Original Article

Comparison of two walk tests in determining the claudication distance in patients suffering from peripheral arterial occlusive disease

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Abstract

Background: The purpose of this study was to compare the six-minute walk test (6MWT) and the incremental shuttle walk test (ISWT) in terms of the initial onset of pain (IOP), maximal claudicating pain (MCP), maximum walking distance (MWD), initial ankle brachial index (IABI), post ankle brachial index (PABI), and difference in ankle brachial index (DFABI), as well as to correlate changes in IOP and MWD, MCP and MWD, IABI and MWD, PABI and MWD, and DFABI and MWD in the 6MWT and ISWT.

Materials and Methods: Participants ($n = 19$, 17 men and 2 women) were randomly allocated to the 6MWT or ISWT and crossed over to the other test after 24 hours. The baseline ankle brachial index (ABI) measurements were taken using the Doppler, following which the participants performed the tests. Post-test MWD, IOP, MCP, and ABI were measured. The paired t test was used pre- and post the walk test and the Pearson correlation was used to find any relationship between the desired variables.

Results: The paired t test at 95% confidence interval for IABI and PABI ($P > 0.05$) was insignificant for the 6MWT and ISWT. The Pearson correlation of MWD with IOP showed a fair correlation, and the correlation of MWD to MCP showed a strong correlation in ISWT.

Conclusion: ISWT can be of vital importance as a tool to assess the functional status of patients suffering from Peripheral Arterial Occlusive Disease (PAOD) in both the clinical and research areas, and reflects a better assessment of the functional limitation when walking with PAOD as compared to the 6MWT.

Key Words: Initial onset of pain, maximal claudicating pain, maximum walking distance, peripheral arterial occlusive disease, walking tests

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INTRODUCTION

The term 'peripheral arterial occlusive disease' (PAOD) encompasses a large series of disorders affecting the arterial beds exclusive to the coronary arteries, abdominal aorta, and the renal and

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mesenteric arteries.[1] One typical symptom of PAOD is intermittent claudication (IC), which is defined as pain, cramps, numbness or a sense of fatigue in the muscles associated with walking, in one or both lower limbs, affecting either the distal or proximal muscle groups.[2] Symptoms are far more common in the lower extremities (typically in the calf) compared to the upper extremities.[1] IC is caused by a decrease in the blood flow leading to tissue hypoxia and consequently reduction in the functional activities of the patient. The claudicating symptoms usually seem to be a function of the distance and/or speed of walking and can be relieved by rest.

Exercise or walk tests as a part of rehabilitation medicine in PAOD play an important role in improving the blood circulation, walking economy, and claudicating distance, which enables the patients to become more functionally independent in the community.[3]

Apart from the therapeutic benefits, exercise or field tests can also be employed for testing purposes, to elicit change or improvement following therapy. Various noninvasive methods are employed to screen and evaluate PAOD, including the ankle brachial index (ABI), submaximal treadmill test, six-minute walk test (6MWT), and incremental shuttle walk test (ISWT).[4]

The 6MWT is a submaximal endurance test that primarily measures the distance walked, although one disadvantage is that its velocity is determined by the patient.[5] The 6MWT is a practical simple test that requires a 100-ft hallway, but no exercise equipment or advanced training for technicians. Walking is an activity performed daily by all but the most severely impaired patients. This test measures the distance that a patient can quickly walk on a flat, hard surface in a period of six minutes (6MWD). It evaluates the global and integrated responses of all the systems involved during exercise, including the pulmonary and cardiovascular systems, systemic circulation, peripheral circulation, blood, neuromuscular units, and muscle metabolism. It does not provide specific information on the function of each organ or system involved in the exercise.[6]

Conversely, the ISWT has the advantage of external control of the patient speed, allowing for a progressive increase of walking effort.[7]

To date no previous study has assessed the efficacy of two tests in determining the Claudication Distance (ICD) in PAOD patients. Our objective was to compare the two tests in people with PAOD, to observe the difference in the walking parameters of the variables of pain and the distance walked. Hence, we compared the 6MWT and ISWT in terms of the following variables: The initial onset of pain (IOP), maximal claudicating pain (MCP), maximum walking distance (MWD), and initial to post ABI changes (IABI, PABI). We also correlated the changes in ABI with the MWD in 6MWT and ISWT.

MATERIALS AND METHODS

A randomized, crossover design was performed in a tertiary hospital setting in Kasturba Hospital, Karnataka, India. Ethical clearance for the study was given by the Institutional Committee of the School of Allied Health Sciences (SOAHS). Participants with the diagnosis of mild-to-moderate PAOD were considered eligible for the study. Peripheral arterial occlusive disease was diagnosed using a Doppler scan study using ABI[8] and the clinical staging of PAOD was done in accordance with a modified version of the Fontaine classification.[9] Of the 19 participants in the study, two were women and seventeen were men, with a mean age of 47±1.41 and 53±12.3 years, respectively. Six participants were having diabetes, ten were smokers, one participant was both, and two were using chewing tobacco.

