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Four-meter Gait Speed: Normative Values and Reliability Determined for Adults Participating in the NIH Toolbox Study

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Abstract

Objectives: To establish reference values and determine test-retest reliability for usual and maximal 4 meter gait speed.

Design: Cross-sectional observational study.

Setting: Offices in 10 geographically dispersed cities in the United States.

Participants: Men and women enrolled in the National Institutes of Health ToolBox norming study.

Intervention: Not applicable.

Main Outcome Measures: Specifically used were data from 18 to 85 year old men and women who were timed over 4 meters (after a static start) while walking at their usual and maximum speeds. Norms for usual and maximum gait speed were derived using data from 1320 participants. Test-retest reliability for 164 participants was described using paired t-tests, intraclass correlation coefficients (ICCs) and minimal detectable changes (MDCs).

Results: Mean usual speed was 1.12 m/s, whereas mean maximum speed was 1.61 m/s. As a general linear model showed 4 meter gait speed to differ significantly according to gait condition (speed), gender, and age group; estimates of normal were calculated accordingly. The usual speed of 80 to 85 year old women was lowest at 0.95m/s; the maximum speed of 18 to 29 year old men was highest at 1.85 m/s. Test-retest measures did not differ significantly, but the ICCs were only fair and the MDCs were high.

Conclusions—Normative reference values provided herein may be helpful in interpreting measurements of 4 meter gait speed obtained from adult men and women. The limited reliability of the gait speed measurements, however, limits their usefulness in making judgments regarding change.

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Keywords

Gait; Speed; Measurement; Normative values; Reliability

Gait speed is a simple, objective, and valid measure of human walking performance that has been employed in diverse settings¹⁻⁴ and recommended for use as a health “vital sign.”^{5,6} Procedures for measuring gait speed vary considerably- perhaps most notably in regard to when timing is started and the distance over which timing occurs.⁷ Timing can involve a static start (eg, when walking begins) or a dynamic start (after an allowance for acceleration). Historically, the most common distances for timing gait have been 10, 6 or 4 meters,⁷ but gait speed measured over 4 meters after a static start is being used increasingly as both a stand-alone measure and as a component of the Short Physical Performance Battery.⁸⁻¹⁰

The widespread use of the 4 meter gait speed test notwithstanding, its value is limited unless information is available for interpreting performance on the test. Such information includes normative reference values and estimates of reliability.¹¹ There is limited availability of such information across the age span for the 4 meter gait speed test conducted with a static start.¹² The purpose of this study of community-dwelling adults, therefore, was to: 1) provide norms for usual and maximum 4 meter gait speed and 2) describe the relative and absolute test – retest reliability of the gait speed measurements.

Methods

This study involved the secondary analysis of publically available data from the norming phase of the National Institutes of Health (NIH) Toolbox for the Assessment of Neurological and Behavioral Function.¹³ The project was approved by the Institutional Review Board of Northwestern University (Chicago, IL).

Participants

Participants were community-dwelling residents of 10 geographically diverse settings in the continental United States. They were tested, following provision of written informed consent, from August through November of 2011. This specific study focused on 1445 adults 18 to 85 years. Of these participants 105 were excluded because they were missing gait speed data and 20 were eliminated because the validity of their gait speed data was suspect (usual or maximum speed < 0.4m/s or usual speed > maximum speed) (Figure 1). Consequently data from 1320 adults (840 women, 480 men) of 18 to 85 (mean 46.6(17.9)) years were used to determine gait speed norms (Table 1). Data from 164 participants (81 women, 83 men) of 18 to 85 (mean 52.8(19.2)) years, who were tested a second time a mean 8.6 (range 4–21) days later, were used to examine reliability.

Procedure

Before measuring neurological and behavioral function, basic demographics were obtained. These included gender, ethnicity, age, height, and weight.

Four-meter gait speed was one of several motor domain measures of neurologic and behavioral function included in the NIH Toolbox norming phase.¹⁴ The course incorporated a starting line marked by a cone, a 4.0 meter finish line, and a 5.5 meter line (marked by a cone). Participants, who wore comfortable walking shoes, started with their toes behind a starting line and were instructed to walk at their “usual speed, just as if” they “were walking down the street to go to the store.” They were told to keep walking past the finish line. Participants started after the command “Ready, 3, 2, 1, Go!” The examiner first demonstrated the test. Next, the participant completed a practice trial. Thereafter a timed trial was completed. Timing with a stopwatch began when the first foot passed the starting line and ended when the first foot passed the finish line. The usual speed timed trial was followed by a maximum speed timed trial. Both timed trials were converted to speed in meters/second.

