Effects of Aging and Exercise on the Cardiorespiratory Fitness of Older Women

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Abstract

Purpose: The present study analyzed the effects of chronological aging and the practice of regular exercise (PRE) on the cardiorespiratory fitness (CRF) of older women. *Methods:* A descriptive study of 78 participants was performed, with longitudinal design and an initial evaluation in 2005 and a second in 2011. The PRE defined groups as Inactive (I), Insufficiently-Active (IA), and Sufficiently-Active (SA). The six-minute walking test measured CRF. MANOVA with repeated-measures was used to verify the effect of time and the PRE groups on CRF ($p<0.05$). *Results:* The participants were classified as having a low socioeconomic level and being overweight. MANOVA demonstrated the effect of time ($F_{1.74}=30.134$; $p<0.05$) and groups ($F_{2.74}=3.729$; $p<0.05$), without interaction ($F_{2.74}=0.811$; $p>0.05$). Post hoc analysis indicated that the effect of time was significant between all groups (I: t=3.786, $p<0.05$; IA: t=2.597, $p<0.05$; SA: t=3.191, $p<0.05$); and the group effect was significant only between the I and SA groups in the second evaluation (First evaluation: $F_{2.76}=1.712$; $p>0.05$; Second Evaluation: $F_{2.77}=3.239$; $p<0.05$, *post hoc* Tukey: group I vs AS =$p<0.05$). A smaller reduction in CRF was found in the SA group (8.0%), followed by the IA (10.3%) and I (14.3%) groups. *Conclusion:* The results of the present study indicated that elderly women who practice exercise regularly had a smaller reduction in CRF than those who were inactive. This suggests that the PRE at recommended levels for health purposes can attenuate the effect of aging on the CRF.

Key words: aging; cardiorespiratory fitness; women; physical exercise.

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INTRODUCTION

The effects of the passing of time, or chronological aging, have been the subject of countless studies.[1,2] One of the main bodily systems affected by this process is the cardiorespiratory system, which is indirectly related to the risk of various chronic conditions, disabilities and early death.[3-,6] Veras[7] reported that the elderly have a higher burden of chronic diseases, especially diseases of the cardiovascular system, which causes increased demands on and use of health services by increasing the cost of treatment of such conditions. According to the Instituto Brasileiro de Geografia e Estatística (the Brazilian Institute of Geography and Statistics), the Brazilian population spent more on healthcare services than did the government in this sector.[8]

Maintaining cardiorespiratory capacity can be considered a determining factor for independent living and overall health, consequently minimizing public and personal spending on the treatment of such conditions. In addition, specifically among the elderly, satisfactory cardiorespiratory fitness (CRF) is required for various activities of daily living that involve large muscle groups for long periods, such as cleaning the house, gardening, getting from one place to another or simply bathing.[9,10] Low levels of CRF represent one of the main risk factors for obesity, hypertension, dyslipidemia, metabolic and cardiovascular disease and dependency. [6,11-15]

The arguments presented highlight the need to improve knowledge of the effects of chronological aging on the CRF of the elderly. However, studies previously conducted for this purpose have presented some limitations, such as discrepancies in the values of declining CRF. Cross-sectional studies indicate a reduction of between 5 and 10% per decade from the age of 30 onwards, while longitudinal studies have found a variance of between 5 and 20%.[16-18] Pollock *et al.*[17] warned of the dangers of such contradictory results and, in order to clarify this issue, conducted a study in which subjects were monitored for 20 years, with evaluations performed at baseline and after ten and twenty years. The sample consisted of professional male runners, who were divided into three groups according to their level of training. The annual decline in CRF was 2.17% among individuals who were still professional athletes, 2.34% among those who participated in competitions occasionally and 4.17% in subjects who had altered their exercise routine from racing to jogging. These results clearly indicate that the maintenance of regular physical exercise minimizes the effect of aging on CRF, and the reduction or absence of exercise dramatically increases the decline in CRF. Consequently, active individuals tend to reduce morbidity and also delay the onset or limitations of disability[6] and thus may have a lower biological than chronological age.

