Malaysian Family Physician
Official Journal of the Academy of Family Physicians of Malaysia
and Family Medicine Specialist Association of Malaysia

ORIGINAL ARTICLE

Six-minute walking distance reference value for healthy Indonesian children: A cross-sectional study from the largest country in South East Asia

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Wardhani RK, Kekalih A, Wahyuni LK, et al. Six-minute walking distance reference value for healthy Indonesian children: A cross-sectional study from the largest country in South East Asia. *Malays Fam Physician.* 2023;18:1. https://doi.org/10.51866/oa.179

Keywords:
Pediatric, 6 Minute walk test, Healthy, Reference value, Predictive equation

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Abstract

Introduction: There is no global reference value for the 6-minute walking distance (6MWD) in paediatric populations, as it can vary greatly depending on local characteristics and anthropometric measures. This study aimed to identify a 6MWD reference value that could be applied in both local and regional settings.

Methods: This cross-sectional multicentre study investigated a healthy paediatric population aged 4–18 years in Indonesia. The 6-minute walk test (6MWT) was conducted in accordance with the American Thoracic Society guidelines. Data were presented as the 6MWD according to age and sex per year. Univariate and multivariate analyses were conducted on the basis of the 6MWDpred Rizky formula.

Results: A total of 634 participants were included in this study. Age, sex, weight, leg length and height affected the 6MWD (P<0.001). In the regression model, sex and height were the predictors of 6MWD, with height as the best single predictor.

Conclusion: The reference charts and 6MWDpred Rizky formula are applicable in multi-ethnic paediatric Indonesian populations but in limited settings.

Introduction

The 6-minute walk test (6MWT) is a functional test performed with patients' submaximal effort to assess the functional ability of their physical activity tolerance.[1] This test is popular in both clinical and research settings because it yields reliable results and is easy and inexpensive to conduct. The 6MWT was originally used for adult patients with cardiopulmonary problems.[1] With recent developments, it has also been used to evaluate the functional ability of patients with other chronic medical conditions, including neuromuscular dystrophy, intellectual disability, leukaemia, pulmonary hypertension, cystic fibrosis and cerebral palsy.[2–5]

Although the 6MWT is initially intended primarily for adult patients, this test is also becoming widely used in paediatric populations. In these populations, this test yields valid and reliable results for determining the functional capacity of children in terms of physical activity tolerance.[1,5,6]

The interpretation of 6MWT results depends on the distance reached by patients – the 6-minute walking distance (6MWD) – in comparison with the normal reference value. The normal reference value can vary depending on several variables such as height, weight, age, sex and race.[6–8] According to the American Thoracic Society (ATS), there is currently no global reference value of the 6MWD.[9] Therefore, each country or region is recommended to compile its own reference value according to age groups and local characteristics.[7,9]

Indonesia is the largest country in South East Asia based on the archipelago and the fourth most populous country worldwide, with varying cultural and racial features. Considering the benefits of the 6MWT in paediatric patients and limited data on the reference value for paediatric populations in Indonesia, this study was therefore conducted. We aimed to identify a reference value for the distance travelled among paediatric Indonesians. For the reference value to represent various characteristics of Indonesians, data were taken from areas categorised as urban and rural in accordance with national regulations.[10]

Methods

This descriptive quantitative cross-sectional

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study was conducted in a paediatric Indonesian population aged 4–18 years. This population was divided into five groups: preschool age (4–6 years), elementary school age (6–12 years), middle school age (12–15 years) and high school age (15–18 years).

Data were taken from school-aged children from four main islands in Indonesia (Java, Sumatera, Kalimantan and Sulawesi). Children from Papua Island were excluded from the study owing to accessibility issues. The sample was selected via multi-stage sampling with the following steps: Districts in the islands were selected in accordance with national regulations and categorised as urban and rural areas. From the selected districts, cluster random sampling was conducted to select several schools. Thereafter, random sampling was performed to select children from each school to participate in this research. The participants were aged 4–18 years, able to follow instructions and physically healthy. Children with medical problems that may affect their physical ability to participate in the 6MWT or those professionally trained as athletes were excluded.

