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Single Limb Stance Times

A Descriptive Meta-Analysis of Data From Individuals at Least 60 Years of Age

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This meta-analysis was conducted to derive normative reference values for single limb stance (SLS) with the eyes opened. The initial analysis involving 22 studies and 3484 participants (60–99 years) identified a mean SLS time of 15.7 seconds. As the studies did not provide homogeneous data, further analysis focused on 3 age groups (60–69, 70–79, and 80–99 years). Data from these individual age groups were homogeneous. Mean SLS times for the groups were 27.0, 17.2, and 8.5 seconds, respectively. These times and the lower limits of the confidence intervals associated with them offer useful estimates of normal SLS times to which the SLS times of tested individuals can be compared. **Key words:** *aging*, *balance*, *measurement*, *normative reference values*

TESTS AND MEASURES of balance are a fundamental component of clinicians' examination of patients with a variety of diseases and disorders.[1] Although there are numerous options for quantifying standing balance, the time an individual can stand on one lower limb (ie, single limb stance [SLS] or unipedal balance) has been used widely, either alone or as part of a larger test battery. Wolfson et al described *SLS time* as "one of the most challenging gauges of stability while standing on a narrow area of support" and averred it to be "the most frequently used measure of balance in physical training studies involving older adults."[2] The reliability of the test has not received much attention,[3–5] but its validity has been demonstrated by its relationship with other important variables such as gait performance,[6,7] fall status,[8,9] self-sufficiency in instrumental activities of daily living,[10,11] and frailty.[10,11] Several investigators have suggested 5 seconds as a criterion standard for SLS times.[9,11,12] Others have reported values for SLS times that were intended to be, or might be used as, normative reference values.[13–29] An examination of the studies reporting these times shows considerable variability in the measurement specifics reported as well as the times described. The purpose of this project therefore was to examine these studies and employ meta-analysis to better typify normal balance of elders as described by SLS times (with eyes opened).

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METHODS

The identification of relevant studies involved electronic searches of MEDLINE (1966–2005), CINAHL (1982–2005), and EMBASE (1995–2005). The searches were limited to works that involved human participants and were published in English. The

last search was conducted in July of 2005. The terms unipedal, one, single, leg, stand, stance, and balance were used in appropriate combinations in the searches. Articles with abstracts suggesting them to be relevant were retrieved. Reference lists of these articles were checked for other potentially relevant articles, which were in turn retrieved. All retrieved articles were examined for fulfillment of 2 inclusion criteria: reporting of means and standard deviations for SLS times (with eyes opened) and testing of participants who were aged 60 years and older. Studies and data were excluded if focused on individuals known to have balance-limiting pathologies (eg, stroke) or problems (eg, falling).

Retained articles were abstracted for information on participants, test specifics, and SLS times. Abstracted information was then tabulated and entered into a Statistical Package for the Social Sciences (SPSS) database. As multiple SLS times were sometimes reported for the same participants (eg, left and right, with and without shoes), only the best SLS time for any group (eg, 75–79 years, nondominant side, shoes on) was entered into the database.

All analyses were conducted via SPSS (Version 11.0) for Windows and the meta-analytic syntax for SPSS posted by Wilson.[30] Specifically used were a meta-analysis analog to the 1-way analysis of variance (METAF.SPS) and a descriptive meta-analysis (MEANES.SPS) for any type of effect size.

RESULTS

Twenty-two studies were included in the analysis (Table 1). Thirteen involved American participants, 2 involved Swedish participants, and 1 each involved Chinese, Polish, Japanese, Australian, Korean, and Greek participants. Data used were based on one (preferred/self-selected, dominant or nondominant side) or both lower limbs. Depending on the study, testing was performed with shoes on, off, or under both the conditions. The maximum time allowed for the test was often not stated. When stated however the most frequent time was 30 seconds (10 studies). Times of 60 seconds (3 studies) and 45 seconds (2 studies) were also stated. The number of trials was often not stated but ranged from 1 to 5 when indicated. In studies where more than a single trial was used, the measurement used was often not stipulated. When designated, it was either the best/maximum time or the average time.

