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Measuring Gait Speed in the Outpatient Clinic: Methodology and Feasibility

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Dr. Karpman: contributed to the design of the study, data collection, data analysis, and writing the manuscript.

Dr. LeBrasseur: contributed to the design of the study, and writing the manuscript.

Dr. DePew: contributed to data analysis and writing the manuscript.

Mr. Novotny: contributed to the statistical analysis and writing the manuscript.

Dr. Benzo (guarantor): contributed to the design of the study, data collection, data analysis, and writing the manuscript.

Running head: Gait speed methodology and feasibility

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Abstract:

Introduction: Gait speed is simple physical function measure associated with key outcomes in the elderly. Gait speed measurements may improve clinical care in patients with COPD. However, there is a knowledge gap about the reliability and variability of gait speed testing protocols in COPD. We evaluated established techniques of measuring gait speed in patients with COPD, and assessed feasibility of implementing gait speed as a routine *vital sign* in outpatient clinic.

Methods: Subjects with stable COPD performed *usual* 4 meter gait speed (4MGS) ("walk at a comfortable/natural pace"), *maximal* 4MGS ("walk as fast as you can safely"), *usual* 10 meter gait speed (10MGS) and *maximal* 10MGS measurements. Walks were measured using stopwatch and automated timing system. For feasibility/implementation phase, patients from entire spectrum of respiratory diseases completed acceptability surveys and clinical assistants administered gait speed measurements using automated timing system. Time to train, administer test, and acceptability by staff was evaluated.

Results: Seventy subjects enrolled, 60% male and age (mean±SD) was 69±10. All methods showed excellent test-retest reliability (ICC 0.95-0.97). The difference between the two timing systems did not exceed suggested minimal clinically importance difference of 0.1 m/s for the usual pace instructions, but did exceed 0.1m/s for maximal pace walks. The difference between 4MGS and 10MGS was 0.13±0.10 m/s.

Feasibility: Most subjects reported that gait speed measurement prior to clinic appointment was very acceptable (66%) or acceptable (33%). Time added to clinic visit measuring 4MGS was 95

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± 20 seconds, and clinical assistants reported gait speed measurements as very acceptable (60%), acceptable (30%), and somewhat acceptable (10%).

Conclusion: Gait speed is a reliable measure in COPD, regardless of instructed pace, distance or timing mechanism, however adhering to one protocol is suggested. 4MGS was easily implemented into clinical practice with high acceptability by patients and clinic staff.

Keywords: gait, pulmonary disease, chronic obstructive, methods, feasibility studies, ambulatory care facilities, patient acceptance of health care

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Abbreviation List:

4MGS: 4-meter gait speed

10MGS: 10-meter gait speed

6MWT: 6-minute walk test

COPD: chronic obstructive pulmonary disease

mMRC: modified Medical Research Council

BMI: body mass index

SEM: standard error of measurement

SEM%: standard errors of measurements

ICC: Intraclass correlation coefficient

CK: Craig Karpman

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Introduction:

Short distance gait speed is a reliable measure associated with falls[1], hospitalizations[2], disability[3] and survival in older adults[4, 5]. Gait speed has been evaluated in numerous patient populations including older individuals with neurologic[6, 7], musculoskeletal[8, 9], and cardiac disease[10]. The routine measure of gait speed has been proposed in the elderly population[11] to be implemented as a vital sign. Gait speed may be a clinically important measure in COPD. Recent studies have shown a link between gait speed and exercise capacity[12, 13] for patients with COPD. However, those studies did not evaluate the several commonly described gait speed protocols, and have not established the effect of distance walked, pace, or timing methods on the reliability and reproducibility of gait speed results in patients with COPD. Prior studies using "fast pace" [14, 15] have not investigated the commonly used distances (4 and 10 meters) or the possible timing systems. Variability in the methodology is believed to affect clinical interpretation and implementation of the gait speed measures[16, 17].

In addition, feasibility of implementing gait speed measurements into a clinical setting has also not been thoroughly evaluated and previous reports do not provide a comprehensive description of protocols or appraisal of real world implementation. Our goals were first, to evaluate the reliability and validity of several previously described protocols of measuring usual and maximal gait speed in COPD, and second, to assess the feasibility of implementing a gait speed measure as a vital sign in a respiratory outpatient clinic.