The decline of CRF over time has been found to range from 5% to 20% per decade. However, Fleg *et al.*[18] indicated that the decline varies depending on the age considered as a base and that from the age of 60 there is a more rapid decline in women. Therefore, it can be considered that changes in CRF can be influenced by physical exercise, gender and also by chronological age, with such changes having been found to be greater among elderly women. The aim of this study was to analyze the effects of chronological aging and regular physical exercise on the CRF of elderly women.

METHOD

Study Design

A descriptive study with a longitudinal design and two assessments was performed. Data from the first assessment (2005-2006) was reassessed in the first semester of 2011 - a mean interval of 5.8 years.

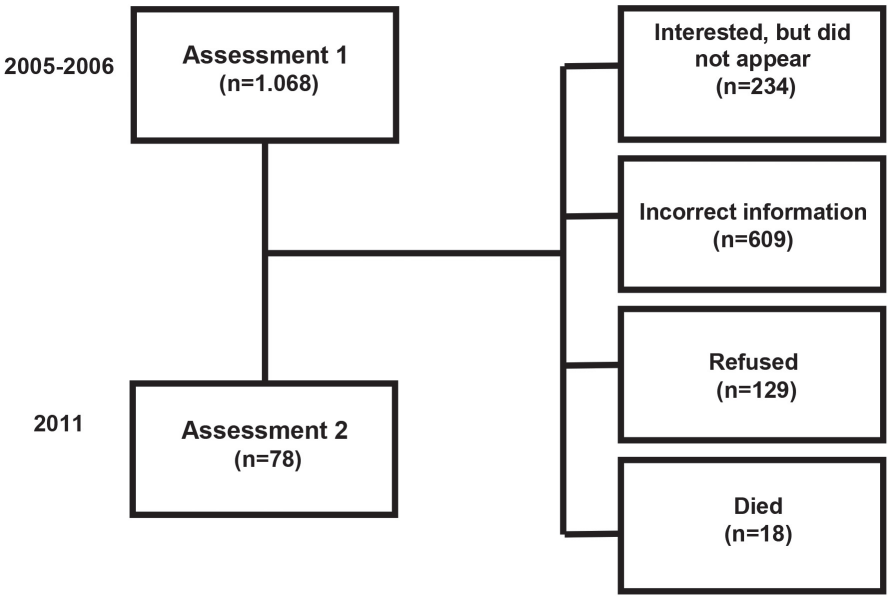


Figure 1. Flowchart of assessments. Curitiba - Parana, 2011.

Population and Sample

The present study was performed in the first semester of 2011, in the city of Curitiba, in the state of Paraná, among members of the Programa Terceira Idade Independente do Grupo de Pesquisa em Fisiologia da Atividade Física e Saúde da Universidade Tecnológica Federal do Paraná (the Independent Seniors Program of the Physiology of Physical Activity and Health Research Group of the Federal Technology University of Paraná. Those eligible (inclusion criteria) to participate in the study were women who participated in the first assessment in 2005 (n=1068) and were part of the Indepdendent Seniors program (2011). Initial contact with potential participants was conducted via telephone by a trained member of the group of researchers of this study, who described the purposes, potential benefits and associated risks of the study. After clarifying any doubts, the reassessment was scheduled. Free transportation was provided for the participants and at the time of reassessment, a researcher repeated the information related to the study and clarified any doubts that persisted. The clinical conditions of the elderly, such as which chronic diseases or disorders they suffered from and whether they were undergoing controlled medical treatment were ascertained through questioning. Some elderly women confirmed their clinical condition by presenting medical certificates, test results and the instructions of medicines used, although not all participants provided such information. Subsequently, the participant was asked to sign a clear and informed consent form, confirming their participation on a voluntary basis. The exclusion criteria were defined as elderly women who presented unfavorable psychological conditions for the tests/questionnaire, or who did not understand the procedures, thus affecting

performance test or questionnaire answers. It was not, however, necessary to exclude any of the potential participants. The final sample consisted of 78 participants (aged over 65).

