Available online at **www.ijmrhs.com**

ISSN No: 2319-5886

International Journal of Medical Research & Health Sciences, 2022, 11(2): 22-28

Does the Walkway Length Matter in Six-Minute Walk Test: An Experimental Crossover Study

Ali Albarrati[1*] and Rakan Nazer[2]

[1]Rehabilitation Sciences Department, College of Applied Medical Sciences, King Saud University, Kingdom of Saudi Arabia

[2]Cardiac Sciences Department, College of Medicine, King Saud University, Kingdom of Saudi Arabia

**Corresponding e-mail: albarrati@ksu.edu.sa*

Received: 03-Feb-2022, Manuscript No. ijmrhs-22-53251 (M); **Editor assigned:** 04-Feb-2022, PreQC No. ijmrhs-22-53251 (P); **Reviewed:** 17-Feb-2022, QC No. ijmrhs-22-53251 (Q); **Revised:** 20-Feb-2022, Manuscript No. ijmrhs-22-53251 (R); **Published:** 28-Feb-2022, **J-invoice:** J-53251

ABSTRACT

Background: *The six-minute walk test is an integrated measure of cardiopulmonary and musculoskeletal systems and exercise capacity. Healthcare providers usually performed the test on a 10-meter track instead of a 30-meter track due to space constraints. This study examined the influence of track length of 10 meters and 30 meters tracks on the 6MWT and cardiopulmonary indices in healthy adults and validates a reference equation for 6MWT on Arab populations.* ***Methods:*** *An experimental randomized crossover study was conducted on healthy participants in this study. Participants with resting blood pressure reading >140/90 mmHg and body mass index >35 kg/m² were excluded. Participants performed the test on 10 meters and 30 meters tracks and repeated the test one week later in reverse order. The rate of perceived exertion and heart rate were recorded pre-and post-test. Participants underwent resting blood pressure and spirometry measurements before the test.* ***Results:*** *Participants covered a greater distance and lower number of turns on a 30 meters track than the 10 meters track ($p<0.001$). Heart rate and rate of perceived exertion increased significantly post the test. The current reference equation for 6MWT underestimated the distance covered on a 30 meters track ($p<0.001$).* ***Conclusion:*** *The track length had a substantial influence on the walking distance. The number of turns significantly affected the distance walked. The existing reference equation for an Arab population underestimates the walking distance on a 30 meters track.*

Keywords: 6 MWT, Cardiorespiratory indices, Reference equation, Track length, Walking distance

INTRODUCTION

The 6-Minute Walk Test (6-MWT) is a global submaximal exercise capacity test that is widely used in clinical practice to assess an individual's cardiopulmonary system and exercise capacity by measuring the distance walked on a flat, hard surface for 6 minutes [1,2]. The 6-MWT is a quick, simple, and inexpensive exercise-based measurement that reflects the individual's exercise capacity to undertake daily living activities [3]. The 6MWT is strongly associated with physiological measures obtained from cardiopulmonary exercise testing including maximum oxygen consumption, maximum heart rate, and other cardiopulmonary indices in various patient populations [4,5]. Healthcare providers use the 6MWT more frequently in practice as a diagnostic tool of exercise capacity and to monitor the effectiveness of interventions in patients with different diseases [1].

The American Thoracic Society (ATS) set practical guidelines and standardized the length of the track to 30 meters, the track length has not been standardized between studies. Accordingly, the 6MWT varies widely, even among healthy and patient populations with variation in the course length [2,6-11]. There is no agreement in regards to

the length of track, shape, and practice sessions before the original trial [8,12]. Literature shows that the length of track and turning bias can significantly affect temporal-spatial gait variables which in turn can affect the distance walked during the test [12-14]. Due to space constraints in some clinical settings, healthcare providers may therefore perform the test on a 10-meter track rather than following the recommended track length by the ATS guidelines [15]. Consequently, the distance walked on a 10-meter track may not reflect the actual exercise capacity and could lead to an interpretation error and inappropriate clinical decision making [1,15-17]. Few studies have compared the walking distance between a 10-meter track and a 30-meter track on elderly and diseased populations with different ethnicities and showed that a 10-meter track underestimated the walking distance compared to a 30-meter track [15-17]. Other studies have generated various reference equations to predict normative values of the 6MWT [9,18-21]. Nevertheless, there has been no study conducted on healthy Arab adult populations examining the effect of different tracks on the 6MWT and comparing them with a previously published reference equation. Therefore, this study aimed to investigate the effect of various tracks on the 6MWT performance of healthy adults and compare them with a previously validated 6MWT equation on healthy Arab individuals.