A hand-held Doppler (*Parks Medical Ultrasonic Flow Detector Model 811*) was used to measure the ABI; detection of pulsation of the posterior tibial artery was done by the Doppler probe, while the pressure was gradually reduced in the cuffs just above the ankle. The Doppler procedure for the diagnosis of the PAOD patients was performed by a qualified therapist in a standard way to ensure homogeneity in the test procedures [Figures 1 and 2].

Participants were excluded if they had resting claudicating pain; systolic blood pressure >180 mmHg and diastolic blood pressure >100 mmHg.

Figure 1: Depicting the materials used for the assessment of PAOD during study

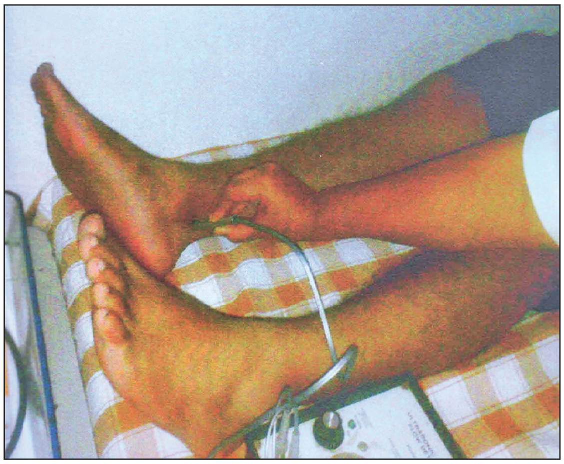

Figure 2: Investigator palpating posterior tibial artery using a Doppler probe

History of revascularization six months prior to the study period, Known cases of respiratory diseases such as, moderate-to-severe chronic obstructive pulmonary disease, asthma or any other exercise-limiting respiratory disease.

Part or complete foot amputation or participants using assistive devices for walking.

Vision impairments, neurological impairments like stroke, parkinsonism or musculoskeletal impairments like chronic osteoarthritis, rheumatoid arthritis, heart disease.

Acute sciatica or vestibular dysfunction, cognitive impairments.

Elderly above the age of 70 years, and ischemic heart disease limiting exercise performance.

Participants were also excluded ($n = 11$) if they did not have any symptoms of intermittent claudication (IC).

Patients with PAOD, who met the criteria after being scrutinized through the exclusions, were included in the study.

A total of 30 participants were eligible, out of whom 19 participants met the inclusion criteria for the study. Informed consent was obtained from all the participants after the study was explained to them.

Participants were provided with instructions for 6MWT[6] according to the American Thoracic Society guidelines. The test was conducted on a 30-meter course, with ground marks at every two meters. Each participant was oriented to walk, as quickly as possible, without running or jogging for six minutes. At each minute a verbal command was given to the participants by the physical therapist to encourage the performance. For the ISWT two cones were set apart on the ground at a distance of 10 m. The initial speed was 0.50 meter/second and was increased by 0.17 meter/second each minute up to the end of the test, which could last up to 12 minutes. The speed during the last stage was 2.37 m/second. After the initial audio signal, the participant was instructed to walk to the other cone before the next beep.[7] The participants were familiarized with both the tests one day prior to the test, after which they were randomized by the lottery method to either the 6MWT or the ISWT. The baseline measures of the ankle brachial index were recorded prior to the performance of the tests. Following a 24-hour period from the first test, the participants were crossed-over to test the performance in the second test. The recorded data for each test included the total distance walked, time of pain onset, time of the limiting claudicating symptoms, and post-test ankle brachial index.

Data analysis

The data are analyzed using the SPSS software package 16 with P-value set as, significant at $P \leq 0.05$. The descriptive statistics were presented as means and standard deviations. The data were analyzed for normality (Kolmogorov-Smirnov). The paired t test was used to identify any significant differences between the two groups in terms of the following variables; difference in ankle brachial index (DF-ABI) and changes from initial ankle brachial index to post ankle brachial index (IABI-PABI). The Pearson correlation test was used to examine the changes between the intermittent claudication distance (ICD) and maximum walking distance (MWD), maximum claudicating pain (MCP) and MWD, MWD and IABI, MWD and DF-ABI, before and after performing each walk test.[10]

