

Short Communication

Validity & reproducibility of a modified six-minute walk test in Libyan adolescents with intellectual disability

Sami Elmahgoub^{1*}, Hassan Mohamed², Osama Al-Hasoumi³, Aseel Aburub¹, Patrick Calders⁴

¹Department of Physiotherapy, Faculty of Allied Medical Sciences, Applied Science Private University, Jordan

²Department of Scientific Sport Training, Faculty of Physical Education and Sport Sciences, University of Tripoli, Tripoli, Libya

³Department of Physiotherapy, Faculty of Medical Technology, University of Tripoli, Tripoli, Libya

⁴Department of Rehabilitation Sciences, Ghent University, Ghent, Belgium

ARTICLE INFO

Article history:

Received 18 Dec 2024

Accepted 02 Feb 2025

Published 03 Mar 2025

DOI: [10.35192/jjoas-n.v19si1.2099](https://doi.org/10.35192/jjoas-n.v19si1.2099)

*Corresponding author:

Department of Physiotherapy, Faculty of Allied Medical Sciences, Applied Science Private University, Jordan

Email: s_elmahgoub@asu.edu.jo

Keywords:

Cardiorespiratory fitness
Six-minute walk test
Peak oxygen uptake
Reliability

ABSTRACT

Background: The six-minute walk test (6MWT) is increasingly recognized as a valuable tool for assessing cardiovascular fitness in adolescents with intellectual disabilities (ID).

Objectives: To assess the reproducibility and validity of a modified 6MWT (with continuous encouragement) in adolescents with ID.

Methods: Thirty male adolescents with ID (age 14–21 years) participated in this study. To test reproducibility, all participants performed a modified 6MWT (with continuous encouragement) twice with an interval of 1 week. To test validity, peak oxygen uptake (peak VO₂) was measured on a bicycle ergometer.

Results: There was no significant difference between the means of the two six-minute walk distances 6MWDs (583.6 vs. 579.9 m; $p=0.42$). The intra-class correlation coefficient was 0.93, indicating excellent reliability. The smallest real difference was 33.5 m. 6MWD correlated significantly with relative peak VO₂ ($\beta=0.41$) indicating validity.

Conclusion: The modified 6MWT with continuous encouragement is a valid and reliable measure of cardiorespiratory fitness in adolescents with ID.

Introduction

It has been well documented that children and adolescents with intellectual disability (ID) have suboptimal levels of cardiovascular fitness compared to their peers without ID (1–3). The reasons for this impaired fitness are sedentary lifestyle and syndrome-specific pathophysiological problems (2–4). Characteristic physical features of this impaired fitness such as decreased muscle strength, aerobic capacity, fat-free mass and an increased fat mass are associated with a reduced metabolic condition and more specifically with an unfavorable lipid profile (5). As a consequence, this population additionally has an increased risk for obesity, diabetes and cardiovascular disease.

A healthy diet and regular physical activity are key stones in the prevention and treatment of this increased risk profile. It has been demonstrated that exercise training has a positive influence on physical and metabolic fitness (6–10). To monitor this effect, the assessment and follow-up demand reliable and valid exercise tests are used. In this regard, the best measure used is the maximal oxygen consumption (VO₂max) determined by ergo-spirometry (cardiopulmonary exercise testing [CPET]) (11, 12). Despite its usefulness, ergo-spirometry is expensive and not always available in daily clinical practice for these people. The six-minute walk test (6MWT) is commonly used to measure the physical performance in adults (13, 14), as well as in children with and without diseases (15, 16). There is strong evidence that the 6MWT is a reliable and valid assessment of functional exercise capacity in both healthy and obese children and adolescents without ID (16, 17). It is frequently selected due to its ease of administration, greater tolerance by patients, and more accurate reflection of daily living activities compared to other walk tests (18, 19). Therefore, it has also been frequently utilized in clinical settings for both adults and children with ID.

A population with ID is characterized by low physical fitness (1), a high prevalence of overweight and obesity (20, 21), low intelligent quotient (IQ) and a higher incidence of orthopedic conditions (such as pes planus, genu varum, etc.) (22). Mild-to-moderate ID affects adaptive behavior: individuals with mild ID require minimal guidance, while those with moderate ID need greater assistance and benefit from simple phrasing, reflecting challenges in comprehension and reasoning. (23). These parameters could have an impact on the outcome or performance of the 6MWT in this population.