Depending on the multiple factors, the criterion SLS times were variable (Table 1), but mean times ranged from 4.3 to 57.7 seconds. The results of the meta-analyses are presented in Table 2. Analysis using data from all 3484 participants of the 22 studies analyzed revealed a mean SLS time of 15.7 seconds for individuals aged between 60 and 99 years. The descriptive meta-analysis showed that the data of the different studies were not homogeneous ($Q = 95.41$, $P < .0001$). When data from the 13 studies whose 1867 participants could be divided into 3 age groups (60–69, 70–79, and 80–99 years) were compared using the analysis of variance, a significant between-group difference was noted ($Q = 12.44$, $P = .0020$). The overall mean for these data was 17.8 seconds. The data from the studies contributing to each individual age group were homogeneous ($Q = 1.46$–7.80, $P \geq .8562$). The mean times for the age groups were 27.0, 17.2, and 8.5 seconds, respectively.

DISCUSSION

The results of this meta-analysis provide an estimate of normal SLS times (with eyes opened) for healthy elders. Based as they are on the consolidation of data from multiple sources, the normative reference values are derived from a larger sample of elders than was tested in any one study. They therefore probably provide a more precise estimate than would be available otherwise.

The meta-analysis confirmed the well-established relationship between age and balance. That is, balance diminishes as age increases.[31] Consequently, it is best that

Table 1. Summary of studies reporting single leg stance times for apparently healthy elders*

Study	Participants	Test specifics	Times, s†
Wolinsky et al[3]	261 African American men and women (60–65 y)	Limb: self-selected Shoes: not stated Maximum time: 30 s Trials: not stated Measurement: not stated	**15.1 ± 11.6**
Iverson et al[18]	54 American men (60–90 y), noninstitutionalized, independent in ADL, walk without assistive device	Limb: both Shoes: on Maximum time: 30 s Trials: 3 Measurement: not stated	15.9 ± 11.5 (right, first) 16.9 ± 12.2 (left, first) 20.7 ± 10.5 (right, best) **21.9 ± 10.2 (left, best)**
Bohannon et al[13]	61 American men and women (60–79 y), no vertigo or neurologic or orthopaedic dysfunction of the trunk or lower extremities	Limb: both Shoes: off Maximum time: 30 s Trials: 5 Measurement: mean of best time for both limbs	**14.2 ± 9.3 (70–79 y)** **22.5 ± 8.6 (60–69 y)**
Lin et al[22]	765 Chinese men and women (≥65 y), no disability in ADL	Limb: either Shoes: not stated Maximum time: none Trials: not stated Measurement: not stated	**9.7 ± 12.7**
Jedrychowski et al[19]	559 Polish men (65–89 y), healthy, independent, and active lives, excluded if residents of homes for elderly and long-stay geriatric wards	Limb: both Shoes: not stated Maximum time: not stated Trials: not stated Measurement: mean of times for both limbs	**17.3 ± 17.9 (80–89 y)** **22.3 ± 24.8 (75–79 y)** **31.6 ± 36.9 (70–74 y)** **57.7 ± 58.0 (65–69 y)**
Briggs et al[4]	71 American women (60–86 y), healthy, independent in ADL, able to walk without assistive device, excluded if serious musculoskeletal or neurologic problems	Limb: both Shoes: off and on Maximum time: 45 s Trials: 3 Measurement: best time for each limb	9.7 ± 10.4 (75–79 y, dominant, shoes off) 10.2 ± 12.2 (80–86 y, nondominant, shoes on) 10.6 ± 11.3 (80–86 y, dominant, shoes on) 10.8 ± 11.8 (75–79 y, dominant, shoes on) 10.8 ± 12.9 (75–79 y, nondominant, shoes off) **12.0 ± 12.9 (75–79 y, nondominant, shoes on)** **12.3 ± 11.5 (80–86 y, dominant, shoes off)** 13.0 ± 13.9 (80–86 y, nondominant, shoes off) 18.6 ± 14.8 (70–74 y, dominant, shoes on) 19.6 ± 16.6 (70–74 y, nondominant, shoes on)

(*Continues*)

Table 1. Summary of studies reporting single leg stance times for apparently healthy elders* (*Continued*)