Methods

Subjects

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Participants with clinically stable COPD were prospectively recruited from an outpatient pulmonary clinic. Inclusion criteria consisted of the following: 1) Diagnosis of COPD based on the Global Initiative for Chronic Obstructive Lung Disease 2011 guidelines[18]; 2) stable respiratory condition one month prior to the study; 3) the ability to walk without limitation from a predominant orthopedic or neurologic disease ("when walking, are you more limited by breathlessness or by pain, unsteadiness, or weakness?"). Clinical characteristics collected included: age, sex, body mass index (BMI) and subjective dyspnea as measured by the modified Medical Research Council (mMRC) dyspnea scale[19]. Approval was obtained from Mayo Foundation Institutional Review Board.

Gait Speed Measurements

Gait speed measurements were performed in a flat and unobstructed clinic hallway. All measurements were obtained by one trained investigator (CK) and each of the gait speed protocols were performed two times for each subject with a 5-10 second break between trials. Each walk was performed with a 2m rolling start where the participant is already walking as they enter the measuring area (Figure 1). Canes, walkers and supplemental oxygen were used if the subject normally used the equipment in daily activity. Usual gait speed over a four meter course (4MGS), maximal 4MGS, usual gait speed over a ten meter course (10MGS) and maximal 10MGS were measured.

Usual 4 Meter Gait Speed

Two cones were placed 8 meters apart, and then an automated timing system was set up two meters after the first cone and two meters before the second cone, as seen in Figure 1. We used the Dual Beam Wireless Infrared Timing System (TracTronix, Lenexa, KS) on six inch tripods

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with a preset two second delay (allowing for rolling oxygen tank, walkers or canes to be used). This provided a two meter acceleration zone, a four meter timing area and a two meter deceleration zone. Subjects were instructed to "walk at a comfortable/normal pace" from one cone to the other. Time to walk 4 meters was measured by the automated timing system and simultaneously by manual stopwatch. The automated timing system would activate once the first timer plane was broken by the participant and would stop once the second timer plane was broken. For the manual measure, the test administrator stood in the middle of the 4m course and started the stopwatch when the participant's first foot completely crossed into the timing area and stopped the stopwatch once the participants first foot completely came out of the timing area.

Maximal 4 Meter Gait Speed

Maximal 4MGS was measured in the same fashion as usual 4MGS other than the walking instructions. Subjects were instructed to "walk as fast as you can safely, without running" from one cone to the other. Maximal 4MGS was measured using both the automated timing system and stopwatch.

Usual 10 Meter Gait Speed

Two cones were placed 14 meters apart, and then an automated timing system was set up two meters after the first cone and two meters before the second cone. This provided a two meter acceleration zone, a ten meter timing area and a two meter deceleration zone. Subjects were instructed to "walk at a comfortable/normal pace" from one cone to the other. Only the automated timing system was used for 10MGS measurements.

Maximal 10 Meter Gait Speed

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Subjects were instructed to "walk as fast as you can safely" from one cone to the other. Only the automated timing system was used for maximal 10MGS measurements.

Feasibility of Measuring Gait Speed in the Clinic

Patient Acceptability

A separate convenience sample, not recruited for the methodology portion of the study, receiving outpatient care in the Pulmonary Department of Mayo Clinic, Rochester was recruited for the feasibility portion of the study. After subjects were checked in for their pre-scheduled appointment and had the standard vital signs performed by clinical assistants (heart rate, blood pressure, etc.), the subjects were approached by study personnel (CK) and asked to perform usual and maximal 4MGS prior to the physician visit. After completion of the gait speed measurements, subjects were surveyed about the acceptability of the study procedures by using a four point Likert scale (not acceptable, somewhat acceptable, acceptable, very acceptable). Demographics of the study participants were also collected.

Clinical Implementation

The second phase of the feasibility study involved training clinical assistants to set up the automated timing system and perform the gait speed measure as a routine clinical vital sign (Figure 2). The time to train staff, time to set up equipment and the added time in clinic to administer test was evaluated. Staff acceptability was assessed using an anonymous Likert scale questionnaire by using a four point Likert scale (not acceptable, somewhat acceptable, acceptable, very acceptable).

