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Reference values for the incremental shuttle walking test

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Summary
Background: Reference values for the incremental shuttle walking test (ISWT) which are applicable to the whole population need to be solidly established. This study aimed to determine which anthropometric and demographic variables influence the walking distance achieved in the ISWT in healthy subjects with a broad age range and to establish a reference equation for predicting ISWT for that population.
Methods: In a cross-sectional study, 242 healthy subjects (102 male) performed two ISWT and had their weight, height and body mass index (BMI) measured.
Results: In general, healthy subjects walked 810 [IQR 25–75%: 572–1030] m in the ISWT, presenting large variability (range 210–1820 m). The walked distance correlated with age ($r = -0.76$), height ($r = 0.49$) and BMI ($r = -0.23$) ($p < 0.001$ for all), but not with weight ($r = 0.06$, $p = 0.315$). A model of stepwise multiple regression showed that gender, age and BMI were independent contributors to the ISWT in healthy subjects, explaining 71% ($p < 0.0001$) of the variability. The derived reference equation was: $ISWT_{pred} = 1449.701 - (11.735 \times age) + (241.897 \times gender) - (5.686 \times BMI)$, where male gender = 1 and female gender = 0.
Conclusion: In conclusion, the variability of the ISWT is explained largely by gender, age and BMI. The reference values for the ISWT can be adequately predicted using the equation proposed in this study.

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Introduction

Exercise tests are commonly used both in clinical practice and in scientific investigations since exercise intolerance is a typical feature in a number of chronic diseases. The objective assessment of exercise capacity through a cardiopulmonary exercise test provides information about the causes of reduced exercise tolerance, which can be eventually improved by specific interventions.[1] Moreover, outcome parameters of exercise tests are used as guide for workload prescription during exercise interventions.[2] As laboratory assessment is not widely available and may be expensive, field tests such as the incremental shuttle walking test (ISWT) have become increasingly popular.

The ISWT is a simple and inexpensive test which evaluates maximal exercise capacity based on the distance walked around a 10 m course according to different speeds dictated by an audio signal.[3] This exercise test has been used as a predictor of mortality[4] and morbidity[5,6] in patients with chronic respiratory and other diseases, as a predictor of exacerbation in patients with pulmonary disease,[7] as well for assessing benefits of interventions[8–10] and detecting oxygen desaturation during exertion.[11]

Although the ISWT has become very useful in clinical and research settings, there were no reference equations to predict the distance walked in the test by healthy subjects. Recently, an equation was developed[12]; however, there are some limitations which can compromise the external validity of that study. Firstly, the sample was composed of subjects aged 40–84 years; therefore the resulting equation is not applicable for young people. Moreover, the coefficient of determination of its regression analysis was relatively modest, explaining only 50% of the total variance in the ISWT. Considering the importance of the ISWT in assessing adequately patients of all ages with cardiopulmonary disease and other health conditions, an equation with higher coefficient of determination and applicable for the whole adult population needs to be solidly established.

Hence, the aims of this study were to determine which anthropometric and demographic variables (weight, height, age and gender) influence the walking distance in the ISWT of healthy subjects with a broad age range and to establish an equation for predicting reference values of the ISWT for this population.

Methods and materials

Subjects

In a cross-sectional study, 246 healthy subjects were included in a convenience sample. They were recruited among students and employees of two universities in Londrina (Brazil), as well as their relatives. Part of the sample of subjects older than 60 years old was also composed by individuals participating in a project which investigates the health conditions of the elderly in Londrina, Brazil (EELO Project). All subjects had their exercise capacity, pulmonary function, anthropometric and demographic data evaluated. Data were collected from November 2008 to December 2010. The study was approved (PP000709) by the Research Ethics Committee of the Universidade Norte do Paraná (UNOPAR), Brazil, and all participants gave written informed consent.

Inclusion criteria were: subjects of both genders aged 18–83 years and absence of any severe and/or unstable disease which could limit the exercise tolerance. Participants were excluded if they were unable to understand or perform any procedure during the protocol or if they would like to leave the study for any reason.

After obtaining the informed consent, a questionnaire was applied in order to investigate health status, medication, smoking habits and whether subjects were engaged in any regular physical activity. Height (cm) and body weight (Kg) were measured and the body mass index (BMI) was calculated. Spirometry (Pony Cosmed, Italy) was performed to ensure normal lung function. The test was conducted according to international standardization[13] and the lung function parameters obtained were forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1) and the direct measurement of maximal voluntary ventilation (MVV). Reference values adopted were those reported by Pereira and colleagues specifically for the Brazilian population.[14]

Incremental shuttle walking test

Two incremental shuttle walking tests were performed with, at least, 30 min of resting in between them. The tests were performed in a 10 m course identified by two cones placed 0.5 m from each end point.[3] The best test, that is, the longest walked distance was considered for analysis. Participants should walk (or run) around the course according to the speed dictated by an audio signal. The initial walking speed was 0.5 m/s and it increased by 0.17 m/s each minute; the speed increment was always indicated by a triple bleep. An adaptation of the modified protocol was used, that is, the audio signals continued until subjects reach their maximal effort, exceeding 12 levels of speed proposed by the modified protocol and even running, if necessary. The authors opted for adapting the protocol in order to avoid a ceiling effect since participants were healthy subjects and could possibly exceed the 12th level in order to ensure their maximal effort. The tests were executed by a physiotherapist or physiotherapy student, all familiarized with the ISWT, and the two tests were conducted by the same evaluator. The initial explanation was standardized and no encouraging phrases were given to the participants during the test. The ISWT was interrupted in case of participants presented one of the following conditions: if the subject could not maintain the required speed due to dyspnea or fatigue; or if the subject failed to complete a shuttle in the time allowed for the second time. Heart rate (HR), arterial blood pressure, perceived dyspnea and leg fatigue (modified Borg scale) were assessed before and after the tests. Maximal predicted HR was calculated as 220 minus age (in years).[15]

Statistical analysis

The statistical analysis was performed using the statistical packages SPSS 17.0 (SPSS Inc., USA) and GraphPad Prism 5 (GraphPd Software Inc., USA). The normality of data