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REFERENCE VALUES FOR THE FIVE-REPETITION SIT-TO-STAND TEST: A DESCRIPTIVE META-ANALYSIS OF DATA FROM ELDERS[1]

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Summary.—This meta-analysis was conducted to generate normative values for the 5-repetition sit-to-stand (STS) test suitable for application to individuals at least 60 years of age. A thorough review of the literature yielded 13 papers (14 studies) relevant to this purpose. After the exclusion of potentially unrepresentative data, meta-analysis of these 13 papers indicated that judgments about normal performance should be based on age. Analysis demonstrated that individuals with times for 5 repetitions of this test exceeding the following can be considered to have worse than average performance: 11.4 sec (60 to 69 years), 12.6 sec. (70 to 79 years), and 14.8 sec. (80 to 89 years).

There is a need for practical and functionally relevant measures of lower-limb strength. The sit-to-stand (STS) test is one such measure. Csuka and McCarty (1985) were perhaps the first to describe the test. Their version of the test involved the performance of 10 repetitions of the STS maneuver. Alternatives to the 10-repetition STS test have evolved, chief among them is the 5-repetition STS test (Guralnik, Simonsick, Ferrucci, Glynn, Berkman, Blazer, Scherr, & Wallace, 1994). The reliability of the 5-repetition STS test has been examined and reported to be adequate (intraclass correlation coefficients = .67–.94) (Fox, Flesenthal, Hebel, Zimmerman, & Magaziner, 1996; Jette, Jette, Ng, Plotkin, & Back, 1999; Ostchega, Harris, Hirsch, Parsons, Kington, & Katzoff, 2000; Schaubert & Bohannon, 2005). The validity of the STS test is supported by the correlation of STS performance with other relevant measures such as knee extension strength (Bohannon, 1998; Jones, Rickli, & Beam; 1999) and gait performance (Bohannon, Smith, Hull, Palmeri, & Barnhard, 1995). Although numerous investigators have described the performance of elders on the 5-repetition test, normative reference values (norms), have not been published (*per se*). Such values are necessary if the normality of an individual's performance is to be judged (Rothstein & Echternach, 1993). The purpose of this meta-analysis, therefore, was to consolidate published performance data and present normative values suitable for clinical application to individuals 60 years of age or older.

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Method

Electronic searches of the Medline (1966–2005), Cumulative Index of Nursing and Allied Health (1982–2005), EMBASE (1995–2005), and Science Citation Index (1994–2005) databases were conducted to identify articles written in English in which were reported performance data for the STS test. The terms "sit-to-stand" and "chair stand" were used in the searches. The titles and abstracts of articles identified by the searches were read and apparently relevant articles were obtained for further examination. Articles were retained for possible inclusion in the meta-analysis if they documented performance data for the 5-repetition version of the STS test for apparently well individuals 60 years of age or older. Articles were excluded if subjects were clearly abnormal, e.g., Women's Health and Aging Study (Guralnik, Fried, Simonsick, Kasper, & Lafferty, 1995), data could not be isolated for subjects 60 years or older, or data were known to duplicate (in whole or in part) those presented in another paper. Included articles were abstracted, and their reference lists were scanned for other potentially relevant articles. Such articles were obtained, examined, and abstracted as appropriate. Specifically abstracted were data on the subject sample, procedures, and performance. Where possible, performance data were divided by decade, e.g., 60 to 69 years, and sex. Authors were contacted as necessary and possible to assist with this breakdown when such was not provided outright. In studies reporting more than one value for STS performance, those obtained at baseline or on the first trial were used.

The Statistical Package for the Social Sciences (SPSS Version 11.0) was used to create a database suitable for the meta-analysis. The following variables were input from each relevant study: age range(s), sex, and the mean and standard deviation of the time (sec.) for five STS repetitions. The variance (standard deviation squared) of the STS times was then computed, followed by calculation of the inverse of the variance. The meanes.sps and metaf.sps macros provided by Wilson[2] were used to analyze the homogeneity of the data from the different studies and to calculate overall means and 95% confidence intervals for STS norms.