METHODS

Design

An experimental randomized crossover study was conducted to measure the 6MWT on different tracks lengths.

Participants recruited in this study were volunteers, free from musculoskeletal injuries, and had no acute illness or chronic disease influencing their exercise capacity. Participants were excluded if they were current and ex-smokers, had resting blood pressures higher than 140/90 mmHg, and Body Mass Indexes (BMIs) greater than 35 kg/m^2. The study was approved by the ethical research committee and all participants provided written informed consent.

Demographic Characteristics

All participants had their heights and weights recorded while wearing lightweight clothing and barefoot using a stadiometer, the BMI (kg/m^2) was then calculated (Seca; Vogel and Halke, Hamburg, Germany).

Physiological Measurement

Before the enrollment, all participants underwent resting blood pressure measurement using Omron device (Omron HEM-907XL) and lung function measurement using a portable spirometer (MicroLoop, CareFusion 232 Ltd, UK) to measure the Forced Expiratory Volume in 1 second (FEV1), the Forced Vital Capacity (FVC) and FEV1/FVC ratio according to the ATS guidelines [22]. Eligible participants underwent blood pressure, heart rate, and oxygen saturation measurement before and immediately after the 6MWT (Omron HEM-907XL).

The rate of perceived exertion was measured at rest and immediately after the 6MWT using the original Borg scale ranging from 6 (no exertion at all) to 20 (maximal exertion).

Six-Min Walk Test

Participants were asked to wear comfortable clothes and shoes. All participants performed a single 6MWT at each visit according to a standard protocol and received the same set of instructions before the walk and were encouraged by the investigator who repeated a set of phrases every one minute during the walk. At the first visit, participants were randomized to walk on a 10-meter track or a 30-meter track for six minutes. A week later, the participants repeated the test at the same time of the day but in reverse order.

All tests were performed between 10:00 am and 4:00 pm in a quiet indoor hallway with a flat straight floor with marks at ten-meter intervals. Two traffic cones marked the turning points in the hallway. Participants were asked to walk at their own pace while attempting to cover as much ground as possible within the allotted six minutes [1].

Data Analysis

The sample size for this study was calculated based on a previous study by Ng, et al. on healthy elderly subjects, who found a mean difference of 59 m between 6MWT on a 30-meter track and a 10-meter track and effect size of 0.4 with alpha level=0.05 and power (beta level=0.80), the number needed was 45 subjects [17]. Data were checked for

normality before analysis using the Kolmogorov-Smirnov test. Pearson correlation coefficients, Intraclass Correlation Coefficients (ICC consistency), and Bland-Altman analysis were produced for the 6MWTs over the 10 meters and 30-meter track. The difference between 6MWT on the 10 meters and 30-meter tracks was analyzed using a paired t-test. Deviations of measured walked distance compared to predicted distances (%pred), based on a validated equation in the Arab population, (2.81 × height in cm)+(0.79 × age in years)-28.5, was used to examine the influence of track length on the use of a previously validated 6MWT equation [18].

RESULTS

Forty-five male participants were recruited in this study. The physical and clinical characteristics of the participants are demonstrated (Table 1). The 6MWTs on both tracks were normally distributed.

Table 1 Physical and clinical characteristics of the participants

Variable	Mean	SD/Median (IQR)
Age (years)	52	(45-67)
Height (cm)	173.33	6.52
Weight (kg)	78.86	17.97
BMI (kg/m^2)	22.7	4.86
FEV_1/FVC	1.15	0.18
FEV_1 (%)	98	14
FVC (%)	85	9
Resting heart rate (bpm)	80	10
Resting O_2 saturation (%)	97	1
Resting Borg scale	6	1
6MWT (30 m)	572	82
6MWT (10 m)	499	95
Predicted 6MWT based on the equation (m)	479	19
Number of turns (30 m)	19	3
Number of turns (10 m)	50	10
Mean turn difference between tracks (m)	31	7
Mean distance difference between tracks (m)	73	50

BMI=Body Mass Index; FEV1=Forced Expiratory Volume in one second; FVC=Forced Vital Capacity; 6MWT=Six-Minute Walking Test

Effect of Course Length

All participants had a shorter walking distance on the 10-meter track compared to the 30-meter track. The distance on the 10-meter track was lower by 73 m (SD 49; 95%CI: 57-87; one-tailed t= -9.8, $p<0.001$) compared to the 30-meter track. There was no correlation between lung function or BMI and walking the distance on both tracks, $p>0.05$. However, there was a high correlation between the 6MWT on the 30 meters and 10-meter tracks ($r=0.85$, $p<0.001$).