The American Thoracic Society (ATS) has published standardized guidelines for 6MWT in adults and children (11, 18). Several factors are influencing the distance covered, such as height, age, gender, body weight, peak oxygen consumption, motivation, impaired cognition, various diseases and medications (16,17,20–22). It is stated that this test has to be fulfilled with standardized verbal encouragements at recommended intervals. The amount of encouragement can give a difference in outcome of up to 30% (13). However, Pastore et al. (23) found that when children with Down syndrome are given standardized, continuous verbal encouragement and guidance, the results of a Bruce treadmill test (measuring aerobic capacity) were higher, better reflecting their actual exercise capacity in comparable research with Bruce treadmill test. However, the validity and reproducibility of this important variant of testing in children and adolescents with ID have been demonstrated in only a few studies (24–26).

The aim of our study was to examine the reproducibility of a modified 6MWT (with continuous encouragement) in adolescents with ID using a test-retest design, and to assess the validity by correlating the six-minute walk distance (6MWD) and the peak VO₂ in this population.

Material and methods

This study has adhered to guidelines for reliability and validity by clearly defining constructs, selecting appropriate measurement tools, and conducting pilot testing (27). Further, test-retest reliability assessment was performed to enhance the reliability and the validity of my measures has been confirmed through comprehensive analyses, expert feedback, and literature reviews.

Participants

Sixty-four adolescents aged 14 to 21 years with mild to moderate ID from the Janzour Center for Intellectual Abilities Development in Tripoli, Libya, were eligible for this study. These students typically possess low to moderate IQs, qualifying them as educable and trainable. Those with significantly lower IQs are not admitted, as they would likely not benefit from the educational programs offered. No data or documentation regarding IQ tests for these students is available. From the initial group, thirty adolescents with a mean age of 17.6 years participated in the study, while the remaining thirty-four either declined to participate or were unable to attend two consecutive sessions due to illness or other commitments. Written consent was obtained from both the participants and their parents. The study received approval from the bioethics committee at the Biotechnology Research Center (BEC-BTRC 9-2022). Participant medical files lacked information regarding the causes and associated impairments of ID. Table I presents the general characteristics of the participants. All subjects took part in the validity study and entered the reproducibility trial.

Measurements

Weight classification

Height was measured to the nearest 0.1 cm using a stadiometer (Holtain Ltd, Crosswell, UK). Weight was recorded to the nearest 0.1 kg on a digital scale (maximum capacity 200 kg; Seca, Hamburg, Germany) with participants dressed in lightweight clothing and without shoes.

Physical fitness

Maximal cardiopulmonary exercise test.

Participants underwent testing on a computer-controlled bicycle ergometer (Marquette Case Marquette Electronics, Milwaukee, WI, USA) following a progressive protocol starting at 30 W and increasing by 15 W each minute, while maintaining a pedaling rate of 65–75 rpm (9). Continuous twelve-lead electrocardiogram and heart rate recordings were taken throughout the test, with manual blood pressure measurements every 2 minutes. Participants were encouraged to exercise to their maximum capacity or until the physician stopped the test due to severe adverse events. Respiratory gas measurements were recorded using a Metalyzer 3B (Cortex, Leipzig, Germany), with oxygen uptake (VO2) continuously monitored through mixed chamber analysis. Peak VO2 was defined as the maximum VO2 achieved during the last 30 seconds of exercise, in line with ATS guidelines (12).

Six-minute walk test (6MWT).

All participants completed a modified, self-paced 6MWT in the same 20-meter corridor under the supervision of the same observer. For the reproducibility study, two observers were involved. Each participant performed the modified 6MWT twice, one week apart, at the same time and location to ensure consistency without disrupting the school schedule. Participants received instructions according to established guidelines, minus verbal encouragement (18). Participants were verbally encouraged using standard phrases throughout the test. The distance covered was measured to the nearest meter at the end of the 6 minutes.

