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Original Research

Resistance Training Contribute to the Aerobic Components of an Exercise Session in Adults but not as Much in Older Adults

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ABSTRACT

International Journal of Exercise Science 10(3): 406-416, 2017. Previous research has indicated that active adults are able to achieve moderate intensity as measured via heart rate during a typical resistance training (RT) session. The main objective was to identify if overweight adults and older adults can reach aerobic moderate intensity at a rate comparable to adults displaying a recommended body mass index. Twenty participants in each group were asked to visit a fitness facility twice if they self-reported doing RT for a minimum two days per week. At the first session baseline characteristics and maximal lifting capacity for each RT exercise. At the second, intensity was monitored via heart rate monitor during a RT exercise program composed of 10 exercises targeting major muscle groups. Three sets of 10 repetitions at 70% of maximal load were completed for each exercise. Moderate intensity was defined as a minimum of 40% of heart rate reserve. The proportion of time spent at moderate to vigorous intensity between the comparison group and the overweight adult group was not significantly different, with a median (25^{th} -75^{th}) proportion time of 82.6% (69.2-94.6) versus 92.5% (73.3-99.1); p=.54 or an average time of 42 minutes versus 45 minutes. The older adults group, however, spent a lower proportion of time at moderate to vigorous intensity compared with the comparison group, 51.5% (22.0-86.6) or 24 minutes; p<.01 compared with the comparison group. This study suggests that a good proportion of time spent doing RT can contribute to an aerobic component of the international guidelines, and therefore reduce the weekly time commitment especially for men and women age below 60 years old.

KEY WORDS: Guidelines, exercise, intensity, heart rate reserve

INTRODUCTION

Very few people achieve the Global Recommendations on Physical Activity for Health published by the World Health Organization (35). More specifically, it was found that less than 14% of Canadian adults (5) and only 10% of American adults (28) are currently reaching

these guidelines when physical activity is objectively measured. Physical activity is important, not only for personal health benefits, but for the public health system, as regular physical activity participation propagates reductions in health care costs (16, 17).

The Global Recommendations on Physical Activity for Health suggest that adults of any age should engage in a minimum of 150 minutes of moderate intensity physical activity, or at least 75 minutes of vigorous intensity physical activity, all in bouts of at least 10 minutes duration. In addition, a minimum of two sessions of resistance training (RT) activities should be performed every week (35). The current physical activity recommendation is associated with lower risk of all-cause mortality, hypertension, osteoporosis, cardiovascular diseases, breast and colon cancers, stroke, and type 2 diabetes in adults (32). Furthermore, physical activity has been associated with a reduction of functional limitations in older adults (25). These medical benefits make it imperative to explore innovative ways to increase the adherence to these guidelines. Recent research has demonstrated an association between shorter bouts of aerobic exercise (<10 minutes) spent at moderate intensity of physical activity and health benefits (1, 13, 20, 23). This suggests that a shorter bout of activity done at moderate or vigorous intensity could lead to health benefits similar to those seen with bouts of a longer duration.

One of the main barriers to physical activity is a lack of time (12). Reaching moderate intensity while completing RT could be an option in an effort to reduce the amount of time. Accomplishing RT activities at an intensity equivalent to at least moderate intensity could contribute as much as 40% of the required weekly commitment required to reach the guideline. Even if the time commitment is unknown for RT, if a typical RT session lasts 50 minutes, the total weekly commitment to reach the current guidelines is 250 minutes (150 minutes of aerobic exercise + two 50-minute RT sessions). Such an alternative could help overweight and older adults who may be struggling to reach moderate intensity via traditional aerobic activities due to their increased risk of mobility issues (31) and osteoarthritis (4, 19). Additionally, overweight individuals may be more motivated to participate in RT exercises, as they could find pride in being stronger than their lean counterparts (7). A recent pilot study that involved active lean adults reported that 51.5% of a RT session was spent at moderate intensity (14); these alternatives could be useful if moderate intensity could be reached while doing RT.

The proposed study is testing the theory that the aerobic and RT components of current recommendations may be concurrently achieved, which could benefit those who currently struggle to achieve the recommended activity goals. In order to test this hypothesis, intensity was monitored during a RT program designed to elicit moderate intensity heart rates (HR).

