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A 30-s Chair-Stand Test as a Measure of Lower Body Strength in Community-Residing Older Adults

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Measuring lower body strength is critical in evaluating the functional performance of older adults. The purpose of this study was to assess the test-retest reliability and the criterion-related and construct validity of a 30-s chair stand as a measure of lower body strength in adults over the age of 60 years. Seventy-six community-dwelling older adults (M age = 70.5 years) volunteered to participate in the study, which involved performing two 30-s chair-stand tests and two maximum leg-press tests, each conducted on separate days 2–5 days apart. Test-retest intraclass correlations of .84 for men and .92 for women, utilizing one-way analysis of variance procedures appropriate for a single trial, together with a nonsignificant change in scores from Day 1 testing to Day 2, indicate that the 30-s chair stand has good stability reliability. A moderately high correlation between chair-stand performance and maximum weight-adjusted leg-press performance for both men and women (r = .78 and .71, respectively) supports the criterion-related validity of the chair stand as a measure of lower body strength. Construct (or discriminant) validity of the chair stand was demonstrated by the test's ability to detect differences between various age and physical activity level groups. As expected, chair-stand performance decreased significantly across age groups in decades—from the 60s to the 70s to the 80s (p < .01) and was significantly lower for low-active participants than for high-active participants (p < .0001). It was concluded that the 30-s chair stand provides a reasonably reliable and valid indicator of lower body strength in generally active, community-dwelling older adults.

Key words: aging, reliability, validity, functional performance

Maintaining lower extremity muscle integrity is important in preventing and delaying the onset of disability, physical frailty, and dependency in later years (Guralnik et al., 1994; Guralnik, Ferrucci, Simonsick, Salive, & Wallace 1995; Judge, Schechtman, Cress, & the FICSIT Group, 1996; Phillips & Haskell 1995; Stump, Clark, Johnson, & Wolinsky, 1997). An age-related decline in lower body strength, for example, is associated with the deterioration of such performance variables as gait, stair climbing, rising from a chair, and balance (Bassey et al., 1992; Bohannon, 1995; Brown, Sinacore & Host, 1995; Evans, 1995; Fiatarone et al., 1990; Judge, 1993; Newcomer, Krug, & Mahowald, 1993; Thapa, Gideon, Fought, Kormicki, & Ray, 1994) and is related to an increased risk for falls and hip fractures (Alexander, Schultz, & Warwick, 1991; Lord, McLean, & Stathers, 1992; Nelson, et al., 1994; Tinetti, Speechley, & Ginter, 1988; Whipple, Wolfson, & Amerman, 1987; Wolfson, Judge, Whipple, & King, 1995). Because of the significance of maintaining lower body strength during aging, its measurement is important in evaluating the functional status of individuals and identifying and treating those at risk for mobility problems and frailty.

A common method of assessing lower body strength in older adults within the community or the "field" setting is through use of a "chair stand" test protocol, which typically measures the time it takes to perform a given number of sit-to-stand repetitions, usually either 5 or 10 (Csuka & McCarty, 1985; Guralnik et al, 1994; Hoeymans, Wouters, Feskens, van den Bos, & Kromhout, 1997; Judge, Schechtman, Cress, & the FICSIT Group, 1996; Nevitt, Cummings, Kidd, & Black, 1989; Newcomer et al.,

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1993; Seeman et al., 1994). Studies indicate that chair-stand performance generally has good test-retest reliability (with R values in the mid .80s or greater) and reasonably good criterion-related validity relative to other measures of interest (e.g., knee extensor strength, stair-climbing ability, walking speed, and risk of falling; Bohannon, 1995; Csuka & McCarty, 1985).

Unfortunately, a common problem with chair-stand tests in many studies has been that the protocols were too difficult for much of the population of interest. One of the first published chair-stand protocols, for example, involved measuring the amount of time it takes for an individual to complete 10 full stands from a seated position without use of the arms (Csuka & McCarty, 1985). However, it has been found that a sizable number of older adults cannot complete 10 stands in a row and, therefore, cannot be evaluated on this test, resulting in what is known as a "floor effect." A floor effect is a measurement phenomenon that occurs when people cannot reach the minimum or the "floor" requirements of a test. As an example, a floor effect was observed even on a 5-stand version of the chair stand test in a recent study, when 22% of a population of over 5,000 community residents could not complete the required five repetitions (Guralnik et al., 1994).

