro, Burgos, Spain) to participate in a program of oncological rehabilitation. Inclusion criteria: (a) CS, (b) Age > 18 years, (c) Eastern Cooperative Oncology Group scale = 0, and (d) physical activity level: walking less than a total of 30–60 min·d⁻¹ 3 d·wk⁻¹ and performing no strenuous exercise such as running, cycling, swimming, or resistance training. Exclusion criteria: (a) heart disease (≥New York Heart Association II), (b) uncontrolled hypertension (blood pressure >160/90 mm Hg), (c) uncontrolled pain, or (d) any other contraindication to start an exercise program such as high risk of bone fractures, severe anemia (<8 g·dL⁻¹), or <50-10⁷/µL of platelet count. Participants were informed about the study. Each participant obtained the consent of the oncologist, and written informed consent was obtained before participating in the study. The study received ethical approval from The Clinical Research Ethics Board of Burgos and Soria (Burgos, Spain). After obtaining peak and submaximal cardiorespiratory variables in the CPET, participants were offered an individualized exercise program (3 sessions per week of 90 minutes each combining aerobic and resistance exercise).

Procedures

Sample Procedures. The software used to monitor HR of CS (“Suunto Team Monitor”) only allows for the simultaneous tracking of 48 subjects; thus, only 48 of all recruited participants who started the exercise program of oncological rehabilitation 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 how the CS participants were recruited. When comparing the characteristics of enrolled vs. nonenrolled subjects, no significant differences were found except for a higher percentage of male participants in the enrolled group. The participants’ characteristics are displayed in Table 1.

Testing Procedures. Each participant performed a CPET (moment 0) in the Sports Medicine Center (City Council of Miranda de Ebro, Burgos, Spain) at the same time (10:00 AM–02:00 PM) and in similar environmental conditions (temperature 20–22° C, relative humidity 45–55%, and barometric pressure 720 mm Hg). The test was performed on an electric braking cycle-ergometer (Variobike 600; Marquette Hellige GmbH, Freiburg, Germany). Participants were asked not to exercise 24 hours before the test. After an unloaded 5-minute warm-up, the load was increased by 8–10 W per minute with an initial load of 20 W. Participants were instructed to maintain the cadence between 60 and 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 confirmation of a maximal effort (meeting 3 out of the following criteria: (a) no increase in VO₂ with increased workload, (b) HR values ≥ 85% estimated maximum HR (HRmaxT) (10), (c) respiratory exchange ratio ≥ 1.10, and (d) RPE = 20 [Borg 6–20] (1,3,16,19]). Regardless of achieving maximal criteria, the maximum values achieved during the CPET are referenced as “peak” and expressed in ml·kg⁻¹·min⁻¹ (19,28). Heart rate was monitored using a 12-lead electrocardiogram. Rating of perceived effort was evaluated at the end of each stage (1 minute) and blood pressure each 2 minutes. VO₂, ventilation, ventilatory equivalents (for oxygen and carbon dioxide), and respiratory quotient for peak and submaximal values (VT and respiratory compensation point [RCP]) were also measured. To detect the VT, the first exponential increase in the O₂ ventilatory equivalent (V̇O₂/VO₂) without a concomitant increase in the CO₂ ventilatory equivalent was considered. The RCP was determined using the ventilatory equivalent method (the first exponential increase in the CO₂ ventilatory equivalent alongside an increase in the ventilatory equivalent for O₂). Two experienced researchers detected these points individually, and in case of any discrepancy, the opinion of a third researcher was obtained. Heart rate at VT and RCP determined 3 intensity exercise zones: below VT determined the light-intensity zone (Z1), between VT and RCP was considered as moderate intensity (Z2), and above the RCP determined the high-intensity zone (Z3) (8,24). Throughout the exercise program (2 years), the CS underwent successive CPETs to understand the evolution of their thresholds (VT and RCP) and to adjust the cardiovascular intensity zones (moment 0, month 6 and month 12; the most deconditioned CS underwent a CPET in month 3). The physiological values of the CS obtained in the CPET (moment 0) are listed in Table 2.

After each CPET, the CS were classified into 3 groups according to their cardiorespiratory fitness: the most deconditioned CS with a VO₂peak < 4.5 METs; the second group of CS was between 4.5 and 6 METs; and the third group corresponded to CS with >6 METs (11).

Training Procedures. The exercise program consisted of 3 weekly 90-minute sessions (aerobic + resistance exercises). All training sessions were performed at the same fitness club (Di Som Fitness Center, Miranda de Ebro, Burgos, Spain) 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). None of these phases was included in the HR analysis. The aerobic exercise consisted of 1 or 2 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 (each CS had a digital watch available showing their HR).

