A Comparison of the 6-Minute Walk Test to Treadmill Exercise Test as a Tool to Evaluate Functional Capacity in Healthy ManilaMed Employees: The CoST TET Study

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Abstract

INTRODUCTION: Functional capacity is a strong predictor of mortality and nonfatal cardiovascular outcomes in both men and women with and without coronary artery disease. This study aimed to compare the distance traveled of the 6-minute walk test (6MWT) to the metabolic equivalent (MET) of the treadmill exercise test (TET) as a measure of functional capacity among healthy ManilaMed (Medical Center Manila) employees and to determine and compare the distance traveled in 6MWT and the MET of TET according to general characteristics such as age, sex, height, weight, and body mass index (BMI) as determinants of maximal walking distance and the cause of the early termination of the TET.

METHODS: This was a single-center prospective cross-sectional study done at a private tertiary hospital. All participants underwent TET and 6MWT. Metabolic equivalent of TET, distance traveled in 6MWT, and the computed MET of the distance traveled were recorded and analyzed.

RESULTS: Fifty healthy employees performed both the 6MWT and the TET to measure their functional capacity. Twenty-two were males, and 28 were females. The mean age was 31.80 ± 7.17 years, and the mean ± SD for BMI was 25.05 ± 4.32 kg/m^2. Using 400 m as predictor of good functional capacity, the farther the distance traveled (>400 m), the higher the MET they achieved in the TET, and the lower the distance traveled (<400 m), the lower the MET achieved in the TET (*t* test $P = 0.0125$). This study also showed that more than or equal to 400-m distance traveled in the 6MWT can be used as a measure of good functional capacity in this population. However, there was a significant difference (*t* test $P = 0.006$) in the computed MET in the 6MWT in relation to the MET achieved in TET. In this study age, sex, and BMI were the predictors of the distance traveled in the 6MWT ($P = 0.0049$) and in the TET.

CONCLUSION: The distance traveled in meters in the 6MWT can be used as an objective measure of functional capacity in healthy population, and >400-m distance can be used as a parameter of good functional capacity. The formula used to compute MET in the 6MWT is not comparable with the MET achieved in TET. Age, sex, and BMI significantly influenced the performance in the 6MWT and TET.

INTRODUCTION

One of the safest forms of physical activity is walking. The ability to walk for a distance is a quick and inexpensive measure of physical function; it is an important component of quality of life, because it reflects the capacity to undertake day-to-day activities.[1]

Most of the activities of daily living are performed at submaximal levels of exertion. Thus, the evaluation of the distance walked during a period of time is a simple test to evaluate the functional capacity. A 6-minute walk test (6MWT) is a practical simple test that is a submaximal exercise to test for functional capacity. Functional capacity is a strong predictor of mortality and nonfatal cardiovascular outcomes in both men and women with and without coronary artery disease (CAD).[2] Treadmill exercise test (TET) is a standard test for functional capacity, but because it is an expensive test, functional capacity has been done subjectively to those who did not do the TET. In our setting as a third-world country, financial status is always an issue; thus, not everybody can afford TET. The 6MWT is an inexpensive test that was also used to assess the functional capacity.

The aim of this study was to determine the distance traveled computed to metabolic equivalent (MET) of a 6MWT in comparison to TET as a test to measure the functional capacity of an individual.

Review of Related Literature

Functional capacity is a strong predictor of mortality and nonfatal cardiovascular outcomes in both men and women with and without CAD.[2] The aging process tends to reduce physical fitness (ie, strength, endurance, agility, and flexibility) and results in difficulties in daily life activities and normal functioning of the elderly.[3]

A 6MWT is a practical simple test that is a submaximal exercise to test for functional capacity. This test was commonly used to hospitalize patients with cardiopulmonary disease to measure the functional capacity and response to medical and surgical therapy.[4] It is also a commonly used and validated field test of exercise capacity for patients with chronic obstructive pulmonary disease.[5] The distance traveled/covered over 6 minutes is used as an outcome by which to compare changes in performance capacity. In the study by Chetta et al,[6] with healthy subjects, 6-min walk distance traveled ranges from 400 to 700 m.

Troosters et al[7] evaluated 6MWT in healthy elderly individuals and found the determining factors in 51 healthy subjects aged 50 to 85 years who are free of disease. This study concluded that the performance on the 6MWT is variable in healthy persons older than 50 years.[7] The variability can be explained by using height, weight, age, and sex.[8] The study by Chetta et al[6] confirms the relevant effect of anthropometrics on walking capacity.