RESULTS

The mean and standard deviation of variables of pain, distance, and ankle brachial index for six minute walk test and incremental shuttle walk test are listed in [Table 1]. The onset of pain was observed more quickly in the 6MWT than the ISWT; ten out of nineteen participants in the 6MWT did not achieve maximal claudicating pain. The initial ankle brachial index and post ankle brachial index had a correlation of 0.85 in the 6MWT and 0.9 in the ISWT, showing a strong correlation in both the tests [Table 2]. In the ISWT, ICD and MWD had a correlation of $r = 0.46$ (fair) and $p = 0.05$, MCP and MWD had a correlation of $r = 0.80$ (strong) and $p = 0.00$, PABI and MWD had a correlation of $r = 0.84$ (strong) and $P = 0.05$. However, in the 6MWT, IOP and MWD had a correlation of $r = 0.32$ (poor) and $P = 0.17$, MCP and MWD had a correlation of r = -0.13 (poor) and P = 0.75, and PABI and MWD had a correlation of r = −0.13 (poor) and P = 0.58, respectively [Table 2]. In the ISWT group, three participants had an initial ankle brachial index (IABI) greater than 1, five had 1-0.9, four had 0.9-0.7, four more had 0.7-0.5, and three had less than 0.5; and in the 6MWT group four had greater than 1, four more had 1-0.9, another four had 0.9-0.7, a further four had 0.7-0.5, and three had less than 0.5, respectively, before the performance of either tests.

Paired t tests for both the test groups showed no statistical differences for IABI–PABI at a confidence interval of 95% [Table 3].

DISCUSSION

The present study is the first study that provides an insight regarding the comparison of the two tests in a clinical scenario. In our study, the onset of pain occurred earlier when participants walked in the 6MWT (2.21 ± 1.59 seconds) rather than in the ISWT (3.42 ± 1.64 seconds). The delayed onset of pain in ISWT could be due to an initial low speed of walking and a smaller gradual progression of each stage. Cunho Filho[11] *et al*. also reported a delayed ICD in ISWT. The delayed onset helped participants to walk free of pain for a relatively longer time (3.4 ± 1.64 minutes). This delayed onset of pain, in our study, did not have any influence on the total distance walked, when compared in both the tests (ISWT = 212.37 ± 168.41 m, 6MWT = 269.52 ± 158.56 m).

Walking is an activity performed daily by most individuals, but it is severely impaired in people with PAOD.[2] MWD reflects an individual's functional capacity in PAOD. However, we found no difference in MWD between the tests, ISWT (212.4 ± 168.41 m) and 6MWT (269.5 ± 158.56 m). Nonetheless, MWD remains a major index for the classification of the severity of PAOD according to the Fontaine or Rutherford classifications.[9]

A study in 150 patients with stable intermittent claudication that compared the importance of claudication pain distance (CPD) and the maximum pain distance (MPD) found no correlation between both walking distances and the angiographic extent of PAOD. Only the MPD correlated with the ankle systolic Doppler pressure and the ankle/brachial pressure index of the claudicating leg.[12]

In the present study, 15 participants were able to achieve their maximal claudication pain in ISWT, with a mean time of 4.93 ± 2.33 minutes. Only nine participants achieved the maximal onset of pain during the 6MWT with a mean time of 2.61 ± 1.45 minutes. The ISWT is metronome-driven and has a stage-wise increment in speed, which stresses the participants at every stage, with different speeds.[7] In the 6MWT, the speed of walking is determined by the person.[6] We have also found PABI in ISWT has a strong correlation with MWD, which is supportive of the fact that persons with PAOD give a better walking performance with ISWT. This explains why ISWT is potentially a superior tool for evaluating walking performance in people with PAOD. Moreover, there has been no significant difference observed before and after the two walking tests for the variables IABI and PABI.

Intensity is a factor that plays a vital role in exercise testing and prescription. In the present study, the intensity imposed by the 6MWT on the participants was not adequate to stress them to achieve their maximal symptoms.

Table 1: Mean and standard deviation of variables of pain, distance, and ankle brachial index for six minute walk test and incremental shuttle walk test, in peripheral arterial occlusive disease

Variables	Incremental shuttle walk test	Six minute walk test	Upper–lower limit at 95% CI	P value
ICD	3.42±1.64	2.21±1.59	0.141-2.280	0.029
MCP	4.93±2.33	2.61±1.45	−0.772-2.897	0.213
MWD	212.37±168.41	269.52±158.56	−158.267-43.952	0.250
IABI	0.80±0.26	0.8±0.26	−0.681-0.637	0.945
PABI	0.77±0.36	0.74±0.36	−0.064-0.125	0.508
DFABI	0.03±0.18	0.07±0.21	−0.103-0.011	0.110