Data analysis

Statistical analysis was performed using SPSS version 16 (SPSS Inc., Chicago, IL, USA). To assess reliability, a paired sample t-test was first conducted to compare the results of the two 6MWTs. Next, a two-way mixed effects intra-class correlation coefficient (ICC) with an absolute agreement definition was calculated to evaluate relative reliability, along with the standard error of measurement (SEM) to assess absolute reliability. Additionally, a Bland-Altman plot with 95% limits of agreement was created to visualize the agreement between the two trials (28). Validity was assessed by calculating Pearson's r correlation between the 6-minute walk distance (6MWD) and

peak VO2.

Results

Descriptive characteristics of the participants are shown in Table I. Participants in the reproducibility and the validity study had a mean age of 17.6 years.

All the participants were able to finish the CPET and the 6MWT without interrupting the test. Results of the physical fitness tests are presented in Table 1.

The mean relative peakVO2 measured in this sample was 22.8 ml/min/kg, indicating a low physical fitness level. The difference between the means of the two walking distances covered during the two tests was not significant (583.6 vs. 579.9 m; p = 0.43). The ICC was 0.93 with a 95% confidence interval (CI) between 0.68 and 0.90, indicating good reliability. The SEM came to 12.1 m, resulting in an SRD of 33.5 m.

Table 1. Characteristics of the participants and results of physical fitness measurements.

	Reproducibility & validity study (n=30)	
	Mean	SD
Age	17.6	2.3
Peak VO2 (l/min)	2.3	0.66
6MWD1	583.6	65.6
6MWD2	579.9	66.8
HR at rest	85	14
HR at end of 6MWT	155	17

VO2, oxygen uptake; 6MWD, six-minute walk distance; HR, heart rate; 6MWT, six-minute walk test.

Figure 1 contains the Bland-Altman plot illustrated the differences between the first and second 6MWDs against the subjects' mean of the two tests, revealing that most differences fell within the 95% limits of agreement, indicating good consistency between the two trials. This suggests that the 6MWD measurements are reliable for repeated testing in this population. In 18 of the 30 participants, the individual best test was the second test.

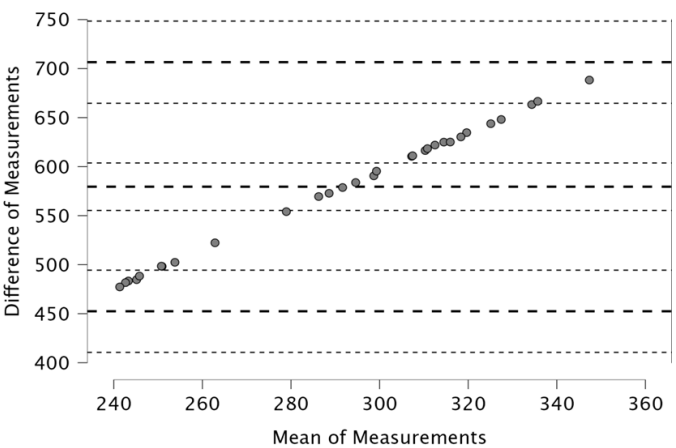


Figure 1. Bland-Altman plot of first and second six-minute walk test.

A significant correlation was identified between the 6MWD and peak VO2, with a correlation coefficient of r = 0.41, as shown in Table 2.

Table 2. Correlation of peak VO2 with Six-minute walk distance

	6MWD	
	Pearson's r correlation	p value
Peak VO2 (l/min)	0.41	0.02

6MWD, Six-minute walk distance; Vo2, Oxygen uptake

Discussion

The main findings of this study are that the modified 6MWT, with continuous encouragement, is a reliable and valid test in overweight children and adolescents with ID. Based on our results, we can conclude that the modified 6MWT, with continuous encouragement, is a valid measure of functional exercise capacity in adolescents with ID, as there was a significant correlation between 6MWD and peak VO₂. These results are in agreement with other studies in children and adolescents without ID (16, 17, 29, 30). Li et al. (17) found a stronger correlation in healthy children and adolescents without ID and lower mean age than our study population by using a treadmill to estimate peak VO₂. We used a bicycle ergometer to estimate peak VO₂ because it is valid and accepted as a standard measure of exercise tolerance and the work load can be adjusted more precisely than on a treadmill (12). Walking and cycling are two different forms of exercise, each with its own metabolic challenges. Although there is a positive correlation between these activities, it is possible that treadmill testing could produce even better outcomes. Morinder et al. (16) reported a significant but weak correlation between 6MWD and peak VO₂ and relative peak VO₂ in obese children and adolescents using a submaximal bicycle ergometry test according to Astrand and Ryhming to predict peak VO₂. Despite the fact that the Astrand test does not measure directly but estimates peak VO₂, the reported correlation coefficient for absolute peak VO₂ was comparable.

