ORIGINAL ARTICLE

The Validity and Reliability of Six Minute Walk Test in a 15 Meter Track

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ABSTRACT

Introduction: Endurance is one of the key fitness measure that should be evaluated daily. Clinical assessment of endurance in daily practice is usually hurdled by limitation of hospital spaces. Another obstacle arise that shorter six-minute walk test (6MWT) track will lead to more turning motion, yielding shorter straight walking distance with increased energy expenditure.

Methods: This cross sectional study compares 6MWT on a 15 meter corridor, to the gold standard Biodex® gait trainer for healthy adults aged 18-50 years. Subjects without any anatomical abnormalities or systemic disorders were recruited, and instructed to turn in a three-step method at track ends to maximize walking distance. Furthermore, validity and reliability assessments to obtain both Pearson correlation and Cronbach Alpha values were performed respectively.

Results: Among 123 subjects, 58 males aged ranging from 18 to 45 years, and females between 18 to 42 years were recruited. Anthropometrical values were similar between gender. Significant difference in walking distance and walking speed was observed. Comparison of walking distance between the two modalities were seen to be statistically similar ($p=0.693$). Pearson validity test was proven significant ($p <0.001$) with a correlation coefficient of $r = 0.998$, while reliability test obtained Cronbach's Alpha value of 0.999, hence showing that these are both valid and reliable.

Conclusion: Good validity and reliability of 6MWT in 15 meter track as compared to the gold standard Biodex® gait trainer was demonstrated in this study. Moreover, shorter track is a potential modification adhering to the limitation of operational space. The three-step turning method could significantly improves total walk distance, and thus is suggested.

Keywords: clinical assessment, endurance, six-minute walk test, walk distance, walking speed

ABSTRAK

Pendahuluan: Daya tahan merupakan salah satu kunci kebugaran utama yang harus dievaluasi setiap hari. Penilaian klinis daya tahan dalam praktek sehari-hari biasanya terhalang oleh keterbatasan ruang rumah sakit. Kendala lain muncul bahwa lintasan uji jalan kaki enam menit (6MWT) yang lebih pendek akan menghasilkan lebih banyak gerakan berbelok, menghasilkan jarak berjalan lurus yang lebih pendek dengan peningkatan pengeluaran energi.

Metode: Studi *cross-sectional* ini membandingkan 6MWT pada koridor 15 meter, dengan standar baku gaya berjalan Biodex® untuk orang dewasa sehat berusia 18-50 tahun. Subyek yang direkrut, tanpa kelainan anatomi atau kelainan sistemik, diinstruksikan untuk berbelok dalam metode tiga langkah di ujung lintasan untuk memaksimalkan jarak berjalan kaki. Selanjutnya dilakukan penilaian validitas dan reliabilitas untuk mendapatkan nilai korelasi *Pearson dan Cronbach Alpha* masing-masing.

Hasil: Di antara 123 subjek yang direkrut, terdiri dari 58 pria berusia antara 18 hingga 45 tahun, dan wanita berusia antara 18 hingga 42 tahun. Nilai-nilai antropometrik serupa antar gender. Perbedaan yang signifikan dalam jarak berjalan dan kecepatan berjalan diamati. Perbandingan jarak berjalan kaki antara kedua modalitas terlihat serupa secara statistik (p=0.693). Uji validitas pearson terbukti signifikan (p <0.001) dengan koefisien korelasi r = 0.998, sedangkan uji reliabilitas diperoleh nilai *Cronbach's Alpha* sebesar 0.999, sehingga menunjukkan keduanya valid dan reliabel.

Kesimpulan: Validitas dan keandalan 6MWT yang baik di lintasan 15 meter dibandingkan dengan standar baku gaya berjalan Biodex® ditunjukkan dalam penelitian ini. Selain itu, lintasan yang lebih pendek merupakan modifikasi potensial yang mengikuti keterbatasan ruang operasional. Metode belok tiga langkah dapat secara signifikan meningkatkan total jarak berjalan kaki dan dengan demikian disarankan.

