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Comfortable and maximum walking speed of adults aged 20–79 years: reference values and determinants

Richard W. Bohannon

School of Allied Health, U-101, University of Connecticut, Storrs, CT 06269, USA and Department of Rehabilitation, Hartford Hospital, Hartford, CT, USA. Fax (+1) 860 233 0609

Abstract

Objectives: to establish reference values for both comfortable and maximum gait speed and to describe the reliability of the gait speed measures and the correlation of selected variables with them.
Design: descriptive and cross-sectional.
Methods: subjects were 230 healthy volunteers. Gait was timed over a 7.62 m expanse of floor. Actual and height normalized speed were determined. Lower extremity muscle strength was measured with a hand-held dynamometer.
Results: mean comfortable gait speed ranged from 127.2 cm/s for women in their seventies to 146.2 cm/s for men in their forties. Mean maximum gait speed ranged from 174.9 cm/s for women in their seventies to 253.3 cm/s for men in their twenties. Both gait speed measures were reliable (coefficients $\geqslant 0.903$) and correlated significantly with age ($r \geqslant -0.210$), height ($r \geqslant 0.220$) and the strengths of four measured lower extremity muscle actions ($r = 0.190$-0.500). The muscle action strengths most strongly correlated with gait speed were nondominant hip abduction (comfortable speed) and knee extension (maximum speed).
Conclusions: these normative values should give clinicians a reference against which patient performance can be compared in a variety of settings. Gait speed can be expected to be reduced in individuals of greater age and of lesser height and lower extremity muscle strength.

Keywords: *gait, measurement, muscle strength*

Introduction

For most individuals, independent functioning in the community presupposes the ability to walk. It should not be surprising, therefore, that surveys of patients or the families of patients participating in rehabilitation show them to consider walking as a high priority [1-3]. Although there are many aspects of walking on which the clinician might focus, speed has often been recommended for use as a measure of status and outcome [3-6]. Given the objectivity of speed and its importance to safe ambulation in the community [7-9], such a recommendation is understandable. If the clinician is to make judgements about the normality of a patient's speed, reference values are required for comparison. Some reference values have been published [10-15]. The applicability of available values, however, may be limited for reasons outlined recently [15]. The primary purpose of this study was to provide reference values for comfortable and maximum gait speed for individuals of 20-79 years of age. I have also assessed the intra-session reliability of the gait speed measures and determined the correlation of selected variables with the gait speed measures.

Materials and methods

Following the provision of written informed consent, 230 apparently healthy individuals between 20 and 79 years of age participated in this descriptive, cross-sectional study. Prior to testing, all subjects claimed no known neuromuscular, musculoskeletal, or cardiovascular pathology affecting their ambulatory capacity and were able to walk at least 30 m without assistance or the use of a device. The age, sex, height and weight of each subject was documented (Table 1). Subjects self-rated their work and leisure activity using the four-level ordinal scale (1-4) of Saltin and Grimby [16]. The modal and median level of activity for the subjects was 2.

Table 1. Characteristics of subjects, sorted by decade of age and sex

Decade	Sex (n)	Age (years) X	Age (years) s	Weight (kg) X	Weight (kg) s	Height (cm) X	Height (cm) s
20s	F (22)	22.2	2.3	59.0	6.5	164.3	6.6
	M (15)	23.9	3.2	80.7	9.4	177.0	6.8
30s	F (23)	35.1	2.7	66.4	18.9	164.0	7.4
	M (13)	34.2	2.9	80.4	13.1	176.0	5.5
40s	F (21)	44.1	2.6	63.2	13.2	162.9	8.1
	M (22)	44.9	2.6	86.2	13.5	175.3	7.3
50s	F (21)	53.8	2.8	64.5	11.4	161.8	5.2
	M (22)	54.9	3.1	87.2	14.3	175.3	7.6
60s	F (18)	64.8	3.0	63.4	9.7	160.4	5.1
	M (18)	66.2	2.8	81.1	9.8	174.9	5.4
70s	F (20)	73.1	3.1	59.3	8.6	157.6	4.8
	M (22)	73.0	2.8	77.3	9.1	174.4	5.5

F, female; M, male; X, mean; s, standard deviation.

A digital stopwatch was used to time subjects as they walked over a 7.62 m (25 foot) expanse of floor. Lower extremity muscle strength was measured with an Ametek Accuforce Force Gauge (Ametek, Largo, FL, USA). The accuracy of the dynamometer was verified periodically by vertical loading with certified weights.

Comfortable and maximum gait speed were both measured twice. Subjects were provided with several meters to accelerate and decelerate before and after the test distance. For the comfortable speed walking trials they were instructed to walk at their normal comfortable (natural) speed. For the maximum speed walking trials they were asked to walk as fast as they could safely without running.

