Published in final edited form as:

Physiotherapy. 2017 December ; 103(4): 387–391. doi:10.1016/j.physio.2017.03.006.

Functional Reach of Older Adults: Normative Reference Values Based on New and Published Data

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Abstract

Objectives—To provide normative reference values for the standing functional reach test for older adults.

Design—Observational study and meta-analysis of data from published studies

Setting—Clinical Research Center

Participants—Older adults:199 hypertensive from INFINITY study and 7535 from consolidation of INFINITY and 20 other studies.

Main outcome measure—Functional reach

Results—The mean (standard deviation) for functional reach for the hypertensive older adults was 27.5 (7.2) cm. For the consolidated sample of older adults, a random effects model determined a weighted mean (standard error) functional reach of 27.2 (0.9) cm with a 95% confidence interval of 25.5 – 28.9 cm.

Conclusion—Pending the availability of data from a large population-based study, the summary data presented herein can serve as a reasonable estimate of normal functional reach for older adults.

Keywords

postural balance; testing; measurement; activity limitation

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Conflict of interest statement: The authors claim no conflicts of interest based on financial or personal relationships relevant to the work.

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Introduction

Standing balance is essential for the safe and effective performance of everyday activities. The Functional Reach Test (FRT), first described in the early 1990s [1-3], is one of many tests of standing balance used with older adults and adults with various pathologies and medical conditions. It has been incorporated, with modification, into several balance test batteries [4,5]. There is evidence for its reliability [1] and its concurrent [2] predictive [6] and known groups [1,7] validity among older adults. However, there are only two publications purporting to provide normative reference values for the test; one, an original study focused on Australian women [7], the other, a meta-analysis of Japanese studies [8]. Given the importance of reference values for interpreting clinical observations and the limited scope of reference values already available for the FRT, we undertook this study of older adults to provide reference values for the FRT. To do this we used original raw data from an ongoing study as well as summary data retrieved from previously published studies.

2. Methods

Participants

This study involved the secondary analysis of original raw baseline data from outpatients residing in the northeastern United States and enrolled in the INFINITY project. The project, approved by the xxxxxxxxxxxxxxxxxxxxxxx Institutional Review Board in 2011 (Clinical trials identifier NCT01650402), is an ongoing study of the effects of blood pressure control on longitudinal alterations in white matter integrity, mobility, and cognition [9]. To qualify for the INFINITY project individuals had to demonstrate systolic hypertension and white matter lesions. They were excluded if they had a Mini-mental Status score of less than 24, a Short Physical Performance Battery score of less than 9, or a history of stroke or other disease compromising their mobility.

Procedures

Basic demographic and anthropometric data were obtained from all participants enrolled in the INFINITY project. The FRT was one of one of 10 mobility tests performed thereafter by participants. The FRT required that participants stood in comfortable shoes adjacent to a wall on which a meter stick was fixed at the level of the acromion of the limb they preferred to use for reaching. They were instructed to lift their preferred limb (22 left, 177 right) to horizontal and reach as far as possible without stepping or touching the wall. Their elbow was extended, their forearm was in neutral pronation-supination, and their hand was open with the fingers extended. This allowed for the initial and maximal reach to be read from a meter stick off the end of the third finger. The measure was performed twice; the longer of the 2 reaches was used in this study.

A PubMed search using the phrase “functional reach” and hand-searches were used to identify articles that might provide summary data for standing functional reach performed by community-dwelling older adults. Studies were excluded if they focused on individuals with a pathology likely to affect functional reach (eg, Parkinson's disease) or if they did not

provide a mean and standard deviation for functional reach. Summary reach data from a study were extracted only if determined from a sample of at least 30 individuals.

Statistical Analysis

The SPSS (18.0) was used to calculate descriptive statistics for demographic, anthropometric, and FRT measures from the original INFINITY sample. Thereafter, FRT summary statistics (mean, standard deviation, and n) from the INFINITY study and 20 other studies identified by the PubMed and hand searches [2,3,6,7,10-25] were consolidated using Comprehensive Meta Analysis (3.0). A random effects model was used.

Results

All together 199 participants were enrolled in the INFINITY study- 91 men and 108 women. By self-description, 183 were Caucasian, 13 were black, and 3 were Asian. Additional demographic and anthropometric variables are summarized in Table 1.

The overall mean (SD) FRT distance in the INFINITY study was 27.5 (7.2) cm. In combination, the INFINITY study and 20 other studies (Table 2) contributed 29 FRT summary data sets from 7535 older adults. The weighted mean (standard error) for FRT distance derived from all of the studies was 27.2 (0.9) cm. The 95% confidence interval was 25.5 to 28.9 cm. The I^2 associated with the analysis was 6.1%. Table 3 presents percentile values for functional reach distances obtained in the INFINITY study and studies consolidated using meta-analysis.