The objectives of the study were to: 1) identify if overweight adults and older adults aiming for a healthy body mass index, increased their HR while doing RT to the same degree as a comparison group of adults who have the recommended BMI; 2) evaluate the average intensity, based on HR, of typical RT exercises; 3) evaluate the average moderate to vigorous intensity bout length while completing a typical RT program.

METHODS

Participants

The study was approved by the Office of Research Ethics & Compliance and informed consent was obtained from all the participants. This cross-sectional study was conducted to determine if overweight adults (age 19-59 years old; BMI ≥ 28 kg/m^2) and older adults (age ≥ 60 years old BMI < 25 kg/m^2) are able to increase their HR to moderate intensity while doing RT in a similar manner as adults who are not overweight (age 19-60 years old; BMI< 25 kg/m^2). Aerobic intensity was calculated in accordance to previously determined HR reserve (HRR) values (33) as measured via a chest strap and watches recoding HR every second (Polar Accurex Plus Woodbury, NY).

Sixty active members from a community centre were recruited to join one of three groups based on BMI and age. To be eligible, participants had to self-report participating in RT for a minimum of two times per week during the previous six months in order to ensure familiarity with the selected exercises. If a participant was unfamiliar with a specific exercise, adequate time was spent to learn proper form and understanding before initiation. Participants were excluded if they were taking any medication that could have an impact on blood pressure or HR.

Protocol

Participants were asked to meet the research team on two occasions, separated by a minimum of 48 hours. All RT exercises took place at the public fitness facilities during operating hours. The first visit included obtaining informed consent, recording general background information described below, and, following a 5-minute warm-up on a cycle ergometer, estimating the 1-reptition maximum (1-RM) for seven of the selected exercises that composed the training regimen. Additionally, the maximal time each participant could complete an abdominal plank was determined (all exercises are outline in supplemental data). Each participant was allocated a 5-minute warm-up on a cycle ergometer before initiating an exercise session. At the second session each participant completed three sets of ten repetitions of each of the selected exercises at a resistance equaling 70% of the participant's 1-RM. For the abdominal plank, each participant performed the exercise three times for a period matching that set initially undertaken during the first visit. The participants were given a 30-second rest interval between each set and a 90-second rest interval between each exercise. As the testing sessions were completed at a public facility, a research assistant ensured the exercise session was properly adapted to provide the appropriate rest intervals. The required resistance, rest times, and exercises were all selected with the goal of achieving and maintaining at least moderate intensity exercise for as long as possible throughout the exercise session.

Anthropometric measures were taken in accordance with the Canadian Society for Exercise Physiology protocols (3). Body weight was measured using a digital scale (OMRON HBF-5186, Illinois, USA) with participants wearing light clothing and no footwear. Height was measured with a standard stadiometer (SECA217, California, USA). Based on these two measures, BMI was calculated as weight (kg)/height (m)^2.

The short form of the International Physical Activity Questionnaire was used to measure self-reported physical activity (6). The questionnaire provided information on the amount of time each participant spent at moderate intensity and vigorous intensity over the past seven days. The history of physical activity questionnaire (22) was used to collect information about the frequency, and the period of time each participant had been engaged in their respective exercise regimen. More specifically, the questionnaire asks: 1- How many days per week are you physically active a) total, and b) RT only. 2- Approximately how many minutes are you physically active each time? 3- How long have you been physically active at this level a) total, and b) RT only.

Participant 1-RM was estimated using a validated indirect strategy (27) for each exercise. Shoulder press, chest press, leg extension, lat pulldown, and lying leg curl were performed using dynamic variable-resistance exercise training machines (Nautilus Corp, Vancouver, Washington). A visual representation of each exercise can be found in the supplementary data. Free weights were used for performing the lunge and squat exercises, while body weight was used for the abdominal plank. A research assistant demonstrated each exercise for clarification purposes and ensured familiarity before starting the predictive 1-RM protocol. Participants then completed their own light warm-up set using minimal resistance. Following a 1-minute rest, and based on a discussion with the participants, a resistance was selected that would ensure the participants would optimally achieve between one and ten repetitions, consecutively. Repetitions that lost form or were not performed throughout the full range of motion were not counted. If a participant completed more than 10 repetitions, a three- to five-minute rest, was provided, further weight was added, and the procedure repeated. This procedure was repeated for a maximum of three attempts. If a participant was not in the target repetition range following three attempts, the session was postponed and repeated another day. Upon completion, the 1-RM was estimated using a validated formula (1-RM = [(# of repetition/30) + 1] load in kg)(2).