The mean walking difference between the two tracks was 73 m, and the limits of agreement were between 23 m and 169 m. Participants performed lower on the 10-meter track compared to the 30-meter track, independent of test performance.

Effect of Tracks on Cardiorespiratory Measures

Participants had a significant increase in heart rate on both tracks, $p<0.001$ (Table 2), but there was no difference in heart rate between the two tracks. Similar to the heart rate, subjects showed an increase in the Borg scale on both tracks, $p=0.023$, but no difference between the tracks.

Table 2 Baseline cardiorespiratory variables and mean change after the 6MWT on the 30 meters and 10-meter tracks

Variable	Resting Mean (SD)	Changes during 6MWT		
		Mean (SD)		
		30 m Track	10 m Track	p-value
Resting heart rate (bpm)	80 (10)	29 (15)	28 (13)	0.001
Resting Borg scale	6 (1)	2 (1.5)	2 (1.4)	0.023
Oxygen saturation (%)	97 (1)	1 (1.2)	0.7 (1)	0.065

Participants showed no change in oxygen saturation between the two tracks, $p>0.05$ (Table 2).

Impact of Course Length on a Reference Equation

The walking distance on both tracks was compared with the existing reference equation previously published on Arab participants. The predicted 6MWT using the reference equation compared to the measured distance on the 30-meter track showed an underestimation of 17%. There was no correlation between the predicted values and the walked distance on a 30-meter track, $p>0.05$, and the reference equation did not predict the walking distance on a 30-meter track, Adjusted $R^2=0.004$, $F=1.006$, $p=0.525$. However, the predicted 6MWT was similar to the 6MWT covered on a 10-meter track (Table 1).

Linear regression showed that the 6MWD on a 10-meter track only explained 73% of the walking distance on a 30-meter track (Adjusted $R^2=0.73$, $F=118.60$, $p<0.001$). The regression equation to estimate standard 6MWT from the 6MWT on a 10-meter track is as follows $Y=71+1.0 \times$ (6MWT on 10 meters).

Impact of Number of Turns

The participants showed to have a lower number of turns on a 30-meter track compared to a 10-meter track, $p<0.001$ (Table 1). Interestingly, an increased number of turns was negatively associated with the mean difference between the two tracks ($r= -0.51$, $p<0.001$).

DISCUSSION

This is the first study to examine the influence of course length of a 6MWT on healthy adults of an Arab population according to the authors' knowledge. The results showed that the 6MWT is substantially affected by the course length. A 10-meter course length significantly underestimated the performance of the participants when compared to a 30-meter course length. The 6MWT on a 10-meter track cannot reflect the actual performance of an individual's exercise capacity and should not replace the recommended course length by the ATS guidelines [1]. Using the existing reference equation for Arab populations to predict the walking distance was found to substantially underestimate the performance of the participants by 17%.

The shorter walking distance on a 10-meter track could be due to the number of turns which subsequently affected the walking speed [6,15,17]. An individual usually needs a longer distance to accelerate and maintain a higher speed [13]. In clinical studies, individuals were found to pace their walking speed based on the length of tracks and tended to speed up if the course length is greater than 20 m and slow below 10 meters long [16]. Macfarlane and Looney showed that individuals need at least 2 m to pace their speed from rest and nearly a similar distance for deceleration to endpoint [13]. Furthermore, in addition to acceleration and deceleration times, the number of turns and time needed to turn, consequently alters the gait speed and ultimately affects the walking distance. In this study, participants on a 10-meter track turned 3-fold the number of turns on a 30-meter track. This indicates that the length of the tracks determines the 6MWT. Shorter distance requires time-consuming turns and efforts and this is manifested by a shorter

distance achieved on a 10-meter track. The results of this study are consistent with previous studies in patients and healthy elderly populations. Beekman, et al. found a mean difference of 50 m between the two tracks in patients with COPD [15]. Likewise, Ng, et al. reported that a healthy elderly population walked 59 m less on a 10-meter track when compared to a 30-meter track [17].