With the goal of modifying the chair stand test to assess a greater proportion of the older adult population, we have experimented with using a standardized "time" protocol (30-sec) instead of a specified "number" of stands protocol (such as 5 stands or 10 stands). In the 30-s chair stand, the procedure involves recording the *number of stands* a person can complete in 30 s rather than the *amount of time* it takes to complete a pre-determined number of repetitions. Using the 30-s protocol, it is possible to assess wide variations in ability levels, with the possible scoring range being between zero (for those who cannot complete even one stand) to a high of 20 or more for highly fit individuals.

The purpose of this study was to determine the test-retest reliability of the 30-s chair stand as a measure of lower body strength in community-dwelling older adults and to test its validity by comparing chair-stand performance to a criterion measure of lower body strength—a 1-RM (repetition maximum) leg press that has been weight-adjusted (resistance/body weight). The leg press, a multiple-joint movement which involves hip extension, knee extension, and ankle plantar flexion, is considered an especially suitable criterion measure of lower body strength in older adults, because it reflects a number of daily life activities such as rising from a chair, getting out of a tub, and picking up an object from the floor (Judge, 1993). Also, to assess the construct (or discriminant) validity of the test, scores of individuals in different age and physical activity groups were compared. A test's ability to discriminate among various groups with expected differences in the construct of interest is considered an indication of the *construct* validity of a test (Morrow, Jackson, Disch, & Mood, 1995; Rikli & Jones, 1997).

Method

Participants

Seventy-six older adults (34 men and 42 women, M age = 70.5 years, SD = 5.5) were solicited from a university-based exercise program to participate in the study (approximately one third were new enrollees, and two thirds were ongoing participants in the program). All participants signed an informed consent and completed a written questionnaire requesting information about their background characteristics and health status. The protocol was approved by the University's Human Participants Review Committee. Eligible participants were over the age of 60 years, community-residing, functionally independent, ambulatory, and did not suffer lower extremity pain, unstable cardiovascular disease, or any other medical condition that would be contraindicated for maximal strength testing of the lower extremity according to American College of Sports Medicine guidelines (ACSM, 1995). Medical clearance was obtained for all participants in the study.

Procedure

Prior to all testing, participants were led in a standardized, 8-min warm-up and static stretch routine emphasizing the lower body. During the first 2 weeks of the study, they participated in one practice session to become familiar with the leg press apparatus, followed by 2 separate days of maximum (1 RM) strength testing, with each session scheduled 2–5 days apart. During the following week, the same participants were assessed on the 30-s chair stand on 2 different days, 2–5 days apart. (On both tests, approximately half the participants performed their second day of testing after a 2-day interval, and about half after a 5-day interval.) The 1 RM and 30-s chair-stand measures were conducted by two graduate students and two faculty who had participated in group training led by the study investigators. A pilot study, using a subsample of 15 participants, indicated that the interrater reliability for the 1 RM testing and for the 30-s chair-stand measures were .91 (95% CI = .81–.94) and .95 (95% CI = .84–.97), respectively. All testers were unaware of the scores participants had received on previous testing.

As an adjunct to the main part of the study, chair-stand scores of 190 male and female residents from a nearby retirement housing complex (M age = 76.2 years, SD = 6.7) were analyzed to determine the test's ability to detect age differences over three age groups—the 60s, 70s, and 80s, as well as differences in people with high and low levels of physical activity. Physical activity level was assessed through self-report, using a simple two-part questionnaire item which asked about exercise frequency and intensity level. The item was similar to that used in the College Alumnus Questionnaire (Paffenbarger, Blair, Lee, & Hyde, 1993). High-active people were those who indicated they participated in moderate physical activity at least three times a week—that is, activity strenuous enough to cause a noticeable increase in breathing, heart rate, and perspiration. Low-active individuals were those who either did not participate in moderate exercise or who participated less than three times a week. Global questionnaire items, such as the one used in this study, have been found to provide a reliable and valid way of classifying individuals into "high" and "low" physical activity categories (Ainsworth, Montoye, & Leon, 1994; Paffenbarger et al., 1993). The warm-up procedures and testing protocols followed in this adjunct phase of the study were the same as those in the main study. Participants were functionally independent, ambulatory without the use of assistive devices, free of lower extremity pain and medical conditions that would prohibit their performance, were primarily Caucasian (> 90%), primarily female (> 80%, with male-female proportions approximately equal across comparison groups), and generally were from above average socioeconomic backgrounds.

