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Reliability, validity, and reference norms of one-minute walk test in assessing cardiopulmonary functional capacity in healthy young adults: a pilot study

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Abstract

Introduction. Although the 6-minute walk test (6MWT) and 2-minute walk test (2MWT) are widely accepted tools for analysing functional capacity, in most clinical settings and populations, they may not be possible to apply owing to time and space constraints. Hence, an alternative walk test, one-minute walk test (1MWT), was introduced. There is, however, a lack of evidence on its reference norms, reliability, and validity. Thus, we aimed to estimate the reference norms, reliability, and validity of 1MWT among healthy young adults.

Methods. A sample of 86 healthy adults aged 18–25 years were recruited by the simple random sampling technique for the normative study, and 14 participants for the validity and reliability study. They were asked to perform 1MWT and 6MWT in accordance with the American Thoracic Society guidelines. 1MWT was performed twice by each participant, with a minimum of 2 days to estimate test-retest reliability. The concurrent validity of 1MWT was established with 6MWT.

Results. The reference norm of 1MWT with mean and 95% confidence interval is 74.3 (72.1–76.6) m. The test-retest reliability of 1MWT was estimated as an interclass correlation coefficient of 0.76 (0.60–0.86) with Cronbach's alpha of 0.76. A good degree of concurrent validity exists between 1MWT and 6MWT, with Spearman's $\rho = 0.79$ ($p < 0.001$).

Conclusions. 1MWT has a good test-retest reliability and a good degree of concurrent validity with 6MWT. The reference norms of 1MWT have also been established.

Key words: exercise test, walk test, 6-minute walk test, reliability of results, reproducibility of findings, validity of results

Introduction

Functional walk tests (FWTs) are utilized in the assessment of walking ability among patients with movement disorders. They also serve as a measurement scale for functional status and exercise capacity. FWTs are inexpensive tools, easy and safe in the evaluation of functional capacity in day-to-day clinical practice as well as in research. Among all FWTs, the 6-minute walk test (6MWT) and the 2-minute walk test (2MWT) are used most frequently. 6MWT is applied to measure the functional capacity of patients undergoing cardiopulmonary rehabilitation [1], to assess the efficacy of treatment, and to determine its effects. Although 6MWT is a widely accepted tool to measure functional capacity, in most clinical settings and populations, it may not be possible to apply owing to time and space constraints. Moreover, 6MWT cannot be used in patients with an unstable cardiopulmonary status, with chronic obstructive pulmonary disease with an acute exacerbation [2], with stroke [3], in older adults [4], etc. Hence, there is a real need for an alternative FWT to measure walking ability, exercise capacity, and the overall functional status of the adult population and children with disabilities.

The original field test was introduced by Balke in the early 1960s [5]. Then, Cooper [6] introduced the original 12-minute walk test (12MWT) for athletes, which was subsequently altered for use in a patient with chronic bronchitis [7]. In consideration of time and space constraints, older adults [8], patients with chronic diseases [9–11], those after cardiac surgery [12], individuals undergoing rehabilitation after amputation [13–16], patients with neurological disorders [17–21], those during fracture rehabilitation [22], etc., shorter walk distances were introduced and found similarly reproducible as the original 12MWT [2]. Thus, both 6MWT and 2MWT replaced the original 12MWT. But still, there was a dearth in literature on measuring functional performance among children with cerebral palsy. This resulted in the development of a valid walk test, a 1-minute walk test (1MWT), by McDowell et al. [23] in 2005, for children with cerebral palsy.

1MWT was introduced to measure functional capacity among most children with cerebral palsy who were ambulant [23] and may constitute an alternative for the traditional 6MWT. After that, many more researchers started exploring the importance of 1MWT among children with cerebral palsy [24, 25]. To the best of our knowledge, however, there is no literature available regarding 1MWT among healthy young adults (HYA). As the present-day clinician lacks time for detailed assessment, 1MWT could be used among the walk tests to evaluate functional capacity in HYA. Nevertheless, there are no reference norms, validity, or reliability data for 1MWT among HYA. We hypothesized that 1MWT would have acceptable validity and reliability as 6MWT. Hence, we aimed to explore the validity, reliability, and reference norms of 1MWT among a sample of HYA.