Study	Participants	Test specifics	Times, s†
			19.8 ± 18.0 (70–74 y, nondominant, shoes off) **20.1 ± 16.0 (70–74 y, dominant, shoes off)** 23.9 ± 18.6 (65–69 y, nondominant, shoes on) 23.9 ± 18.6 (65–69 y, nondominant, shoes on) 24.3 ± 16.8 (65–69 y, dominant, shoes on) 25.7 ± 18.6 (65–69 y, nondominant, shoes off) **28.3 ± 17.9 (65–69 y, dominant, shoes off)** 34.1 ± 14.0 (60–64 y, nondominant, shoes on) 37.8 ± 13.9 (60–64 y, nondominant, shoes off) 38.1 ± 13.0 (60–64 y, dominant, shoes off) **38.5 ± 11.6 (60–64 y, dominant, shoes on)**
Rudisill and Toole[24]	60 American men and women (60–79 y), most active in recreational or fitness activity	Limb: either Shoes: not stated Maximum time: not stated Trials: 3 Measurement: not stated	**11.1 ± 12.2 (70–79 y, women)** **14.5 ± 14.2 (70–79 y, men)** **17.1 ± 16.4 (60–69 y, men)** **20.5 ± 12.3 (60–69 y, women)**
MacRae et al[8]	94 American men and women (60–89 y), living independently in the community, walk without assistance	Limb: self-selected Shoes: bare feet Maximum time: 30 s Trials: 2 after 1 practice trial Measurement: best time	**17.2 ± 11.9**
Gehlsen et al[26]	30 American men and women (71.3 ± 4.4 y), no history of falls	Limb: not stated Shoes: not stated Maximum time: not stated Trials: not stated Measurement: not stated	**18.7 ± 10.1**
Kinugasa et al[6]	495 Japanese men and women (65–89 y)	Limb: preferred Shoes: not stated Maximum time: 60 s Trials: not stated Measurement: not stated	**38.6 ± 22.5**

(*Continues*)

Table 1. Summary of studies reporting single leg stance times for apparently healthy elders* (*Continued*)

Study	Participants	Test specifics	Times, s†
Hill et al[27]	96 Australian women (>70 y), community dwelling, independent in domestic ADL, walk without assistive device, regularly going outdoors, no falls in previous year	Limb: both Shoes: not stated Maximum time: 30 s Trials: not stated Measurement: not stated	9.2 ± 5.6 (80+ y, right) **11.4 ± 8.4 (80+ y, left)** 18.2 ± 10.2 (75–79 y, left) **18.7 ± 10.0 (75–79 y, right)** 19.8 ± 8.7 (70–74 y, left) **21.9 ± 8.3 (70–74 y, right)**
Kim et al[28]	253 Korean women (65–84 y), participants in adult education programs	Limb: preferred Shoes: not stated Maximum time: not stated Trials: 3 Measurement: not stated	**4.2 ± 4.5 (80–84 y)** **6.9 ± 9.7 (75–79 y)** **9.4 ± 10.2 (70–74 y)** **13.7 ± 14.8 (65–69 y)**
Wiksten et al[25]	26 American women (>60 y), healthy, nondisabled, excluded if had conditions that might limit balance or muscle performance	Limb: both Shoes: off (bare foot) Maximum time: 45 s Trials: 3 Measurement: best time of each limb	33.0 ± 14.4 (dominant) **33.3 ± 16.0 (nondominant)**
Netz and Argov[23]	252 Israeli men and women (60–89 y), independent, community dwelling	Limb: both Shoes: not stated Maximum time: 60 s Trials: 2 Measurement: best time of each limb	7.1 ± 13.3 (80–89 y, left) **7.7 ± 13.2 (80–89 y, right)** 16.0 ± 17.6 (70–79 y, left) **18.4 ± 19.5 (70–79 y, right)** 22.5 ± 20.6 (60–69 y, left) **26.4 ± 22.2 (60–69 y, right)**
Wolfson et al[2]	77 American men and women (≥75 y), excluded if unable to walk 8 m without assistance, diagnosed with neurologic disease affecting mobility, taking balance- or strength-impairing medications	Limb: not stated Shoes: off (bare foot) Maximum time: 30 s Trials: 2 Measurement: best time	**5.4 ± 0.9** **9.1 ± 2.3** **10.4 ± 2.5** **12.2 ± 2.7**
El-Kashlan et al[15]	30 American men and women (60–79 y), excluded if had vestibular or health problems contributing to disequilibrium	Limb: both Shoes: not stated Maximum time: 30 s Trials: 3 Measurement: mean of 3	17.5 ± 10.5 (70–79 y, left) **18.2 ± 10.0 (70–79 y, right)** 25.8 ± 6.2 (60–69 y, left) **27.1 ± 6.4 (60–69 y, right)**
Bulbulian and Hargan[14]	56 American men and women (60–80 y), no medical, pathological, or pharmacological factors affecting balance	Limb: dominant Shoes: on (gym) Maximum time: 60 s Trials: not stated Measurement: not stated	**42.8 ± 20.4 (60–69 y)** **35.6 ± 23.0 (70–79 y)**