Resting HR was determined in order to calculate HRR. Participants were seated for at least five minutes in a chair with back support before a measurement of resting HR was taken. The exercise intensity was calculated and interpreted via HRR. If the HR of the participant was ≥ 40% of HRR [(220-age – HR_{rest}) * 0.4] + HR_{rest} during the RT program (measured every five seconds), it indicated that the participant was reaching moderate intensity at that point in time (33). If the HR of the participant reached ≥ 60% of HRR [(220-age – HR_{rest}) * 0.6] + HR_{rest} during the RT program (measured every five seconds), it indicated that the participant was reaching vigorous intensity at that given moment (24). The proportion of time spent at a minimum of moderate intensity was calculated by the number of readings that were equal to, or above the HRR threshold, and divided by the total time of the RT session.

For this research study, a 'bout' was defined as any activity at or above moderate intensity during at least one minute of the exercise program. The average and longest bout times were calculated and reported in Table 2.

Statistical Analysis

The distribution of continuous variables were tested for normality using the Shapiro-Wilk tests. Due to a combination of most variables not being normally distributed and a relatively small sample size, characteristics of the sample were described using the median (25-75th percentile). Mann-Whitney U or Chi-Square tests were used to compare individual groups for statistical differences. All statistics were performed using SPSS version 18.

RESULTS

General characteristics are described in Table 1. As per design, the comparison group (p=0.001) was significantly younger than the older group and leaner than overweight group (p=0.001). However, the comparison group was also younger than the overweight group. Self-reported time spent at moderate intensity was greater in the comparison group when compared to the overweight group (p=0.03), and the years of doing RT was significantly greater in the older group compared with the comparison group (p=0.002).

Table 1. General characteristics.

	Comparison Group N= 20	Adults Group N= 20	Older Adults Group N= 20
Age (years)	22 (21-25)	30 (24 -43)*	65 (60-70)*
Sex (men)	10 (50)	12 (60)	11 (55)
BMI (kg/m²)	23.5 (22-24)	29.7 (29-33)*	23.7 (22-25)
PA frequency (days/ week)	5.0 (4.2-6.7)	4.0 (3.0-5.4)	5.0 (3.9-5.9)
RT (days/week)	3.5 (2.5-4.0)	3.0 (2.0-3.5)	3.0 (1.6-3.0)
PA time (min/week)	380 (272-450)	308 (165-545)	325 (274-440)
Moderate Intensity (min/week)	135 (92-262)	60 (0-142)*	138 (38-236)
Year at current PA level (years)	3.0 (4.0-19.0)	1.5 (0.5-4.8)	3.5 (1.3-14.5)
Years doing RT (years)	4.5 (2-7)	3.5 (1-8)	12.5 (4-28)*

Data are presented as median (25-75 percentile), or N (%) *$p \leq 0.05$ significantly different from comparison group. BMI; Body mass index, PA; physical activity, RT; resistance training.

As per design, the workout time was 50 minutes; of which 40.6 minutes, or 82.3% of the time, was spent at a minimum of moderate intensity when evaluating the whole sample (Table 2). While there was no difference between the comparison group and the overweight group in time spent at moderate to vigorous intensity, a smaller duration was spent at moderate to vigorous intensity when comparing the older group to the comparison group (p=0.03). However, within the older groups, secondary analyses showed that that older men were spending more time (81.1% or 41 minutes versus 31.1% or 16 minutes) of the session at moderate intensity compared with older women, but this difference between men and women was not observed in the other two groups.

Interestingly, no differences were observed in time spent at vigorous intensity between the comparison group and the other two groups. For the whole sample, the average bout of moderate-intensity physical activity was 2.2 minutes, with the longest span of 10.4 minutes during the RT session. Differences were observed between the comparison and the older group for both variables (p<0.01), but not compare to the overweight group.