Statistical analysis

The Statistical program for the Social Sciences (SPSS 18.0) was used for all analysis. A $2 \times 2 \times 7$ general linear model was applied to determine whether expected differences in gait speed existed between: 1) usual and maximum conditions, 2) gender categories, and 3) age groups. Categorical variables were summarized using frequencies; continuous variables were summarized using means and standard deviations, and in the case of gait speed, using confidence intervals and histograms as well. Repeated measures t-tests and intraclass correlation coefficients (ICCs, model 3,1) were used to describe relative reliability. Absolute reliability was described using minimal detectable change ($MDC_{95\%}$), where $MDC_{95\%} = 1.96 \times (\text{standard error of measurement (SEM)}) \times \sqrt{2}$ and $SEM = SD \times \sqrt{1 - ICC}$.¹⁵

Results

Figure 2 shows that both usual and maximum 4 meter gait speeds were normally distributed. The mean usual gait speed was 1.12 m/s; the mean maximum gait speed was 1.61 m/s. The general linear model demonstrated that gait speed was significantly higher at maximal than at usual speed ($F=3028.8$, $p<0.001$), for men than for women ($F=47.9$, $p<0.001$), and for younger participants than for older participants ($F=24.9$, $p<0.001$). Therefore, demographics and estimates of normal gait speed were summarized separately (Table 1) for the 2 gait speed measures of men and women within different age groups. The gait speeds varied considerably, ranging from a mean of 0.95 m/s for the usual speed of 80 to 85 year old women to 1.85 m/s for the maximum speed of 18 to 29 year old men.

Table 2 summarizes findings describing the reliability of the gait speed measurements. Repeated measures t-tests showed no significant difference between the test and retest speeds, but ICCs were only fair according to the standards suggested by Fleiss.¹⁶ Figure 3 shows BlandAltman plots illustrating the reliability of 4 meter usual and maximum speed. The MDCs were large- suggesting that 4 meter gait speed would have to increase 45% or more to conclude that a real change has taken place.

Discussion

This study presents normative reference values and estimates of reliability for gait speed measured over 4 meters after a static start. The values and estimates are provided for both usual and maximum speed tests.

Normative values for gait speed were available prior to our current investigation, but they were derived primarily from studies using dynamic starts and longer test distances.¹⁷ Dynamic starts, which allow for acceleration before timing begins, are associated with higher gait speeds than static starts.¹⁸ As might be expected then, the normative speeds reported herein are slower than those presented in a meta-analysis of studies employing a dynamic start.¹⁷ For example, mean usual gait speed for 70 to 79 year old men was 1.07 m/s in this study but 1.26 m/s in the aforementioned meta-analysis.

We are not aware of any studies purporting to provide normative data for 4 meter gait speed (static start) to which our results might be compared. However, at least two studies involving timing with a stopwatch report summary data for usual 4 meter gait speed for adults. Sustakoski et al reported a mean usual 4 meter gait speed of 0.97 m/s for 104 adults (mean age 77.2 years) able to “ambulate household distances independently.”¹⁸ Maggio et al, who allowed participants to use canes or walkers, described a mean 4 meter gait speed of 0.91 m/s for 69 men (mean age 79.0 years) and 0.78 m/s for 103 women (mean age 78.2 years).¹⁹ The mean 4 meter gait speed of 80 to 85 year old NIH Toolbox participants was relatively comparable, 0.97 m/s for 40 men (mean age 81.8 years) and 0.95 m/s for 42 women (mean age 81.9 years).

The relative reliability of gait speed over 4 meters has been reported in a few studies. However, the reliability was determined using measurements obtained: during a single test session (ICC = 0.72 – 0.93),^{20,21} using a dynamic start protocol (ICC = 0.87 – 0.93),²¹ from participants walking at a fast pace (ICC = 0.64),²² or from samples of individuals with specific pathologies such as chronic obstructive pulmonary disease (ICC = 0.97).²³ The absolute reliability (MDC₉₅ and MDC%₉₅) of 4 meter gait speed has been reported in one study,²¹ but that study involved a dynamic start protocol and data from a single test session. Consequently, neither the relative nor absolute reliability in this study can be interpreted in light of other published work. That noted, the reliability of measurements obtained in this study is disconcerting. The instructions for conducting the tests are explicit, so other issues must be responsible for the limited reliability. Instrumented testing¹⁹ may help to improve reliability, but it is not as practical as hand-timing.