(*Continues*)

Table 1. Summary of studies reporting single leg stance times for apparently healthy elders* (*Continued*)

Study	Participants	Test specifics	Times, s†
Greendale et al[16]	59 American men and women (>60 y), excluded if had pain limiting function or injurious falls, used assistive devices	Limb: not stated Shoes: not stated Maximum time: not stated Trials: not stated Measurement: not stated	**15.9 ± 1.5**
Gustafson et al[17]	17 Swedish men and women (73–80 y), healthy, active	Limb: both Shoes: off (bare foot) Maximum time: 30 s Trials: not stated Measurement: best	**20.9 ± 11.6**
Kronhed et al[21]	30 Swedish men and women (70–75 y), healthy, community dwelling, walked safely without aids	Limb: both Shoes: off (bare foot) Maximum time: 30 s Trials: 3 Measurement: best	12.0 ± 11.0 (right) 16.0 ± 12 (left) 20.0 ± 10.0 (left) **21.0 ± 10.0 (right)**
Kalapotharakos et al[20]	33 Greek men and women (60–74 y), inactive but without limitations in ADL	Limb: nondominant Shoes: off Maximum time: no limit Trials: 3 Measurement: best	**28.5 ± 10.0 (70–74 y, men)** **47.2 ± 18.5 (60–69 y, women)** **48.0 ± 15.0 (60–69 y, men)**
Lindsey et al[29]	105 American women (60–88 y)	Limb: both Shoes: not stated Maximum time: 30 s Trials: 1 after 1 practice trial Measurement: best	**28.1 ± 5.3 (60–69 y)** **16.6 ± 10.7 (70–79 y)** **16.8 ± 13.2 (80–89 y)**

*ADL indicates activities of daily living.
†Times used in meta-analysis are set in bold.

judgments as to the normality of SLS performance be based on the 3 age groups (60–69, 70–79, and 80–99 years) presented in Table 2. The age groups contain fewer participants, but their data are homogeneous and the lower limits of their confidence intervals do provide a standard below which an individual's performance can be considered less than normal.

Table 2. Summary of meta-analysis of single limb stance times*

Age category, y	Studies/groups (*n*)	Total sample (*N*)	Seconds balanced, mean (95% CI)	Homogeneity, *Q* (*P*)
60–99	22/49	3484	15.7 (12.6–18.7)	95.41 (.0001)
60–69, 70–79, 80–99	13/37	1867	17.8 (14.1–21.6)	12.44 (.0020)
60–69	11/14	851	27.0 (20.4–33.7)	7.80 (.8562)
70–79	12/17	870	17.2 (11.6–22.8)	4.91 (.9962)
80–99	6/6	146	8.5 (1.0–16.1)	1.46 (.9178)

*CI indicates confidence interval.

The standards for 60- to 69-year-olds (20.4 seconds) and 70- to 79-year-olds (11.6 seconds) surpass the 5-second test duration used by Vellas et al[9] and described as crucial by Jonsson et al.[12] The criterion standard for 80- to 99-year-olds (1.0 second) is less than 5 seconds.

This study had several limitations. First, the consolidated sample for the oldest age group (80–99 years) was not particularly large (n = 146). Second, many potentially relevant determinants of balance (other than age) could not be addressed. In some cases, information was not specified (eg, shoes on or off). In other cases, there were too few studies in which a condition was present to warrant subgroup analysis. Finally, the meta-analysis employed the best SLS performance data reported for the participants of an included study. Granting that some consistent rule for selection was necessary, selection of the best performance data may have resulted in higher SLS values (means and lower limit of confidence interval) than would have been obtained otherwise. Attenuating this possibility is the use of maximum times (eg, 30 seconds), which some individuals, particularly those who are younger, may be able to exceed. While the cessation of timing after a limited period adds to the practicality of the test, it also leads to a ceiling effect that can result in the underestimation of average performance.

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