Comparison of Functional Ramp Walk Test and 6-min Walk Test in Healthy Volunteers: A New Approach in Functional Capacity Evaluation

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Abstract

Objective: Inclined surfaces or ramps are the common obstacles faced by elderly and cardiopulmonary disabled in accessing public amenities. Ramp walking is one of the most common functional demands to be met by a common man in the industrialized world. To assess the functional (uphill walking) capacity, we need a different functional stress test over the routinely used 6-min walk test (6MWT). Hence, a new 3-min steep ramp walk test (3MRWT) was constructed to meet the demands similar to an uphill walk and to provide more functional stress than routinely used 6MWT. Methodology: The observational, crossover study design was adopted for this study. Fifteen healthy participants (8 males, 7 females) performed both tests in a randomized order with a washout time of 6 h in between the tests. Walking distance to both ramp and ground, heart rate, blood pressure, saturation ($S_{O_2}$), dyspnea, and fatigue with Borg exertion scale were compared prior and after the two walk tests. Results: The average distances covered in 6MWT were 510.5 ± 55.06 and 440.65 ± 25.08 meters and in 3MRWT were 270.18 ± 30.8, 230.05 ± 15.06 meters for male and female respectively. The difference between 3MRWT and 6MWT distances covered by the participants was statistically significant ($t = 0.893$). The mean difference between the heart rate, saturation and perceptions were highly significant ($P < 0.001$). Conclusion: The study results show that 3MRWT is valid over routinely administered 6MWT and may provide greater functional stress (uphill or ramp walk capacity) in a shorter duration in healthy individuals in assessing the maximal functional capacity in a ramp or uphill walking.

Keywords: 3-min ramp walk test, 6-min walk test, functional capacity, submaximal exercise test, valve replacement

Introduction

Inclined surface or ramps are the common obstacles faced by elderly and cardiopulmonary disabled in accessing public amenities. Ramp walking is one of the most common functional demands to be met by an ordinary man in the industrialized world. This component is usually neglected or overseen in human performance laboratories in the measurement of functional capacities.

Walk tests have been a fascinating attraction in the measurement of functional capacity in the modern clinical arena; 2-min walk test (2MWT), 6MWT, and 12MWT are the most common. Various exercise tests in clinical use represent increasing complexity – 6MWT, stair climbing, shuttle walk test (SWT), detection of exercise-induced asthma, and cardiac stress test – the latter being more complex than the former. However, it may not check the ability of the individual to walk in slope or uphill. For the functional stress test, still step tests are utilized, but the validity is always questionable. Laboratory-based ramp walk protocols in a treadmill are not readily accessible, costly, needs expertise, and cumbersome for functional capacity testing in primary care centers.

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Uphill or ramp walking demands balance in elderly. It also requires more energy and induces much hemodynamic stress than level-walking. Walk tests are convenient, cost little, and are easy to complete. In cardiac rehabilitation, symptom-limited exercise testing with bicycle or treadmill is used traditionally. However, this might not be suitable for evaluating elderly patients who have problems with balance, neuromuscular coordination, vision, or gait.

To assess the functional capacity, we need a short-term operational stress test over the gold standard 6MWT and to provide an operational stress test with better sensitivity. Hence, we developed a 3-min steep ramp walk test (3MRWT) which is fulfilling the criteria of the practical walk test. Although ramp walking can be trained using the treadmill, it is not feasible for the Indian patients as they are not familiar with the treadmill and their fear may also show variation in the functional assessment. When developing the new functional walk test, it should produce a similar cardiopulmonary response or higher response than with gold standard 6MWT, so we proposed this study to compare 3MRWT with 6MWT in normal healthy individuals.

We hypothesized that none of the available field tests (either walk test or step test) measures real hemodynamic parameters or the functional stress of the persons climbing slopes or ramps. The purpose of this study was to develop a self-paced ramp walk field test to assess the functional capacity in healthy individuals.

**Methodology**

Our study was initiated after getting approval from the institutional human ethics committee. The participants were assigned for two tests with washout time of 6 h between the tests [Figure 1] after getting informed consent in their language (Tamil and English). This study was conducted in the ward belonging to Department of Cardiothoracic and Vascular Surgery, Pulmonary Medicine department of PSG Hospitals, Coimbatore, Tamil Nadu, India.