Increased heart rate and rate of perceived exertion indicate that the cardiorespiratory system has been triggered to meet the demand of the musculoskeletal system and oxygen supplement. Exercise increases the heart rate by stimulating the sympathetic nervous system that produces catecholamines including epinephrine and norepinephrine [6,8]. As the heart rate increases, breathing rate subsequently increases to meet the ventilation requirement during exercise, and this is expected to increase the rate of perceived exertion. However, there is no change in oxygen saturation post-exercise testing which reflects no respiratory impairment. This was expected as we screened participants for lung disease using spirometry and excluded any participants with a history of smoking before recruitment.

Using the reference equation that has been previously published in an Arab population seems to be unsuitable to predict the walking distance on a 30-meter track. The current equation markedly underestimates the walking distance when it was compared to the recorded walking distance for the subjects using the recommended course length by the ATS guidelines. This is not surprising as the participants in this study walked 143 m above the average walking distance reported by Alameri, et al. on their population [18]. However, the equation estimates approximately the walking distance achieved on a 10-meter track. Therefore, clinicians and researchers should be cautious when using the existing Arab reference equation as it could be misleading clinical judgments and therefore lead to inappropriate interventions.

The mean difference of 73 m between the two tracks is of clinical importance and has practical relevance when assessing and treating patients with different disease conditions in rehabilitation settings. Therefore, a 6MWT obtained on a 10-meter track cannot be compared to a 30-meter track and subsequently affects clinical decision-making on this basis. A 6MWT on a 10-meter track needs further research to determine its thresholds and its minimum clinically important difference on different populations. In this study, participants performed no practice trial before the test. Previous studies have examined the practice effect over repeated trials of the 6MWT and showed inconclusive evidence about how many trials should be recommended in clinical practice. In healthy adult populations, a practical trial before the test is not required as the magnitude of the practice effect on the 6MWT ranged from 3.9% to 7.2% of the 6MWT measured between the first and second trial [8,23]. Nonetheless, the 6MWT is a reproducible and reliable measure.

Limitations

This study was conducted on a group of male participants, and these findings cannot be extrapolated to females. Nevertheless, it showed a substantial difference in the walking distance between the tracks. Due to the nature of the study design, causality could not be determined. There was no practical trial before the test, but this was minimized by cross-over randomization.

CONCLUSION

A 6MWT on a 10-meter track substantially underestimates the walking distance on a 30-meter track. The current Arab reference equation is not suitable to estimate the walking distance on a 30-meter track in healthy adults.

DECLARATIONS

Acknowledgement

The author is thankful to the Deanship of Scientific Research, College of Applied Medical Sciences Research Center at King Saud University for funding this research.

Conflict of Interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics Approval and Consent to Participate

The study was approved by the King Saud University ethics committee (CAMS 072-3839), and participants signed a consent form.

Authors Contributions

Ali Albarrati and Rakan Nazer designed the study. Ali Albarrati analyzed and interpreted the data. Ali Albarrati and Rakan Nazer drafted the manuscript. Ali Albarrati and Rakan Nazer read and approved the final manuscript.

Funding

There was no funding obtained for this study.

Availability of Data and Materials

The datasets used and/or analysed during the current study are available.

REFERENCES

[1] American Thoracic Society. "ATS statement: Guidelines for the six-minute walk test." *American Journal of Respiratory and Critical Care Medicine,* Vol. 166, 2002, pp. 111-17.

[2] Saad, Helmi Ben, et al. "6-minute walk distance in healthy North Africans older than 40 years: Influence of parity." *Respiratory Medicine,* Vol. 103, No. 1, 2009, pp. 74-84.

[3] Steffens, Daniel, et al. "Activity level predicts 6-minute walk distance in healthy older females: An observational study." *Physiotherapy,* Vol. 99, No. 1, 2013, pp. 21-26.

[4] Carter, Rick, et al. "Predicting oxygen uptake for men and women with moderate to severe chronic obstructive pulmonary disease." *Archives of Physical Medicine and Rehabilitation,* Vol. 84, No. 8, 2003, pp. 1158-64.