Subjects and methods

Recruitment

A sample of 86 HYA aged 18–25 years were recruited by the simple random sampling technique for the normative

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study, and 14 participants for the validity and reliability study. HYA who had undergone any surgery of the abdomen or lower limb within the previous 6 months, who presented a respiratory or cardiovascular disorder, neurological disorder, any systemic illness, or anomalies of foot were excluded from the study. The recruited individuals were informed about the purpose, procedure, possible risks, and potential benefits of the study in advance and were guaranteed the confidentiality of personal data.

Anthropometric measurements

Before the performance of FWTs, all recruited HYA were subjected to an anthropometric evaluation (height and weight) in accordance with the international standards for anthropometric assessment by the International Society for the Advancement of Kinanthropometry [26]. The body mass index was then analysed. To avoid any dissimilarities, all the measurements were recorded nearly the same hours of the day, with the participants comfortably dressed.

Performing functional walk tests

The 6MWT and 1MWT were performed with the standardized procedure adopted by the American Thoracic Society in implementing 6MWT [27] by using a 30-m walkway. Both walk tests were administered and recorded by the first author, who is a qualified physiotherapist with 5 years of clinical experience. The tests were delivered in the corridors of the Physiotherapy Department of a recognized university. During the tests, HYA were wearing their own comfortable clothes and shoes. Ample lighting and noise-free surroundings were ensured throughout the completion of FWTs. The participants were asked to complete 2 trials of 1MWT at their own pace, and the mean of the 2 results was used for analysis. They were told to start walking once instructed and walk as far as possible within 1 minute, until instructed to stop. The distance walked was recorded to the nearest 1 cm. The individuals were instructed not to run or jog or walk slow or fast, but to walk in their own pace, covering the distance as far as they could in 1 minute. We have emphasized the phrase 'walk as far as possible,' as recommended for HYA [28, 29]. Between the 2 instances of 1MWT, a 10-minute seated rest was provided to the participants.

Reference value

The minimum required sample to estimate the reference value was calculated from our unpublished pilot study data with 14 randomly selected individuals [30] by using the following formula:

$$n = (Z\alpha\ \sigma/d)^2$$

By substituting $Z\alpha = 1.96$; σ (standard deviation) = 9.14 m, and d (standard error of mean) = 1.95 m, the minimum required sample size was found to be $n = 85$. Hence, we recruited a sample of 86 HYA to estimate the reference norms of 1MWT.

Concurrent validity

The sample size for determining the concurrent validity was estimated by using the expected validity, r or $\rho = 0.76$ by allowing 5% type 1 error and 20% type 2 error in the following formula [31]:

$$n = [(Z\alpha + Z\beta)/C]^2 + 3$$

where $C = 0.5*\ln[(1 + r)/(1 - r)]$. Thus, the minimum required sample was estimated to be $n = 11$. Hence, we randomly recruited 14 participants for determining the concurrent validity. The same rater performed 6MWT among the 86 HYA and thereby established the concurrent validity of 1MWT with the criterion-referenced 6MWT.

Test-retest reliability

For estimating test-retest reliability, 14 randomly selected participants were asked to perform 1MWT and were rated twice by the same rater on different occasions with a minimum interval of 24 hours [32]. As the minimum sample size of $n = 13$ was required to report test-retest reliability measured at 2 times with 90% power [33], we reported the test-retest reliability among 14 subjects.

Data analysis

The Kolmogorov-Simonov test was used to assess the Gaussian distribution. Descriptive statistics were showcased in terms of mean and 95% confidence interval (CI) as the data did not follow normality. The Mann-Whitney *U* test served to determine the statistical difference between the sexes, and concurrent validity was set by using Spearman's correlation test [34]. The test-retest reliability was proved by utilizing the interclass correlation coefficient (ICC) with 95% CI. The Bland-Altman graph for the 2 sessions of 1MWT was plotted to report the level of agreement between the sessions [35]. The SPSS software, version 19.0 (IBM, Armonk, NY, USA) for Windows 10 Home Edition was used to analyse all the above data.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Student Project Committee of the Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation (approval No.: MMIPR/SPCA/17/11).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

