Rosalba Saavedra, Brian Bischoff, and Elijah Weiss.

Introduction

In the USA, the population is becoming less healthy and physically active.[1-4] Over half of adults were overweight or obese in 2014,[3] and only 1 in 5 adults met the 2008 Physical Activity Guidelines.[2] As these health issues become more prevalent, healthcare professionals will need to test clients in order to perform primary and secondary prevention interventions. One tool healthcare workers can use to screen clients for functional status and disease risk is a walking speed test.[5-7] Walking speed tests can predict current functional independence and future health deterioration, potentially screen for chronic lifestyle diseases such as hypertension, and help with clinical decision making such as whether someone will be homebound, their likelihood of hospitalization and the location of release after hospital visits.[5,7,8]

Recently, Alves and colleagues reviewed the use of walking speed tests for examining cardiovascular disease events and health risk factors in older adults.[5] The studies reviewed used different test distances. In eight of the studies, the distances ranged from 2.44-4.6m, and in five they ranged from 6-6.15m. One study utilized a 20 meter test, and another used either 2.4m or 6m depending on self-rated fitness levels. Alves et al. concluded that although walking speed tests generally offer many benefits to assess people's health, they also display a large variation in results when different versions of this test were compared because there is no set protocol to conduct a walking speed test.[5] This is significant to them because different protocols generate a gap in knowledge of and a questioning in the test's accuracy.[5]

Middleton et al. published a white paper on the efficiency of walking speed for health examination.[8] This walking test is 20m total, however, only the middle 10m of it is used to measure walking speed; the first and last 5m are used for to accelerate and decelerate walk pace. The walking speed test will be potent as long as there is room for acceleration and deceleration.[8] It is important to realize what is a true walking speed change and what is measurement error to efficiently and effectively provide a health screening.[8]

Optimal Distance for Normal Gait Speed Testing

Saavedra, R., Bischoff, B., & Weiss, E.

Alves et al.[5] and Middleton and colleagues[8] argue that although walking speed tests are powerful tools for health screenings, the variation of protocols present different cutoff points in health within each test. Decline in walking speed can be a sign for potential problems that can affect people's health.[5, 8] However there is still a gap in knowledge and no standard method on how to conduct a walking speed test that can provide consistent results and that is effective for determining exact health outcomes. This gap generates a confusion when a walking test is used as a health screening tool and it weakens the usefulness of this clinical measure. It is important that a standardized walking test needs to be established and incorporated into the practices of health care professionals and people accessing their own health however, it is unknown what exact distance of gait speed test most validly represents overall gait speed. Therefore, the purpose of the current study was to determine an optimal distance to calculate gait speed that can be used to standardize walking tests in clinical settings.

Methods

Participants were full or part time students at California State University Monterey Bay (CSUMB) who could walk without a walking aid. This project was approved by the CSUMB Committee for the Protection of Human participants. All participants provided written informed consent before commencing the assessments. Participants were asked to attend one session at the Exercise Physiology laboratory at CSUMB. Participants were instructed to refrain from eating, smoking, or ingesting caffeine or alcohol within 3 hours of their testing session, or from exercising prior to their testing session, and to wear athletic shoes and clothing. After 5 minutes of seated rest, participants were assessed for resting blood pressure and heart rate. They were then assessed for height using a stadiometer, and weight and body fat percentage using a Tanita BF-350 Total Body Composition Analyzer (Tanita, Tokyo, Japan).

Participants were brought outside to a level concrete sidewalk that we permanently marked to indicate distances from a starting line. We marked -30cm, 0m, 5 m, 10m, and 20m. Sets of Brower

Timing Gates (Brower Timing Systems, Draper, USA) were placed at the starting line and at the 0, 5, 10, and 20m marks.

Participants were informed of the walking test procedures; participants were instructed to begin walking when they felt the most comfortable. They were instructed to walk at their normal pace on the concrete passing through each set of timing gates. Participants were instructed to walk down and touch the water fountains beyond the last timing gates to ensure they would not slow down before completing the test. When ready, they started with their toes on the -30 cm line (i.e. 30cm from the first timing gate) per standard procedure,[9] and began the test at their volition. Participants only completed a single trial, as our previous research has shown that measuring gait speed with the Brower Timing gates shows near perfect reliability.[10]

Note that each participant walked through all three segments (0-5m, 5-10m, and 10-20m), and the timing gates recorded gait speed of each individual at each segment. Therefore, a mixed effect model was used in order to account for the correlated data (i.e., accounting for one's own gait speed). Using the model, we estimated the average gait speed at each segment and the average difference between two segments. We used R version 3.5.0, and we used lme4 and lmerTest packages to complete the analyses.

