



# Measurement Properties of the Incremental Shuttle Walk Test

## A Systematic Review

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**Background:** The incremental shuttle walk test (ISWT) was developed > 20 years ago and has been used to assess peak exercise capacity in a variety of chronic diseases. The aim of this systematic review is to describe the measurement properties of the ISWT in a clinical population.

**Methods:** Of 800 articles identified by electronic and hand searches, 35 were included. Twenty-one articles included data on the validity of the ISWT, 18 on the reliability, four on the responsiveness, and four on the interpretability.

**Results:** Most of the studies were conducted in patients with COPD (n = 13) or cardiac disease (n = 8). For criterion validity, comparisons between distance covered during the ISWT and peak oxygen consumption reported correlations ranging from 0.67 to 0.95 ( $P < .01$ ). Intraclass correlation coefficients for test-retest reliability ranged from 0.76 to 0.99. The ISWT was shown to be responsive to pulmonary rehabilitation and bronchodilator administration. The minimal clinically important difference (MCID) in patients with COPD was 48 m. Predictive equations for the distance in the ISWT are available for healthy individuals.

**Conclusions:** The ISWT can be considered a valid and reliable test to assess maximal exercise capacity in individuals with chronic respiratory diseases. The ISWT has been shown to be responsive to pulmonary rehabilitation and bronchodilator use in individuals with COPD, cystic fibrosis, and asthma. Further studies examining responsiveness and the MCID of the ISWT in patients with conditions other than lung diseases are required for the interpretation of interventions in other populations.

*CHEST* 2014; 145(6):1357–1369

**Abbreviations:** 6MWT = 6-min walk test; COSMIN = Consensus-Based Standards for the Selection of Health Status Measurements Instruments; HR = heart rate; ICC = intraclass correlation coefficient; ISWD = incremental shuttle walk distance; ISWT = incremental shuttle walk test; MCID = minimal clinically important difference; PR = pulmonary rehabilitation;  $\dot{V}O_{2peak}$  = peak oxygen consumption

The incremental shuttle walk test (ISWT) was developed by Singh and colleagues<sup>1</sup> (based on a shuttle run test of 20 m originally described by Léger and Lambert<sup>2</sup>) to measure disability in patients with COPD. It is an inexpensive tool and has been used to assess exercise capacity in the pulmonary rehabilitation (PR) setting for patients with COPD<sup>3–8</sup> as well as for patients with other conditions, such as cardiac disease,<sup>9,10</sup> obesity,<sup>11</sup> cancer,<sup>12</sup> peripheral arterial disease,<sup>13</sup> intermittent claudication,<sup>14</sup> bronchiectasis,<sup>15</sup> pulmonary hypertension,<sup>16</sup> and critical illness.<sup>17</sup> The ISWT was developed using an incremental format as a possible surrogate for laboratory-based symptom-limited maximal exercise tests.<sup>1,18</sup>

The ISWT is a 12-level test (1 min in each level) imposing an incremental acceleration as the subject walks up and down a 10-m course. In brief, two cones are set apart to provide a between-cone distance of 9 m.<sup>1</sup> The walking speed is dictated by an audio signal. The speed starts at 0.50 m/s and is increased each minute by 0.17 m/s until a final speed (level 12) of 2.37 m/s. The test is finished when the subject is limited by dyspnea or a heart rate (HR) > 85% predicted maximum<sup>1</sup> or when the subject is unable to maintain the required speed and fails to complete a shuttle for a second consecutive time.<sup>19</sup> The primary outcome is the distance covered calculated from the completed number of shuttles.

Understanding the measurement properties of an instrument helps with the selection of a specific instrument and facilitates the interpretation of the results in the clinical or research setting. Thus, the aim of this systematic review is to describe the measurement properties of the ISWT in a clinical population.

## MATERIALS AND METHODS

### Literature Search

The literature search was performed through the following electronic databases: PubMed, MEDLINE, EMBASE, LILACS, CINAHL (Cumulative Index to Nursing and Allied Health Literature), PEDro (Physiotherapy Evidence-Based Database), and Cochrane Library. The dates were January 1992 to April 2012, and key terms used were “incremental shuttle walk test,” “incremental shuttle walking test,” and “ISWT.” Hand searches of the references of all identified studies were also performed.