The protocol of the study was submitted to and approved by the Ethics Research Committee of the Pontifícia Universidade Católica do Paraná (the Catholic University of Paraná) (CEP Nº. 0004798/11), in accordance with the guidelines of the Declaration of Helsinki and Resolution 196/96 of the National Health Council on research involving human beings.

Procedures

In order to avoid the influence of circadian variations, all evaluations were performed in the same period of the day (between 08:00 and 10:00 hours). The subjects were instructed not to perform vigorous physical activity the day before, as well as not to eat for a period of two hours prior to the assessment. All assessments were conducted at the academic office of the Physical Education Department of the Universidade Tecnológica Federal do Paraná.

Socioeconomic level

Socioeconomic status was determined by applying the Brazil economic classification criteria and was used for the descriptive characterization of the sample.[19] The results obtained from the questionnaire classifies socioeconomic level into seven classes: E (0-5 points), D (6-10 points) C (points 11-16), B2 (17-20 points), B1 (21-24 points), A2 (25-29 points) and A1 (30-34 points). For the purposes of classification, the classes were grouped into three categories: Upper (A1 and A2), Middle (B1 and B2) and Lower (C, D and E).

Anthropometric variables

Body mass and height were measured according to the procedures proposed by Lohman *et al.*[20] The individual being evaluated stood barefoot with her feet together, wearing light sports clothes (shorts, t-shirt or top) so that the measurement could be carried out with a mechanical scale with stadiometer (Welmy model 104A; resolution of 0.1 kilograms). Body mass index (BMI) was obtained by using the body mass/height ratio,[2] where the value of body weight is in kilograms and height in meters.

Practice of Regular Physical Exercise - PRE

The *Modified Baecke Questionnaire for older adults*[21] was used to measure the PRE. This instrument supplies a score based on the energetic demand of the physical activities performed by elderly persons, being subdivided into three domains of physical activity: domestic activities, sports/exercise and recreation/leisure. The score obtained in each area, as well as the sum of the areas is classified in metabolic equivalents (ME). This score is obtained from the intensity, duration in hours/week and period practiced (months previous year) of the reported activity. This study used only the sport/exercise domain in order to classify the elderly persons into three groups according to PRE score: Inactive (n=18) for those with a score of zero, Insufficiently Active (n=25), for those with scores greater than zero and less than 2.29, and Sufficiently Active (SA, n=34) for those with a score higher than 2.29 in the second assessment. The cut-off points followed the recommendations of the *American College of Sports Medicine* for the elderly,[9] which states that to be considered satisfactorily active older individuals should engage in moderate intensity physical activities (score=1.368), with a duration of 30 minutes per session and a frequency

of five weekly sessions (score=2.5); practiced for more than six months (score=0.67). The calculation was therefore performed by multiplying the scores: 1.368x2.5x0.67=2.29. Thus, the groups were classified considering only the level of physical activity specific to physical exercise, and not total physical activity level (the sum of all domains of the questionnaire). The questionnaire was conducted by previously trained evaluators in order to reduce variability among evaluators. The instrument had satisfactory validity when compared with other methods of measuring physical activity,[22] such as the Bouchard Record (a subjective measure), with a correlation of r=0.78, and the pedometer (objective measure), with a correlation of r=0.72. Reproducibility in elderly subjects was r=0.89.[23]

Cardiorespiratory Fitness

Cardiorespiratory fitness was measured by the six-minute walk test (6WT) in meters.[24] The test was conducted along a 54.4 m rectangular track (18.0 m long and 9.2 m wide). The distance walked in six minutes for each individual was recorded. The test was halted if, at any time, the participant showed signs of dizziness, pain, nausea, or undue fatigue. [Reproducibility: r=0.91 (95% CI 0.84-0.95); validation: r=0.71].

