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Does the Incremental Shuttle Walking Test require maximal effort in healthy subjects of different ages?

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Abstract

Objective To evaluate if the Incremental Shuttle Walking Test (ISWT) requires maximal effort in healthy subjects of different ages.
Design Cross-sectional.
Setting University-based research laboratory.
Participants 331 healthy subjects separated into six groups according to age: G1, 18 to 28 years; G2, 29 to 39 years; G3, 40 to 50 years; G4, 51 to 61 years; G5, 62 to 72 years and; G6, 73 to 83 years.
Main outcome measures Two ISWTs were performed and participants were permitted to run and to exceed 12 levels during the test, if necessary. Heart rate (HR) and symptoms of dyspnoea and fatigue were recorded before and after the test, and the percentage of age-predicted maximal HR (HR_{max}) was calculated. Maximal effort was defined as HR_{max} >90% of age-predicted HR_{max}.
Results Almost 31% of the subjects exceeded 12 levels in the ISWT. At the end of the test, all groups presented a median [interquartile range] HR greater than 90% of HR_{max} (G1: 100 [95 to 104]; G2: 100 [96 to 105]; G3: 103 [97 to 108]; G4: 99 [91 to 106]; G5: 96 [87 to 106] and G6: 96 [91 to 109]% HR_{max}). Regarding symptoms, all groups showed higher values after the test ($P<0.05$). A multiple logistic regression analysis identified female gender, older age and a lower HR before the test as determinants of not achieving 90% of HR_{max} at the end of the test.
Conclusions The ISWT requires maximal effort in healthy individuals, but for that it is necessary to extend the test beyond twelve levels. Female gender, older age and lower heart rate before the test are the determinants of not reaching maximal effort.

Keywords: Exercise test; Exercise tolerance; Heart rate

Introduction

Different exercise tests are available nowadays for the assessment of maximal exercise capacity. Many of these, however, require specialized training and equipment, involving high costs and making their availability limited in clinical practice [1]. Field exercise tests, such as the Incremental Shuttle Walking Test (ISWT), have been suggested as an option to overcome these and other limitations. In this test the maximal distance covered in a short course during a protocol with increasing speeds is used as an estimation of maximal exercise capacity [2]. Although conceptually characterized as a walking test, the ISWT can be considered maximal. The test starts with a walking speed of 0.5 m/s, but increments of

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0.17 m/s occur every minute until the subject is not able to keep up with the speeds anymore [2]. Thereby, in the final levels of the test participants are required to walk fast (or even run), thus eliciting significant effort.

The ISWT is an adapted version of the progressive and externally paced 20-m shuttle run test developed by Leger and Lambert [3], broadly used with athletes. The test was adapted in order to be used in subjects with chronic airways obstruction, known to present with reduced exercise capacity, and the adaptation consisted basically of a shorter course (*i.e.*, 10 m instead of 20 m) and the adoption of a 12 level protocol [2]. Since its development, many different studies have incorporated the ISWT as an assessment tool in patients with a variety of conditions [4–12].

Stockton *et al.* demonstrated that the ISWT can be performed safely early in the post-discharge rehabilitation period in most patients after burn injury [7]. In subjects with chronic obstructive pulmonary disease, the ISWT was valid and useful to identify candidates for surgical resection [8]. It was also shown in COPD that two ISWTs are needed to assess exercise capacity during a maintenance exercise program [13]. van Bloemendaal *et al.* found that the ISWT is a valid and reliable measure of functional walking capacity in patients after stroke [6], whilst Pepera *et al.* found that there appears to be no learning effect in the ISWT over long test–retest durations in patients with cardiovascular disease [9].

Despite the widespread use of the ISWT in diseased and/or functionally limited subjects, its use in subjects without any important disease/limitation or healthy subjects is less common [14–17]. In one of the first studies in the healthy population, Probst *et al.* found important correlations between ISWT and anthropometric and demographic variables, establishing a reference equation for predicting the distance covered during the ISWT [16].

However, it is not clear yet if the ISWT can be considered a maximal exercise capacity test in healthy individuals. Therefore, the present study was developed to evaluate if the ISWT requires maximal effort in healthy subjects of different ages.

Methods

Study design and participants

In this cross-sectional study, 331 healthy subjects were recruited from a convenience sample. These subjects were either students and employees of two universities in Londrina, Paraná, Brazil; or elderly subjects part of an interdisciplinary thematic project, the Study on Aging and Longevity (EELO, abbreviation for the name in portuguese), developed at Universidade Norte do Paraná (UNOPAR), in Londrina, Paraná, Brazil [18–22]. EELO aimed to evaluate socio-demographic factors and indicators of health conditions of older adults in Londrina, Paraná, Brazil; more information can be found at http://www2.unopar.br/eelo/index.html.

The inclusion criteria were: male or female sex; age ≥18 years old; absence of any severe and/or unstable disease that could limit the exercise capacity of subjects; and absence of any osteomuscular alterations that could impair the performance in the ISWT. The exclusion criteria were: inability to understand or perform any proposed test, and withdrawn consent.

Procedures

All subjects were assessed for: demographics (age, sex), anthropometrics (weight, height, and body-mass index), clinical data (comorbidities, current medication, smoking status, and engagement in regular physical activity), lung function, and exercise capacity. All outcomes were collected between March 2009 and October 2011.

Lung function

Simple spirometry (Pony Cosmed® spirometer, Cosmed, Italy) was performed to rule out subjects with lung function abnormalities. The following parameters were recorded: forced vital capacity; forced expiratory volume in the first second; the ratio between forced expiratory volume in the first second and forced vital capacity; and maximal voluntary ventilation. The test was performed after bronchodilation and according to international recommendations [23]. The parameters assessed were compared to national reference values [24,25].

Exercise capacity

The ISWT was adopted for the assessment of maximal exercise capacity [2,26]. Two tests were performed with at least 30 minutes of rest between them, and the test with the longest distance was recorded. The performance during this test was compared to national reference values as described by Probst *et al.* [16]. The two ISWTs were performed in a 10-m course identified by two cones placed 0.5 m from each end point. Participants walked (or ran) around the course according to different speeds dictated by an audio signal. The initial walking speed was 0.5 m/s, but increments of 0.17 m/s occurred every minute. An adaptation of the protocol described by Singh *et al.* [2] was adopted, in which the subjects were permitted to run and to exceed the 12th level during the test, if necessary. This adaptation was adopted in order to guarantee a maximal response during the test and to avoid a possible ceiling effect [4]. The test was interrupted in case of one of the following conditions: if the subject could not maintain the required speed due to dyspnoea or fatigue; or if, for the second time, the subject failed to complete a shuttle in the allowed time.

Heart rate (HR) was measured continuously during the test with a Polar HR monitor (2010 Polar Electro Oy, FI-90440 Kempele, Finland). Arterial blood pressure and self-reported dyspnoea and leg fatigue (modified Borg 0 to 10 category