

Reference Equation for Prediction of a Total Distance During Six-minute Walk Test using Indonesian Anthropometrics

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ABSTRAK

Tujuan: mengembangkan persamaan acuan untuk prediksi jarak tempuh menggunakan antropometri Indonesia dari subyek sehat menetap. Selanjutnya, prediksi yang diperoleh dibandingkan dengan rumus prediksi enright berbasis kaukasia. **Metode:** penelitian dilakukan dengan desain potong lintang yang melibatkan 123 subyek (58 laki-laki dan 65 perempuan) dewasa sehat Indonesia dengan sikap hidup sedentary. Rentang usia subyek penelitian ditetapkan antara 18-50 tahun. Denyut jantung direkam menggunakan Polar, diharapkan masih dalam zona submaksimal (120-170 kali per menit). Subyek penelitian melakukan dua macam uji jalan enam menit. Uji jalan pertama dilakukan pada lintasan 15 meter dengan protokol yang telah disusun oleh peneliti. Uji jalan kedua dilakukan pada Biodex® gait trainer yang digunakan sebagai baku emas jarak tempuh. **Hasil:** didapatkan jarak tempuh rerata 547 ± 54.24 m yang tidak berbeda bermakna terhadap baku emasnya 544.72 ± 54.11 m ($p > 0.05$). Dilakukan multiple regresi untuk membuat rumus baru. **Kesimpulan:** rumus prediksi jarak tempuh dengan nilai antropometri Indonesia lebih sesuai digunakan di Indonesia.

Kata kunci: uji jalan enam menit, rumus prediksi jarak tempuh, antropometri Indonesia.

ABSTRACT

Aim: to develop a reference equation for prediction of the total distance walk using Indonesian anthropometrics of sedentary healthy subjects. Subsequently, the prediction obtained was compared to those calculated by the Caucasian-based Enright prediction equation. **Methods:** the cross-sectional study was conducted among 123 healthy Indonesian adults with sedentary life style (58 male and 65 female subjects in an age range between 18 and 50 years). Heart rate was recorded using Polar with expectation in the sub-maximal zone (120-170 beats per minute). The subjects performed two six-minute walk tests, the first one on a 15-meter track according to the protocol developed by the investigator. The second walk was carried out on Biodex® gait trainer as gold standard. **Results:** an average total distance of 547 ± 54.24 m was found, not significantly different from the gold standard of 544.72 ± 54.11 m ($p > 0.05$). Multiple regression analysis was performed to develop the new equation. **Conclusion:** the reference equation for prediction of the total distance using Indonesian anthropometrics is more applicable in Indonesia.

Key words: six-minute walk test, reference equation for prediction of total distance, Indonesian anthropometrics.

INTRODUCTION

Walk test is a tool for the evaluation of functional capacity, which is relatively easy to perform. Balke designed the twelve-minute walk test for healthy subjects.¹ Twelve-minute walk tests have been broadly used to evaluate the functional capacity of individuals with cardiopulmonary disorders.²⁻⁴ However, ATS now recommends a six-minute walking test (6MWT), because it is more tolerable to subjects with cardiopulmonary disorders.⁵

Various studies on walk tests used 10-m,⁶ 15-m,⁷ and 400-m tracks,⁸ whereas the 6MWT is most commonly used.⁹⁻²⁰ Several studies have been conducted using this test in patients,²¹ healthy adults²² and children.²³⁻²⁶

Total distance is the primary outcome parameter of the 6MWT. It is interpreted as predicted value to walking distance. Therefore, reference equation for prediction of the total distance during 6MWT is an important variable to measure functional capacity. Previous equation by Enright is inappropriate due to the difference in anthropometry between Caucasians and Indonesians. Anthropometric value, such as height, affects the total distance, since it influences the step length. This was confirmed by Bereket who found a correlation between height and step length.²⁷ The step length of Caucasians is about 72 cm,²⁸ which is very different from Indonesian step length of approximately 45 cm.²⁹ Clinical implication of using Enright's equation is a lower real functional capacity level, as Enright's equation gives an overestimated value to Indonesian real value.

