ABSTRACT

Introduction: Aerobic fitness is an important predictor that contributes to the preservation of functional independence during the aging process. Its measurement represents a fundamental tool in the identification of multiple health problems. Objective: To compare the aerobic capacity of adults and elderly subjects through international studies and to develop percentiles by age group using the LMS method. Methods: A cross-sectional descriptive study was conducted with 1146 subjects (437 men and 709 women). The age group of the sample ranged from 50 to 84 years. The subjects evaluated came from the physical activity programs offered by the National Sports Institute (IND) and by the city council of Talca (Chile). Body mass, stature, oxygen saturation (SatO2), six-minute walk test, and systolic and diastolic blood pressure were assessed. Body Mass Index (BMI) was calculated for both sexes. The LMS method was used to propose the percent distribution. Results: Aerobic capacity decreases with age (28.5% for men and 29.9% for women). There was a negative relationship between age and the six-minute walk test (men r = -0.13 and women r = -0.39). There was a discrepancy between the elderly subjects in the current study and those from international studies. The normative data for the classification of aerobic fitness were expressed in percentiles (p3, p5, p10, p15, p25, p50, p75, p85, p90, p95 and p97). Conclusion: The aerobic performance of elderly subjects diminishes as they age; in addition, the current results differ from international studies, which motivated the development of percentiles to classify aerobic fitness in everyday situations, especially in places with few resources and particularly where field tests are considered a priority for large-scale physical evaluation. Level of evidence II; Diagnostic studies – investigation of diagnostic test.

Keywords: Exercise; Aged; Walk test; Exercise test.
The sample selection was non-probabilistic (accidental). The evaluated participants (437 men and 709 women). Their age varied from 50 to 84 years old. The evaluated participants were classified by age and sex using the LMS method.

Aerobic capacity tends to decline with advancing age. These changes are associated with a progressive loss of functional independence in the elderly, as well as with the onset of risk and premature death. Thus, the classification of aerobic capacity in this population becomes relevant, as influencing the performance of daily activities regardless of the ability to maintain aerobic capacity and muscle strength.

Functional aerobic capacity represents the maximum rate of oxygen consumption due to muscle contractions and is considered the gold standard measurement for the functional limit of the cardiorespiratory system. It is one of the main variables in the field of exercise physiology and is frequently used to indicate aerobic fitness.

In general, it is measured objectively by means of a laboratory and/or field stress test. It is useful to assess the physical condition of an individual, to diagnose and/or predict ischemic heart disease, to develop an exercise prescription, and to guide cardiac rehabilitation processes.

Aerobic capacity standards for the elderly, specifically regarding aerobic capacity, are currently being proposed in many regions of the world. These studies have normative values, which are used to evaluate performance standards in relation to age and sex, and according to each country. In countries such as Chile, which is in the process of implementing nutritional transition and presents substantial differences in sociocultural and regional issues, international standards could barely help identify the loss of functional mobility and physical independence in the elderly.

In this context, the proposal of a regional standard could be an alternative to identify the real state of aerobic fitness in the elderly. In addition, to the best of our knowledge, Chile does not have standards that allow diagnosing, classifying, and monitoring aerobic capacity of the elderly. Thus, it is necessary to introduce this information in elderly programs as a preventive health tool.

Therefore, several studies have used the six-minute walk test, which measures the functional and cardiorespiratory capacity of the elderly, to evaluate aerobic fitness. This test is used to classify the aerobic fitness of the elderly, in view of its good acceptance, its tolerance, and its ability to closely reflect daily activities.

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Therefore, the present study aims to a) compare the aerobic capacity of adults and elderly to international studies and b) develop percentiles by age and sex using the LMS method.

MATERIALS AND METHODS

A cross-sectional and descriptive study included 1,146 subjects (437 men and 709 women). Their age varied from 50 to 84 years old. The sample selection was non-probabilistic (accidental). The evaluated subjects signed an informed consent form (ICF) and were included in physical activity programs offered by the National Sports Institute (IND) and the Talca City Hall (Chile). The assessed volunteers were referred to the Maule Health Service in the city of Talca (Chile). This institution is part of the Risk Factors Research Program for Cardiovascular Disease (PIFRECV) of the University of Talca, Chile. The volunteers participated in a physical activity program, which was held once a week and lasted 90 minutes.

The participants were informed about the variables that would be collected during the research and the subjects that accepted these conditions were included in the study. Individuals presenting morbid obesity and/or a previous history of serious illnesses that prevented them from performing the six-minute walk test, such as heart failure, were excluded. This research was approved by the Ethics Committee of the Autonomous University of Chile, in Talca, under protocol number UA-104-17, and was developed according to the Helsinki recommendations.