Statistical Analysis

All analyses were conducted using the Statistical Package for the Social Sciences (SPSS, 18.0) for Windows. In order to obtain the descriptive analysis of data, measurements of central tendency and variability were applied (mean and standard deviation). MANOVA with repeated measures was used to check the effect of time and of the PRE groups on cardiorespiratory fitness. For all analyzes, a significance level of $p<0.05$ was adopted.

RESULTS

The characteristics of the participants are shown in Table 1, which describes a stable socioeconomic status (SES), height and body weight and body mass index (BMI). The sample therefore comprised individuals of low SES with a nutritional status indicative of overweight.

Table 1. Descriptive characteristics of participants. Curitiba, Parana, 2011.

(n=78)	First Assessment	Second Assessment
Age (years)	67.2 (5.4)	73.2 (5.2)
SES (points)	13.8 (4.5)	14.2 (4.0)
Body Mass (kg)	68.5 (11.0)	68.4 (12.1)
Height (m)	1.54 (0.06)	1.54 (0.06)
BMI (kg/m^2)	28.5 (3.9)	28.6 (4.2)

SES: Socioeconomic Status; BMI: Body Mass Index.

Alterations in CRF are shown in Table 2. The average PRE values for the first and second assessments are shown. The groups were named according to the following characteristics: Inactive (I - no PRE), Insufficiently active (IA - PRE that does not meet recommendations for the promotion of health), and Sufficiently active (SA - meets or exceeds PRE recommendations for health promotion).

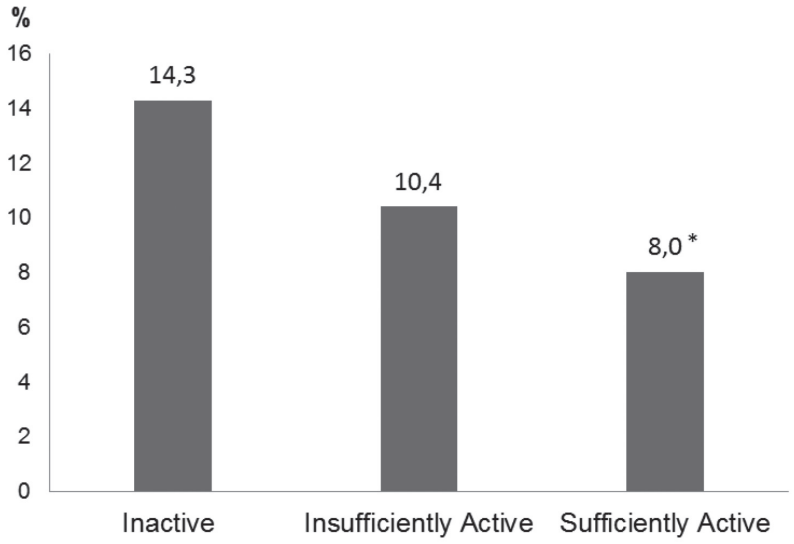
MANOVA showed an effect for time ($F_{1.74}$=30.134; p<0.05) and groups ($F_{2.74}$=3.729, p<0.05), without interaction ($F_{2.74}$=0.811, p>0.05). Further analysis indicated that there were differences between assessments for all groups (I: t =3.786, p<0.05; IA: t=2.597, p<0.05; SA: t=3.191, p<0.05). The differences between groups were only significant between I and SA in the second assessment (First Assessment: $F_{2.76}$ =1.712, p<0.05; Second Assessment: $F_{2.77}$=3.239, p<0.05, *post hoc* Tukey: group I vs SA =p<0.05)

Based on data from Table 2, the percentage decline in cardiorespiratory fitness (Figure 1) was calculated. In this figure, it can be seen that the decline was significantly higher in the group of inactive elderly persons, or those who said they did not practice regular exercise. Those who reported performing regular exercise (the sufficiently active group) achieved the smallest reduction over time.