The main strengths of the 6MWT stem from its simplicity in concept and performance. It has been proven to be reliable, low-cost/inexpensive, ease to standardize, safe, easy to apply, and accepted by test subjects, including those who are deconditioned, elderly, or frail and severely limited patients who cannot be tested with standard (and more expensive) maximal cycle ergometer or TETs.[9] Since then, the 6MWT has been used as a performance-based measure of functional exercise capacity in other populations including healthy older adults, people undergoing knee or hip arthroplasty, those with fibromyalgia, and patients with scleroderma and has also been used with children.[10] The distance covered over a time of 6 minutes is also used as the outcome by which to compare changes in performance capacity.[11]

During the 6MWT, any person will have an increased risk of an adverse event. Adverse event during the test may present with arrhythmia, cardiovascular collapse, or respiratory distress while walking at a usual pace. Some of the baseline characteristics such as body weight, body mass index (BMI), waist circumference, and flexibility were found to be predictors of the 6MWT interruption,[9] and the determinants of maximal walking speed were height, age, and peripheral muscle strength.[6]

The TET using the Bruce protocol is a maximal test that is used to measure functional capacity. This test is also used to detect abnormal heart rhythms (arrhythmias) and diagnose the presence or absence of CAD[10]; because it is an expensive test, not all patients who require this test can afford and can comply with it. Thus, the purpose of this study is to determine if the MET in the 6MWT can be compared with the MET of the TET. Although it has been known that TET is the standard test in measuring exercise capacity, the 6MWT is noninferior as the test for functional capacity.[11]

Implication and Importance

This study compared the distance traveled in meters computed to the MET of the 6MWT as a test of functional capacity to the MET of the TET. The comparison of the test will help the clinician decide on the utility of 6MWT to a healthy individual who has financial problem who cannot afford the standard TET. It can also be used as an alternative to healthy individuals/patients who cannot tolerate or who do not want to perform the TET to test for their functional capacity.

OBJECTIVES

Primary Objective: To compare the distance traveled of the 6MWT to the MET of the TET as a measure of functional capacity among healthy ManilaMed (Medical Center Manila) employees.

Secondary Objective: To determine and compare the distance traveled in 6MWT and the MET of TET according to general characteristics such as age, sex, height, weight, and BMI as determinants of maximal walking distance and the cause of the early termination of the TET.

METHODS

This study was done at ManilaMed Hospital, Manila, Philippines.

Study Population
We studied a sample of 50 healthy ManilaMed employees; 22 were males (44%), and 28 were females (56%). The mean age was 31.80 ± 7.17 years, and mean BMI was 25.05 ± 4.32 kg/m^2. The participants were ManilaMed employees who were randomly selected. All the subjects fulfilled the inclusion criteria; they are free from injury and had no history of hospitalization or chronic disease influencing their exercise capacity.

Study Design
This was a single-center, prospective, cross-sectional study.

Overview of Methods
The subject was identified by a given number from 01, 02, 03, and so on, to maintain anonymity. The screening was done for each employee who was randomly picked. During the screening, a baseline standard supine electrocardiogram (ECG), history, and physical examination were done. Official ECG reading was done by the coauthor. Informed consent was signed by the eligible ManilaMed employees before the procedure. All the participants wear their mask during the test because this study was done during the COVID-19 pandemic. ManilaMed employees underwent TET at the Heart Station on the fifth floor. The participants were given 3 days' rest after the treadmill stress to give time for their body to recover. Between 3 and 7 days after TET, the employee underwent 6MWT at the sixth floor of ManilaMed. Results of the procedures were recorded in the data sheet.

A crash cart was available at the test site in case of emergency. The investigator was certified in cardiopulmonary resuscitation course and advanced cardiac life support accredited by the Philippine Heart Association.

The distance traveled by the employee in meters of the 6MWT was recorded and analyzed and then was computed to MET. The result was compared with the MET achieved in the TET. The results were analyzed using statistical methods. The mean ± SD and *P* value for the baseline characteristics were used. Paired *t* tests for both the 6MWT and TET were also computed. Then, a comparison of the distance traveled computed to MET of the 6MWT and MET of the treadmill exercise was done.

Data Analysis
Data such as age, sex, height, weight, BMI, and distance traveled in meters computed to METS of the 6MWT and the MET of the TET were recorded and checked for distribution.

The mean ± SD and *P* were used to calculate the baseline characteristics such as age, sex, height, weight, and BMI. Differences between males and females were analyzed using the two *t*-tailed tests.