The resistance training included 11 exercises engaging the major muscle groups (chest press, shoulder press, leg extension, leg curl, leg press, leg calf raise, abdominal crunch, low-back
extension, arm curl, arm extension, and lateral pull-down). One repetition maximum (1RM) was estimated from 6RM test to assess lower-body (leg press) and upper-body (bench press) muscle strength (1,4). The intensity of the resistance exercises was individually adjusted to an intensity of 50% of 1RM to allow 12–15 repetitions for 2–3 sets of the large muscle group exercises and 2 sets of the small muscle group exercises. The resistance was increased by 5–10% when the subject 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 in a 15–20RM zone. This exercise program for CS is included in an oncological rehabilitation program aimed to improve their quality of life. Therefore, we mainly focus on muscular endurance training, since this is key to perform daily tasks. This approach to training will also improve overall muscle strength and increase muscle mass (15). In addition, endurance training minimizes the risk of injuries in the early phases of the exercise program, which could otherwise create a sense of discouragement among the subjects, leading to their subsequent withdrawal from the program.

The participants were monitored in each training session with an HR monitor (Suunto Dual Confort Belt and Suunto Watch; Suunto, Vantaa, Finland). All data were transferred to the “Suunto Team Monitor” program and analyzed with the “Suunto Team Manager” program. Two years of cardiorespiratory and resistance exercise data were collected (from November 29, 2010, to December 10, 2012): 2,862 aerobic training sessions and 2,974 of resistance training. The incomplete and erroneous files were removed. The time spent in each intensity zone was assessed (8,24) by the same researcher.

**Statistical Analysis**

Descriptive statistics were calculated for the continuous variables (mean ± SD) and frequencies for the noncontinuous variables. The normality criterion was verified for each variable (Kolmogorov-Smirnov test) and for the groups that would be compared with 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 3 intensity zones in each exercise type, the paired t-test was performed for the parametric variables and the Wilcoxon signed rank test for the nonparametric variables. One-way analysis of variance was used for the parametric samples, and the Kruskal-Wallis H test was used for the nonparametric samples to compare the time percentage.

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**Figure 1. Recruitment of CS participants. CS = cancer survivors.**
Results

The adherence to the assigned aerobic exercise intensity (Z2) was 66.6 ± 29.3% of the total time (Table 3) (significant differences with the other 2 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).

Resistance exercise in Z1 was 34.3 ± 29.9% of the time, in Z2, it was 54.5 ± 27.6% of the time, and in Z3, it was 11.2 ± 20.6% of the time. 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 fittest CS (>6 METs) showed the greatest adherence to the assigned intensity in aerobic exercise (74.8 ± 24.3% of the time in Z2). 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 MET CS group exercised 43.9 ± 36.8% of the time in Z3 and showed statistically significant differences with the >6 MET CS group (p < 0.05) (Figure 3). In resistance training, the 4.5–6 MET 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 MET CS group (p < 0.05). The <4.5 MET 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 vigorous intensity with the other 2 groups (p < 0.05 with 4.5–6 METs and p < 0.01 with >6 METs). The >6 MET group exercised 44.1 ± 27.7% of the time in Z1 (Figure 4).

Significant positive correlations were found between V̇O₂peak and the time percentage in prescribed Z2 in aerobic exercise (r = 0.35, p < 0.05) (Figure 5A), although the association was moderate-low. Between V̇O₂peak and time percentage in Z3 during aerobic exercise, it was found a negative significant correlation (r = -0.31, p < 0.05) (Figure 5B), as well as with percentage in Z3 during resistance exercise (r = -0.4, p < 0.01) (Figure 5C). Likewise, 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 objectives of the study were: (a) to evaluate the adherence of CS to the individualized intensity zones assigned to each them during aerobic training, (b) to assess the training time distribution for each of the cardiovascular intensity zones during resistance training, and (c) to determine the influence of CS’ V̇O₂peak on cardiac responses during both aerobic and resistance training. According to the hypothesis, CS exercised the majority of time within the moderate-intensity zone (Z2) in both aerobic and resistance training. However, significant differences between the Z1

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*BMI = body mass index; S = surgery; Ch = chemotherapy; R = radiotherapy.
†Data are presented as mean ± SD for continuous variables and as frequency (%) for categorical variables.

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<th>Absolute and relative physiological values of the participants determined in the CPET (moment 0).†</th>
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*CPET = cardiopulmonary exercise test; V̇O₂ = oxygen uptake; VT = ventilatory threshold; RCP = respiratory compensation point; RER = respiratory exchange ratio; HR = heart rate.
†Data are presented as mean ± SD.
and Z3 zones were only present in aerobic training. Furthermore, during aerobic training, CS with greater cardiorespiratory fitness (>6 METs) had the best adherence in their designated intensity zone, but without significant differences with the rest of the groups. However, during resistance training, CS with cardiorespiratory fitness between 4.5 and 6 METs exercised most of the time in the moderate-intensity zone. Also, CS with the worst cardiorespiratory fitness exercised most of the time in the high-intensity zone, both in aerobic and resistance training.

