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Six-Minute Walk Distance in a Healthy Middle-Aged Iranian Population

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Abstract

Background: The predictive equation of the six-minute walk test designed for one population cannot reliably be used for another population. Despite introducing multiple prediction equations, there is no local such equation for our country, Iran, presently.
Methods: In this cross-sectional study, we included 116 (65 males) healthy Iranian adult subjects to measure six-minute walk distance (6MWD), define influential factors, and formulate a native predictive equation. All the studied cases aged between 20 to 50 years old. We performed 6MWT according to the guideline of American Thoracic Society.
Results: The mean value of 6MWD was 629.98 ± 81.38 meters, (ranged 421 to 729). On average, men walked 114.29 meters more than women that was statistically significant. Moreover, 6MWD had a direct correlation with subjects' height ($r = 0.627$, $P < 0.001$); however, it had an inverse correlation with their age ($r = -0.303$, $P < 0.001$) and weight ($r = -0.218$, $P = 0.019$). Multiple regression equation derived this formula: 6MWD = 485.25 - (99.42 × sex male = 0, female = 1) + (2.791 × height cm) - (1.614 × weight) - (1.273 × age year), which explained 61% of variability. We observed that most other countries' predictive equations could not be reliably applied to our population.
Conclusions: In this study, we measured 6MWD in a healthy middle-aged Iranian population and proposed a native predictive equation, which might trigger further research and application of this simple and inexpensive test in our country.

Keywords: Iran, Middle-Aged, Walk Test

1. Background

The 6-minute walk test (6MWT) is a simple and inexpensive method that measures submaximal functional capacity non-invasively. It can be used before and after a medical intervention, even in patients with moderate to severe underlying heart or lung diseases. Not infrequently, it can be used as a single tool to estimate functional capacity or predict patients' morbidity or mortality. In such circumstances, comparison with predictive equation is needed.

The members of American Thoracic Society Committee on 6MWT encouraged researchers from all over the world to publish local reference equations for healthy people using a standard protocol (1). In this regard, currently, different prediction equations for different age groups have been proposed by investigators from several countries. However, these equations are best applicable to people of the country reported from it and cannot accurately predict distance walked when being used in other regions (2, 3).

The local nature of 6MWT may explain some differences between distances walked; nevertheless, there are some population-related or clinical variables that may influence test results. Among these are patients' anthropometric characteristics, their socioeconomic status, level of education, number of deliveries (for women), cognitive function, level of physical activity, length of steps, etc. (4-8).

2. Objectives

Currently, some prediction equations have been developed for countries located in the Middle East (9, 10). However, due to different ethnicity and population characteristics of people living in our country, Iran, great need is felt to design a country-specific reference equation. In this respect, we designed this study to formulate a prediction equation for 6MWT in a population of middle-aged healthy Iranian individuals. To the best of our knowledge and according to our literature review, this

was the first study that presented a prediction equation for 6MWD in healthy middle-aged Iranian subjects.

3. Methods

Considering the number and age group of study participants in previous works, this was a cross-sectional study carried out on a sample of 116 (65 men and 51 women) healthy Iranian subjects aged between 20 to 50 years old. The study protocol was approved by the Ethics Committee of Shiraz University of Medical Sciences, Shiraz city, Fars province, Iran (No: 91-01-01-5183). The duration of the study was eight months, from December 2013 to July 2014.

Included subjects were selected using convenient sampling method between volunteers recruited from students, healthcare workers, and relatives of patients admitted to Faghihi Hospital (a referral teaching hospital affiliated with Shiraz University of Medical Sciences). We attempted to include healthy cases belonging to all age groups between 20 to 50 years old equally.

Subjects were not entered the study if they had a previous history of any cardiovascular and pulmonary diseases, history of cough, dyspnea, or chest pain, history of cigarette smoking for more than five-pack/years, musculoskeletal diseases, blood pressure of more than 180/120 mmHg, a pulse rate > 100 beats per minute, the current administration of beta-blockers, or if they suffered from any acute illness, such as influenza. Written informed consent was obtained from all participants.

The 6MWT was performed in accordance with the guideline of American Thoracic Society (1). All tests were performed in a corridor with a 30-meter distance marked by two cones. Before test, patients' demographic data (sex, age, weight, height, level of education, and physical activity) was recorded. Subjects were divided into two groups based on their level of education:

(1) Diploma or below diploma

(2) Academic education

Level of Physical activity was simply asked from participants and recorded as:

(1) Routine daily physical activity

(2) A maximum of 30 minutes/day of walking

(3) More than 30 minutes/day of walking

In addition, data, including respiratory rate, heart rate, blood pressure, oxygen saturation, and modified Borg scale for dyspnea and fatigue, were recorded pre- and post-test. Each subject received the same instruction before and during test. For confirmation of results, two 6MWTs were performed 15 minutes apart. The results of the second test were also recorded.

3.1. Statistical Analysis

Data were analyzed using the SPSS Statistical Software Package (SPSS version 18.0; Chicago; IL; USA). Data are presented as mean ± standard deviation (SD) for normally distributed variables. Variables comparisons were performed using *t*-test or ANOVA. Moreover, 6MWD results were correlated with patients' age, sex, weight, height, level of education, and degree of physical activity using Pearson's correlation coefficient. A stepwise linear regression model was used to determine if any of the above-mentioned variables were independent predictor's of 6MWD.