Measure

Keiser Leg Press. The Keiser leg press, involving pneumatic (air) resistance, was used to assess lower body strength. All participants received 1 day (approximately 30 min) of instruction and practice to become familiar with the equipment, followed 1 week later by two 1-RM tests, 2–5 days apart. Each testing session began with an instructor leading an 8-min general warm-up including stretching and five to six submaximal practice repetitions on the leg press equipment. On each of the 1-RM tests, incremental resistance was added until failure occurred, failure being defined as inability to perform the movement with proper form through the full range of motion without pain. All measurements were taken utilizing identical equipment positioning. Each repetition lasted 6 s, with 30–60 s of rest between repetitions. Most participants required no more than five repetitions to reach maximum strength. The best of the two trials (over the two testing days) was used as the criterion score for subsequent analyses. In a previous study, the 1-RM testing protocol used for this study was found to have high test-retest reliability (.98) (Rikli, Jones, Beam, Duncan, & Lamar, 1996). Leg press scores were recorded as relative strength scores (resistance applied divided by body weight) to be consistent with the variables involved in chair stand performance (strength and body weight) and as recommended by assessment authorities (ACSM, 1995; Heyward, 1998; Morrow et al., 1995).

30-s Chair Stand. The chair-stand test was administered using a folding chair without arms, with a seat height of 17 inches (43.2 cm). The chair, with rubber tips on the legs, was placed against a wall to prevent it from moving during the test. The test began with the participant seated in the middle of the chair, back straight, feet approximately shoulder-width apart and placed on the floor at an angle slightly back from the knees, with one foot slightly in front of the other to help maintain balance when standing. Arms were crossed at the wrists and held against the chest. At the signal "go," the participant rose to a full stand (body erect and straight) and then returned back to the initial seated position. The participants were encouraged to complete as many full stands as possible within a 30-s time limit. The participant was instructed to be fully seated between each stand. While monitoring the participant's performance to assure proper form, the tester silently counted the completion of each correct stand. Following a demonstration by the tester, a practice trial of one repetition was given to check proper form, followed by the 30-s test trial. The score was the total number of stands executed correctly within 30 s (more than halfway up at the end of 30-s counted as a full stand). Incorrectly executed stands were not counted.

Data Analysis

Test-retest reliability was estimated by calculating the intraclass correlation coefficient (R) utilizing one-way analysis of variance A(NOVA) procedures appropriate for a single trial (Baumgartner & Jackson, 1995). As suggested by Morrow and Jackson (1993), 95% confidence intervals were also calculated. Pearson correlation analysis was used to determine the relationship between the 30-s chair stand and the leg press, with 95% confidence intervals computed for each of the correlation r values. Separate one-way ANOVAs were used to compare chair-stand scores across the various age groups (60s, 70s, and 80s) and between individuals with high and low activity levels.

Results

All participants in the main phase of the study (34 men and 42 women, 95% Caucasian) were able to complete all testing. Participant characteristics are presented in Table 1. Test-retest means, standard deviations, intraclass R values, and 95% confidence intervals for the chair stand are presented in Table 2. The moderately high test-retest correlations for all participants and for men and women separately ($.84 < R < .92$), together with a nonsignificant change in scores from Day 1 testing to Day 2 ($p > .05$), indicates that the 30-s chair stand provides reliable and stable measurement data. Test score stability is especially important in intervention studies where stable baseline data are needed to make accurate statements about treatment effects or about the amount of change observed over time.

The moderate correlation between chair-stand and weight-adjusted leg-press performance for all participants (r = .77, 95% CI = .64 - .85) and the separate correlations for men (r = .78, 95% CI = .63–.88) and women (r = .71, 95% CI = .53–.84) support the criterion-related validity of the chair stand.