Kata Kunci: daya tahan, jarak berjalan kaki, kecepatan berjalan, penilaian klinis, tes berjalan enam menit

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INTRODUCTION

Nowadays there is a need for routine evaluation of aerobic endurance, in which field tests have been shown to be the most feasible in any practical setting, in particular the six minute walk test (6MWT).[1] It should be noted that 6MWT only focuses on prediction of cardiorespiratory endurance as quantified by maximum oxygen consumption (VO_2max) from walking distance, instead of its counterpart gold standard, the cardiopulmonary exercise testing (CPET) that obtains the real values through breath-to-breath analyses.[2]

However, the 6MWT have been proven to be the most practical examination to perform, especially in the cardiopulmonary field throughout wide age group.[2-4] Essentially, since attaining the most accurate and longest walking distance is very crucial, 6MWT comes with one major drawback, being the course length.[5]

In the original 6MWT, it was shown that a long hallway of 30 meter is required to reduce the number of turns the subject should make in the six minute duration.[6] However, this seem impractical at most settings, and thus many adjustments have been made regarding the course length throughout the years.[5-8] One recent study in healthy adults had shown that the shortest course length being 10 meter, will have the shortest walking distance yield as compared to longer length, increasing nonlinearly in 20 and 30 meter length respectively.[5]

Similar conclusion could be obtained from the pediatric study, as revealed in a systematic review that studies had various course lengths to adapt to its practicality, thus resulting in the inability to summarize a single reference value.[7] Two main issues that arise regarding course length would be turning method in shorter course, and also anthropometric values which may affect step length, both of which may differ between individuals.

Turning becomes one issue to address as the seamless turning ability may decline with age.[9] It was shown in a cross sectional observation of age matched stroke patients, gait turning patterns change significantly.[10] This would mean that the turning method itself must be observed in determining shorter length than 30 meter, as instability tends to add longer time in turning and thus reduces total distance.[11,12] Shorter course length have been shown to significantly reduce walking distance by up to 100 meter, this will cause inaccurate predictions due to the additional turns taken.[5,13] Thus a standardized turning may be essential in order to eliminate additional effort which would reduce total walking distance.[5,13]

Another issue then arises, showing how walking distance achievement may differ with anthropometric measurements, which widely varies between races.[8,14-16] Leg length in particular have been addressed to correlate with cadence and step length, which would then affect regression predictive formula when they are not measured.[17] Several studies had pointed out that Caucasian values may not be applied readily for Asian population, and thus each race would require their own individualized reference values.[8,14]

METHODS

The population used in this research are healthy Indonesians with both parents being Indonesian. Inclusion criteria, 18-50 years old, physically healthy without significant neuromuscular, musculoskeletal, cardiorespiratory or circulatory disorders, and good balance. Screening for these disorders were performed by physical examination, findings of anatomical abnormalities and limb weakness will result in exclusion. Screening for cardiac disorders were carried out by electrocardiography (ECG), while respiratory function is tested by spirometric examination, to remove obstructive and restrictive pulmonary disorders. Circulation is represented by hemoglobin levels which is responsible in oxygen transport, with venous blood laboratory assessment. Normal limits

are 13.0g/dl in males and 12.0g/dl in females according to the hospital protocol. Assessment of balance disorders is conducted by Romberg examination and time up and go test. Screening of Body Mass Index (BMI) used Secca scales and height measurements, where BMI 18.5 –24.9 are considered normal according to sex. Inclusion criteria for lifestyle was those with a sedentary lifestyle, which is revealed during history taking.

Table 1. Characteristics of Subject Study (Males = 58; Females = 65)

Variable	Mean	SD	95% Confidence	P-value*
Age (years)				
- Male	26.78	7.3	24.93 – 28.62	<0.001
- Female	21.92	5.50	20.56 – 23.29	
BMI (Kg/m^2)				
- Male	21.41	1.83	20.93 – 21.89	0.475
- Female	21.65	1.82	21.20 – 22.10	
Persentage FEV1 (%)				
- Male	103.76	9.49	101.27 – 106.26	0.214
- Female	101.56	10.08	99.06 – 104.06	
Persentage FVC (%)				
- Male	98.94	8.48	96.71 – 101.17	0.375
- Female	100.41	9.85	97.97 – 102.85	
Ratio FEV1/FVC				
- Male	90.48	5.20	89.12 – 91.85	0.38
- Female	91.28	4.75	90.11 – 92.45	
Walking Distance (m)				
- Male	581.89	49.41	568.90 – 594.89	<0.001
- Female	516.72	37.40	507.46 – 525.99	
Walking Speed (Km/hour)				
- Male	5.81	0.49	5.69 – 5.94	<0.001
- Female	5.16	0.37	5.07 – 5.25	

The number of samples was calculated by using three methods to determine the number of subjects in the main study, namely one-sample situations for a population proportion (two-sided test), linear regression formula, and rule of thumb. In the use of one-sample situations for a population proportion (two-sided test), with a 95% confidence interval, 90% power (test power), 65% anticipated proportion, and 40% of an initial proportion based on actual research, the obtained minimum subject estimation was 113 people. In the use of subject search for the linear regression formula, the independent variables were calculated. There were eight independent variables, with α = 5%, β = 20%, and R^2 25%, a sample of 54 was

obtained. Whereas when applying the rule of thumb, 5 to 10 subjects per independent variable, then 80 subjects were needed in total. The track used in the study is 15-meters long with marks per 3 meters, 30-centimeters wide to the right and to the left of the center line. The track is flat with no obstacles. Subject will be instructed to walk as straight as possible to the center line of the trajectory (Figure 1). When the subject arrives at both ends, the subject rotates to a reverse direction by the three-step method (Figure 2 and 3).