4. Results

Overall, 116 subjects completed the study. Among them, 67 cases (57.8%) had academic education. Also, 72 (62.1%), 24 (20.7%), and 20 (17.2%) subjects had usual daily physical activity, a maximum of 30 minutes of daily walking, and more than 30 minutes of daily walking, respectively. The mean heart rates of the subjects were about 69% of maximum heart rate predicted for age. Other characteristics and 6MWT data are summarized in Table 1.

Table 1. Anthropometric and Physiological Characteristics of the Study Population

Variables	Mean ± SD
Age (y)	33.9 ± 8.51
Height (cm)	168 ± 9.46
Weight (kg)	68.7 ± 13.92
Body mass index (kg/m^2)	24.26 ± 3.97
Pre-test heart rate (per minute)	79.34 ± 9.96
Post-test heart rate (per minute)	128.2 ± 16.97
Post-test heart rate/Maximum heart rate	0.69 ± 0.1
Pre-test systolic/Diastolic blood pressure (mmHg)	105.99 ± 15.88/65.6 ± 11.07
Post-test systolic/Diastolic blood pressure (mmHg)	117.27 ± 17.71/65.99 ± 14.05
Pretest dyspnea (Borg score)	00.00
Posttest dyspnea (Borg score)	0.16 ± 0.48

The mean value of 6MWD was 629.98 meters (± 81.38), (ranging between 421 to 729 meters). On average, men walked 114.29 meters more than women that was statistically significant (men: 680.23 ± 55.93 meters, women: 565.94 ± 61.32 meters). For all of the cases, 6MWD had a direct correlation with their height ($r = 0.627$, $P < 0.001$) and); however, it showed an inverse correlation with their age ($r = -0.303$, $P < 0.001$) and weight ($r = -0.218$, $P = 0.019$).

The 6MWD increased progressively from subjects with routine physical activity to those with a maximum of 30 minutes of daily physical activity. However, these had no statistically significant difference (P = 0.059). Nevertheless, when we combined data of cases with routine daily physical activity with those subjects that had a maximum of 30 minutes of daily walking (mean 6MWD = 622.23 ± 94.35 meters) and compared this new group with those subjects that had more than 30 minutes of daily physical activity (6MWD = 667.20 ± 76.71 meters), the difference was significant (P = 0.024). The mean value of 6MWD for subjects with academic education was 648.45 ± 67.75 meters, that showed a statistically significant difference compared to those with diploma or below diploma (604.73 ± 91.81 meters) (P = 0.004).

4.1. Predictive Equation

As mentioned, there was a significant correlation between 6MWD and subjects' gender, age, height, weight, academic education, and to some extent, daily physical activity. Multiple, stepwise linear regression revealed that academic education and daily physical activity did not significantly affect 6MWD. Normal value for 6MWD could be predicted using this formula:

6MWD = 485.25 - (99.42 × sex male = 0, female = 1) + (2.791 × height cm) - (1.614 × weight) - (1.273 × age year)

This equation accounted for 61% of the total variance for the 6MWD.

4.2. Comparison with Some Published Regression Equations

We compared the mean value of 6MWD among our studied population with most previously published researches when applicable (Table 2). Walk distance was underestimated by all of the previously published equations up to 285 meters, except for Ben Saad et al.'s and Troosters et al.'s formula, which had no statically significant difference from our study (4, 5, 11).

5. Discussion

Several previous researches studied 6MWD among healthy populations in different regions of the world. In our study, similar to most previous studies, gender, age, height, and weight had independent determinants of 6MWD.

The present work showed that men had a significant longer 6MWD than women. Most previous studies showed similar findings (8, 12, 17). However, different 6MWD between two genders were reported previously. Ben Saad et al. reported the maximum difference was 160 meters (4). However, few studies reported that gender was not an independent predictive factor for 6MWD (5, 14, 19). It has been suggested that the significant influence of gender on 6MWD is attributable to the different anthropometric features of men and women and factors like greater absolute muscle mass and muscle strength in male subjects compared to the women (12).

It has been previously suggested that age is among important factors, which negatively affects the final 6MWD in healthy people, independent of their sex (2, 10, 12). Our results confirmed this fact among middle-aged Iranian subjects. However, Camarri et al.'s investigation, which examined 70 Caucasian subjects aged between 55 to 75 years old suggested that the factor of age has no significant influence on 6MWD (6). This finding may be explained by the fact that their work -like our study- included only a small sample size with a narrow age range.

According to Casanova et al., the impact of age on final 6MWD is more prominent in subjects aged more than 60 years old (2). Factors, including a gradual decrease in maximal oxygen uptake and reduction of human muscle mass and muscle strength that occur with advancing age can explain a reduced 6MWD in older people (12). It seems that the influence of age on distance walked in 6MWT is varied among cases with different age decades. Similar to our results, there are previous studies that showed the positive effect of height on an increase in 6MWD (8, 14, 15). One explanation for this correlation can be the longer average stride length in taller study subjects.