Table 2. Resistance training session intensity.

	Comparison Group N= 20	Adults Group N= 20	Older Adults Group N= 20
Time MI (min)	41 (34-48)	46 (35-47)	26 (11-40)*
% Time MI	83 (69-95)	93 (73-99)	51 (22.86)*
% Time VI	29 (18-41)	32 (16-52)	13 (4-36)
Average HR during RT session	137 (123-136)	133 (121-142)	103 (94-115)*
Average Bout Length at MI (min)	3 (2-4)	5 (2-39)	1 (1-3)*
Longest Bout at MI (min)	13 (8-27)	17 (8-44)	4 (2- 15)*

Data are presented as median (25-75 percentile) *$p \leq 0.05$ significantly different from comparison group.
MI; moderate intensity, HR; heart rate, RT; resistance training.

Table 3 presents the proportion of time spent at moderate to vigorous intensity for each exercise. Overall, the participants spent the highest proportion of time at moderate intensity doing lat pulldown 100.0% (80.0-100.0), leg extension 100.0% (50.0-100.0), and shoulder press 100.0% (40.0-100.0). The only difference observed among the groups was during the leg curl exercise, where the older group spent significantly more time at moderate intensity compared to the comparison group (p=0.02).

Table 3. Intensity of each exercise.

	Comparison Group N= 20	Adults Group N= 20	Older Adults Group N= 20
Squat	48.7 (38-79)	93.7 (52-100)	83.3 (7-100)
Chest press	40.5 (0-81)	75.0 (43-100)	53.8 (0-100)
Lunges	88.9 (82-100)	100.0 (70-100)	93.7 (64-100)
Lat pulldown	91.6 (75-100)	100.0 (85-100)	80.0 (17-100)
Leg extension	90.0 (53-100)	90.0 (58-100)	100 (7-100)
Shoulder press	100.0 (58-100)	92.8 (59-100)	100.0 (17-100)
Leg curl	83.3 (63-89)	99.9 (97-100)*	60.0 (8-100)
Plank	69.0 (51-79)	78.5 (61-96)	70.0 (28-100)

Data are presented as median (25-75 percentile) *$p \leq 0.05$ significantly different from comparison group.

DISCUSSION

Our findings indicate that when executing a typical RT program, the majority of the time is spent at moderate intensity, for adults regardless of BMI and older men. In addition, some exercises were the most beneficial when it came to achieving moderate intensity; lat pulldown, leg extension, and shoulder raise exercises.

The time spent at moderate intensity documented in this study – 82.3% was greater than the 51.5% observed in our original pilot study (14). This difference is likely explained by the RT program, which was utilized to enhance the time through a reduction in the number of upper-body exercises, an increase in multi-joint exercises of larger muscle groups, and a decrease in resting time (14). It may be possible to increase this duration even more through alternate RT methods, such as circuit or high-intensity interval training (HIIT). This was recently shown by Falcone et al. (8) who utilized a hydraulic resistance system to show that active young men

completing HIIT were capable of achieving and maintaining higher HRs compared to a general RT program including more rest, indicating the potential benefits of HIIT. Peinado et al. (33) also reported an average HR equal to 51% of HRR, well above the required 40% throughout the duration of RT (26) for young adult men and women while performing a seven-exercise circuit training program. These examples can help add evidence to the realistic possibility of using RT exercise to accumulate time towards the Physical Activity Guidelines, and may encourage future research exploring the long-term health benefits of doing so.

No significant difference was observed between the older adults group and the comparison group for the proportion of time spent at moderate intensity. This result came despite the fact that the older adults were capable of lifting heavier weights as determined by their 1-RM (results not shown). While this difference in strength is not surprising (10, 36), this finding indicates that regardless of the absolute differences that may exist in overall strength, as long as the proportional load lifted (% 1-RM) remains consistent our RT program is capable of achieving, and maintaining, an intensity that could be utilized towards an individual's physical activity goal for a significant duration of time in young adults. However, when it came to the older adults and the comparison group, an unexpected difference in the time spent at a minimum of moderate intensity existed. There may be an age-related decline associated this exercise approach. In the older group, a clear sex-related difference was noted: 81.1% of the time was spent at moderate intensity among the men, while only 31.6% was recorded among the women. Thus, it appears older men are able to reach an equivocal time at moderate intensity compared with the comparison and the overweight groups. The fact that older women did not reach at moderate intensity as much might stems from the fact that older women have less absolute muscle strength than older men (18), resulting in a lower training volume when reaching the same proportion of 1-RM.