Based on the mean comparison formula, the calculated minimum required number of participants in this study was 100 for each age group.[11] Considering a dropout rate of 10%, we included a minimum of 120 participants in each age group. The total minimum number of participants required was 600 for the five age groups; 50% of the participants included were from urban areas and 50% from rural areas. To ensure that the data were representative of the Indonesian population, we calculated the proportion of participants from the four main islands by considering the population density in each region.

The 6MWT was conducted in accordance with the ATS guidelines.9 The participants were asked to walk in a flat and straight corridor approximately 30 m in length. Before the test, the participants rested for 10 minutes by sitting at the starting line. The examiners then began to measure the participants' vital signs and observe for any contraindications. The participants began the 6MWT by walking rapidly, during which time the distance walked was measured. After the 6MWT, the vital signs were re-examined. The level of exertion post-6MWT was evaluated using the Modified Borg (mBorg) Scale. The mBorg Scale measures the perceived exertion, including muscle fatigue and dyspnoea based on subjective sensation during physical activity.[12] Children with difficulties assessing their mBorg Scale score were assisted by the examiners.

Data were presented as the mean distance travelled in the 6MWT according to age. Correlations were estimated using Pearson's correlation coefficients. A multivariate analysis was conducted, and the coefficients were used in a formula to predict the 6MWD.

Results

We collected data from 634 school-aged children from across Indonesia. The anthropometric characteristics of each age group are shown in **Table 1**. The boys had an overall higher mean values for height, weight and leg length than the girls; all mean anthropometric characteristics increased with age.

Table 1. Anthropometric characteristics of the participants.

Age group (year)	Sex (N)	Height (mean±SD)	Weight (mean±SD)	Leg length (mean±SD)
4–6	58 F	108.95±6.31	17.83±4.48	55.22±4.54
	63 M	109.81±7.95	18.84±5.13	54.85±4.72
	121 T	109.36±7.13	18.31±4.81	55.04±4.61
7–9	64 F	123.60±8.31	25.09±5.07	65.28±5.51
	60 M	123.88±7.61	26.52±7.19	64.53±4.77
	124 T	123.74±7.93	25.79±6.27	64.89±5.13
10–12	68 F	137.62±8.69	34.62±9.74	73.64±6.10
	69 M	138.50±9.95	38.85±13.44	74.01±5.85
	137 T	138.06±9.31	36.72±11.87	73.82±5.96
13–15	68 F	152.92±6.66	47.81±10.39	83.56±2.41
	63 M	159.97±7.98	52.46±14.86	86.84±5.12
	131 T	156.58±8.15	50.22±13.06	85.26±5.04
16–18	56 F	155.67±6.65	51.00±9.57	83.72±6.01
	61 M	165.73±6.87	56.52±10.48	86.82±5.07
	117 T	160.49±8.41	53.64±10.35	85.20±5.77

F: female; M: male; T: total; SD: Standard Deviation

We collected data representative of each Indonesia's main island with the following distribution: 56 from Kalimantan, 367 from Java, 66 from Sulawesi and 141 from Sumatera. In each main island, both rural and urban areas were represented evenly. The 6MWD according to the participant characteristics is shown in **Table 2**.

Table 2. Six-minute walking distance according to the demographic profile.

		n	% (n=634)	Mean (m)	Min (m)	p5	Median (m)	p95	Max (m)
District characteristic	Rural	324	51.4%	498	255	354	496	682	784
	Urban	306	48.6%	506	262	360	492	723	790
Region	Kalimantan	56	8.9%	395	262	303	386	525	583
	Java	367	58.3%	506	319	372	510	633	744
	Sulawesi	66	10.5%	690	560	603	681	782	790
	Sumatera	141	22.4%	444	255	360	442	535	585
Age group	4–6 years	121	19.2%	422	255	319	404	603	675
	7–9 years	124	19.7%	494	303	346	498	660	787
	10–12 years	137	21.7%	513	304	363	480	724	780
	13–15 years	131	20.8%	542	321	380	540	735	790
	16–18 years	117	18.6%	533	374	401	540	670	782
Sex	Male	314	49.8%	521	255	357	513	726	790
	Female	316	50.2%	482	262	354	474	666	787

There was no significant difference in the 6MWD (P=0.6, t test) between the urban (498±103.9 m) and rural residents (506±107.0 m). The children from Sulawesi showed the longest 6MWD (P<0.001, t test). The boys had a significantly longer mean distance than the girls (P<0.001, t test). The mean distance appeared to increase with age, with the longest mean distance found in the 13–15-year age group, but thereafter appeared to decrease in the 16–18-year age group.