Results

The 13 papers (14 studies) included in the meta-analysis are summarized in Table 1 (Seeman, Charpentier, Berkman, Tinetti, Guralnik, Albert, Blazer, & Rowe, 1994; Greendale, Salem, Young, Damesyn, Marion, Wang, & Reuben, 2000; Aoyagi, Ross, Nevitt, Davis, Wasnich, Hayashi, & Takemoto, 2001; Schlicht, Camaione, & Owen, 2001; Lord, Murray, Chapman, Munro, & Tiedermann, 2002; De Rekeneire, Resnick, Schwartz, Shorr, Kuller,

[2]http://mason.gmu.edu/~dwilsonb/home.html.

Simonsick, Vellas, & Harris, 2003; Lusardi, Pellechhia, & Schulman, 2003; Murphy, Olson, Protas, & Overby, 2003; McCarthy, Horvat, Holtsberg, & Wisenbaker, 2004; Melzer, Lan, Tom, Deeg, & Guralnik, 2004; Henwood & Taaffe, 2005; Lindsey, Brownbill, Bohannon, & Ilich, 2005; Schaubert & Bohannon, 2005). The subjects in these studies were primarily American, but STS data from Japanese, Australian, and Dutch individuals were also reported. In most studies the chair used was not described in detail. Where designated, chair heights ranged from 43.0 to 47.0 cm. The timing of the 5-STS repetitions varied; some studies began timing with the command go, and others began with the initiation of the standing movement; some studies ceased timing on the completion of the fifth stand and others ceased when subjects returned to the seat after the fifth stand. All studies involved subjects standing without use of the upper limbs (usually described as folded across the chest), but two studies permitted subjects to use the upper limbs if they were otherwise unable to achieve standing. Most studies did not stipulate the speed at which subjects were instructed to perform the STS task; of the six in which this was done, five subjects completed the task as quickly as possible, and one subject performed the maneuver at his usual pace.

The times required for 5-STS repetitions were highly variable across studies and ages. Mean times ranged from 8.0 sec. for Japanese subjects 65 to 69 years to 21.2 sec. for American women 80 to 89 years. Meta-analysis of the times showed that they lacked homogeneity ($Q = 26177.5$, $p < .001$). Therefore, the analysis was rerun after excluding the Japanese and Japanese-American subjects of Aoyagi, *et al.* (2001), whose times appeared substantially faster than those of the other subjects of similar age, and the 60- to 69-yr.-old subjects of Murphy, *et al.* (2003), whose times appeared substantially slower than those of other subjects of similar age and who were found on more careful analysis to have numerous comorbidities. The reanalysis showed that data remained heterogeneous (Table 2). Therefore, studies with data that could be separated by decade were analyzed separately. The analysis (Table 2) showed a significant between-age group effect ($Q = 7789.2$, $p < .001$), but homogeneity within the 60- to 69-yr. group (M time = 11.4 sec.) and 80- to 89-yr. group (M time = 12.7 sec.). The times for the 70- to 79-yr. group ($M = 12.6$ sec.) remained heterogeneous ($Q = 1199.7$, $p < .001$). Separate analysis of the men and women within the age group (not reported) did not eliminate the heterogeneity.