The three-way analysis of variance was used to analyze if the MET of the 6MWT will differ according to age, sex, and BMI. A simple correlation was used in the comparison between the distances traveled in meters computed to MET of 6MWT to BMI.

Study Duration
The study started from November 2020 to January 2021 during COVID time where lockdowns, limited physical activities, and wearing of mask were implemented. The Centers for Disease Control and Prevention states that wearing mask during exercise is safe, but it may be uncomfortable to the subjects and may also contribute to the decrease in their performance.

Sample Size
The statistical computation of the sample size was to include a minimum of 34 employees to achieve a power of 80% and a level of significance of 5%, for detecting an effect size of 0.5 between employees. However, the author and the coauthor decided to include 50 healthy ManilaMed employees. No employee terminated his/her participation during the study period.

Data Management and Analysis
Data are reported as mean ± SD and *P* value. The differences between sexes were analyzed using two *t*-tailed tests. The three-way analysis of variance was used to analyze if the MET of the 6MWT will differ according to age, sex, and BMI. A simple correlation was used in the comparison between the distances traveled in meters computed to METS of 6MWT to BMI. The standard *t* test was used to compare the computed MET of the 6MWT versus the achieved METS in the TET.

Ethical Considerations
The principal investigator and supervising investigators have read, understood, and complied with the Data Privacy Act of 2012. The investigators in this study comprised one cardiology fellow-in-training and two active cardiology consultants of ManilaMed. This study was reviewed by the ManilaMed Ethics Review Committee.

The principal investigator and the coauthor had full access to the data collected. The validity of the consent form was limited only to the subject's participation in this study. Informed consent was obtained from all the participants included in the study. The section of cardiology paid the standard supine ECG and the TET. Snacks were provided after the TET and 6MWT. The data collected from the subjects were reviewed and analyzed by the primary investigator (N.F.N.) and the coauthor (M.B.-C.). The data collection form has a designated control number to maintain the anonymity of the subjects included. Personal identification in the data collection forms was not required from the subjects, and it was substituted by an assigned number. The results collected for each participant were not stigmatized and did not affect his/her TET result or the 6MWT.

ManilaMed employees 18 to 59 years of age with normal baseline supine ECG, free from injury, and who had no history of hospitalization or chronic disease influencing their exercise capacity gave their informed consent. The inclusion and exclusion criteria listed above were applied to each participant.

Data Protection Plan Description

The original copies of the data were kept in the section of cardiology lockers at the Heart Station on the fifth floor of ManilaMed, until 2 years after the study period. The author (N.F.N.) and the coauthor (M.B.-C.) accessed the data. The personal laptop of the author was used alone in the storage and analysis of the data. There was automatic activation of password protection after 5 minutes of inactivity on the personal laptop. Encryption with password protection of all files containing the data was activated, and there was no automated backup copying of the data. All copies of data will be shredded after 2 years. No violations were reported for the Data Safeguarding Plan to the Restricted Data Investigator and the home-institution institutional review board.

RESULTS

Fifty healthy ManilaMed employees underwent treadmill stress test (TET) and 6MWT; 44% (n=22) were males, and 56% (n=28) were females (Table 1). The mean age was 31.80 ± 7.17 years. The majority of the participants (56%) were within the age group 20 to 30 years; 34% were aged 31 to 40 years, 4% were 41 to 50 years old, and 6% were older than 51 years. Most of them have normal BMI (36%), but 28% were preobese, 20% were overweight, and 16% were obese (Figure 1).

The distance traveled in 6MWT shown in this graph is not linearly correlated with the MET they acquired in the TET. However, most of the participants who achieved >400-m distance traveled in the 6MWT achieved >10 MET in TET.

Figure 2 shows that the higher the distance traveled (>400 m), the higher the MET they achieved in TET, and the lower the distance traveled (<400 m), the lower the MET achieved in TET with the $P = 0.0125$ using *t* test.

Table 2 shows that those who achieved >400-m distance traveled in 6MWT have high MET at 11.7 compared with those who achieved <400 m, $P = 0.0125$.

Figure 3 shows that there was no correlation of the computed MET of the 6MWT and the MET of the TET, $P = 0.0006$.

Table 1. Baseline Characteristics

	Frequency (%)	Mean ± SD
Sex Male Female	 22 (56) 28 (44)	
Age	20–30 y (56) 31–40 y (34) 41–50 y (4) >51 y (6)	31.80 ± 7.17
Height		162.68 ± 8.64
Weight		66.71 ± 15.26
BMI Normal Overweight Preobese Obese	 18.5–22.9 kg/m^2 (36) 23–24.9 kg/m^2 (20) 25–29.9 kg/m^2 (28) >30 kg/m^2 (16)	25.05 ± 4.32

BMI=body mass index.