The mean distance covered on the 6MWT by our children and adolescents (582 m) was comparable to the outcome of the obese adolescents with ID (570 m) of Elmahgoub et al. (24), and to obese children (570 m) of Morinder et al. (16). Further, it was somewhat lower than that of the obese children (611 m) reported by Calders et al. (31) and significantly lower than that of the normal-weight children (670 m) of Morinder et al. (16), Li et al. (17) (680 m) and Geiger et al. (ranging between 700 and 750 m) (15). Participants of this study have different BMI categories; this could explain the difference on the 6MWD achieved when comparing to the 6MWD achieved either by normal weight children or adolescents with or without ID.

The 6MWT had an acceptable reliability, as the ICC (0.93) between the two 6MWDs in this study was excellent. A good and acceptable reliability has been observed in obese adolescents with ID, ICC (0.82) (24, 25). In addition, this has also been demonstrated in other studies on healthy and obese children and adolescents (16, 20) and different disease conditions (32, 33). Li et al. (17) assessed test-retest reliability in non-obese healthy children without ID, and the ICC (0.94) and the SEM (15 m) were quite similar compared to the ICC (0.93) and SEM (12 m) observed in our study. This can be explained by the fact that we used continuous encouragement during the test while children in the study of Li et al. had normal IQ and used the recommended guidelines of encouragement. Enright et al. (13, 14) reported that this form of encouragement could increase variability up to 30%.

The IQ has been found to be significantly associated with 6MWD; the higher the IQ, the longer the 6MWD (24). In this study, the participants were educable and/or trainable as their IQ categories were mild to moderate. The IQ level between 45 and 55 and IQ ranging from 55 to 70 were representing moderate and mild ID respectively. The classification of ID represents a combination of patients' level of intelligence and adaptive behavior, based on valid psychological tests. The participants recruited from the mild ID need a little guidance and assistance to be personal independent, but the participants from moderate ID require assistance with several activities and need to be addressed with simple sentences. Due to the fact that they have to understand the goal and execution of the test, it is possible that there is higher comprehension in the mild ID compared to the moderate ID influencing variability of the outcome (34). Additionally, Wouters et al (26) conducted the 6MWT with children and adolescents suffering from moderate to severe ID, they discovered that the 6MWD was 349 ± 98 meters, significantly lower than the participants in this study, who had mild to moderate ID. This difference may indicate the influence of IQ and comprehension levels on the test results. Moreover, intrinsic motivation to keep up the pace during the walking test could be higher in those with mild compared to moderate ID. This could be seen during the tests because continuous motivation was much more intense in those with moderate ID, but this was neither objectivated nor are literature data available to confirm this.

Furthermore, age has a controversial finding in correlation the

6MWD. It was a significant predictor for the 6MWD in many studies (15, 20). The trials used specific age groups of children and adolescents with normal development of 7–16 and 3–18 years, respectively, but with specific characteristics (pre-pubertal, pubertal and post-pubertal). In obese adolescents with ID, there was no significant correlation of age with the 6MWD (31). Probably this was due to the fact that participants' ages of Elmahgoub et al. study (24) were ranged from 14 to 22 years and were probably all post-pubertal.

Several factors enhance the strength of this study: it specifically focused on Libyan adolescents with ID, addressing a significant gap in literature concerning this underserved group and providing valuable insights. Additionally, 6MWT yields measurable data on physical endurance and mobility, which can be useful for tracking progress over time in this population. Conducting the study within a Libyan context ensures the findings are relevant to the local population, potentially leading to tailored interventions.

However, the study also has limitations. We only assessed the reproducibility and validity of the 6MWT in individuals with ID, without including a control group of those without ID. Future research could benefit from comparing these factors across different groups to gain deeper insights into the specific characteristics of ID. The small sample size used in this study may limit the generalizability of the findings and statistical power. Additionally, cultural perceptions of exercise and physical activity might impact participation and performance in the 6MWT. Future investigations should consider a larger sample size across various age ranges and anthropometric categories (such as weight and BMI) to strengthen this research question and develop a predictive equation for 6MWD in this population.