Procedures

Anthropometric and physiological evaluations were assessed in the movement analysis laboratory of the Kinesiology School of the University of Talca, Chile. All volunteers were assessed Monday through Friday between 8:30 and 11:00 am, from January to April 2015. The anthropometric evaluation was performed by an experienced professional who was trained to collect the samples. The physiological evaluation and the six-minute walk test were performed by two evaluators. Initially, anthropometric variables were measured, followed by physiological parameters. Subsequently, the six-minute walk test was performed.

Body mass (kg) was recorded using an electronic scale (United Kingdom, Ltd) with 100 g accuracy. An aluminum stadiometer (Seca Gmbh & Co. KG, Hamburg, Germany) was used to measure height. The body Mass Index (BMI) was calculated by the following formula: $BMI = \frac{Body\ Mass\ (kg)}{Height\ (m)^2}$. Oxygen saturation level ($O_2S$) was measured by resting pulse oximetry (mmHg). A Nonin 8500 handheld pulse machine (Nonin Medical, Plymouth, MN), transmitting the signal with a red and infrared light, was used. Blood pressure was measured using a mercury sphygmomanometer with stethoscope (Riester) and the recommendations described by the Pan American Health Organization were followed. The procedure consisted of a 10-minute period of rest, and then both the systolic blood pressure (SBP) and diastolic blood pressure (DBP) were recorded.

Before conducting the physical tests, the individual warmed-up for 10 to 15 minutes by performing flexibility, coordination, balance, and rhythm shifting exercises. The walk test was performed according to the suggestions of the American Thoracic Society, in a closed gym, on a flat surface that was 30 meters long and 10 meters wide. Colored adhesive strips were placed every three meters. Cones were located to mark the...
end points of this 30-meter surface, as to identify the beginning and the end. The procedure consisted of evaluating the volunteers one by one. At the end of the six minutes, the participants’ walking distance was recorded. The participants performed the test while wearing sportswear, warm clothing, and socks.

**Statistical analysis**

The data normality was verified using the Kolmogorov-Smirnov test. For the descriptive analysis, mean values and standard deviations were reported for each age group. Significant differences in sex were verified by the Student’s t-test for independent samples. In this study, age groups were compared by sex, applying the one-way analysis of variance and Tukey’s post hoc test. To compare the percentage of decline in aerobic capacity, the study published by Gusi et al. in Spain, Marques et al. in Portugal, and Rikli and Jones in the United States, were used. Pearson’s r was used to correlate the chronological age to the distance walked in the six-minute walk test. In all cases, a p-value of <0.05 was adopted.

To generate smoothed percentiles for the six-minute walk test, by age and gender, we applied the LMS method using software (LMS Chart Maker version 2.3). The final percentile curves were smoothed to create three age-specific curves: L (Lambda; asymmetry), M (Mu; median) and S (Sigma; coefficient of variation). The percentiles p3, p5, p10, p15, p25, p50, p75, p85, p90, p95, and p97 were calculated.

Comparisons referring to the cardiorespiratory capacity obtained during the six-minute walk test are shown in Table 2. In general, men walked greater distances when compared to women (p<0.05), except the group aged between 55 and 59 years, where no significant differences were observed. When compared by age range, differences start to appear in men from 65-69 years onwards, while in women from 60-64 years onwards.

Figure 1 shows the negative relationship between chronological age and the results obtained during the six-minute walk test (men r = -0.13 and women r = -0.39). As age increases, aerobic capacity decreases faster in women than in men. Table 2 also shows that the percentage decrease in aerobic capacity in both sexes was relatively higher when compared to that in studies published in Spain and the United States.

**Table 1.** Anthropometric and physiological characteristics of the studied sample.

<table>
<thead>
<tr>
<th>Age range (years)</th>
<th>n</th>
<th>Body mass (kg)</th>
<th>Height (cm)</th>
<th>BMI (kg/m²)</th>
<th>O2S (mmHg)</th>
<th>SBP (mmHg)</th>
<th>DBP (mmHg)</th>
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<tr>
<td>50 to 54</td>
<td>34</td>
<td>81.5</td>
<td>15.5</td>
<td>170.8</td>
<td>6.4</td>
<td>27.9</td>
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<tr>
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<td>74.3</td>
<td>8.6</td>
<td>168.3</td>
<td>7.5</td>
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<tr>
<td>60 to 64</td>
<td>109</td>
<td>78.9</td>
<td>13.8</td>
<td>167.6</td>
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<td>28.2</td>
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<td>87</td>
<td>74.5</td>
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<td>166.5</td>
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<td>75.6</td>
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<td>75 to 79</td>
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<td>50 to 54</td>
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<td>72.0*</td>
<td>12.0</td>
<td>159.5*</td>
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<tr>
<td>55 to 59</td>
<td>61</td>
<td>72.4*</td>
<td>12.4</td>
<td>155.3*</td>
<td>5.9</td>
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<td>60 to 64</td>
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<td>70.6*</td>
<td>11.4</td>
<td>157.6*</td>
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<td>65 to 69</td>
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<td>68.3*</td>
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BMI: Body Mass Index; X: Mean; SD: Standard Deviation; O2S: Oxygen Saturation; SBP: Systolic blood pressure; DBP: Diastolic blood pressure.