We formulated a reference value chart for both female and male 6MWD using mean±2 SD in each age group (**Figures 1** and **2**). The 6MWD progressed quite rapidly according to age until the rate of increase slowed down after the age of 12 years (boys) and 11 years (girls). The mean distance peaked at the age of 15 years (boys) and 14 years (girls) and decreased thereafter. Age was significantly correlated with the 6MWD (**Table 3**).

Table 3. Correlation analysis between the anthropometric characteristics and the 6MWD.

Variable	Univariate	Multivariate			
	P value	Unstandardised coefficient	Standard error	95% CI	P value
Age	0.001				
Weight	0.001				
Height	0.001	1.89	0.18	1.53–2.26	0.001
Sex	0.001	31.40	7.69	16.29–46.51	0.001

Figure 1. Reference value chart for the 6 Minutes Walking Distance in metres according to age in years for boys.

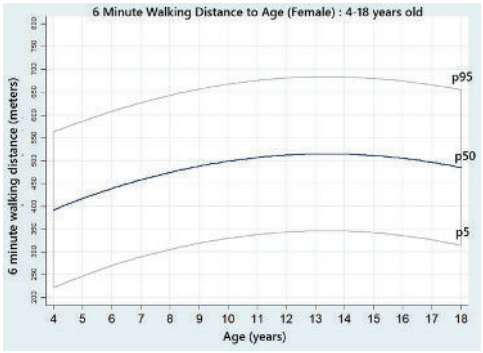

Figure 2. Reference value chart for the 6 Minutes Walking Distance in metres according to age in years for girls.

Anthropometric measurements that may affect the 6MWD such as the leg length, height and weight in addition to age and sex were evaluated. All factors were significant in the univariate analysis. The data are shown in Table 3.

We then used stepwise multiple regression to analyse the best predictive equation for the 6MWD. Height and sex were found as the predictors of the 6MWD in the paediatric population. Height was a better single predictor than sex.

$6MWD_{pred}$ Rizky formula (boys)=224.96+1.89 (height)+31.4
$6MWD_{pred}$ Rizky formula (girls)=224.96+1.89 (height)

Discussion

To the best of our knowledge, this study is the first to report data on a reference value of the 6MWD for Indonesian children. It has a sample size large enough to propose a reliable reference chart for each sex and equation for 6MWD prediction for the Indonesian paediatric population.

The study was conducted in multiple centres across four main islands in Indonesia and is therefore the first to include participants representing a large multi-ethnic country. The 6MWD reference value could also be representative of Mongoloid ethnicity in South East Asia owing to similarities in demographic characteristics. Another similar research in Thailand was conducted but only among 9–12-year-old children. The study showed a longer 6MWD with a mean value of 657 m in girls and 693 m in boys within an age group similar to that in our study.[13]

The reference value of the 6MWD may differ in each region, as it is affected by many factors such as anthropometric characteristics, speed of habitual walking and other lifestyle-related aspects.[14,15] However, our data showed that there was no significant difference in the 6MWD between the children living in rural and urban areas. This may seem counterintuitive, as most believe that rural living has a higher physical demand. However, the nature of rural living evolves over time. Children living in rural areas generally have a smaller mean height and are more prone to obesity. This may be associated with a low educational level and poor socioeconomical status linked with rural areas.[16–18]

We also found significant differences in the 6MWD according to sex. The boys had a longer mean distance than the girls, similar to previous findings. This may be attributed to the greater muscle mass, higher physical activity level and greater height more commonly found in boys.[15,19,20] Our study also showed that the leg length had the best correlation with the 6MWD, as it is a primary determinant of the stride length that results in a longer distance walked.[21]