### Selection of Articles

The title and abstract of all articles were reviewed. Articles were considered relevant if reliability, validity, responsiveness, or interpretability of ISWT in any population was assessed. Articles not written in English, French, or Portuguese were excluded. One reviewer (V. F. P.) reviewed all the titles and abstracts to identify the relevant studies for which the full manuscripts were retrieved. In case of doubt, a second reviewer (T. J.-F.) was consulted.

### Measurement Properties

Validity was defined as the extent to which an instrument measures what it is intended to measure.<sup>20</sup> In this systematic review, criterion validity (when one test is compared with a gold standard) and construct validity (when two measures reflect the same phenomenon) were considered. Reliability was defined as the degree to which the measure is consistent and free of random error.<sup>20</sup> Studies of test-retest reliability or of measurement error

were considered. Responsiveness is defined as the ability of an instrument to detect minimal change over time<sup>20</sup>; thus, in this review, changes in the incremental shuttle walk distance (ISWD) are compared with changes in other outcomes. Interpretability was also considered and defined as the degree of change (ie, minimal important change, norm scores, floor-ceiling effects).<sup>21</sup>

### Quality Assessment

Studies describing the measurement properties of the ISWT were assessed for study quality using the Consensus-Based Standards for the Selection of Health Status Measurements Instruments (COSMIN).<sup>21</sup> Each article was reviewed and assessed by two independent investigators (V. F. P. and T. J.-F. or V. F. P. and S. M.). Discordances in scoring between the two reviewers were resolved by consensus. The assessment was based on a rating score system of four points,<sup>22</sup> classifying the quality of the study as excellent, good, fair, or poor.<sup>21</sup> Some studies analyzed more than one measurement property; in these cases, quality assessment and data extraction were performed separately for each property.

COSMIN provides a set of items for analysis of each measurement property (criterion validity, seven items; construct validity [hypotheses testing], 10 items; reliability, 14 items; responsiveness, seven items). On the basis of the COSMIN recommendations, the total score for the methodologic quality of each study was obtained from the worst score counts of each set of items. In accordance with recommendations by Terwee et al,<sup>21</sup> we established two scoring definitions. Sample size (item 3 of each property), the first criterion, was considered poor for  $n < 10$ , fair for  $n = 10$  to 19, good for  $n = 20$  to 29, and excellent for  $n > 30$ . The second criterion was established for appropriate time interval for reliability studies. The time interval was considered not appropriate if the ISWTs were conducted on the same day.

In COSMIN, a no scoring system is available for interpretability or generalizability. Therefore, we extracted information on norm scores and minimal important change (interpretability) or data on the characteristics of the sample (generalizability).

### Data Extraction and Synthesis

Data extraction was performed and verified by two reviewers (V. F. P. and R. A. E.). Data regarding source, sample size, measurement property, and main observed findings were retrieved. The PRISMA (Parameters of the Preferred Reporting Items for Systematic reviews and Meta-Analyses) statement was applied.<sup>23</sup> We did not perform a meta-analysis because this was beyond the scope of this review. To obtain additional data, corresponding authors of two articles were contacted and responded. Ethics approval was not necessary because this is a systematic review.

## RESULTS

### Literature Search

Figure 1 shows the flowchart of studies included in this systematic review. Of 800 articles identified by electronic and hand searches, 35 met the inclusion criteria (all of them were written in English), with some reporting on more than one property. Twenty-one articles included data on the validity of the ISWT, 18 on reliability, four on responsiveness, and four on interpretability.

### Validity

Table 1 shows the details of the 21 studies that assessed validity of the ISWT in patients with COPD

Manuscript received September 1, 2013; revision accepted December 2, 2013; originally published Online First January 2, 2014.

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**Funding/Support:** The authors have reported to *CHEST* that no funding was received for this study.

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