Statistical Analysis

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Data was summarized using means ± standard deviation. Intraclass correlation coefficient (ICC) calculations were used to evaluate reliability between test and retest of 4MGS and 10MGS measurements, and automated and manual timing for usual and maximal 4MGS [20]. Variability between repeat measurements was analyzed using standard error of measurement (SEM) and standard errors of measurements (SEM%). The SEM provides the error value in the same unit as the initial measure, and the SEM% describes the error in percent, allowing for comparison between tests that have different units. Validity of stopwatch measurements compared to automated timer was evaluated using Bland Altman method and calculating the 95% limits of agreement between the two timing systems. Since all gait speed measures were performed twice, the fastest speed was used during analysis[3]. Spearman rank correlation was used for evaluation of the association between the timing systems throughout the spectrum of the gait speeds. For all analyses, a p value ≤ 0.05 was considered statistically significant.

Results

Seventy subjects enrolled in the methodology study and performed each of the four gait speed measurements. Subjects had a (mean ± SD) age of 66±9 years, BMI of 30±6 kg/m^2, forty-three (60%) were male, and sixty-nine (99%), were Caucasian. The severity of COPD was moderate-severe with a percent predicted forced expiratory volume in one second (FEV1 %) 53±18, and eleven (16%) were on supplemental oxygen. Subjects were short of breath with minimal activity, based on mMRC score of 2±1. The mean gait speeds, are summarized in Table 1.

Test-Retest Reliability

The 4MGS measurements showed excellent test-retest reliability at both usual and maximal pace and when timed with either the automated timing system or manual stopwatch (all ICCs ≥ 0.95,

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detailed in Table 2). The usual and maximal 10MGS measurements also demonstrated exceptional agreement for test-retest with ICCs of 0.97 and narrow confidence intervals. We found a low measure of variability for 4 and 10MGS measures with SEM values ranging from 0.04 to 0.08 m/s (Table 2).

Timing Method Validity

First, we evaluated the correlation between the stopwatch and automated timing systems using ICC, and found excellent values of 0.99 (0.98-0.99) for usual 4MGS and 0.99 (0.98-0.99) for maximal 4MGS. We then used Bland Altman analysis to plot the difference between the two methods and found a mean difference of 0.01 m/s for both usual and maximal pace. The 95% limit of agreement for usual pace was -0.10 to 0.08 m/s, and was larger at -0.15 to 0.12 m/s for maximal pace (Figure 3). As evident by the Bland Altman figures, the variation between the two timing systems did not exceed 0.1 m/s for the usual pace instructions and the best agreement was seen at the slower gait speeds. The maximal 4MGS Bland Altman figure shows that the variation increased with faster speeds and the 95% limit of agreement exceeded 0.1 m/s.

4MGS versus 10MGS Measurements

The usual 4MGS and usual 10MGS had a difference of 0.12$\pm$0.10m/s, p=<.001 and the difference between maximal 4MGS and 10MGS was also significant at 0.06$\pm$0.14m/s, p=<.001. Bland Altman analysis found a mean difference of 0.12 m/s and a 95% limit of agreement of (-0.07 to .31 m/s) for usual pace, and a mean difference of 0.08 m/s and a 95% limit of agreement of (-0.20 to 0.36 m/s) for maximal pace. (Figure 4)

Patient Acceptability

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A separate cohort of 100 subjects participated in the acceptability portion of the feasibility study. The age was 63 ± 15 and the most common disease processes were COPD, interstitial lung disease, and asthma. The average usual 4MGS as measured by the automated timing system was 1.1 ± 0.26m/s and the maximal 4MGS was 1.59 ± 0.42m/s. Ninety-nine out of 100 subjects reported that the gait speed measurement prior to the clinic appointment was either very acceptable (66%) or acceptable (33%). One subject reported that the 4MGS measurement was somewhat acceptable.