Discussion

This meta-analysis provides an estimate for normal performance on the 5-repetition STS test. By coalescing the data from multiple studies, estimates based on a larger and more diverse sample is possible. The heterogeneity en-

TABLE 1
SUMMARY OF TIMES (SEC.) OF MALES AND FEMALES FOR COMPLETING FIVE SIT-TO-STANDS FROM 13 PAPERS (14 STUDIES)

Study	Subjects	Chair	Timing
Aoyagi, *et al.* (2001)	163 Japanese 650 Japanese-Americans 9342 Americans Females 65–85 yr.†	Standard	Time to stand up 5 times
De Rekeneire, *et al.* (2003)	2370 Americans Females & males 70–79 yr.†	Not stated	Not stated
Greendale, *et al.* (2002)	62 Americans Females and males ≥ 60 yr.‡	Not stated	Not stated
Henwood & Taafe (2005)	25 Australians Females and males 60–80 yr.‡	Hard-backed (43 cm)	Not stated
Lindsey, *et al.* (2005)	94 Americans Females 60–88 yr.‡	Not stated	Time from command "go" to buttocks contacting chair on fifth landing
Lord, *et al.* (2002)	669 Australians Females and males 75–93 yr.†	Armless (43 cm)	Not stated
Lusardi, *et al.* (2003)	75 Americans Females and males ≥ 60 yr.‡	Armchair	Time for 5 sit-to-stand-to-sit cycles
McCarthy, *et al.* (2004)	47 Americans Females 60–69 yr.‡	Standard padded armless (43.2 cm)	Time for 5 repeated chair stands
Melzer, *et al.* (2004)	1867 Dutch Females and males ≥ 60 yr.†	Straight-backed	Time from initial sitting to fully erect position at end of fifth stand
Melzer, *et al.* (2004)	4682 Americans Females and males ≥ 60 yr.†	Armless	Time from beginning of stand to completion of fifth stand (fully erect)
Murphy, *et al.* (2003)	32 Americans Females and males >60 yr. (nonfallers)‡	Standard	Time of 5 stand-to-sits
Schaubert & Bohannon (2005)	19 Americans Females and males 60–89 yr.‡	Straight-backed armless (48.3 cm)	Time from instruction "go" to return to sitting after fifth rise
Schlicht, *et al.* (2001)	24 Americans Females and males 61–87 yr.‡	Armless (47.0 cm)	Time from instruction "go" to return to seated position fifth time
Seeman, *et al.* (1994)	1192 Americans Females and males 70–79 yr.†	Not stated	Time to complete five chair stands

(continued on next page)

TABLE 1 (Cont'd)

Summary of Times (sec.) of Males and Females For Completing Five Sit-to-Stands From 13 Papers (14 Studies)

Performance	Time ($M \pm SD$)
Without arms if possible	8.0 ± 0.2 (65–69 yr., Japanese)*
	8.2 ± 0.2 (65–69 yr., Japanese-American)*
	11.4 ± 0.0 (65–69 yr., American)
	8.7 ± 0.3 (70–74 yr., Japanese)*
	8.5 ± 0.1 (70–74 yr., Japanese-American)*
	12.4 ± 0.0 (70–74 yr., American)
	9.5 ± 0.8 (75–79 yr., Japanese)*
	9.0 ± 0.1 (75–79 yr., Japanese-American)*
	13.2 ± 0.0 (75–79 yr., American)
	9.5 ± 1.2 (80–85 yr., Japanese)*
	9.9 ± 0.2 (80–92 yr., Japanese, American)*
	15.6 ± 0.0 (80–99 yr., American)
Not stated	14.2 ± 4.0
Not stated	14.1 ± 0.4
Arms folded across chest, as fast as possible	9.9 ± 1.6
	12.5 ± 2.9
Without hands, hands folded in front of chest	8.4 ± 2.1 (60–69 yr.)
	9.8 ± 3.9 (70–79 yr.)
	11.7 ± 1.2 (80–89 yr.)
Arms folded across chest, as fast as possible	12.1 ± 5.4 (75–79 yr., males)
	12.2 ± 4.1 (75–79 yr., females)
	12.9 ± 5.5 (80–84 yr., males)
	13.4 ± 5.6 (80–84 yr., females)
	13.7 ± 7.2 (85–89 yr., males)
	14.1 ± 6.5 (85–89 yr., females)
	17.2 ± 8.0 (90+ yr., males)
	15.1 ± 12.9 (90+ yr., females)
Without arm rests unless required	12.7 ± 1.8 (60–69 yr., females)
	11.6 ± 3.4 (70–79 yr., males)
	13.0 ± 4.8 (70–79 yr., females)
	16.7 ± 4.5 (80–89 yr., males)
	17.2 ± 5.5 (80–89 yr., females)
Arms crossed against chest, standing up (legs straight) and sitting down (full weight on chair)	11.3 ± 2.4
Without arms, as quickly as possible	12.7 ± 4.4
Without use of arms, arms folded across chest, at usual pace	14.2 ± 5.4
Arms folded across the chest	14.3 ± 2.6 (60–69 yr., males)
	19.8 ± 6.0 (60–69 yr., females)*
	15.0 ± 2.7 (70–79 yr., males)
	14.7 ± 2.6 (70–79 yr., females)
	21.2 ± 8.5 (80–89 yr., females)
Without arms, as fast as possible	9.0 ± 1.7 (60–69 yr.)
	13.7 ± 6.6 (70–79 yr.)
	17.7 ± 5.6 (80–89 yr.)
Arms across chest, as quickly as possible	9.9 ± 1.7
	9.2 ± 2.1
Without using arms	12.3 ± 2.9