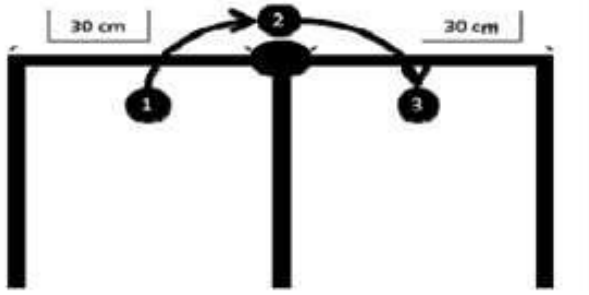

Figure 1. Track and How to perform three steps rotation on each of the track end.

Figure 2. How to perform three steps turning method on each of the track end.

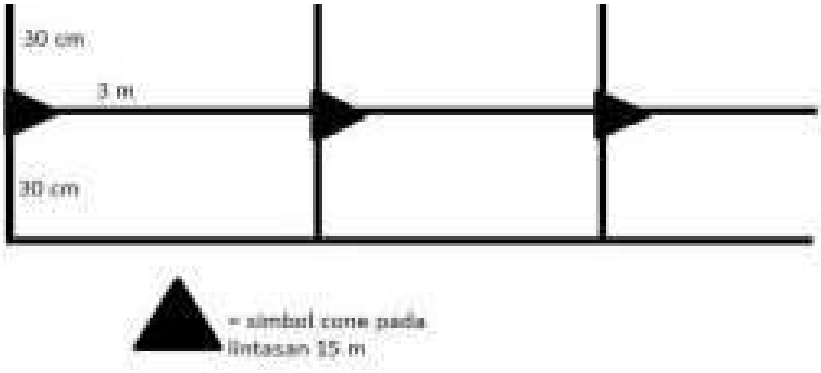

Figure 3. 15 meter illustration of track.

Walking speed was maintained uniformly for six minutes, until it reached the Borg scale of 12–13 and the pulse was above 120 beats/minute, thus depicting the attainment of steady state. Gold standard of the 6-minute walk test walking distance was obtained with the 6-minute walk test on the Biodex® gait trainer, using the speed obtained from the 6-minute walk test on the track. The walking speed was obtained by converting the walking distance acquired. Data obtained from the Biodex® gait trainer was displayed and recorded on a computer, the results were displayed in the form of walking distance in meters. All statistical data analyses were carried out using SPSS version 20.

Univariate analysis was used to display the characteristics of the subjects. The analysis of the difference between the 15-meter track distance with the Biodex® gait trainer in males and females was carried out using statistical tests with unpaired T-test, it is considered significant if $p < 0.05$ with a 95% confidence interval. The validity test was performed using the Pearson test and the reliability test was conducted to obtain Cronbach Alpha value. The validity test is regarded as good if $p < 0.05$ with the correlation coefficient (r) is close to the value of 1. The validity test is referred to be good if the alpha value >0.7 and is better if the value is close to 1.

RESULTS

This study had recruited 123 subjects, with males aged ranging from 18 to 45 years, whereas for females is between 18 to 42 years. No significant cardiac findings were seen in the subjects. The minimum limit for FEV1 in males was 81.22% while in females was 79.71%, while FVC attained values of 85.36% for males and 81.76% for females. BMI ranged from 18.50 to 24.80 for men and women. All of these values revealed that the subject's characteristic in the study satisfies the criteria of healthy sedentary adults. The total walk distance was obtained from the results of the 6-minute walk test with an average of 581.89 meters for men and 516.72 meters for women. The walking speed was obtained by converting the walking distance from the 6-minute walk test. The results of walking speed for men were ranging from 5.81 km/hour and 5.16 km/hour for women.