**Figure 1.** Relationship between chronological age and distance walked in the six-minute test by gender.

**RESULTS**

Table 1 shows the anthropometric and physiological variables that characterize this sample. Men presented a higher body mass and were taller compared to women (p<0.05). Regarding BMI and O2S, the values were similar in both sexes, except in the group aged between 55 and 59 years, in which women presented a higher BMI and O2S. Regarding the systolic blood pressure (SBP) women showed higher values in four age groups (50 to 69 years). In relation to diastolic blood pressure (DBP), men generally presented higher values, except in the group aged between 75 and 79 years.

Comparisons referring to the cardiorespiratory capacity obtained during the six-minute walk test are shown in Table 2. In general, men walked greater distances when compared to women (p<0.05), except the group aged between 55 and 59 years, where no significant differences were observed. When compared by age range, differences start to appear in men from 65-69 years onwards, while in women from 60-64 years onwards.
However, these results were lower than those obtained in studies carried out in Portugal. In general, when compared to international studies, adults from Chile present a decreased aerobic capacity compared to those found in studies conducted in Japan, Portugal, United States, Spain and Brazil,9,10,12,16 which included subjects of a similar age range. Moreover, the negative correlations obtained with the elderly included in those studies reflect their decreased aerobic capacity. In general, aerobic fitness in the aging populations decreased by approximately 9-10% every 10 years;17 however, the decline values observed in this study and those monitored for over two decades were between 28.5% and 29.9%.

These findings highlight a faster decrease in aerobic capacity when compared to studies carried out in Spain12 and the USA,11 for example. However, the elderly population in Portugal10 shows a faster decline (35.6% to 37.6%) in relation to the elderly population from Chile and other countries. These results suggest the need to prioritize physical activity as a strategy to improve the functional fitness and quality of life of the elderly, since physical exercise is inversely related to the development of heart disease, diabetes, certain cancers, depression, and most causes of mortality.18,19

Thus, maximum aerobic fitness is an important independent predictor of mortality in the elderly.20 Maintaining adequate levels of aerobic fitness can contribute to the preservation of functional independence while getting older. Therefore, its measurement is a fundamental tool to apply to adults and the elderly, since it can serve as an initial diagnosis to identify multiple health problems.21

Hence, from the differences observed in the six-minute walk test compared to international works, this study developed percentiles to classify aerobic capacity in middle-aged and elderly adults. The differences observed in this study and those monitored for over two decades were between 28.5% and 29.9%.

**DISCUSSION**

The results in this study indicate that aerobic capacity decreases with advancing age in both sexes. These findings are consistent and comparable to findings in studies conducted in Japan, Portugal, United States, Spain and Brazil,9,10,12,16 which included subjects of a similar age range. Moreover, the negative correlations obtained with the elderly included in those studies reflect their decreased aerobic capacity. In general, aerobic fitness in the aging populations decreased by approximately 9-10% every 10 years;17 however, the decline values observed in this study and those monitored for over two decades were between 28.5% and 29.9%.

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observed in the study demonstrate that the use of international percentiles standards could overestimate and/or underestimate the results obtained in the studied individuals.

The percentiles proposed in this study for middle-aged and elderly adults of both sexes might contribute to further investigations, practical health implementation methods, and prevent the decline in aerobic fitness. Thus, normative standards should be generally used to disclose an individual’s state in relation to the population and are fundamental to analyze future international trends and comparisons.9,12

Therefore, in a country like Chile, where 11.4% of the population is elderly, a percentage that keeps increasing significantly,22 the percentiles we developed might provide valuable information to health science professionals. They can provide education, motivation, and can raise awareness in the older population regarding the organization and planning of intervention programs, according to the subjects’ needs. In addition, the government can provide guidance to implement preventive health strategies and policies.21,23

As a consequence, the normative values proposed herein can be used to classify, diagnose, and monitor the aerobic capacity of middle-aged and elderly adults of both sexes. The cutoff points established for men and women can be interpreted as the following. A score lower than p15 indicates a low level and/or warning signal, p15 and p85 indicates an adequate status, and above p85 indicates a high level of aerobic fitness. This information can also help monitor the aerobic fitness performance by professionals working with this population and set proper goals.

In conclusion, the aerobic capacity of the elderly decreases with advancing age. However, the difference between the results obtained and the data collected in international studies encourages development of the percentiles capable of classifying daily aerobic fitness, especially in situations of scarce resources, and when field tests are considered a priority for a large-scale evaluation. Calculations can be performed using the following link: http://www.reidebihu.net/testcaminata.php

All authors declare no potential conflict of interest related to this article

REFERENCES