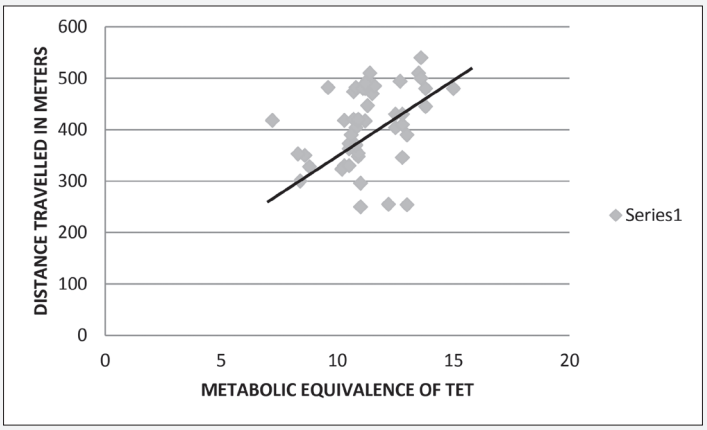

Figure 1. Correlation of distance traveled (in meters) in 6MWT to metabolic equivalent of TET.
Abbreviations: 6MWT=6-minute walk test; TET=treadmill exercise test

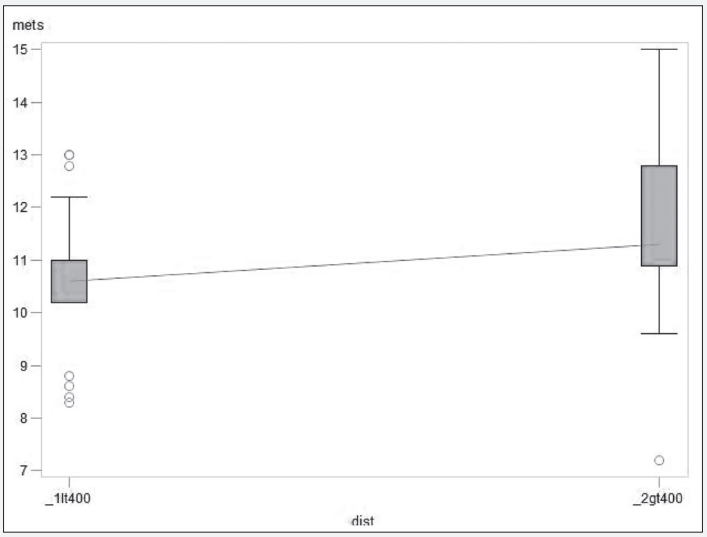

Figure 2. Boxplot of the distance traveled in the 6MWT and the MET achieved in TET.
Abbreviations: 6MWT=6-minute walk test; dist=distance; gt=greater than; lt=less than; MET=metabolic equivalent; TET=treadmill exercise test.

Table 2. Comparison of the Average MET of TET in Comparison With Distance Traveled Using *t* Test

	Distance Traveled <400 m	Distance Traveled >400 m	*P*
Average MET of TET	10.6	11.7	0.0125

MET=metabolic equivalent; TET=treadmill exercise test.

Using the standard *t* test, the METs achieved in the 6MWT and the TET were significantly different, *P* = 0.006.

Table 4, comparing the computed MET of the 6MWT and TET according to sex, shows that males achieved higher MET in both the 6MWT and TET than females, achieving 10.82 ± 1.13 (6MWT) and 11.90 ± 1.51 (TET), *P* = 0.0110, and 9.85 ± 1.78 (6MWT), 10.78 ± 1.45 (TET), *P* = 0.0049, respectively.

Figure 4 shows that younger employees achieved a greater distance traveled of 401 to 500 m and 301 to 400 m for ages 20 to 30 years and 31 to 41 years, respectively. On the other hand, those 41 years or older achieved a shorter distance traveled between 200 and 500 m.

Those with normal BMI achieved the farthest distance traveled of >500 m and 401 to 500 m. However, those who were preobese and overweight achieved 401 to 500 m (Figure 5).