Clinical Implementation

Gait speed measurement was implemented as a vital sign in the outpatient clinic for a 60 day period. During those months, every morning prior to clinic, the cones and automated timers were set up by clinical assistants in a low traffic hallway to conduct 4MGS measurements. The time to set up the equipment each day was 3 ± 1 minutes. To evaluate the time added to the standard clinic intake procedure, we measured the time it took to complete the 4MGS measurement for ten randomly selected subjects. The average time added to the clinic visit by measuring 4MGS was 95 ± 20 seconds. Using the automated timers, 9 of 10 clinical assistants reported that collecting the gait speed measurements during clinic as very acceptable (6) or acceptable (3). One clinical assistant reported the measurement as somewhat acceptable. The time to train staff ranged from 9 to 12 minutes.

Discussion

Gait speed measurements are reliable in patients with COPD regardless of instructed pace (usual or maximal), distance (4 meters or 10 meters), or timing system (stopwatch or automated timer).

Our feasibility study showed that gait speed was easily incorporated into a clinical setting with high acceptance by patients and staff with the use of an automated timing system.

Our work adds to the field by comprehensively evaluating the numerous technical variables involved in measuring gait speed in COPD, and utilizing the more commonly described distances of four and ten meters. The excellent reliability, regardless of distance or timing mechanism, seen in our study is consistent with prior work in this field. The ICC values for test-retest and for agreement between timing systems also ranged from 0.96-1.00 in the study by Peters et al when evaluating healthy, older adults[21]. Our group had better test-retest reliability for usual 10-meter gait speed (ICC 0.97 vs ICC 0.87) when comparing to usual 30-meter gait speed measured in a smaller COPD cohort[14].

This study showed that in patients with COPD, there is good agreement between stopwatch and automated timing system measurements for usual gait speed measurements. That agreement did not hold true with maximal walking speeds. The 95% confidence interval for agreement between timing systems for *maximal* 4MGS reached the 0.1 m/s cutoff. The latter may or may not be clinically significant since the minimal clinically important difference (MCID) for gait speed of 0.1m/s has been postulated for usual but not for maximal gait speed [11]. If maximal gait speed is used, based on this work, stopwatch and automated timing systems cannot be used interchangeably. We presume that the automated timing system would be more accurate than the hand held stopwatch for maximal pace short distance walks which take only a few seconds to complete. Our finding of minimal variability for the timing systems with the usual pace gait speed measurements is consistent with prior studies [21].

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We also found that there was a significant difference in gait speeds measured between longer (10 m) and shorter (4 m) walks, and that difference was greater than 0.1m/s (meaningful difference) suggesting that is better to stick to one protocol of gait speed measure. Similar to our results, Peters et al identified enough variability between 4MGS and 10MGS that they would not use the measurements interchangeably[21]. A large review also found that longer walks were on average faster than shorter walks in healthy, older patients[17]. The opposite was seen in the neurologic disease cohort from the same review[17], where the shorter walks were faster. There are also several prior studies showing no significant variation in the gait speeds between shorter and longer walking distances[22]. A plausible explanation for the difference in our study is an inadequate acceleration zone of two meters, and during a longer walk (10 m) this limitation is masked by the extended duration of the test. Whether gait speed is actually faster in COPD when measuring over a longer distance is unclear, but there is enough variability throughout studies that we would recommend to consistently use a single distance.

Feasibility

With improved understanding of various gait speed protocols, we can better select the methods for implementation of gait speed assessment in the clinical setting. Using the information gleaned from the methodology section of this study, we set up a real-world feasibility study of measuring gait speed in an outpatient clinic. We found nearly unanimously positive results from subjects undergoing their clinic evaluations. We also evaluated the time to train and the overall burden for clinical assistants in administering the test, and found positive results in both domains. We believe that this positive response is based on the simplicity and the ease of performing the measures. Studenski et al. also evaluated the feasibility of measuring gait speed

in the clinic of a cohort of veterans [23]. They also found that participants and healthcare professionals were accepting of the testing.

We selected to use the automated laser timer system for the feasibility portion of the study even when most studies measuring walking speed use a stopwatch as the timing mechanism. We wanted to use a method that required minimal training which could be completed in less than fifteen minutes. In a tertiary clinical setting where numerous personnel are measuring the walking speed, a method that is simplest to train and with the lowest chance of variability between operators would be most effective in facilitating clinical implementation. As described in the Short Physical Performance Battery protocol provided by the National Institute on Aging (www.grc.nia.nih.gov, Accessed May 20th, 2013), the stopwatch timing method requires operators to be trained with extensive and detailed instruction. However using a stopwatch with instruction from the National Institute on Aging could also be a reasonable option for clinical use if the training time is available or cost of the automated laser timer system (289 US dollars) is a barrier. Based on our results we would not recommend alternating between stopwatch and timer system if a *maximal* speed protocol is used.