Our research showed the negative impact of weight on 6MWD. However, the results of previous studies on the effect of weight on 6MWD are inconsistent. Some studies, similar to our work, showed an inverse correlation of weight with 6MWD (2, 4, 5, 11, 16). Few previous researches showed a positive effect of weight (6, 13). In some other studies, weight had not included in the final equation (8, 9, 12, 17). One explanation for this disparity is that weight may have a variable impact on 6MWD at different ages or body habitus.

In the present study, although the levels of physical activity and education showed positive effects in univariate analysis, multivariate analysis revealed that these variables had no independent effects. These findings may be due to the nature of 6MWD test, which mainly measures submaximal functional capacity and minimum cardiorespiratory and musculoskeletal fitness of healthy subjects. On the other hand, it seems that in healthy people, the main demographic characteristics, including gender, height, and age (and to some extent weight), consistently have independent effects on their walk distance. Surprisingly, the coefficient of these variables is not the same or near each other in different predictive equations.

Table 2. Comparison of the Mean 6-Minute Walk Distance Between Our Studied Population and Previous Reports

Study	Mean 6MWD [a]	Difference to Our Study [a]	95% Confidence Interval	P-Value
Rao et al. (10)	469.88 ± 101.24	-160.1 ± 10.525	-180.79 to -139.41	P < 0.0001
Alameri et al. (9)	409 ± 51	-220.98 ± 6.678	-234.10 to -207.85	P < 0.0001
Ben Saad et al. (4)	640 ± 95	-5.98 ± 11.628	-28.85 to 16.89	P = 0.6074
Casanova et al. (2)	571 ± 90	-58.98 ± 9.207	-77.06 to -40.89	P < 0.0001
Enright et al. (5)	344 ± 88	-285.98 ± 8.347	-302.34 to -269.61	P < 0.0001
Iwama et al. (12)	577 ± 80	-52.98 ± 10.227	-73.12 to -32.83	P < 0.0001
Nusdwinuringtyas et al. (13)	547.45 ± 54.24	-82.98 ± 8.899	-100.51 to -65.44	P < 0.0001
Poh et al. (14)	560 ± 105	-69.98 ± 16.843	-103.26 to -36.69	P = 0.0001
Palaniappan Ramanathan and Chandrasekaran (15)	495.09 ± 83.85	-134.89 ± 10.658	-155.88 to -113.89	P < 0.0001
Britto et al. (16)	586 ± 106	-43.98 ± 10.375	-64.34 to -23.61	P < 0.0001
Vaish et al. (17)	536. 1 ± 46.9	-93.88 ± 9.196	-112.00 to -75.75	P < 0.0001
Ngai et al. (18)	563 ± 62	-66.98 ± 12.58	-91.81 to -42.14	P < 0.0001
Troosters et al. (11)	631 ± 93	1.02 ± 14.293	-27.2 to 29.24	P = 0.9432

[a] Values are expressed as mean ± SD.

As previously explained, one unique equation cannot be used to predict the walk distance in different populations. Currently, several equations for the prediction of 6MWD have been introduced. Only two previous equations were predictive for our study population (4, 11). There may be some explanations of how different investigations have provided different equations: Among these are factors like heterogeneity of studied populations, different levels of motivation, and test layouts. Different prediction equations can explain a wide range of total variability of 6MWD (20). Our equation can explain 61% of total variance, which is in a high range compared to most previous studies.

This work had some limitations. We did not examine some factors that may affect the final result of 6MWD. For example, as the study of Camarri et al. showed, forced expiratory volume in the first second (FEV1) can significantly and independently predict the final 6MWD (6). Another factor that can negatively influence the final 6MWD is the number of previous pregnancies for women (4). Also, the level of physical activity of participants was self-reported. Additionally, further larger studies with a wider age range of participants are required to include and assess these variables accurately.

5.1. Conclusions

In spite of the simplicity and low cost of 6MWT, it was infrequently applied in our country. In this study, we measured 6MWD in a sample of a healthy middle-aged population and tried to propose a native predictive equation. This study may make a base for future researches and help apply this simple test to our healthy and diseased populations.

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Footnotes

Authors' Contribution: Mohammad Javad Fallahi, Behnam Ein-Mozaffari and Behnam Dalfardi contributed to the study concept and design. Mohammad Javad Fallahi and Behnam Ein-Mozaffari collected the data. Behnam Ein-Mozaffari and Behnam Dalfardi analyzed the data and drafted the paper. Mohammad Javad Fallahi supervised the work. All authors approved the final version of the manuscript.

Conflict of Interests: The authors declare that they have no conflicts of interest.

Data Reproducibility: The data presented in this study are openly available in one of the repositories or will be available on request from the corresponding author by this journal representative during submission or after publication. Otherwise, all consequences of possible withdrawal or future retraction will be with the corresponding author.

Ethical Approval: The study protocol was approved by the Ethics Committee of Shiraz University of Medical Sciences, Shiraz city, Fars province, Iran (No: 91-01-01-5183). IR.SUMS.REC.1392.5183

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