In addition, chair-stand scores collected on residents at a nearby retirement housing complex were analyzed to determine the test's ability to discriminate across various age groups and physical activity levels. Analysis of variance and follow-up Tukey comparisons, indicated significant declines in chair stand performance across each age group (p < .01). As seen in Table 3, the mean number of chair stands performed within a 30-s period declined in a linear fashion—in age groups from the 60s to the 70s to the 80s. Analysis of variance also indicated that high-active individuals scored significantly higher (p < .0001) on the chair stand test than low-active individuals (those who did not participate in moderate exercise or participated less than three times a week). Mean scores and ANOVA F values are presented in Table 3. To assist in interpreting the magnitude of the mean differences, *effect size* was calculated for all comparison groups. Effect size for the high versus low activity level means is .83, indicating a "large" effect (Thomas & Nelson, 1996). Effect sizes for the 60s to 70s and 70s to 80s age group comparisons were .38 and .30, respectively, suggesting that the differences generally would be described as being greater than "small" but less than "moderate."

All participants in both phases of the study were able to complete the 30-s chair stand, with scores ranging from a minimum of 2 to a maximum of 21 correct stands executed within the 30-s period. Scores indicate, therefore, that the 30-s chair stand has the capability of assessing a wider range of ability levels than chair-stand tests which require an established number of stands, such as 5 or 10. As mentioned earlier, 22% of a community-residing older adult population in one study was unable to rise from a chair the required five times (without use of arms) and, therefore, could not be scored on the test administered (Guralnik et al., 1994). In the present study, only 8.2% of the total number of participants could not complete as many as five stands.

Summary and Conclusion

Studies have shown that lower body strength is an important factor in maintaining functional ability in later years (Guralnik et al., 1994; Judge et al., 1996; Phillips & Haskell, 1995). Studies also suggest that chair-stand tests, in general, provide fairly reliable and valid indications of lower body strength and function (Bohannon, 1995; Csuka & McCarty, 1985). However, the most commonly used chair-stand protocols (the 5- and 10-stand tests) have been found to be too difficult for many older adults, with as much as 22% of the community-residing population in some cases unable to complete even 5 stands (Guralnik

Table 1. Means and standard deviations of participant characteristics and chair-stand and leg-press performance

Characteristics	Men (n = 34)		Women (n = 42)	
	M	*SD*	*M*	*SD*
Age (years)	72.6	6.6	69.1	5.1
Height (cm)	177.0	7.4	163.1	5.8
Weight (kg)	83.1	16.6	71.2	14.3
Chair stand*	13.7	3.2	12.7	3.6
Leg press**	3.2	1.8	2.4	.8

*Scores are number of chair stands in 30 s.
**Scores are reported as relative strength (resistance in pounds/body weight in pounds).

Table 2. Test-retest means, standard deviations, intraclass correlations (R), and 95% confidence intervals (CI) for chair stand

Participants	Test 1		Test 2		*R*	95% CI
	M	*SD*	*M*	*SD*		
			# of chair stand			
Total (n = 76)	13.1	3.4	13.4ᵃ	4.0	.89	.79–.93
Men (n = 34)	13.7	3.2	13.8ᵃ	3.8	.84	.77–.90
Women (n = 42)	12.7	3.5	13.0ᵃ	4.2	.92	.87–.95

ᵃAnalysis of variance revealed no significant differences between Test 1 and Test 2 scores (p > .05).

Table 3. Chair stand mean scores, standard deviations, and analysis of variance F values for age and activity groups

	n	*M*	*SD*	*df*	*F*	*p*
Age groups				2, 187	4.4	< .01
60–69 years	32	14.0	2.4			
70–79 years	96	12.9	3.0			
80–89 years	62	11.9	3.6			
Activity groups				1, 188	21.9	< .0001
High active	144	13.3	2.8			
Low active	46	10.8	3.6			

et al., 1994). Therefore, the purpose of this study was to assess the test-retest reliability and the validity of an alternative protocol, a 30-s chair-stand test. This test has the potential for measuring a wide range of ability levels, from those who can perform only one stand (or no stands) in the time allotted to those who can complete as many as 20 or more repetitions in 30 sec.