[5] Zugck, C., et al. "Is the 6-minute walk test a reliable substitute for peak oxygen uptake in patients with dilated cardiomyopathy?" *European Heart Journal,* Vol. 21, No. 7, 2000, pp. 540-49.

[6] Enright, Paul L., and Duane L. Sherrill. "Reference equations for the six-minute walk in healthy adults." *American Journal of Respiratory and Critical Care Medicine,* Vol. 158, No. 5, 1998, pp. 1384-87.

[7] Geiger, Ralf, et al. "Six-minute walk test in children and adolescents." *The Journal of Pediatrics,* Vol. 150, No. 4, 2007, pp. 395-99.

[8] Gibbons, William J., et al. "Reference values for a multiple repetition 6-minute walk test in healthy adults older than 20 years." *Journal of Cardiopulmonary Rehabilitation and Prevention,* Vol. 21, No. 2, 2001, pp. 87-93.

[9] Iwama, Angela May, et al. "The six-minute walk test and body weight-walk distance product in healthy Brazilian subjects." *Brazilian Journal of Medical and Biological Research,* Vol. 42, No. 11, 2009, pp. 1080-85.

[10] Poh, Hermione, et al. "Six-minute walk distance in healthy Singaporean adults cannot be predicted using reference equations derived from Caucasian populations." *Respirology,* Vol. 11, No. 2, 2006, pp. 211-16.

[11] Soares, Maria Raquel, and Carlos Alberto de Castro Pereira. "Six-minute walk test: Reference values for healthy adults in Brazil." *Brazilian Journal of Pulmonology,* Vol. 37, No. 5, 2011, pp. 576-83.

[12] Sciurba, Frank, et al. "National emphysema treatment trial research group six-minute walk distance in chronic obstructive pulmonary disease: Reproducibility and effect of walking course layout and length." *American Journal of Respiratory and Critical Care Medicine,* Vol. 167, No. 11, 2003, pp. 1522-27.

[13] Macfarlane, Pamela A., and Marilyn A. Looney. "Walkway length determination for steady state walking in young and older adults." *Research Quarterly for Exercise and Sport,* Vol. 79, No. 2, 2008, pp. 261-67.

[14] Taylor, Matthew J. D., Siobhan C. Strike, and P. Dabnichki. "Turning bias and lateral dominance in a sample of able-bodied and amputee participants." *Laterality,* Vol. 12, No. 1, 2007, pp. 50-63.

[15] Beekman, Emmylou, et al. "The first reference equations for the 6-minute walk distance over a 10 m course." *Thorax,* Vol. 69, No. 9, 2014, pp. 867-68.

[16] Ng, Shamay S., et al. "Walkway length, but not turning direction, determines the six-minute walk test distance in individuals with stroke." *Archives of Physical Medicine and Rehabilitation,* Vol. 92, No. 5, 2011, pp. 806-11.

[17] Ng, Shamay S., et al. "Effect of walkway length and turning direction on the distance covered in the 6-minute walk test among adults over 50 years of age: A cross-sectional study." *Physiotherapy,* Vol. 99, No. 1, 2013, pp. 63-70.

[18] Alameri, Hatem, Sulaiman Al-Majed, and Abdelrahman Al-Howaikan. "Six-min walk test in a healthy adult Arab population." *Respiratory Medicine,* Vol. 103, No. 7, 2009, pp. 1041-46.

[19] Camarri, Bernadine, et al. "Six minute walk distance in healthy subjects aged 55-75 years." *Respiratory Medicine,* Vol. 100, No. 4, 2006, pp. 658-65.

[20] Casanova, Ciro, et al. "The 6-min walk distance in healthy subjects: Reference standards from seven countries." *European Respiratory Journal,* Vol. 37, No. 1, 2011, pp. 150-56.

[21] Chetta, Alfredo, et al. "Reference values for the 6-min walk test in healthy subjects 20-50 years old." *Respiratory Medicine,* Vol. 100, No. 9, 2006, pp. 1573-78.

[22] Culver, Bruce H., et al. "Recommendations for a standardized pulmonary function report. An official American Thoracic Society technical statement." *American Journal of Respiratory and Critical Care Medicine,* Vol. 196, No. 11, 2017, pp. 1463-72.

[23] Najafi, Bijan, et al. "Does walking strategy in older people change as a function of walking distance?" *Gait & Posture,* Vol. 29, No. 2, 2009, pp. 261-66.