Conclusions

In conclusion, our study's findings suggest that the modified 6MWT with continuous encouragement is a valid and reliable measure of cardiorespiratory fitness in adolescents with ID. The unique characteristics of this population; such as lower IQ, a higher prevalence of overweight, and reduced physical fitness significantly influence the results of the 6MWT, highlighting its potential for future research and clinical application

Abbreviations

Six-minute walk test (6MWT), intellectual disability (ID), Intelligent quotient (IQ), Six-minute walk distance (6MWD), American Thoracic Society (ATS), Oxygen uptake (VO₂)

Availability of Data and Materials

Data are available upon request.

Author Contributions

SE, and HM designed the research study. SE, OE and HM performed the research. AA, and PC provided help and advice on running the research. SE, HM and AA analyzed the data. SE, HM, and OE wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

Ethics Approval and Consent to Participate

Ethical approval was obtained from the bioethics committee at the Biotechnology Research Center (BEC-BTRC 9-2022). A signed written consent was obtained from both the participants and their parents.

Acknowledgment

We gratefully acknowledge the time participants spent while doing the data collection.

Funding

This research was funded by the Libyan Authority for Scientific Research

Conflict of Interest

The authors declare no conflict of interest.

References

- Fernhall B. Physical fitness and exercise training of individuals with mental retardation. *Med Sci Sports Exerc* 1993;25:442–450.
- Pitetti KH, Campbell KD. Mentally retarded individuals—a population at risk? *Med Sci Sports Exerc* 1991;23:586–593.
- Pitetti KH, Boneh S. Cardiovascular fitness as related to leg strength in adults with mental retardation. *Med Sci Sports Exerc* 1995;27:423–428.
- Disabil Rehabil Downloaded from informahealthcare.com by University of Gent on 01/09/12 For personal use only. 6 S. S. Elmahgoub et al. Disability & Rehabilitation
- Dodd KJ, Shields N. A systematic review of the outcomes of cardiovascular exercise programs for people with Down syndrome. *Arch Phys Med Rehabil* 2005;86:2051–2058.
- Flore P, Bricout VA, van Biesen D, Guinot M, Laporte F, Pépin JL, Eberhard Y, et al. Oxidative stress and metabolism at rest and during exercise in persons with Down syndrome. *Eur J Cardiovasc Prev Rehabil* 2008;15:35–42.
- Bell LM, Watts K, Siafarikas A, Thompson A, Ratnam N, Bulsara M, Finn J, et al. Exercise alone reduces insulin resistance in obese children independently of changes in body composition. *J Clin Endocrinol Metab* 2007;92:4230–4235.
- Benson AC, Torode ME, Fiatarone Singh MA. Effects of resistance training on metabolic fitness in children and adolescents: a systematic review. *Obes Rev* 2008;9:43–66.
- DeStefano RA, Caprio S, Fahey JT, Tamborlane WV, Goldberg B. Changes in body composition after a 12-wk aerobic exercise program in obese boys. *Pediatr Diabetes* 2000;1:61–65.
- Elmahgoub SM, Lambers S, Stegen S, Van Laethem C, Cambier D, Calders P. The influence of combined exercise training on indices of obesity, physical fitness and lipid profile in overweight and obese adolescents with mental retardation. *Eur J Pediatr* 2009;168:1327–1333.
- Skowronski W, Horvat M, Nocera J, Roswal G, Croce R. Eurofit special: European fitness battery score variation among individuals with intellectual disabilities. *Adapt Phys Activ Q* 2009;26:54–67.
- American Thoracic Society, American College of Chest Physicians ATS/ACCP Statement on cardiopulmonary exercise testing. *Am J Respir Crit Care Med* 2003;167:211–277.
- Mezzani A, Agostoni P, Cohen-Solal A, Corrà U, Jegier A, Kouidi E, Mazic S, et al. Standards for the use of cardiopulmonary exercise testing for the functional evaluation of cardiac patients: a report from the Exercise Physiology Section of the European Association for Cardiovascular Prevention and Rehabilitation. *Eur J Cardiovasc Prev Rehabil* 2009;16:249–267.