Results indicated that the 30-s chair stand has good test-retest reliability ($.84 < R < .92$), with R values as high or higher than those obtained for previously published protocols. Hoeymann et al. (1997) reported a test-retest reliability of .82 using a 5-stand protocol to evaluate 105 older men in the Netherlands. Also using the 5-stand test, Seeman et al. (1994) reported a test-retest reliability of .73 for the 70–79-year-olds in the MacArthur Successful Aging Studies. Using a 10-stand protocol, both Netz and Argov (1997) and Newcomer et al. (1993) reported test-retest R values of .88 on their older adult populations. A comparison of reliability estimates across studies, however, should be made with the realization that there often is considerable variation in study protocols. For example, in the above comparison studies, not only was there variation in the number of stands required (5 vs. 10), but there also was a wide range in the size of the participant population—from an n of 16 (Newcomer et al., 1993) to an n of 105 (Hoeymann et al., 1997). Further, the test-retest time intervals in the above studies ranged from 2 weeks (Seeman et al., 1994) to 10 weeks (Newcomer et al., 1993), with all intervals being considerably longer than the 2–5-day intervals in the present study. To our knowledge, there is no data suggesting the "ideal" time interval for reliability testing of strength measures. Patterns of delayed muscle soreness and fatigue have been studied relative to strength *training* but not for single bouts of strength *testing*. None of the participants in the present study nor in a previous strength assessment study involving 2–5-day test-retest intervals (Rikli et al., 1996), reported experiencing muscle soreness on the day of their retests.

Data in this study also indicate a moderate correlation between 30-s chair-stand performance and weight-adjusted 1-RM leg-press strength, with r values ranging from .71 to .78. Although few other studies have been specifically designed to assess the criterion-related validity of the chair stand, Csuka and McCarty (1985) suggested that the sit-to-stand scores of their participants correlated well with previously published data on knee flexor and extensor strength. Newcomer et al. (1993), in comparing chair stand performance with manual muscle testing of the knee extensors, reported considerably lower correlations (.47–.60) in a study involving older participants with a variety of chronic health conditions. However, the weaker correlations in the Newcomer et al. study may be due to the fact that the strength scores were not adjusted for body weight, a critical variable when assessing functional performance.

Other results in the present study showed significant declines ($p < .01$) in 30-s chair stand scores for people in their 60s, 70s, and 80s, thus supporting the construct validity of the test (i.e., its ability to detect differences where differences are expected to exist). Although the observed age-related decline in performance of only one chair stand per decade in this study may seem to lack practical significance (despite the statistical significance of the finding), similar results in other studies suggest that this pattern of decline may, in fact, be a fairly stable phenomenon. Similar declines in chair stand performance ($p < .001$) were observed for a 60-, 70-, and 80-year-old community-dwelling population in Israel (Netz & Argov, 1997). Also, a strong correlation (.88 for men and .71 for women) between chair-stand performance and age was reported in the Csuka and McCarty (1985) study.

Also supporting the discrimination ability of the test, superior chair-stand performance was found for *high-active* individuals in this study compared to *low-active* people ($p < .0001$). Although this finding primarily supports the ability of the chair stand to discriminate between fairly extreme groups of individuals (high active vs. low active), other evidence suggests that chair-stand performance is sensitive enough to also detect less dramatic differences, such as those associated with moderate, short-term treatment effects. In fact, Binder, Brown, Craft, Schechtman, and Birge (1994) found significant chair-stand improvement in their sample of only 16 community-dwelling adults, ages 66–97 years, following an 8-week low-to-moderate exercise training intervention.

In conclusion, results of this study suggest that the 30-s chair stand has good test-retest reliability and provides a reasonably valid indication of lower body strength in generally active, community-dwelling older adults. Also, the 30-s chair stand is capable of assessing a wider range of ability levels than chair-stand tests which require a prescribed number of repetitions (usually 5 or 10). Further, results suggest that the 30-s chair stand has good discrimination power, particularly with respect to detecting expected differences in age categories and in physical activity level groups. In summary, the 30-s chair stand provides researchers and practitioners with a simple and effective tool for assessing lower body strength and detecting muscle weakness in generally active, community-residing older adults.

Additionally, it may be of interest to note that the 30-s chair stand, as an indication of lower body strength, has been developed as part of a larger battery of "functional fitness" tests for older adults. Other items in the battery address upper body strength, aerobic endurance, lower and upper body flexibility, and motor ability. A nationwide study, involving over 7,000 participants in 21 different states, provides normative performance standards for all test items, including the chair stand. The complete test battery and results of the normative study are published elsewhere (Rikli & Jones, 1999a, 1999b).

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