Discussion

The purpose of this study was to provide an estimate of normal for the FRT. We provide summary values for a large sample of older adults with systolic hypertension as well as an estimate derived from a consolidation of studies of mostly community-dwelling older adults. These summary values include means, standard deviations, confidence intervals, and percentiles. Although the mean FRT distance of individual studies varied considerably (17.8 to 36.8 cm), the mean for the hypertensive participants in the INFINITY study (27.5 cm) was very similar to the weighted mean for the consolidated studies (27.2 cm). Both, however, are less than the weighted mean reported by Kamide et al for older Japanese adults (29.4 cm). The confidence interval around the weighted mean for the consolidated studies is quite narrow (25.5 to 28.9 cm). We believe, therefore, that the weighted mean, confidence intervals, and percentiles we derived through consolidation should provide a better guide than individual studies for clinicians seeking to interpret patient performance on the FRT. The low I^2 value associated with the consolidation suggests that most of the variance in FRT distance between studies was the result of chance and that the studies were homogeneous. Sensitivity analysis through the elimination of data from individual studies did not result in a further solidification of homogeneity.

This study has several limitations. One limitation is that our search was not comprehensive. Only the PubMed database was used. We, therefore, may have missed studies with relevant FRT data. Other limitations relate to the samples tested and procedures used. The INFINITY

study sample included only hypertensive older adults with white matter lesions. We did not consider this to be a problem as both hypertension and white matter lesions are prevalent among older adults [26,27]. Other study samples contributing data to our estimation of FRT norms were of multiple nationalities- which may differ in stature and other structural characteristics. The samples also varied in age- means ranged from 69.0 to 82.0 years and gender composition. Factors such as these can affect FRT distance [1,8] but could not be addressed given the manner of data presentation in consolidated articles. Several studies contributing data to our consolidation included small proportions of rest home or long-term care residents [13,14]; their performance on the FRT may be less than that of individuals who live completely independently. Several studies also contributed data for known fallers [3,10]. As falls are a common occurrence among older adults, we did not deem it appropriate to exclude data from individuals who had fallen.

The procedures used to measure functional reach in consolidated studies varied in regard to the limb used for reaching (eg, right, dominant, or preferred). The procedures also differed in terms of reaching instructions. In their original description of the FRT, Duncan et al indicated that “no attempt was made to control the subjects' methods of reach [1].” Some other investigators followed their example [14], whereas others asked that participants keep their “feet flat the floor [7,19].”

Conclusion

Herein we provide normative estimates for functional reach based on the findings of an ongoing study and the consolidation of data from 20 other studies. The estimate from the consolidated studies (27.2, 25.5-28.9 cm) provides a reasonable standard for interpreting FRT performance by community-dwelling older adults.

Acknowledgments

This work was supported by National Institutes of Health R01AG022092 and R01DA024667, and The Lowell P Weicker, Jr. Clinical Research Center, XXXXXXXXXXXXXXXX

Funding: This work was supported by National Institutes of Health R01AG022092 and R01DA024667, and The Lowell P Weicker, Jr. Clinical Research Center, University of Connecticut Health Center, Farmington, CT.

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Table 1
Demographic and functional reach data for a sample of 199 hypertensive older adults enrolled in the INFINITY study

Variable	All Mean (SD) min-max	Men Mean (SD) min-max	Women Mean (SD) min-max
Age (yr)	80.6 (4.1) 75-97	80.9 (4.3) 75.0-97.0	80.3 (3.9) 75-93
Height (cm)	166.0 (10.0) 141.0-191.0	173.4 (6.8) 152.0-191.0	159.9 (7.3) 141.0-179.0
Weight (kg)	76.7 (17.5) 39.0-141.1	86.4 (15.4) 49.9-121.6	68.6 (14.9) 39.0-141.1
BMI (kg/m ²)	27.9 (4.9) 18.0-46.0	28.7 (4.5) 19.0-42.0	27.1 (5.2) 18.0-46.0
Functional reach (cm)	27.5 (7.2) 10.6-47.0	29.3 (7.5) 10.6-47.0	26.1 (6.5) 11.0-39.6

Table 2

Summary of 20 studies contributing functional reach data to a meta-analysis including INFINITY data.