Table 2. Alterations in cardiorespiratory fitness. Curitiba, Parana, 2011.

	Inactive – I (n=18)	**Insufficiently Active – IA (n=25)**	**Sufficiently Active – SA (n=34)**
6MWT_A1 (meters)	484.9 (60.2)	513.3 (85.9)	522.7 (62.4)
6MWT_A2 (meters)	410.6 (115.0)*	459.7 (93.3)*	480.8 (92.6)*§

Mean and standard-deviation, in brackets; 6MWT: Six-minute walk test; A1: first assessment; A2: second assessment. *Differences between A1 and A2; §Differs from inactive group_A2, p<0.05.



Mean temporal variation of 5.8 years.

Figure 2. Alterations in cardiorespiratory fitness due to chronological aging. Significant difference with Inactive group (p<0,05). Curitiba, Parana, 2011.

DISCUSSION

Although chronological aging brings an inevitable decline in cardiorespiratory fitness (CRF), the practice of regular exercise (PRE) can mitigate this process. As noted in the results, the decline in CRF was worse in the group of women classified as "inactive" in comparison with those in the "active" group. In the active group, the decline was only 8%, or 1.3% per year, statistically different to the inactive group, which exhibited a decrease of 14.0%, or 1.8% per year. Furthermore, it was observed that the CRF level of the active group during reassessment (480.8 m) was similar to that found in the inactive group in the first assessment (484.9 m). These results indicate that elderly persons who fulfilled the PRE recommendations managed to mitigate the decline in CRF and maintained fitness levels of 5.8 years earlier compared with their inactive peers.

In contrast, a cross-sectional study by Krause *et al.*[3] analyzed the decline in CRF of 960 elderly women, grouped into age groups with intervals of five years (60 to <80 years). CRF was evaluated by the six-minute walk test (6MWT). The groups were divided into: 1) did not engage in physical activity, similar to the inactive group of this study; and engaged in 2) low and 3) moderate intensity physical activity, corresponding to the groups insufficiently and sufficiently active, respectively. From the cross-sectional data, it was found that the annual decline was 0.74% for group 1 and 2, and 0.64% in group 3. However, the results of the present study showed an annual decrease of 2.46%, 1.79% and 1.37% respectively for each group. It was therefore observed that the cross-sectional data underestimated the true decline in CRF in inactive women by more than threefold, and around twice for those who practiced physical exercise. The implications of such comparisons indicate that cross-sectional surveys tend to underestimate the results of longitudinal studies. In keeping with this study, Fleg *et al.*[18] carried out a study with a sample of 435 men and 375 women aged 21-87 years who participated in the Baltimore Longitudinal Study of Aging. Oxygen consumption (VO2) was measured in a submaximal treadmill test with Balke protocol, via a metabolic analyzer, measuring gas exchange every 30 seconds. VO2 was used to determine the longitudinal rate of decline in cardiorespiratory fitness (CRF). The results show a substantially greater longitudinal decline than those shown in cross-sectional analyzes. The lesser decline reported in cross-sectional studies can be partly explained by natural selection, favoring research with genetically benefited individuals or those who maintained an active lifestyle.[18]

The study by Fleg *et al*[18] reported a rapid decline in CRF in women aged 60 years and over. For example, the CRF of women aged 40 decreased by 9.6% per decade, while the CRF of women aged over 70 years old decreased by 17.2%, with values adjusted for lean mass. Through a linear regression model, a decline in CRF of 3% to 6% per decade was found for the 20 to 30-year age group, rising substantially to over 20% per decade for the 70 or over age group in both men and women. It was therefore calculated that young and middle-aged adults exhibited an annual decline of 0.3%, while older adults aged 70 years and over had a decline of 2% a year, suggesting that there is a greater decline in CRF with age.