The isometric strength of four lower extremity muscle actions (hip flexion, hip abduction, knee extension and ankle dorsiflexion) was measured twice on each side by a single tester using a method described thoroughly elsewhere [17]. The four actions were measured in the middle portion of their range with gravity lessened or eliminated. The hip and ankle actions were tested with subjects supine; knee extension was tested with subjects sitting. As the reliability of the strength measures has been confirmed elsewhere [17], only the peak force (in Newtons) of the first trial was used to characterize the strength of each muscle action.

The Systat statistical program was used to perform descriptive and inferential analyses [18]. Intraclass correlation coefficients (equation 3,1) were used to test the intra-session reliability of the gait speed measures. Determinants of gait speed were examined using Pearson product moment correlations, Spearman correlations and multiple regression as appropriate. A multifactorial mixed model analysis of variance was also used.

Table 2. Descriptive statistics summarizing hand-held dynamometer measurements of lower extremity muscle strength

Muscle action	Side	Force (N) X	Force (N) s	Range
Hip flexion	N	148.2	57.5	37.8-322.9
	D	150.4	55.8	36.0-336.0
Hip abduction	N	236.2	77.4	103.7-437.8
	D	241.3	75.0	77.4-473.5
Ankle dorsiflexion	N	271.9	80.7	95.6-533.6
	D	277.2	90.9	84.0-558.2
Knee extension	N	404.1	139.5	120.9-650.0
	D	408.9	137.9	117.1-650.0

N, nondominant; D, dominant; X, mean; s, standard deviation.

Results

The gait speed measures were found to be highly reliable. The coefficients were 0.903 and 0.910 for comfortable and maximum speed, respectively. Consequently, the results of the first trials are used exclusively in all subsequent analysis. A summary of the lower extremity muscle strength measurements is presented by action and side in Table 2.

Correlational analysis (Table 3) showed age, height and all muscle action strengths to correlate significantly ($P < 0.05$) with both comfortable ($r = 0.190$-0.251) and maximum ($r = 0.292$-0.558) gait speed. For maximum gait speed, sex also was correlated significantly ($r = 0.161$). Neither leisure activity nor work activity correlated significantly with either gait speed measure ($r_s = -0.076$-0.109). Regression

Table 3. Pearson correlations between gait speed and independent variables ($n = 230$)

Independent variable	Gait speed: Comfortable r	Comfortable (P)	Maximum r	Maximum (P)
Sex	0.079	(0.236)	0.161	(0.014)
Age	-0.210	(0.001)	-0.558	(0.000)
Weight	0.070	(0.289)	0.089	(0.181)
Height	0.220	(0.001)	0.324	(0.000)
Ankle dorsiflexion strength				
N	0.202	(0.002)	0.406	(0.000)
D	0.214	(0.001)	0.363	(0.000)
Knee extension strength				
N	0.248	(0.000)	0.500	(0.000)
D	0.250	(0.000)	0.495	(0.000)
Hip flexion strength				
N	0.221	(0.001)	0.352	(0.000)
D	0.190	(0.004)	0.381	(0.000)
Hip abduction strength				
N	0.251	(0.000)	0.295	(0.000)
D	0.203	(0.002)	0.292	(0.000)

N, nondominant side; D, dominant side.

Table 4. Mean (X) and standard deviation (s) of comfortable and maximum gait speed presented by sex and decade of age

	Comfortable gait speed (cm/s)				Maximum gait speed (cm/s)			
	Actual		Height-normalized[a]		Actual		Height-normalized[a]	
Sex/decade	X	s	X	s	X	s	X	s
Men								
20s	139.3	15.3	0.788	0.093	253.3	29.1	1.431	0.162
30s	145.8	9.4	0.828	0.052	245.6	31.5	1.396	0.177
40s	146.2	16.4	0.829	0.090	246.2	36.3	1.395	0.197
50s	139.3	22.9	0.794	0.119	206.9	44.8	1.182	0.259
60s	135.9	20.5	0.777	0.116	193.3	36.4	1.104	0.198
70s	133.0	19.6	0.762	0.105	207.9	36.3	1.192	0.201
Women								
20s	140.7	17.5	0.856	0.098	246.7	25.3	1.502	0.142
30s	141.5	12.7	0.864	0.087	234.2	34.4	1.428	0.206
40s	139.1	15.8	0.856	0.098	212.3	27.5	1.304	0.160
50s	139.5	15.1	0.863	0.104	201.0	25.8	1.243	0.158
60s	129.6	21.3	0.808	0.131	177.4	25.4	1.107	0.157
70s	127.2	21.1	0.807	0.131	174.9	28.1	1.110	0.176

[a] actual speed (cm/s)/height (cm).

analysis demonstrated that weight, height, sex and nondominant hip abduction strength offered the best overall explanation of comfortable gait speed ($r = 0.360$, $r^2 = 0.129$). Regression analysis revealed that age, height, weight and nondominant knee extension strength provided the best overall explanation of maximum gait speed ($r = 0.643$, $r^2 = 0.414$).