ATS recommends that every population develop their own predictive reference equation. Therefore, this study was designed to develop a reference equation, which is appropriate with Indonesian anthropometric characteristics (Mongoloid race) and it was compared with the Caucasian-based Enright predictive equation.³⁰ Age is taken into account in the equation, because age as well as height and weight affect the total distance walked.³¹

METHODS

This cross-sectional study was participated by 123 subjects, 58 male and 65 Indonesian healthy female adults with sedentary life style. The subject age ranged between 18 and 50 years. Other data taken are height and weight of subjects. The study was conducted in the Department of Medical Rehabilitation Cipto Mangunkusumo Hospital (RSCM) and the Kinematics Laboratory Universitas Negeri Jakarta (UNJ) from January until August 2010, after obtaining clearance by the Ethical Committee of the Medical Faculty of Universitas Indonesia. All subjects performed two 6MWT, the first one on the walking track according to the protocol that had been developed by the investigator. The second walk test was carried out on Biodex®gait trainer, which was used as the gold standard.

After the new formula was obtained, then normality residual tests were done on 40 subjects randomly selected from 123 sample.

Subjects

The subjects' criteria were determined through initial interviews and examinations. In this context, the subjects were informed about the study and they confirmed their consent to participate. We interviewed subjects about their personal data such as age, ethnicity and occupation. The examinations included physical examination (good posture, normal BMI), ECG, spirometry (FEV1/FVC>75%, FVC>80% predicted), and normal haemoglobin levels. Drop-out criteria were applied when the subject did not reach maximal pulse rate of 120 beats per minute during the walking test on the track, and if the subject had difficulty in balancing, or was diagnosed with musculoskeletal, cardiovascular and respiratory disorders.

Protocol and Measurement

During the night before the walking test, the subjects were advised to get proper rest. The test was done within two hours after breakfast and other physical exercises were avoided before the test was accomplished. All subjects had good vision or corrected eyesight. They were advised

to stay calm during the test and were allowed to conduct the walking test barefooted or in shoes. In the latter case, we made sure that the subjects' footwear was comfortable.

Six-Minute Walking Test (6MWT)

All subjects performed 6MWT twice. First, the test was conducted on a 15-m track according to the investigator's protocol. The second test was carried out on Biodex®gait trainer with the speed obtained from the first test.

Data Analysis

For data analysis, we used SPSS version 13. Univariate analysis was performed to evaluate frequency distribution of descriptive statistics and mean difference test based on the gender of each variable. Bivariate analysis was used to find the correlation between independent and dependent variables and for evaluation of statistical significance ($p < 0.05$). Multivariate analysis was performed to recognize the magnitude of independent variables that may have an effect on formulating the regression model of the reference equation of the total distance.

RESULTS

Subject Characteristics

Subject characteristics are presented in **Table 1**, i.e. 52.8% were female and 47.2% male. In the initial interviews, all subjects had been informed about the test, had confirmed their consent and to be native Indonesian, since the reference equation to be developed had to be consistent with Indonesian anthropometrics. Variables in **Table 1** show that there is a significant difference between female and male subjects. Male subjects have heavier weight, taller height, longer leg length, longer step length and greater total distance compared to females ($p < 0.05$).

Table 2 shows the results with Biodex®gait trainer. No significant difference was found between the distance on the 15-m track and Biodex®gait trainer ($p > 0.05$).

Prediction of Total Distance

Male and female subjects exhibited significant differences regarding the length of left and right steps, which were correlated with the total distance (**Table 3**; $p < 0.05$).