Limitations:

Even though our objective was to comprehensively measure the possible gait speed protocols, we did not measure static start. Since this research was performed by recruiting from a busy clinic and patient schedule, there was a limitation of how many protocols could be tested at the same time. In addition, rolling start is thought to provide less variability in the results of gait speed by not having the acceleration phase[17] of the static start gait speed measure which can increase the noise to signal ratio. Future studies may be warranted to evaluate static and rolling start in the

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same cohort. The feasibility portion of our study included a heterogenous group of respiratory diseases, but we used a gait speed protocol developed in a cohort of patients with COPD. We also did not compare the feasibility of automated timer versus stopwatch, and the acceptability was not compared with 10MGS measurements.

Conclusion

Gait speed is a reliable measure in COPD regardless of instructed pace, distance or timing mechanism. Based on this work, we recommend using one method consistently: same distance and speed instructions all the time. Four meter gait speed was easily implemented into clinical practice with excellent acceptability by patients and clinic staff using an automated timing system. We hope these results inform and ignite health care providers to incorporate this feasible and useful measure into daily clinical practice.

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Figure Legends

Figure 1: Gait Speed Measure Diagram

Figure 2: Picture of Automated Timing System for Four Meter Gait Speed

Figure 3: Difference Between Stopwatch and Timer for Usual and Maximal 4MGS. 4MGS: four meter gait speed. The solid line represents the mean difference in the gait speed between the two measures, and the dashed lines represent the upper and lower 95% confidence intervals.

Figure 4: Difference Between Usual and Maximal 4MGS vs 10MGS Measures. 4MGS: four meter gait speed, 10MGS: ten meter gait speed. The solid line represents the mean difference in the gait speed between the two measures, and the dashed lines represent the upper and lower 95% confidence intervals.

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Table 1: Walking Speeds

Walking Speed Protocol	Mean Speed ± SD	Min-Max
Usual 4MGS (Stopwatch) (m/s)	1.13 ± .23	0.68-1.74
Usual 4MGS (Timer) (m/s)	1.14 ± .24	0.68-1.82
Usual 10MGS (Timer) (m/s)	1.27 ± .24	0.87-2.00
Maximal 4MGS (Stopwatch) (m/s)	1.68 ± .37	0.98-2.50
Maximal 4MGS (Timer) (m/s)	1.69 ± .38	0.93-2.67
Maximal 10MGS (Timer) (m/s)	1.77 ± .39	1.05-2.78

Data are presented as mean ± SD; Abbreviations: 4MGS= four meter gait speed;

10MGS= ten meter gait speed; m/s= meters per second

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Table 2: Test-Retest Reliability of Various Gait Speed Measurements

Test	ICC (95%CI)	Mean Difference (95% CI)	SEM (m/s)	SEM (%)
Usual 4MGS (Stopwatch)	0.95 (0.92-0.97)	0.01 (-0.03 to 0.01)	0.05	4.4
Usual 4MGS (Timer)	0.95 (0.91-0.97)	<0.01 (-0.02 to 0.02)	0.05	4.4
Usual 10MGS (Timer)	0.97 (0.95-0.98)	<0.01 (-0.02 to 0.01)	0.04	3.3
Maximal 4MGS (Stopwatch)	0.95 (0.93-0.97)	0.02 (-0.04 to 0.01)	0.08	4.8
Maximal 4MGS (Timer)	0.95 (0.92-0.97)	0.02 (-0.05 to 0.01)	0.08	4.8
Maximal 10MGS (Timer)	0.97 (0.96-0.98)	0.03 (-0.05 to <0.01)	0.07	4.0

Abbreviations: 4MGS= four meter gait speed; 10MGS= ten meter gait speed; SEM= standard error of measurement; SEM%= standard errors of measurements; ICC= intraclass correlation coefficient; CI= confidence interval