The participating CS in our exercise program spent most of the aerobic training time (66.6 ± 29.3%) in the prescribed zone (moderate-intensity zone, Z2). The adherence to the assigned intensity was yielded positive results. In CS exercise programs, it is necessary to provide detailed information about the exercise regimen, mainly in terms of intensity. This allows for the objective interpretation of the results while also providing information about the subject’s tolerance and regimen safety (30). A study with breast CS found similar results (65% of the time, the workouts were performed in the established HR range) (7). In our study, 26.9 ± 29.9% of the training time was performed in Z3, and CS spent 6.6 ± 12.8% of the time in Z1. These results suggest that the intensity of VT is easily surpassed, but also the intensity of RCP. The 22.2% of CS showed low adherence (<40% of the time at Z2). These CS need more supervision in their training sessions. If exercise intensity is not controlled, the cardiovascular response in this group could be different from required.
Resistance training was performed 54.5 ± 27.6% of the time at moderate intensity or Z2, significantly lower (p < 0.05) than the time in Z2 doing aerobic exercise. Resistance exercise provided enough stimuli 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 performed in Z1, which increase time percentage in this zone. These results suggest that resistance training

Figure 4. Distribution of cardiovascular response to resistance training by peak MET-based groups. *p < 0.05 vs. 4.5–6 METs, †p < 0.01 vs. < 4.5 METs, #p < 0.05 vs. < 4.5 METs. MET = metabolic equivalent (1 MET = 3.5 mlO₂·kg⁻¹·min⁻¹ or 1 kcal·kg⁻¹·h⁻¹); Z1 = light-intensity zone (<VT); Z2 = moderate-intensity zone (VT-RCP); Z3 = vigorous-intensity zone (>RCP); VT = ventilatory threshold; RCP = respiratory compensation point.

Figure 5. Association between (A) VO₂peak vs. AT time % (Z2), (B) VO₂peak vs. AT time % (Z3), (C) VO₂peak vs. RT time % (Z3), and (D) RT time % (Z3) vs. AT time % (Z3). VO₂ = oxygen uptake; AT = aerobic training; RT = resistance training, T = time; Z2 = moderate-intensity zone; Z3 = vigorous-intensity zone.
can provide high-intensity cardiac stimuli for CS. This means that resistance training has the potential to induce large increases in VO₂peak (13). This training mode can induce peripheral changes that enhance the capacity of the muscle to use oxygen through increased capillarization and conversion of IIX muscle fibers (fast-glycolytic muscle fibers) to IIA muscle fibers (fast-oxidative muscle fibers) (21). Identifying the real 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, and execution speed), we could expect different cardiovascular responses, enabling us to design the exercise according to the needs of each CS (26). Cancer is accompanied with loss of muscle mass and a decline in physical function (9,17,31). In these cases, resistance training is the best way to increase this physical function and muscle mass (2,7,12,15,17), in addition to eliciting moderate- or even high-intensity cardiac responses with a probable increase of cardiorespiratory fitness (13,19,21). This type of exercise should be available to all CS. When significant loss of muscle mass is evident, resistance exercise should be one of the most important parts of their exercise program (6). When it is combined with aerobic training, greater improvement in VO₂peak and in quality of life could be obtained (6,15,21).

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 MET and >6 MET groups) presented the best adherence to assigned intensity (72.3 ± 26.4% and 74.8 ± 24.3% 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) and high adherence in Z3. Minimal effort for a healthy individual means intense effort for this group of CS. Deconditioned CS need more supervised and controlled exercise sessions to improve the adherence to the assigned intensity. In resistance training, the most deconditioned CS (<4.5 METs) spent more time at vigorous intensity (26.4 ± 33.5% of the time in Z3), than the other groups. A 4.5–6 MET group trained 67.8 ± 25.8% of the time in Z2, showing a similar cardiovascular response to aerobic exercise (72.3 ± 26.4% of the time). This means that for the group of 4.5–6 METs, resistance exercise could offer the intended cardiovascular response at moderate intensity, in addition to peripheral and muscle improvements. By modifying the resistance exercise components, we could increase the time at moderate intensity (Z2) and achieve the desired cardiorespiratory response, especially in the most CS deconditioned group. As in this group, the percentage of time in Z1 (low intensity) is high, reduction of the recovery time between sets, increase in the number of repetitions per set or both at the same time, could be a strategy to increase the percentage of time spent in Z2 and therefore obtain an improvement in their cardiorespiratory fitness.

Cancer survivors who trained more time at high intensity in 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 characteristics of CS (mainly their cardiorespiratory fitness) rather than being influenced by the type of exercise.

In conclusion, the individualization of exercise intensity resulted in good adherence to the prescribed intensity. Less fit CS (<4.5 METs) 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 VO₂peak. 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 assigned for each CS (with a CPET or with specific intensity guidelines for CS (11)), proper exercise-intensity adherence (good >80% of training time in Z2) is needed to maximize the physiological and psychological effects of exercise and to improve quality of life (11,14,15,22).

In aerobic exercise programs for CS, it is necessary to provide detailed information about the exercise workout assignment, mainly in terms of physical intensity. Less fit CS (VO₂peak < 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).

**Acknowledgments**

The authors thank all the cancer survivors who participated in this research. The authors have no professional relationships with any companies or manufacturers identified in this study. The authors have no conflict of interests that are directly relevant to the content of this study. This study was supported by GIAfys Cancer Foundation.

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