Comparison of the total walk distance on a 15-meter track with the Biodex® gait trainer as the gold standard reference resulted in obtaining the average mileage which were 547.45 meters on the track and 544.72 meters on the gait trainer. This result did not show any significant difference with p of 0.693 with unpaired T test. The results of the validity test with Pearson showed $p < 0.001$ with a correlation coefficient of $r = 0.998$ which indicated good validity. On the other hand, results of the reliability test had obtained a Cronbach's Alpha value of 0.999, depicting perfect reliability that revealing good validity of the 6MWT in 15 meter track.

Table 2. Walking distance on the track of 15 meter compared to Walking distance on Biodex Gait Trainer (Males = 58; Females = 65)

Variable	Mean	SD	95% Confidence	P-value*
Walking Distance (m)				
- Track	547. 45	54.24	537.77 – 557.13	0.693
- Gait Trainer	544.72	54.11	535.06 – 554.38	

*Independent t-test

DISCUSSION

The 6-minute walk test is a reliable, valid, and responsive test for measuring lung functional capacity according to the recommendations of the American Thoracic Society, its good validity and reliability applies for a wide range of medical conditions, including chronic heart failure.[5,14]

Subjects recruited in this study were classified as healthy adults without mobility or nutritional disorders. The average distance obtained on the 15-meter track is 547.45 meters, while the Biodex® gait trainer accrued 544.72 meters, with no statistically significant difference ($p = 0.693$). Additionally both validity and reliability tests had also shown good results with adequate correlation coefficient and Cronbach's alpha values ($r = 0.998$ and alpha value = 0.999). Studies had shown that walking distance seemingly had the highest significant correlation with the maximum O_2 prediction, achieving a correlation coefficient of 0.65 in the Mongoloid race.[5,6] Therefore, these indicate that the 6-minute walk test with a 15-meter track can be applied following this protocol.

Turning at the shorter track prove to expend more energy, thus may reduce total walking distance, significantly showing poorer performance.[5] This study had utilized a specific turning protocol, which may prove to have good energy efficiency, resulting in similar results in both 6MWT in 15 meter track and the gold standard Biodex® gait trainer. The three-step turn is made to avoid the occurrence of overly wide rotation, and does not utilize pivoting, which was generally adapted in stroke patients with weaker balance on one side.[10] It was previously shown that unstable turn might follow up to unstable gait, being unable to walk in a straight line as the subject tries to restore their balance following the pivot turn.[9,10] In an extensive observation of turns, it was shown that young subjects with no difficulty of turning that none would initiate their turn with forward leaning, it would either be vertically aligned trunk and hip, slight backward lean, or initiated by lower extremity before being followed up by trunk.[9] The three steps turning method effectively adapt this physiologic trajectory of turning, hence reflecting adequate motor control, and leading to better quality of life.[18,19] It is evident that the three steps method could be systematically taught to patients in order to achieve maximum walking distance in a shorter, 15 meter track.

Various studies suggest that the travel distance is affected by the length of the track.[5,20,21] ATS recommends that length of the track used for the 6-minute walk test be 30-meters.[22] However, in practice not all 6-minute test runs are

conducted on a 30-meter track due to various reasons, which one of it is limited operational space.[20,21,23] Beekman's research suggests that a course of less than 30-meters results in shorter travel distance due to a higher number of turns.[14,21,24,25] Other studies suggest that some elderly subjects increase their walking speed on longer (>20 meter) trails, compared to a shorter trajectory (<10 meter).[26]

Over the years, 6MWT have been considered the most efficient, yet still covering a wide range of diagnoses, studies in particular address restrictive lung disorders and also applicable to healthy adults in monitoring.[1] Therefore, performing a well-adapted 6MWT exercise testing with shorter distance modification may present to be an effective screening method.

The time limit of examination in each patients have made these limitations inevitable, however these could hopefully lead to better exploration of the field in future studies. Additionally as the study only used healthy subjects without balance disorder, several adaptations which may differ between patients are required in order to reach maximum walking distance. Nevertheless, this study had shown the validity and reliability of this tool, as well as the normal values in healthy adults, which may be used as a reference value in assessing subjects with endurance disorder.

CONCLUSION

Good validity and reliability of the 6MWT as compared to the gold standard Biodex® gait trainer was demonstrated in this study, making 6MWT in 15 meter track an effective examination to be performed in daily practice. Furthermore, shorter track is a potential modification adhering to the limitation of operational space situation. It should be noted that turning method at the ends of the corridor could significantly reduce total walk distance, thus a specific three step turn method is suggested. With all these kept in mind, it could be seen that the 6MWT could be means of effective screening for healthy subject.

Future Studies

As addressed previously, crossover studies which examines subjects to perform their normal turning, as compared to instructed three step turn could enhance the applicability of this 15 meter track in a wider population, especially for those with cognitive disorder.

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