**Participants**

Healthy volunteers were recruited through advertisement in hospital notice board and local institutional weekly newspaper. Ninety five people volunteered for the study. From them, 22 volunteers were selected by picking from a bowl having names of all volunteers. Participants aged 25-65 years, both male and female were included in the study. Participants with a known history of unstable cardiac disorders such as recent angina, cardiac surgeries <2 months, and uncompensated pulmonary ailments – current asthma, bronchitis exacerbations <3 weeks were excluded from the study. The participants with current orthopedic diseases such as osteoarthritis, neurogenic claudication, new vertebral disc, facet problems <3 weeks, and fractures <2 months were excluded from the study. Furthermore, participants with movement and balance disorders such as stroke, Parkinson’s, recent surgeries on lower limbs and trunk <2 months, visually challenged, balance disturbances such as vertigo were excluded from the study. Height and weight were checked using calibrated measures for all the participants.

**6-min walk test**

This is a self-paced walk test. It was conducted as per the American Thoracic Society (ATS) guidelines (2002). This test involves the participant to walk as far as possible in 6 min around two cones placed at 30 m. The encouragement words were delivered as per ATS guidelines at the end of every 1 min. During every lap, saturation, pulse rate, and exertion level were noted. Baseline and postwalk blood pressure was also noted.

**3-min Ramp walk test**

This test was developed according to the standardization of 6MWT by ATS and American association of Respiratory Care, 2008. The standardization of the ramp parameters was done after auditing 15 hospitals and discussion with hospital-based Civil Engineers and contractors by the authors. The standardization of the ramp across hospitals are as follows: 20-m ramp with an elevation of 30°, 10-feet length for 1-foot steep raise, and 57 feet elevation [Figure 2]. The participant was instructed to walk in the ramp up and down for 3 min. 3MRWT is self-paced walk test such as 6-min level walk test in gauging the uphill walk capacity of the individual. Total time of test was set at 3 min because the investigators anticipated a similar exertion in walking uphill of 3 min rather than walking level ground 6 min. The encouragement similar to 6MWT was given during each minute of the test during ramp walk up and down.
Outcome measures
The data collected during the tests were pulse rate, SpO2, and after the tests distance walked, blood pressure changes. Symptoms of breathlessness and fatigue were evaluated through modified rate of perceived exertion scale.

Data analysis and interpretation
We summarize data as mean ± standard deviation (SD) and tested between group differences using unpaired t-test. We tested within-group change from baseline by paired t-test. P < 0.05 was considered statistically significant. Analysis was done using SPSS 17.0 software (SPSS Statistical Package, 2007, Chicago, IL, USA).

RESULTS
Fifteen participants including 7 females and 8 males completed the study. All participants found it easy to pace themselves and no difficulties were encountered in administering both tests. The characteristics of the participants are described in Table 1. Both males and females performed well in the both walk tests [Figure 3]. Male participants walked better in both trials; it may be due to heterogeneity in anthropometry, physical activity, and motivation. Both genders showed a better performance in the 3MRWT rather than the 6MWT. The distance covered in both tests for male and female, respectively, in 6MWT was 510.5 ± 55.06, 440.65 ± 25.08 meters and in 3MRWT was 270.18 ± 30.8, 230.05 ± 15.06 m.

Table 2 summarizes the changes in cardiorespiratory parameters during the 3MRWT and 6MWT. It shows the mean ± SD values of SpO2, heart rate, systolic and diastolic blood pressure, at the

Table 1: Characteristics of the participants

| Demographics       | Mean±SD       |
|--------------------|---------------|
| Age, years         | 43.67±11.62   |
| Height, cm         | 154.4±7.88    |
| Weight, kg         | 65.27±10.32   |
| BMI, kg/m²         | 25.91±3.83    |
| SpO2 (baseline), % | 98.4±0.65     |
| HR (baseline), beats/min | 77.86±8.15 |
| Mean arterial BP (baseline), mmHg | 102±9.96 |

Table 2: Change in cardiorespiratory parameters during 3-min ramp walk test and 6-min walk test

|                  | 3 MRWT | 6 MWT | Paired t | Significance (P) |
|------------------|--------|-------|----------|------------------|
| HR (beats/min)   | 78±9   | 78±8  | 3.802    | 0.002            |
| Change from baseline | 43±13  | 34±10 |          |                  |
| Mean arterial BP (mmHg) | 97±8   | 102±10| 2.598    | 0.021            |
| Change from baseline | 102±7 | 103±6 |          |                  |
| Saturation (%)   | 98±1   | 98±1  | 1.702    | 0.111            |
| Change from baseline | 97±1  | 97±1  |          |                  |

3MRWT=3-min steep ramp walk test, 6MWT=6-min walk test, BP=Blood pressure, HR=Heart rate
beginning and the end of each exercise test. As compared to the 6MWT, the mean change in heart rate and arterial blood pressure were higher after the 3MRWT. These differences were statistically significant. However, the change in oxygen saturation was not significantly different. Moreover, no difference was observed in the symptoms of shortness of breath and fatigue after the two tests, since all of them were healthy participants.