The maintenance of satisfactory levels of CRF can affect the independence of the elderly. These findings were investigated longitudinally (over 13 years) by Wang *et al.*[6] The study sample consisted of 961 individuals classified as runners and non-runners (who had never run), with an initial age of 50-72 years. Aiming to determine the degree to which disability could be delayed, the study compared the development of such disabilities between the groups, finding that the runners group delayed this process by approximately 8.7 years (CI 95% 5.5 to 13.7) compared to the non-runners group. The results indicate that regular physical exercise, or in this case, predominantly aerobic exercise, can delay the onset of disability, morbidity and mortality, influencing the quality of life of individuals, as disability is linked to the condition of independently performing activities of daily living.[6,15,25]

Chronic diseases are indirectly related to CRF. The CRF of elderly women suffering from two and three chronic diseases was 15% and 23% (as measured by maximal oxygen uptake in a maximum treadmill test using a metabolic analyzer, measuring gas exchange with each breath) lower, respectively, than those who did not have any chronic disease.[26] A study by Krause *et al.*[27] with 1,064 older women found a higher prevalence (53.9%) of hypertension in women with low CRF (assessed using the six-minute walk test). Furthermore, it was observed that the groups with a higher CRF had a 33% and 36% lower chance, respectively, of developing hypertension.

The results of this study exhibit some limitations, such as the sample loss between assessments and the lack of a confirmed medical diagnosis of the chronic diseases (CDs) of the participants. The main limitation was linked to the sample size, although this fact does not minimize the scientific and clinical relevance of the findings in demonstrating that the CRF of older women may be influenced by physical exercise, gender and also by chronological age; emphasizing principally that active women, or those who performed regular exercise were able to mitigate the decline of CRF to a greater degree than their inactive peers (who did not participate in exercise). It can be only be said that the main CDs self-reported by the elderly women were: hypertension (SAH), diabetes, back pain (non-specific) and arthrosis. Although due to the inaccuracy of such information these details were not included in the analysis of the study, it is clear that CDs may accelerate the decline of CRF, especially in the case of cardiovascular (such as hypertension) or metabolic (such as diabetes) diseases. It is recommended that future studies include the medical diagnosis of CDs and that this variable is included in statistical analysis in order to verify the effect of CDs on alterations in CRF.

CONCLUSION

Evidence has shown that maintaining high or satisfactory levels of CRF throughout life, including when older, can act as a protective factor against various chronic conditions.[3,11,13] The results of the present study indicate that elderly women who regularly practiced physical exercise suffered a lesser decline in CRF than their inactive peers. It was also observed that the CRF level of the active group during reassessment (480.8 m) was similar to that found in the inactive group during the first assessment (484.9 m), indicating that elderly persons who fulfilled PRE recommendations maintained levels of fitness of 5.8 years earlier than their inactive peers. This result confirms the initially presented hypothesis that the maintenance of physical exercise can positively influence the inevitable process of aging of CRF. It should be emphasized that the results presented in the present study relate 1) specifically to "exercise" and do not include definitions of "active" in various activities of daily living (in the domains: domestic, leisure, occupational or movement); and 2) longitudinal comparisons, which are more accurate than cross-sectional data, which usually exhibit underestimated values, and do not indicate the true decline in CRF among the elderly. Thus, it is recommended that older people continue to perform physical exercise at recommended levels in order to mitigate the effect of aging on CRF and avoid negative health consequences. Specific public health interventions for the elderly that guarantee the right to health and promote the practice of supervised physical exercise, rather than simply increasing the overall level of physical activity among this population, are also required. Supervision of exercise is important due to the other clinical conditions presented by the majority of elderly people, which classify this group as a unique population that requires specific guidelines for benefiting health and to avoid triggering the harmful effects of incorrectly performed exercise.

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