- Enright PL, McBurnie MA, Bittner V, Tracy RP, McNamara R, Arnold A, Newman AB. The 6-min walk test: a quick measure of functional status in elderly adults. *Chest* 2003;123:387–398.
- Enright PL, Sherrill DL. Reference equations for the six-minute walk in healthy adults. *Am J Respir Crit Care Med* 1998;158:1384–1387.
- Geiger R, Strasak A, Trembl B, Gasser K, Kleinsasser A, Fischer V, Geiger H, et al. Six-minute walk test in children and adolescents. *J Pediatr* 2007;150:395–9, 399.e1.
- Morinder G, Mattsson E, Sollander C, Marcus C, Larsson UE. Six-minute walk test in obese children and adolescents: reproducibility and validity. *Physiother Res Int* 2009;14:91–104.
- Li AM, Yin J, Yu CC, Tsang T, So HK, Wong E, Chan D, et al. The six-minute walk test in healthy children: reliability and validity. *Eur Respir J* 2005;25:1057–1060.
- ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. *Am J Respir Crit Care Med* 2002;166:111–117.
- Takken T, Engelbert R, van Bergen M, Groothoff J, Nauta J, van Hoeck K, et al. Six-minute walking test in children with ESRD: discrimination validity and construct validity. *Pediatr Nephrol* 2009;24:2217–2223.
- Poirier P, Després JP. Exercise in weight management of obesity. *Cardiol Clin* 2001;19:459–470.
- Concolino D, Pasquazzi A, Capalbo G, Sinopoli S, Strisciuglio P. Early detection of podiatric anomalies in children with Down syndrome. *Acta Paediatr* 2006;95:17–20.
- Van Gheluwe B, Kirby KA, Hagman F. Effects of simulated genu valgum and genu varum on ground reaction forces and subtalar joint function during gait. *J Am Podiatr Med Assoc* 2005;95:531–541.
- Pastore E, Marino B, Calzolari A, Digilio MC, Giannotti A, Turchetta A. Clinical and cardiorespiratory assessment in children with Down syndrome without congenital heart disease. *Arch Pediatr Adolesc Med* 2000;154:408–410.
- Elmahgoub SS, Van de Velde A, Peersman W, Cambier D, Calders P. Reproducibility, validity and predictors of six-minute walk test in overweight and obese adolescents with intellectual disability. *Disability and rehabilitation*. 2012;1:34(10):846–51.
- Janssens H. The reliability and validity of the six-minute walk test and twenty-meter shuttle run test in children with intellectual disability (Doctoral dissertation, Ghent University).
- Wouters M, Evenhuis HM, Hilgenkamp TI. Physical fitness of children and adolescents with moderate to severe intellectual disabilities. *Disability and rehabilitation*. 2020 Aug 27;42(18):2542–52.
- Kottner J, Audigé L, Brorson S, Donner A, Gajewski BJ, Hróbjartsson A, et al. Guidelines for reporting reliability and agreement studies (GRRAS) were proposed. *International journal of nursing studies*. 2011 Jun 1;48(6):661–71.
- Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986;1:307–310.
- Nixon PA, Joswiak ML, Fricker FJ. A six-minute walk test for assessing exercise tolerance in severely ill children. *J Pediatr* 1996;129: 362–366.
- Li AM, Yin J, Au JT, So HK, Tsang T, Wong E, Fok TF, et al. Standard reference for the six-minute-walk test in healthy children aged 7 to 16 years. *Am J Respir Crit Care Med* 2007;176:174–180.
- Calders P, Deforche B, Verschelde S, Bouckaert J, Chevalier F, Bassle E, Tanghe A, et al. Predictors of 6-minute walk test and 12-minute walk/run test in obese children and adolescents. *Eur J Pediatr* 2008;167:563–568.
- Wathen D. Load assignment. In: Baechle TR, editor. *Essentials of strength training and conditioning*. Champaign, IL: Human Kinetics; 1994. pp. 435–446.
- Beckerman H, Roebroek ME, Lankhorst GJ, Becher JG, Bezemer PD, Verbeek AL. Smallest real difference, a link between reproducibility and responsiveness. *Qual Life Res* 2001;10:571–578.
- Solway S, Brooks D, Lacasse Y, Thomas S. A qualitative systematic overview of the measurement properties of functional walk tests used in the cardiorespiratory domain. *Chest* 2001;119:256–270.