DISCUSSION

The 6MWT is a self-paced, easy-to-perform test that can measure one's functional capacity. It was also used in patients who have cardiopulmonary disease to measure their functional capacity and the patients' response to medical and surgical therapy.[4] Functional capacity is a strong predictor of mortality and nonfatal cardiovascular outcomes in both men and women with and without CAD.[2]

A 6MWT is a practical simple test that is a submaximal exercise to test for functional capacity. This test was commonly used to hospitalize patients with cardiopulmonary disease to measure their functional capacity and response to medical and surgical therapy. It is also a commonly used and validated field test of exercise capacity for patients with chronic obstructive pulmonary disease.[4] The distance traveled/covered over 6 minutes is used as an outcome by which to compare changes in performance capacity. In the study by Chetta et al,[6] with healthy subjects, 6-min walk distance traveled ranges from 400 to 700 m. Using 400 m as a predictor of good functional capacity, as shown in Figure 2, the farther the distance traveled (>400 m), the higher the MET they achieved in the TET, and the lower the distance traveled (<400 m), the lower the MET achieved in the TET (*t* test *P* = 0.0125). This study also showed that more than or equal to 400-m distance traveled in the 6MWT can be used as a measure of good functional capacity in this population. However, there was a significant difference (*t* test *P* = 0.006) in the computed MET in the 6MWT in relation to the MET achieved in TET (Figure 3 and Table 3). Thus, the formula used in computing the

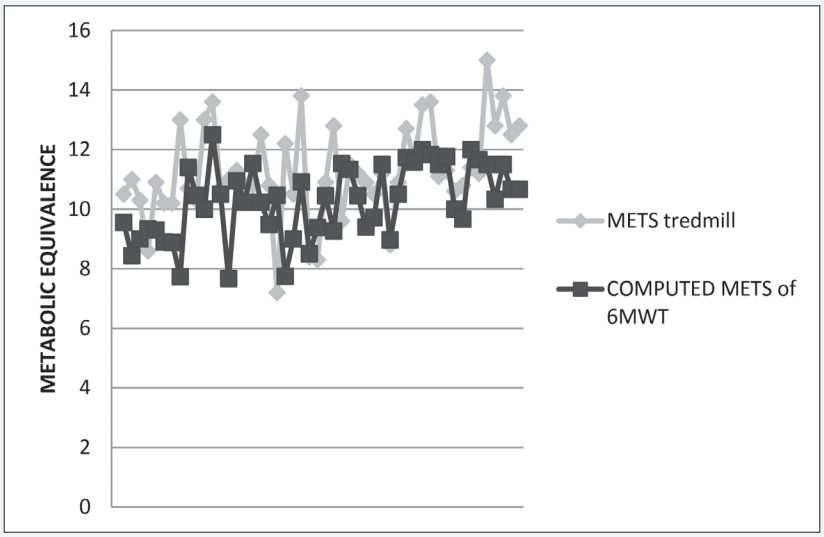

Figure 3. Linear correlation of computed MET of 6MWT and MET of TET. Abbreviations: 6MWT=6-minute walk test; MET=metabolic equivalent; TET=treadmill exercise test.

Table 3. Comparison Between 6MWT and TET by MET Using Standard *t* Test

Computed MET in 6MWT	MET Achieved in TET
10.27 ± 1.24	11.27 ± 1.56
P value from two-sample test	0.0006

6MWT=6-minute walk test; MET=metabolic equivalent; TET=treadmill exercise test.

Table 4. Comparison of the Computed MET of the 6MWT and TET According to Sex (Two-Tailed t Test)

	Female	Male	*P*
MET of 6MWT	9.85 ± 1.78	10.82 ± 1.13	0.0049
MET of TET	10.78 ± 1.45	11.90 ± 1.51	0.0110

6MWT=6-minute walk test; MET=metabolic equivalent; TET=treadmill exercise test.

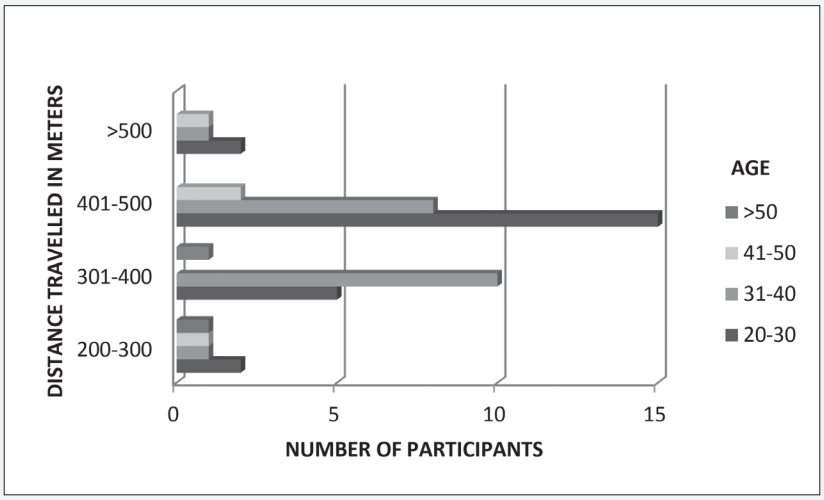

Figure 4. Distance traveled in 6MWT and TET by age. Abbreviations: 6MWT, 6-minute walk test; TET, treadmill exercise test.