A total of 86 HYA, including 31 males and 55 females, took part in the study. The demographic characteristics of the recruited subjects are displayed in Table 1. Even though there was a significant difference ($p < 0.001$) in the participants' height and weight, body mass index did not exhibit a significant difference ($p > 0.05$). The reference norm of 1MWT with mean and 95% CI is 74.3 (72.1–76.6) m. The difference in 1MWT results between males and females recruited is presented in Table 2. Table 3 shows the concurrent validity of 1MWT against 6MWT by using Spearman's correlation coefficient (ρ). In accordance with Portney and Watkins's criteria in judging the relationship, there is a good degree of association between 1MWT and 6MWT with mean Spearman's ρ of 0.79 ($p < 0.001$). The test-retest reliability of 1MWT between the 2 sessions by the same rater is reported in Table 4, with ICC (95% CI) and Cronbach's alpha. In accordance with Shrout and Fleiss's criteria in estimating reliability, there is a good reliability between the sessions [36]. The Bland-Altman plot for the 2 sessions of 1MWT falls well within 2 standard deviations (Figure 1) and there are 7 outliers of the total sample recruited. Thus, the agreement between the sessions was satisfied.

Discussion

To check the reliability and validity of 1MWT among HYA, the 86 participants recruited in the study were matched with their age between male and female HYA. Both validity (ρ = 0.79; $p < 0.001$) and reliability were found to be good. To the foremost of our knowledge, the current study is the first one to verify the reliability and validity of 1MWT among HYA.

Table 1. Demographic characteristics of the recruited healthy young adults (31 males, 55 females)

Demographic characteristics	Median		IQR		Range		*p*
	M	F	M	F	M	F	
Age (years)	22	21	21–13	19–22	19–26	18–26	0.50
Height (cm)	173	159	167–178	153–163	154–184	149–173	< 0.001
Weight (kg)	67	53	63–72	46–63	49–83	39–85	< 0.001
BMI (kg/m^2)	23.3	21.7	21.2–24.5	18.3–24.2	19.1–26	15–32	0.50

BMI – body mass index, IQR – interquartile range, M – male, F – female

Table 2. Reference norms of 1MWT for healthy young males and females

Functional walk test	Males (*n* = 31)	Females (*n* = 55)	*p*
1MWT (m)	75 (71.3–78.7)	73 (71–75)	0.83

1MWT – 1-minute walk test

Table 3. Concurrent validity of 1MWT among healthy young adults against 6MWT

Functional walk test	6MWT	1MWT	Spearman's correlation coefficient (ρ)	*p*
Distance (m)	429 (397.6–460.3)	77.8 (73–82.5)	0.79	< 0.001

1MWT – 1-minute walk test, 6MWT – 6-minute walk test

Table 4. Test-retest reliability of 1MWT among healthy young adults

Functional walk test	1st session	2nd session	ICC	95% CI	Cronbach's alpha (α)
1MWT (m)	74.4 (72–77)	73.7 (72–75.6)	0.76	0.6-0.86	0.76