Article	Sample	Functional Reach *
Weiner et al (1992) ²	American: Community-dwelling (convenience) 45 adults: age 78.0 (8.4) yr	Limb: not stated 27.7 (7.9)
Duncan et al (1992) ³	American: Community-dwelling (convenience) 161 men (no falls): age 74.1(4.7) yr ; 56 men (1fall) : age 77.4(7.3) yr	Limb: dominant No falls = 25.9 (10.9) 1fall = 19.8 (11.9)
Idland et al (2013) ⁶	Norwegian: Home-dwelling (random) 300 women: age 80.9(4.1) yr	Limb: dominant 26.1(6.9)
Isles et al (2004) ⁷	Australian: Community-dwelling (random) 90 women: age 60-69 yr ; 91 women: age 70-79 yr	Limb: right Age 60-69 = 36.8(5.0) Age 70-79 = 34.1(5.1)
Brauer et al (2000) ¹⁰	Australian: Community-dwelling (convenience) 65 women (no falls): age 72.3(0.6) yr ; 35 women (1 fall): age 74.1(1.1) yr	Limb: right No falls = 29.6 (6.5) 1fall = 29.1 (7.7)
Aoyagi et al (2009) ¹¹	Japanese: Community-dwelling (convenience) 170 adults: age 72.6(4.6) yr	Limb: not stated 35.0 (5.0)
Russell et al (2008) ¹²	Australian: Community-dwelling fallers (convenience) 344 adults: age 75.9(8.5) yr	Limb: not stated 22.7 (10.3)
Aslan et al (2008) ¹³	Turkish: Rest-home (6.9%) or own home-dwelling (convenience) 115 adults: age 69.1(3.8) yr	Limb: not stated 17.8 (7.1)
Rockwood et al (2000) ¹⁴	Canadian: Long-term care (14.0%) or community-dwelling (representative) 2305 adults: age 78.1 (69-104) yr	Limb: not stated 27.0(12.0)
Daubney & Culham (1999) ¹⁵	Canadian: Community-dwelling (convenience) 39 adults (no falls): age 75.3(6.3)yr	Limb: not stated 29.3 (8.1)
Davis et al (1998) ¹⁶	American of Japanese ancestry: Community-dwelling (random) 705 women: age 74(55-93) yr	Limb: not stated 30.9 (6.1)
Tomita et al (2015) ¹⁷	Japanese: Community-dwelling (convenience) 278 women: age 72.6(5.2) yr	Limb: not stated 24.4 (6.3)
Yamada et al (2011) ¹⁸	Japanese: Community-dwelling healthy (convenience) 77 adults (TUG 8.2s): age 73.9(6.6) yr; 76 adults (TUG 8.3-10.9s): age 79.1(7.0) yr; 78 adults (TUG 11.0s):age 82.0(6.9) yr	Limb: dominant TUG 8.2s =29.0(7.0) TUG8.3-10.9s = 26.5(6.7) TUG 11.0s= 21.3(7.1)
Norris & Medley (2011) ¹⁹	American: Community-dwelling healthy adults (convenience) 78 adults: age 81.7(5.9) yr	Limb: dominant 27.3 (6.5)
Wang et al (2011) ²⁰	Taiwanese: Community-dwelling adults (convenience) 120 adults: age 73.2(5.0) yr	Limb: not stated 31.2 (5.4)
Morita et al (2005) ²¹	Japanese: Community- dwelling (population-based) 402 women: age 69.0(5.8) yr	Limb: not stated 23.5 (6.7)
Aoyama et al (2011) ²²	Japanese: Community-dwelling (convenience) 58 women: age 80.5(5.7) yr	Limb: not stated 18.5 (8.2)
Kwon et al (2007) ²³	Japanese: Community-dwelling (convenience) 456 men: age 77.7 (4.0) yr; 638 women: age 77.8 (4.2) yr	Limb: not stated Men = 35.3 (5.4) Women = 32.7 (5.6)
Yamada & Ichihashi (2010) ²⁴	Japanese: Community-dwelling (convenience) 112 adults (nonfallers): age 81.4 (4.9) yr; 59 adults (fallers): age 79.5 (6.2) yr	Limb: not stated Nonfallers = 24.4 (5.7) Fallers = 24.5 (5.7)
Takahashi et al (2006) ²⁵	Japanese: Community-dwelling (convenience) 149 men: age 79.3 (5.4) yr; 234 women: age 78.1 (6.2) yr	Limb: not stated Men = 25.5 (9.8) Women = 24.5 (9.0)

* Reach distance is presented as mean (SD) in cm

Table 3
Normative percentiles values for forward reach from INFINITY Study and Consolidated Studies

Percentile	INFINITY	Consolidated
5	15.7	19.4
10	18.3	21.1
25	22.6	24.0
50	27.5	27.2
75	32.4	30.4
90	36.7	33.3
95	39.3	35.0