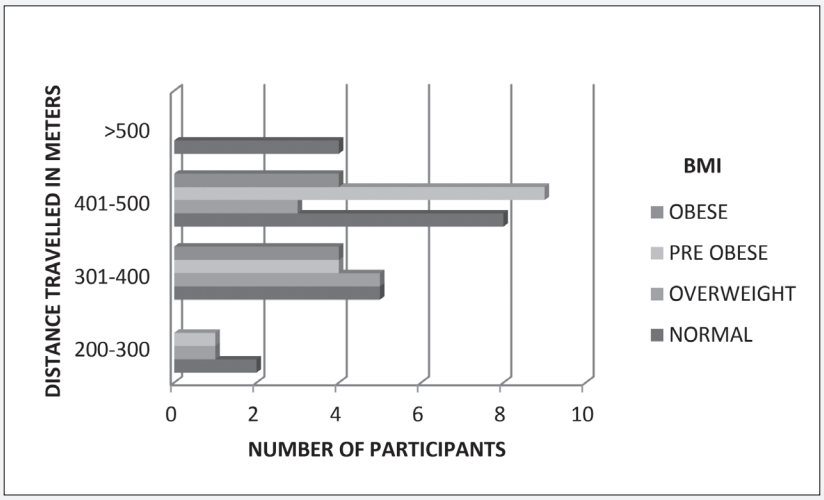

Figure 5. Bar graph with distance traveled in 6MWT by BMI. Abbreviations: 6MWT, 6-minute walk test; BMI, body mass index.

MET in the 6MWT cannot be reliably used as a measure of MET. One of the reasons might be because the formula used in computing MET in 6MWT is dependent on the intensity of the activity. The 6MWT is done on a flat surface with mild intensity (self-paced walking) and limited time (6 minutes), whereas the TET was done in a graduated elevated surface with moderate to vigorous intensity and limited symptoms. This study was also done during COVID time, where lockdowns, limited physical activities, and wearing of mask were implemented. The Centers for Disease Control and Prevention states that wearing mask during exercise is safe, but it may be uncomfortable to the subjects and may also contribute to the decrease in their performance.

In this study, age, sex, and BMI were the predictors of the distance traveled in the 6MWT ($P = 0.0049$) and in the TET. Those who achieved 401 to 500 m in the distance traveled in 6MWT were between 20 and 40 years of age, and only 200 to 400 m in those who were older than 50 years (Figure 4). This was also mentioned in the study by Troosters et al[7] that the performance on the 6MWT is variable in healthy persons older than 50 years. Males achieved the highest distance traveled in meters and MET compared with females in both the 6MWT and TET, with $P = 0.0049$ (Table 4). Employees with normal BMI achieved the highest distance traveled in meters compared with preobese and obese (Figure 5). In the study by Chetta et al,[6] among healthy individuals 20 to 50 years of age, the relevant effect of anthropometric characteristics on walking capacity was considered. There were no adverse events noted, such as arrhythmia, cardiovascular collapse, or respiratory distress, during the 6MWT and TET.

The distance traveled in meters can be used as a parameter for exercise prescription and changes in performance in areas where there is no available equipment for a standard TET and can be used as an objective measure of functional capacity in evaluating individuals for preoperative evaluation with more than 400 m traveled as a measure of good functional capacity.

RECOMMENDATION

For future studies, in conducting 6MWT for healthy individuals, walking should be done in the fastest pace one can tolerate, and 10 MET should be set as computed from the distance traveled as a parameter for a good functional capacity.

CONCLUSION

The distance traveled in meters in the 6MWT can be used as an objective measure of functional capacity in healthy population, and >400-m distance can be used as a parameter of good functional capacity. The formula used to compute MET in the 6MWT is not comparable with the MET achieved in TET. Age, sex, and BMI significantly influenced the performance in the 6MWT and TET.

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