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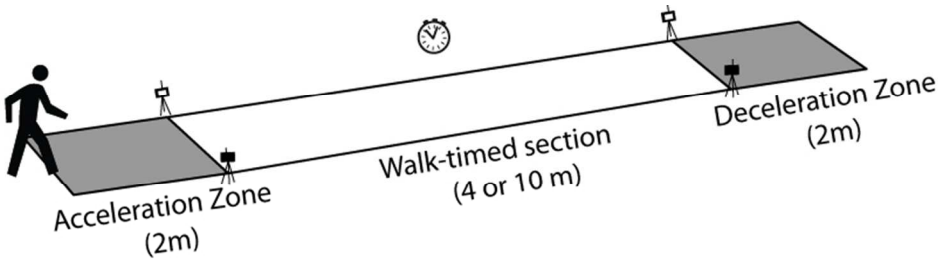

Gait Speed Measure Diagram
144x38mm (150 x 150 DPI)

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Picture of Automated Timing System for Four Meter Gait Speed
863x1151mm (72 x 72 DPI)

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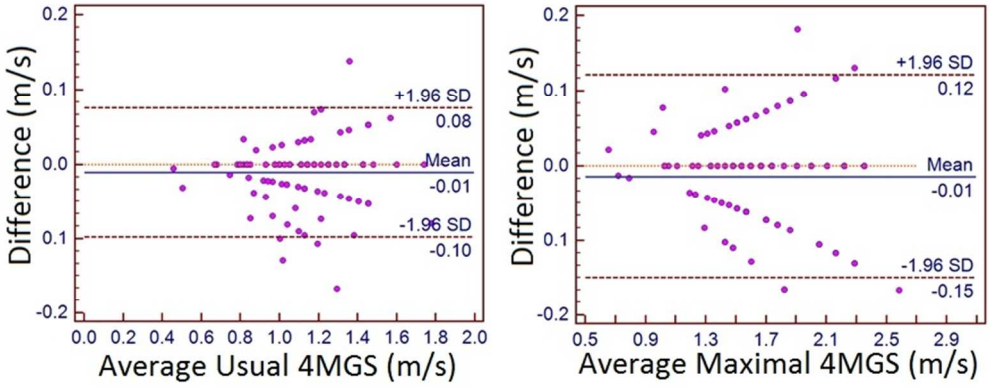

Difference Between Stopwatch and Timer for Usual and Maximal 4MGS. 4MGS: four meter gait speed. The solid line represents the mean difference in the gait speed between the two measures, and the dashed lines represent the upper and lower 95% confidence intervals.
233x94mm (96 x 96 DPI)

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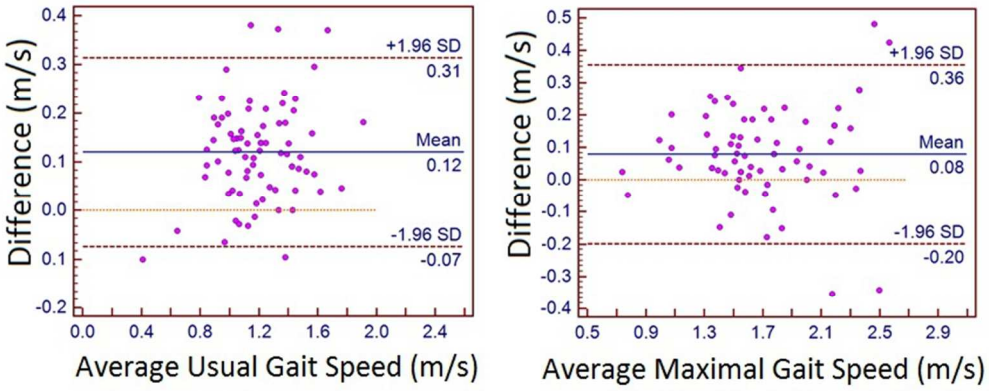

Difference Between Usual and Maximal 4MGS vs 10MGS Measures. 4MGS: four meter gait speed, 10MGS: ten meter gait speed. The solid line represents the mean difference in the gait speed between the two measures, and the dashed lines represent the upper and lower 95% confidence intervals.
225x89mm (96 x 96 DPI)