Table 1. Subject characteristics based on age, height, body weight, leg length, step length, total distance

Variables	n	Mean (SD)
Age (years)		
- Male	58	26.78 (7.03)
- Female	63	21.92 (5.50)
Height (cm)		
- Male	58	165.47 (6.23)
- Female	63	155.22 (4.44)
Weight (kg)		
- Male	58	58.58 (7.33)
- Female	63	52.18 (5.35)
Leg Length (cm)		
- Male	58	87.06 (4.45)
- Female	63	83.58 (3.49)
Step Length Right		
- Male	58	0.78 (0.05)
- Female	63	0.69 (0.04)
Step Length Left		
- Male	58	0.74 (0.05)
- Female	63	0.66 (0.04)
Total distance (m)		
- Male	58	581.89 (49.41)
- Female	63	516.72 (37.40)

Table 2. Distance on 15 meter track compared to distance on Biodex® Gait Trainer (n=123)

Variables	Mean (SD)	P value*
Distance (m)		
- Track	547.45 (54.24)	0.693
- Biodex®gait rainer	544.72 (54.11)	

*independent sample t-test

Table 3. Correlation between total distance, step cycle, right and left steps length and leg length (n=123)

Variables	Pearson correlation	P value
Distance	0.276	0.002
Step Length right	0.376	0.0005
Step Length left	0.409	0.0005

Moreover, in order to predict each subject's total distance, the variables correlated with the total distance had to be determined first. Using Pearson correlation, three variables obviously have significant correlation with the total distance (**Table 4**). First, we recognized

Table 4. Correlation between age, height, body weight and total distance (n=123)

Variables	Pearson correlation	P value
Age (years)	0.243	0.007
Height (cm)	0.434	0.0005
Body weight (kg)	0.323	0.0005

significantly different total distances between male and female subjects. The significant correlation of age, height and body weight with total distance ($p < 0.05$) was used in a regression model to develop the reference equation for the prediction of the total distance.

Total distance (m) =

$$586.254 + 0.622 \text{ BW (kg)} - 0.265 \text{ BH (cm)} - 63.343 \text{ gender}^* + 0.117 \text{ age}$$

$R = 0.606$; $R^2 = 0.367$ and $\text{Adjusted } R^2 = 0.345$

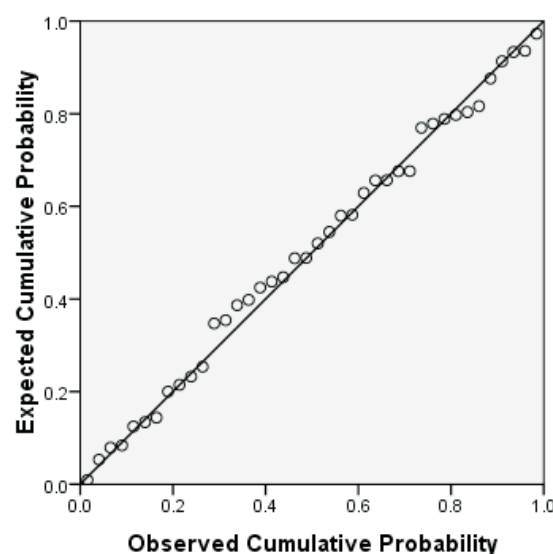
* 0 = male; 1 = female

Table 5 shows the comparison between predicted total distance using Nury and Enright equations and the actual value in six-minute walk distance (6MWD) (n=123).

Table 5. Comparison between predicted total distance using Nury and Enright equations and the actual value in 6MWD (n=123)

Total distance (m)	Mean (SD)	P value
6MWD Track	547.45 (54.24)	0.986
Nury Equation	547.52 (32.84)	
6MWD Track	547.45 (54.24)	0.0005
Enright Equation	728.39 (50.47)	

On the results of normality residual testing it appears that $p = 0.864$ (> 0.005) so it is concluded that the residual formulae are fulfilled normal distribution assumptions. In the **Figure 1** also seen that residual points are scattered around and approaching straight line pattern, which confirms that the data distribution is normal. It is indicated that the error value of distance predictions by using new formulae with linear regression modeling approaches zero or the distance predictions value are almost like the gold standard of distance prediction.

**Figure 1.** Normal P-P plot of regression standardized

DISCUSSION

The present study has included gender differences from the beginning since there are different anthropometric measures between male and female subjects. Chumanov et al.³² found that there is a greater non-sagittal movement in females compared to males, which shortens women's step length. Therefore, in the review on requirements of regression formula, the assessment included only the correlation of height, body weight and age with total distance.