This study results show that there is a significant difference between 3MRWT and 6MWT in assessing the maximal functional capacity of healthy individuals.

**Discussion**

We presented here preliminary results on normal healthy individuals to find a short-term functional stress test over the gold standard 6MWT and to provide an operational stress test with better sensitivity. Hence, we developed a 3MRWT which is fulfilling the criteria of the practical walk test. Our new functional walk test produced a higher cardiopulmonary response than routinely employed 6MWT.

Like the 6MWT, 3MRWT was also easy to administer, better tolerated, and reflects activities of daily living better than the other walk tests. It could be a useful measure of functional capacity to assess people with at least moderately severe impairment. The test could be used for preoperative and postoperative evaluations and for measuring the response to therapeutic interventions in patients with cardiac and pulmonary diseases.[31]

A recent review by De Feo et al., found that the assessment of the functional physical capacity by 6MWT early after cardiothoracic surgery may be useful to adopt the modalities of the training program to obtain the best result at the most appropriate training intensity.[32] Likewise, our 3MRWT also may be helpful in rehabilitation area to assess functional capacity and to guide operational activities.

In a randomized controlled trial involving patients with chronic obstructive pulmonary disease (COPD), cardiorespiratory performance during 6MWT and SWT were compared. Patients performed two 6MWTs and two SWTs in a randomized order on the same day. In this trial, SWT and 6MWT induced a similar cardiorespiratory performance in patients recovering from acute exacerbation of COPD. Both tests were reproducible and feasible even in hospitalized patients.[5] This trial formed the basis of our study.

In another randomized, double-crossover experimental study in patients with COPD showed that course length (10 m vs. 30 m) substantially influences the performance of patients in a 6MWT. The statistical and clinically meaningful difference in 6MWD in patients with COPD, singly depending on the length of the walk course, highlights a practical problem. Existing reference equations cannot be applied to predict the walking distance in the frequently used 6MWT on a 10 m course for people with COPD, due to a substantial overestimation. Unique reference equations for the 6MWT on a 10-m course seem necessary.[33]

The tests were performed only once to demonstrate the changes in cardiorespiratory parameters. For the results to be more significant, double cross-over method can be adopted. The participants of the study were not equally recruited according to the gender category (8 males, and 7 females). Each gender and age group may show some variation during the test. Further, the results may not be extrapolated to clinical populations. Due to lesser sample size, inherent variation in the baseline is inevitable and the washout period shall be prolonged.

This study can be conducted with composite sample across the country as a multicenter trial with healthy individuals, cardiorespiratory conditions such as COPD, coronary artery bypass grafting, and lung surgeries and presurgery screening, outcome measure in a cardiopulmonary rehabilitation and other functional capacity evaluation areas, exercise testing areas to prove the sensitivity of 3MRWT.

This study suggests that the staged incremental response may be similar in both tests that imply that 3MRWT may be an efficient possibly as equivalent to the gold standard 6MWT in clinical exercise testing arena. Thus, we propose that 3MRWT may provide a greater hemodynamic stress in the smaller time frame. As 3MWT takes smaller time frame, it may be reproducible that can be allowed for future studies to investigate.

**Conclusion**

In summary, 3MRWT might be an efficient alternative to the 6MWT in eliciting better cardiorespiratory stress responses to assess the maximal functional capacity. The 3MRWT is simple, easy to administer, requires no equipment, time and cost saving, safe, and is reproducible.

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**Conflicts of interest**

There are no conflicts of interest.

**References**

1. Wasserman K, Hanson JE, Sue DY, et al. Principles of Exercise Testing and Interpretation. 3rd ed. Philadelphia: Lippincott, Williams & Wilkins; 1999.
2. Weisman IM, Zeballos RJ. An integrated approach to the interpretation of cardiopulmonary exercise testing. Clin Chest Med 1994;15:421-45.
3. ATS board of directors, guidelines for the six minute walk test. Am J Respir Crit care Med 2002;166:111-7.
4. De Feo S, Tramarin R, Lorusso R, Faggiano P. Six-minute walking test after cardiac surgery: Instructions for an appropriate use. Eur J Cardiovasc Prev Rehabil 2009;16:144-9.
5. Vagaggini B, Taccola M, Severino S, Marcello M, Antonelli S, Brogi S, et al. Shuttle walking test and 6-minute walking test induce a similar cardiorespiratory performance in patients recovering from an Acute Exacerbation of Chronic Obstructive Pulmonary Disease. Respiration 2003;70:579-84.
6. Beekman E, Mesters I, Hendriks EJ, Klaassen MP, Gosselink R, van Schayck OC, et al. Course length of 30 metres versus 10 metres has a significant influence on six-minute walk distance in patients with COPD: An experimental crossover study. J Physiother 2013;59:169-76.