Results

Thirty six students completed the assessment (24 female, 11 male, 1 declined to answer; mean age = 21.5 ± 2.6 years, height = 168.8 ± 10.4 cm, mass = 77.2 ± 19.3 kg). Students walked 1.361 meters per second (m/s) on average between 0-5 meters, 1.449 m/s between 5-10 meters, and 1.467 m/s between 10-20 meters (Figure 1). A 95% confidence interval (CI) was used for this study. For the 0-5 meter segment, the CI was calculated between 1.292-1.429 m/s; for the 5-10 meter segment, the CI was 1.380-1.517 m/s; and for the 10-20 meter segment the CI was 1.398-1.535 m/s. Comparing segment 0-5m to segment 5-10m, the estimated difference was 0.088 m/s with a 95% CI between 0.062-0.079 m/s with a p-value < 0.0001. Comparing segment 0-5m to segment 10-20m, the estimated difference was 0.106 m/s with a 95% CI between 0.079-0.132 with a p-value of <0.0001. Comparing segment 5-10m to segment 10-20m the estimated difference was 0.018 m/s with a 95% CI between -0.009-0.044 m/s with a p-value of 0.18.

Discussion

Comparing segments 0-5m and 5-10m the walking speed of the 5-10m segment was faster than the walking speed of the 0-5m segment. This result is expected; because subjects start from no momentum, it takes time and distance for them to accelerate to their normal walking speed. The 0-5m segment shows that subjects are increasing their speed from a standing point. However when comparing the 5-10m segment to the 10-20m segment, results display a consistency in walking speed. This shows that the 5-10m segment is sufficient to provide an accurate representation of average walking speed in a test.

Previous work has studied the practical utility of different lengths when conducting gait speed tests. Kon and his fellow researchers,[11] studied the validity and reliability of using a normal-speed 4 meter walk speed test and found it to be reliable, but they did not compare different lengths of walk tests. In Karpman et al.[12], their research team performed both 4 and 10 meter walk speed trials at the subjects' usual pace and found that both tests could be used in a clinical setting. Peters and colleagues suggested that a 10 meter walk test be the preferred method of gait speed testing as opposed to the 4 meter walk test.[13] This was concluded because they had found a lack of concurrent validity for the 4 meter test to predict gait speed obtained from the 10 meter test while walking at the patients' normal gait speed. Our results support the findings of the Peters and colleagues'[13] article who found testing under 5 meters to be statistically different but it differs from both Karpman et al.'s[12] and Kon et al.'s[11] findings who supported the use of 4 meter gait speed testing.

An aspect that previous research studies did not include but was included in ours was the comparison to a walk test above 10 meters. Our research included a longer segment of measurement (10m

Saavedra, R., Bischoff, B., & Weiss, E.

-20m) which helps determine a more accurate representation of a person's average gait speed. Comparing this longer walking speed distance with the 0-5m and 5m-10m segments strengthened the argument for the 5m-10m walk test trials and weakened the support for tests under 5 meters.

Conclusion

Testing patients in clinical settings using walk speed tests under 5 meters is not advised because a patient will still be accelerating to their actual walking speed. The most efficient distance would be between 5-10 meters.

Mentors: Eric Martin, PhD, and Steven Kim, PhD

Optimal Distance for Normal Gait Speed Testing

Saavedra, R., Bischoff, B., & Weiss, E.

Appendix

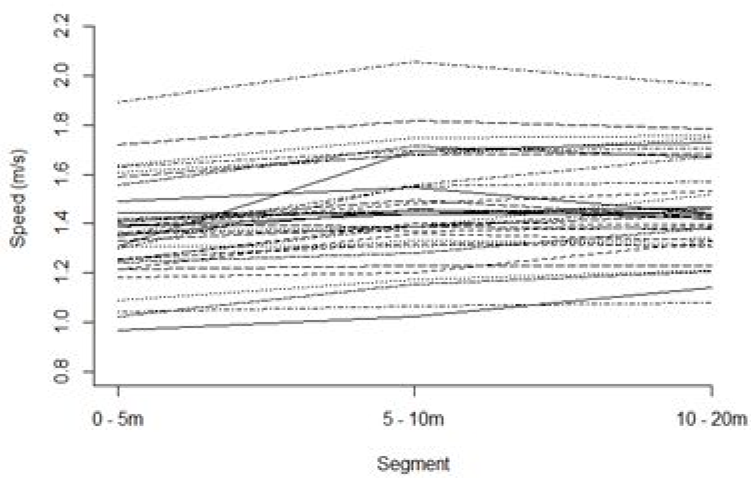

Figure 1. Graphical representation of each participant's gait speed for the 0-5, 5-10, and 10-20m segments.

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Optimal Distance for Normal Gait Speed Testing

Saavedra, R., Bischoff, B., & Weiss, E.

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