Based on the results of the correlational and regression analysis, reference values for actual gait speed were determined for each sex and decade separately. Actual gait speed and height-normalized gait speed [actual speed (cm/s)/height (cm)] are summarized in Table 4. The mixed model analysis of variance showed a significant effect of condition (comfortable versus maximum) on speed ($F = 1736.99$, $P = 0.000$), a significant effect of decade of age on speed ($F = 16.639$, $P = 0.000$) and a significant interactive effect of condition and decade of age on speed ($F = 22.730$, $P = 0.000$). The interaction reflects the greater rate of decline in maximum speed gait compared with comfortable speed gait with increased decade of age. The interactive effects of gait measurement condition (comfortable *vs* maximum) and decade of age are illustrated in Figure 1.

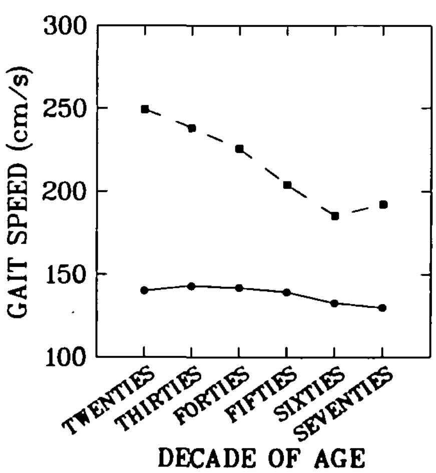

Figure 1. Mean maximum (broken line) and comfortable (solid line) gait speeds of 230 subjects presented by decade of age.

Discussion

The reference values for gait speed presented in this study are not the first published [10-15]. The values are, however, more comprehensive than most as they include both actual and height-normalized descriptions of both comfortable and maximum gait speed. Moreover, the values presented in this paper were obtained using procedures that are applicable in a variety of settings. Consequently, the performance of individuals tested in such settings, using the methods described herein, can be compared with the values presented in Table 4. The reliability of the gait speed measures of this study and the general comparability of the comfortable speed measures with previously reported measures [10-15] provide further support for the value of the reported measures. For most clinical applications the actual measures of gait speed reported in this paper are probably sufficient for reference. Given the relationship of height and gait speed and the established usefulness of height for reducing inter-individual variability in gait speed [19, 20], some clinicians may wish to determine an individual's height and use it to normalize gait speed before consulting reference values and making judgements about the normality of that individual's performance.

The identification of determinants of gait speed serves several purposes. One is to provide an appropriate framework for presenting reference values. The separate provision of reference values normalized against height is one example of such a use. Also relevant to this study is the presentation of values by sex and decade of age. The presentation of reference values for both the comfortable and maximum speed conditions is another.

Another reason for identifying determinants is to find variables which, if altered, may result in the alteration of another variable of interest. Although correlations do not prove cause and effect, they do provide an explanation of patient performance and indicate targets for potentially fruitful interventions. In this study, as in several studies of apparently healthy individuals previously published [10,11,15], muscle strength measures represent such variables. Not only did all measured muscle action strengths correlate significantly with both gait speeds, but the strength of a specific action added significantly to the explanation of gait speed offered by other non-strength variables. Consequently, strength does not appear to be a mere spurious covariate. This fact notwithstanding, no single muscle action strength explained more than 25% of the variance in gait speed. Consequently, muscle strength should not receive an excessive emphasis if the intention of a therapeutic intervention is to increase gait speed. The higher correlations between muscle strength and gait speed among patients with weakness [21-23] and evidence that strengthening regimens are sometimes accompanied by increases in gait speed [24, 25], on the other hand, suggest that the importance of muscle strength should not be disregarded.

Conclusion

Reference values for both comfortable and maximum gait speed are presented which clinicians can use as a basis for judgements about patient performance. Age, height and lower extremity muscle strength were correlated significantly with both comfortable and maximum speed but the influence of the variables on maximum speed was greater. These correlations have relevance to the interpretation of gait speed measurements and the selection of potentially fruitful targets for therapeutic interventions.

Key points

- Gait speed measures obtained during a single test session are reliable.
- Gait speed decreases with increased age.
- Maximum gait speed declines more steeply than comfortable gait speed with increasing age.
- Absolute and height normalized gait speed values provided herein can serve as a basis for judgements about patient walking performance.

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Daisy Hansen, age 92 with her wedding photographs. Photograph: Ian Beesley.