†Population sample. ‡Convenience sample. *Excluded from meta-analysis.

countered in the meta-analysis suggests that all individuals of 60 or more years should not be considered together. The homogeneity of data from individuals in the 60- to 69-yr. and 80- to 89-yr. age groups supports their consolidation regardless of sex or test specifics. Although performance data of the 70–79 yr. age group remained heterogeneous, sex and test specifics (analysis not reported) did not provide an explanation. As the upper limits of the 95% confidence interval for performance of the 70- to 79-yr. group (12.6 sec.) fell between that of the younger (11.4 sec.) and older (14.8 sec.) groups, it may provide a rough estimate of normal performance.

TABLE 2
SUMMARY OF FINAL DESCRIPTIVE META-ANALYSIS OF SIT-TO-STAND TIMES*

Age (yr.)	*n*		Sit-to-Stand (sec.)		Homogeneity	*p*
	Studies/Groups	Total Sample	*M*	95% CI	*Q*	
60–99	14/37	20617	12.1	12.1–12.1	20972	<.001
60–69	6/6	4184	11.4	11.4–11.4	6.126	
70–79	8/12	8450	12.6	12.6–12.6	1199	<.001
80–89	6/10	344	12.7	10.7–14.8	4.012	

*Excludes some data from two studies (see Table 1).

The homogeneity of some data notwithstanding, the inconsistency in the procedures used for the 5-repetition STS test is disconcerting. Chair height, which is known to affect STS performance (Schenkman, Hughes, Samsa, & Studenski, 1996), was often not described or when described ranged from 43.0 to 47.0 cm. Granting that the chairs in diverse settings may differ, a minimal range of heights should be used for testing. A narrow range, e.g., 43.0 to 46.0 cm, is suggested as reflective of most standard chairs encountered in home and institutional settings. The 5-repetition STS test should definitely be performed without the use of the upper limbs as their use has a considerable influence on the ability to stand from sitting (Eriksrud & Bohannon, 2003). Further, as the 5-repetition STS test is used to quantify muscle performance, it follows that instructions should require that subjects perform the task as quickly as possible. As the intent is to quantify work against gravity, it makes sense to stop timing with completion of the fifth stand rather than with a return to sitting after the fifth stand.

As with all meta-analyses, this one has limitations. In spite of a thorough search, some studies may have been missed. Of the studies included, key determinants of performance may not have been available or were overlooked. The decision to exclude data from specific groups may not have been appropriate. Still, the summary provided acknowledges these facts. So the data presented provides more guidance in interpreting performance than was available before. Normative data obtained from a well defined, diverse, and stratified population based sample are still needed. The procedures used to obtain the data need to be well defined and controlled.

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