#ICD: Intermittent claudication distance (seconds); MCP: Maximal claudicating pain (seconds); MWD: Maximum walking distance (meters); IABI: Initial ankle brachial index (ratio); PABI: Post ankle brachial index (ratio); DFABI: Difference in ankle brachial index pre-post

Table 2: Correlation of Pain, Ankle Brachial Index, and Maximum Walking Distance in incremental shuttle walk tests (ISWT) and six minute walk test (6MWT) in peripheral arterial occlusive disease, using Pearson test of correlation

Variables	ISWT	P value	6MWT	P value
ICD	r=0.460	P=0.048	r=0.324	P=0.176
MCP	r=0.789	P=0.000	r=-0.125	P=0.784
IABI	r=0.199	P=0.414	r=0.205	P=0.400
PABI	r=0.050	P=0.839	r=0.222	P=0.361
DFABI	r=0.221	P=0.363	r=-0.134	P=0.583

#ICD: Intermittent Claudication Distance (seconds); MCP: Maximal claudicating pain (seconds); MWD: Maximum walking distance (meters); IABI: Initial ankle brachial index (ratio); PABI: Post ankle brachial index (ratio); DFABI: Difference in ankle brachial index pre-post

Table 3: Comparisons between variables of pain, distance, and ankle brachial index in the six minute walk test and the incremental shuttle walk test in peripheral arterial occlusive disease using paired t test

Variables	P value for six minute walk test	P value for incremental shuttle walk test
IABI–PABI	0.48	0.67

*Initial Brachial Index (RATIO) - IABI, Post Ankle Brachial Index (RATIO) – PABI

An atherosclerotic stenosis usually drops pressure between the arm and foot, affecting a person's walking ability. This drop in pressure can be measured by detection of pulsation at the elbows and ankle with a Doppler probe, by gradually reducing the pressure in the cuffs just above elbows and the ankle.[8] Usually the normal pedal pressure is 10-20 mmHg higher than the brachial pressure, and normal ABI is around 1.1.[8] The number of participants with initial ankle brachial index greater than 1 were three, 1-0.9 were five, 0.9-0.7 were four, 0.7-0.5 were four, and less than 0.5 were three in the ISWT group and in the 6MWT group greater than 1 were four, 1-0.9 were four, 0.9-0.7 were four, 0.7-0.5 were four, and less than 0.5 were three, respectively, before the performance of either test. An ABI of less than 0.9 normally indicates a hemodynamically significant lesion (may be asymptomatic or with mild symptoms); 0.5-0.8 is associated with claudication (moderate symptoms); 0.25-0.5 with rest pain (severe symptoms); and less than 0.25 with tissue loss, ulceration or gangrene.[8]

A poor correlation was observed between the initial severity of ABI and MWD ($r = 0.2$; $P = 0.41$) in ISWT and ($r = 0.21$; $P = 0.40$) in 6MWT [Figures 1 and 2]. Even differences in ABI (DF-ABI) after ISWT and 6MWT did not have a significant correlation with MWD ($r = 0.22$, $r = -0.13$, respectively). Our findings agreed with those of an earlier study, which stated that walking distance correlated poorly with limb hemodynamics.[13]

A possible reason for this finding can be that hemodynamic measures are poor predictors of the symptom-limited capacity, despite the major role of decreased arterial blood flow in limiting exercise performance. This suggests that alterations in skeletal muscle fibers may play an important role. It is postulated that type I fibers convert to type II fibers, suggesting a greater capacity for nonoxidative rather than oxidative metabolism in the PAOD muscles.[14]

The novelty of the present study lies in the fact that the two tests have not been compared for ICD or MWD, to test their efficacy in a clinical scenario. Moreover, a study analyzing the effect of an 18-month Exercise Rehabilitation Program has found an improvement in the claudicating distances, walking economy, six-minute walk distance, physical activity level, and peripheral circulation, after six months of the exercise rehabilitation program. Hence, the authors of the present study feel that a study with therapeutic effects of both the tests can also be undertaken to analyze the further effects of these tests in PAOD.[15]

The limitations of the study include the fact that ISWT appears to be superior to 6MWT in a clinical setting, to elicit pain among the study participants. The distance covered in 6MWT and ISWT did not differ significantly among the participants in PAOD. Furthermore, the small sample size and the walking parameters may have influenced the walking ability.

CONCLUSION

We conclude from the present study that ISWT can be of vital importance as a tool to assess functional limitation during walking in PAOD, in the clinical aspect, and it also reflects a better functional assessment of walking in patients with PAOD as compared to the 6MWT. Moreover, incremental shuttle walk tests induced maximal claudicating pain in all the participants and showed a better correlation with the variables of pain and distance walked, in PAOD.

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