Study limitations

Beyond issues addressed heretofore, this study had several limitations. First, all participants were residents of the United States; their performance may not generalize to residents of other countries or regions. Second, although the total sample of United States residents was ample, subgroup analysis (eg, by ethnicity) is not supported by the small numbers in some strata. Third, as we used a publically available database and were not present during testing we cannot vouch for the veracity of measurements.

Conclusions

Normative reference values provided herein may be helpful in interpreting measurements obtained from individuals. Their limited reliability, however, limits their usefulness in making judgments regarding change.

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List of Abbreviations:

ICC	intraclass correlation coefficient
MDC	minimal detectable change
NIH	National Institutes of Health

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Figure 1.
Flow chart illustrating how the final sample was realized

Figure 2. Histograms illustrating the distribution of 4 meter usual speed (left) and maximum speed (right)

Figure 3.
Bland-Altman plots illustrating the reliability of 4 meter usual speed (left) and maximum speed (right)

Summary of demographic and gait speed (m/s) performance of men and women 18–85 years

Table 1.

Strata	Age n (y)	Height (m)	Mass (kg)	Usual Gait Speed			Maximum Gait Speed		
				Mean(SD)	95% CI	Mean(SD)	95% CI	Mean(SD)	95% CI
Gender (age group [y]) n	Mean(SD)	Height (m)	Mean(SD)	Mean(SD)	95% CI	Mean(SD)	95% CI	Mean(SD)	95% CI
Men (18–29) 80	23.9(3.6)	1.79(0.08)	82.3(17.1)	1.18(0.20)	1.13–1.22	1.85(0.31)	1.78–1.92		
Men (30–39) 76	34.9(3.0)	1.76(0.06)	92.2(19.8)	1.21(0.21)	1.16–1.26	1.75(0.30)	1.68–1.82		
Men (40–49) 87	44.0(2.9)	1.75(0.07)	90.9(19.1)	1.21(0.24)	1.16–1.26	1.75(0.44)	1.66–1.85		
Men (50–59) 74	53.7(2.6)	1.78(0.08)	93.0(18.0)	1.16(0.20)	1.12–1.21	1.63(0.30)	1.56–1.70		
Men (60–69) 62	64.2(2.8)	1.76(0.08)	87.2(15.1)	1.16 (0.22)	1.10–1.22	1.67(0.37)	1.57–1.76		
Men (70–79) 61	73.8(2.9)	1.75(0.08)	87.2(17.0)	1.07(0.24)	1.01–1.14	1.57(0.42)	1.47–1.68		
Men (80–85) 40	81.8(1.8)	1.74(0.07)	78.3(12.1)	0.97(0.20)	0.90–1.03	1.39(0.33)	1.29–1.50		
Women (18–29) 179	25.4(3.0)	1.62(0.07)	72.9(19.9)	1.11(0.20)	1.09–1.14	1.57(0.29)	1.52–1.61		
Women (30–39) 223	34.2(2.9)	1.63(0.07)	76.6(20.2)	1.15(0.20)	1.12–1.18	1.66(0.35)	1.61–1.71		
Women (40–49) 153	43.9(2.9)	1.63(0.07)	78.3(19.9)	1.14(0.23)	1.10–1.18	1.64(0.35)	1.58–1.69		
Women (50–59) 100	53.6(2.7)	1.62(0.07)	75.4(16.4)	1.15(0.22)	1.10–1.19	1.60(0.29)	1.54–1.65		
Women (60–69) 82	63.7(2.7)	1.62(0.07)	75.9(18.2)	1.05(0.22)	1.04–1.02	1.51(0.43)	1.41–1.60		
Women (70–79) 61	73.2(2.7)	1.60(0.07)	75.1(18.2)	0.99(0.22)	0.94–1.05	1.29(0.28)	1.22–1.36		
Women (80–85) 42	81.9(1.5)	1.61(0.06)	69.7(10.4)	0.95(0.24)	0.88–1.02	1.28(0.24)	1.20–1.35		

Table 2.

Statistics summarizing the test-retest reliability of gait speed measurements

Speed	Test Mean (SD)	Retest Mean (SD)	T (p)	ICC (95% CI)	Standard Error	MDC _{95%}	MDC _{95%} %
Usual	1.11 (0.23)	1.15 (0.22)	1.893 (0.061)	0.406 (0.270–0.526)	0.18	0.50	45.0
Maximum	1.59 (0.36)	1.59 (0.36)	0.109 (0.914)	0.461 (0.331–0.573)	0.26	0.72	45.3

Abbreviations: T = t-test, p = p-value, ICC = intraclass correlation, MDC = minimal detectable change