This study used a 15-m track, instead of the 30-m track recommended by ATS. Studies on 6MWT have used various lengths i.e. 15 m⁷ and 20 m,² while the 30-m track is an outdoor track.⁶ The method used was according to ATS reference,⁵ modified in the protocol by a special three-step manoeuvre at both ends of the track. This manoeuvre help to maintain balance and keep the speed steady during the rotation resulting in similar total distances, which were not significantly different from the gold standard, i.e. the total distance obtained with Biodex® gait trainer.

After developing the reference equation for prediction of the total distance, the data of 123 subjects were applied to the equation. There was no significant difference between the mean results of the newly developed equation and the actual total distance. Significant difference was

found compared to the Enright equation ($p < 0.05$, **Table 5**). The Caucasian-based equation resulted in an overestimation.

Iwama et al.³³ developed a reference equation for the prediction of the total distance in Brazilian healthy subjects. In total, 134 sedentary subjects were included, 73 of them females with an age range of 13-84 years. The authors reported that the 6MWD was significantly greater in males than in females. They compared the measured 6MWD with values predicted by five reference equations, which had been developed for other populations. Four equations significantly overestimated and one significantly underestimated measured values.³³

Alameri et al.³⁴ reported normal total 6MWD from a Saudi Arabian population. They developed a regression formula and compared it with the common Caucasian-based formula. According to Alameri, the total distance in Saudi Arabian population is shorter than in Caucasian population. If the Caucasian-based reference equation for prediction of the total distance is used in Saudi Arabian population, it will result in an overestimation.³⁴

For the Asian region, such an equation was developed in Chinese healthy subjects. Poh et al.³⁵ developed the reference equation for the prediction of total distance in Singaporean population since they found that the Caucasian-based equation is not suitable for Singaporean population. The ages of their 32 Chinese subjects (16 male, 16 female) were between 45 and 85 years. The subjects had three fast walking tests and the longest possible distance was recorded. In their study, Poh et al.³⁵ did not differentiate between female and male subjects. Although they found significant differences in height, body weight and leg length between male and female subjects, there was no significant difference of the total distance between male and female subjects. When they compared their own data with the Caucasian-based equation for prediction, they found a difference of more than 75 meters.³⁵

Our subjects walked as fast as possible until they reached the sub-maximal zone, which was similar with the study conducted by Poh et al.³⁵

To this end, we developed our formula to predict maximal VO₂.³⁶ Previously, the Caucasian-based predicted maximal VO₂ formula by Cahalin et al.³⁷ had been used. The formula to predict maximal VO₂ in healthy subjects is necessary for similar reasons as for the reference equation for the prediction of the total distance. Such reference equations were developed by Enright,³⁰ Iwama,³³ Alameri,³⁴ Poh,³⁵ and ATS guidelines⁵ for healthy subjects, which may serve as references for patients with chronic diseases.

Functional capacity is important in the medical field of physical rehabilitation³⁸ as an assessment to determine appropriate intervention for rehabilitation and to evaluate the outcome.^{39,40} A walking distance of less than 82% of the predicted value is considered abnormal. The interpretation of changes in results is referred to as Minimal Clinically Important Difference (MCID). This value is available for the 6MWD. An MCID is a change of 54 m in the 6MWD.⁴⁶

The 6MWT has been performed in children,⁴¹ adults,^{42,43} and elderly³⁰ and has been used to evaluate functional capacity in individuals with chronic obstructive pulmonary disease (COPD),^{44,45} restrictive pulmonary disease,⁴⁶ cardiac disorders,⁴⁷⁻⁴⁹ and stroke.⁵⁰ In addition to its application in healthy subjects, the equation for the prediction may also act as a reference for individuals with chronic diseases. Currently, both the reference equations for prediction of the total distance and the formula of predicted maximal VO₂ are used for people with chronic disorders.

CONCLUSION

The Caucasian-based reference equation for the prediction of the total distance in the 6MWT is not appropriate to be applied for all populations. Our newly developed equation is based on Indonesian anthropometrics. Further research should investigate whether this equation can be generally applied to Mongoloid ethnics, other than Indonesian.

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