1MWT – 1-minute walk test

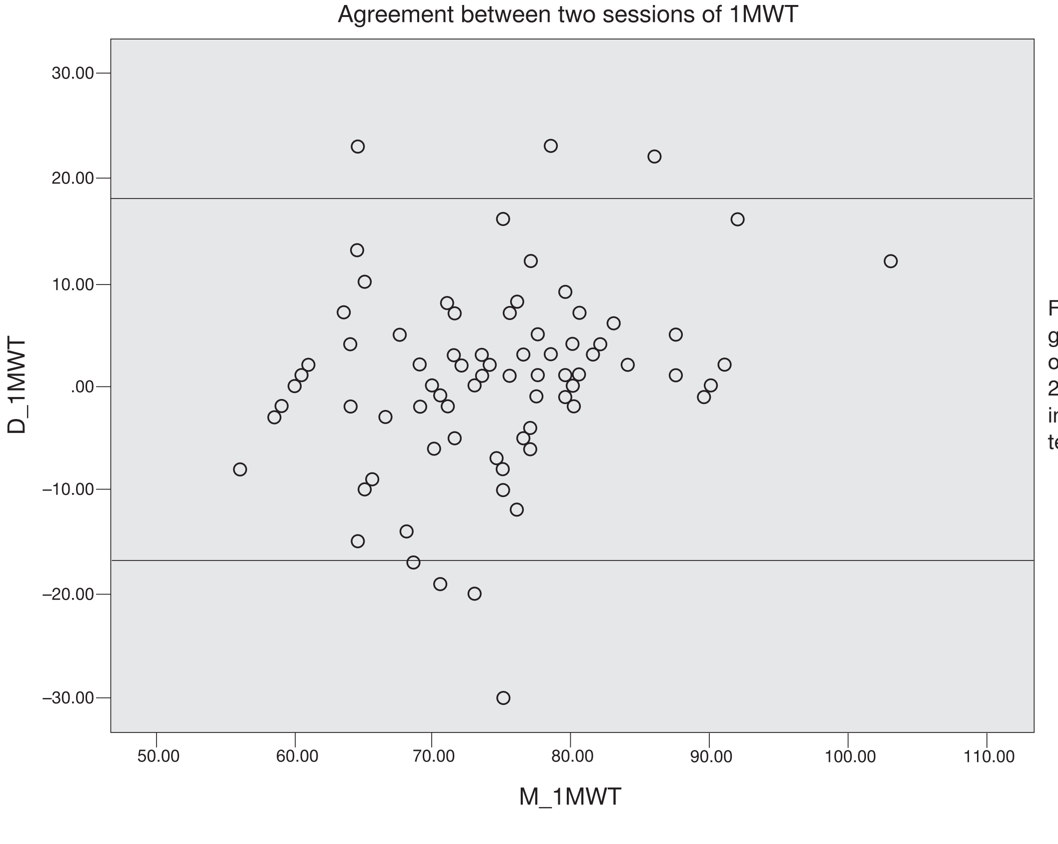

Figure 1. The Bland-Altman graph showing the level of agreement between 2 measurements by the same investigator for 1-minute walk test (1MWT)

The test-retest reliability of 1MWT among children with cerebral palsy is excellent (ICC = 0.94) [37] when compared with the good reliability among HYA in accordance with Shrout and Fleiss's criteria in estimating reliability. 1MWT exhibits an excellent relationship with functional capacity as determined with the Gross Motor Function Measure-88 (r = 0.92) [23]. This is in line with the findings of our study, with a good concurrent validity of 1MWT ($\rho = 0.79$; $p < 0.001$) with the criterion measure for functional capacity by 6MWT.

In a previous study [37], children with bilateral spastic cerebral palsy were able to cover 81.4 ± 19.8 m and 81.4 ± 18.2 m in 2 consecutive sessions when compared with 74.4 (72–77) m and 73.7 (72–75.6) m, respectively, in the study among HYA. Children with bilateral spastic cerebral palsy were able to cover a longer distance than HYA as they were instructed to walk fast and were given practice trials before the walk test began [37]. Similarly, in another study by the same author, children with cerebral palsy of Gross Motor Function Classification System level 1 or 2 were able to cover 100 ± 12 m and 82.6 ± 17.4 m, respectively [23]. In both studies by McDowell et al. [23, 37], children with cerebral palsy covered a longer distance than our participants probably because they were instructed to walk fast, whereas in our study, the subjects were asked to walk at their natural walking pace, neither slow nor fast.

1MWT is a simple test that can be easily performed. It is time-saving, cost-effective, requires less skill to perform, is easy to understand, and not exhausting to the participants. As most walk tests are time-consuming and fatiguing for patients, 1MWT could overcome these drawbacks in clinical practice. This test is a reliable and valid measure of cardiopulmonary functional capacity. 1MWT is sufficiently powered and hence could be extrapolated to document pre- and post-physiotherapy progression in young adults with cardiopulmonary diseases.

Conclusions

1MWT presents a good test-retest reliability and a good degree of concurrent validity with 6MWT. The reference norms of 1MWT have been established. Hence, 1MWT can be used as an alternative to the established 2-, 6-, and 12-minute walk tests in clinical practice.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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