Puberty may affect the physical activity level and total energy expenditure.[22] In our study, the graph showed that the 6MWD mainly increased with age until it flattened after the age of 12 years (boys) and 11 years (girls); this is the common age of puberty in children. Similar results regarding flattening of the 6MWD curve after puberty were obtained in the Switzerland study by Ulrich et al.[23] There may be differences in the puberty effect according to sex in terms of physical activity and activity-related energy expenditure. Young girls have been thought to have less access to structured activity and less social desire for physical activity.[24] However, our study did not examine the correlation between puberty and the 6MWD.

Herein, the mean 6MWD peaked at the age of 14 years (girls) and 15 years (boys). Generally, growth spurts occur in the mean 3 years after the start of puberty. This agrees with our findings that the mean height increased proportionally with age until it peaked at the age of 15 years and tended to stagnate thereafter. The peak 6MWD among the children aged 14 or 15 years may also be affected by the growth spurt state. The decreasing mean 6MWD among the children aged 16–18 years could be caused by the slowing growth rate and gradually declining physical activity rate in older children.[25]

In Indonesia, there is no reference equation for predicting the 6MWD in healthy paediatric populations. Hence, the Rizky formula was established to complement the widely used 6MWD predictive formula for adult Indonesian populations – the Nury formula.[8] The Rizky formula uses height and sex as the predictive variables. Although the true leg length has the strongest correlation with the 6MWD, we used height in our predictive equation, as it is easier and does not require a specific competency to be accurately measured even in limited settings.

Other studies aiming to predict the 6MWD in children mostly used height in combination with other variables. Geiger et al. found that height combined with age explained 49% and 50% of the variabilities in the 6MWD in male and female individuals, respectively.[6] Saad et al. and Lammers et al. reported that height, weight and age were predictive of the 6MWD.[26,27] Li et al. found that height and the heart rate difference before and after the 6MWT affected the 6MWD.[19]

Limitations

The normative reference value chart may have a wide confidence interval because of the varying numbers of children according to age per year, despite the similar total number of participants per age group. We did not also measure motivation in this study. The 6MWT is a self-paced test whose results could be highly influenced by factors such as examiner's encouragement and participant's motivation.[28]

Conclusion

This is the first nationwide multicentre study conducted in accordance with the ATS guidelines to provide representative reference values of the 6MWD in a healthy paediatric Indonesian population. The reference charts and 6MWDpred Rizky formula are applicable in multi-ethnic paediatric Indonesian populations but in limited settings. The findings could be used as a reference in other South East Asian countries with a predominant Mongoloid ethnic population.

Acknowledgements

We would like to thank the following medical doctors from the Faculty of Medicine Universitas Indonesia and PMR doctors from the participating healthcare centres across Indonesia for their contributions in obtaining data for this study: Dr Melda Warliani, Dr Ananda Marina, Dr Okta Hariza, Dr Leni Kopen, Dr Lia Miranda and Dr Agus Suwandi Gandra.

Author contributions

The authors of this study contributed as follows: conception and design RKW, AK, LKW, BL, AL; analysis and interpretation of data RKW, AK, AL, SMB ; 2) drafting the article or revising it critically for important intellectual content; RKW, LKW, BL, SMB, YGY, MSB and 3) final approval of the version to be published by all authors.

Ethical approval

The study protocol was approved by the Institutional Review Board (IRB) of the Faculty of Medicine Universitas Indonesia (IRB no. 19-07-0890). Informed consent was confirmed by the IRB.

Conflicts of interest

The authors declare no conflicts of interest.

Funding

The study was not funded by any institution or organization.

Data sharing statement

Data are available upon request

How does this paper make a difference in general practice?

- The 6-minute walk test is an efficient, easy-to-use and cost-effective method for measuring physical activity tolerance.
- This study is one of the first studies conducted in a paediatric Mongoloid population in South East Asia to measure reference values of the 6-minute walking distance.
- The normal reference value of the 6-minute walking distance in the paediatric population differs according to age, height and sex.

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