Evidence suggests that both sporadic (<10 minutes) and non-sporadic bouts of moderate intensity are associated with health benefits (1, 13, 20, 23). The average bout length in our sample was 2.2 minutes. Surprisingly, the maximum average bout length in the comparison group and the older group were greater than 10 minutes. Therefore, even if one subscribes to the theory that bouts of moderate intensity shorter than 10 minutes are just as valuable as bouts of 10 minutes or more to gain health benefits, our results show that it is possible to reach 10-minute bouts of moderate intensity while participating in RT. The duration of bouts could be influenced and potentially be lengthened through a manipulation of the rest periods between both the sets and the different exercises (30). The older adults group performed shorter bouts of moderate intensity compared with the comparison group in both sessions. One potential explanation for this phenomenon may be the decline of muscle mass with age, limiting the capabilities of the older adults group. This could also lead to another explanation, in which both the older adults group and the comparison group were probably working close to their lactate threshold and forced to use anaerobic pathways to produce energy. As Wiswell et al. (34) explain, absolute work rate at lactate threshold declines with age, implying that while both groups were pushing themselves equally, the older adults group were incapable of maintaining such a work rate as long as the comparison group.

Certain exercises were more efficient than others at increasing the proportion of time spent at moderate intensity (Table 3). As previously stated, when the participants performed the lat pulldown, leg extension, and shoulder press exercises, the average participant spent the entire time at moderate intensity. For lunges, participants were at moderate intensity 94.5% of the time. No differences were observed between groups. It is well established that large muscle groups and multi-joint exercises recruit more muscle fibers, and, therefore, require a higher oxygen consumption for energy (11, 24). However, exercises such as squats and chest press also require a large muscle group, and the proportion of time spent at moderate intensity was lower (71.4% and 53.8%). An explanation for this may exist in the population's comfort level in completing these exercises. While the population was familiar with squat and bench press exercises, many of the older people displayed a hesitance when it came to adding weight for these selected exercises during the predictive 1-RM protocol. This led to a lower weight for the duration of the RT regimen, making it difficult for the participants to achieve the desired increases in HR. Alternate study protocols should be considered for this group of people to increase the comfort level with all exercises.

Despite the best efforts of the research team and the encouraging results and potential public health implications, some limitations need to be addressed. First, the participants in the study were selected only if they were already doing some form of RT. This implies that people who have never completed such a program may not be capable of reaching moderate intensity when they first start RT. Secondly, maximal HR was predicted and not objectively measured. Moreover, as there are many factors that can be changed in a RT session (e.g., sets, repetitions, rest, exercise tempo, exercise selection), it is possible that other RT exercises, rest intervals, overall load, or regimen design could lead to an individual spending more or less time at moderate intensity. Additionally, we did not measure intensity via indirect calorimetry. Some studies suggest that HR and oxygen consumption may not be strongly correlated while doing RT (9, 15, 21). Finally, this study observed the participants throughout a single RT session. Additional research monitoring the effects of a regimen implemented longitudinally would be beneficial.

In conclusion, these findings suggest that completing a RT program developed to increase muscular strength while maintaining an elevated heart rate could be used as an effective method for assisting adults in reaching the Global Recommendations on Physical Activity for Health. More specifically, older men, along with general adults age 60 or under may be able to attribute more than 80% of the time they spend in RT towards their aerobic physical activity time. Therefore, in order to reach the Global Recommendations on Physical Activity for Health while utilizing RT, adults and older men could do so by completing three RT sessions weekly at 70% of 1-RM for about 60 minutes. Further research is required to investigate the potential) health benefits by replacing the more traditional aerobic exercise with RT.

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