Original Research

Normative Reference Values and Validity for the 30-Second Chair-Stand Test in Healthy Young Adults

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Background

Clinicians often use physical performance tests (PPT) to measure performance measures in sports since they are easy to administer, portable, and cost-efficient. However, PPT often lack good or known psychometric properties. Perhaps, the 30-second chair-stand test (30CST) would be a good functional test in athletic populations as it has been shown to demonstrate good psychometric properties in older adults.

Hypothesis/Purpose

The purpose of this study was to determine normative values for and concurrent, convergent and discriminative validity of 30CST for healthy young adults aged 19-35 years.

Study Design

Cross-sectional

Methods

Eighty-one participants completed this study. All participants performed two trials of 30CST, 5-times sit-to-stand (5xSTS), and lateral step-up test (LSUT). Investigators used the International Physical Activity Questionnaire Leisure Domain (LD-IPAQ) to divide participants into insufficiently or sufficiently active groups based on the weekly metabolic equivalent of task per the Physical Activity Guidelines for Americans.

Results

Participants (Mean + SD age, 25.1 ± 3.4 years; body height, 1.71 ± 0.09 m; body mass, 72.6 ± 16.1 kg; females 47) performed an average of 33.0±5.4 30CST repetitions. The 30CST performance was negatively associated with 5xSTS (r=-0.79 p=0.01) and positively associated with LSUT performances (r=0.51, p=0.01) when using Pearson correlations. In addition, the sufficiently active group performed significantly greater 30CST repetitions than the insufficiently active group (mean difference = 2.5; p=0.04).

Conclusions

In addition to finding a reference value for 30CST performance in young adults, investigators found that the 30CST displayed concurrent and convergent validity in assessing functional lower extremity (LE) muscle strength and discriminated between those with sufficient and insufficient physical activity levels. Training and rehabilitation professionals could use the 30CST for testing functional LE muscle strength for athletes

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in pre-season or during rehabilitation. Future investigators should perform studies to determine if 30CST predicts sport performance.

Level of Evidence

Level 2

INTRODUCTION

Greater lower extremity (LE) muscle strength associates highly with athletic performance skills such as jumping and changing directions.[1] Clinicians often use physical performance tests (PPT) to measure functional LE muscle strength, performance, during pre-season screenings, and for prediction of injury recovery or return to sport.[2,3] Clinicians use PPT because they are inexpensive, portable, and easy to administer.[4] However, all PPT measurement properties have not been studied extensively and their results should be interpreted with caution.[2,3,5] One functional test that has received little attention by researchers in young adults and particularly in those involved in sports is the 30-second chair-stand test (30CST). During the 30CST, the individual performs the sit-to-stand-to-sit maneuver without using their arms as many times as possible from a standardized height chair in 30 seconds. The investigators believe this test may be useful in assessing functional LE strength and performance in young adults since 30CST has good psychometric properties to measure functional LE strength in older adults,[6] and other sit-to-stand-tests (i.e., 5 Times Sit-to-Stand) has shown early promise as a lower extremity measure in young adults.[7] Specifically, the 30CST has good test-retest reliability[6,8,9] and criterion validity[6,8] in older adults. In addition, 30CST could discriminate older individuals of varying age groups based on physical activity levels.[6] Additionally, the importance of 30CST is evidenced by its inclusion in function and balance assessments in two well accepted balance evaluation programs designed for older adults: Stopping Elderly Accidents, Deaths & Injuries (STEADI) Algorithm by Center for Disease Control and Prevention (CDC)[10,11] and Otago programs championed by the CDC.[12]

In adults aged 20-59 years, McKay et al. demonstrated that the 30CST possesses criterion validity for LE muscle strength.[13] However, there is no data concerning the validity of the 30CST in young adults (18 to 35 years). The existing data may not be valid since muscle strength declines after the third to fourth decade of life.[14] Validity is important since this psychometric property assures a test can discriminate between individuals with and without certain characteristics, evaluate change across times, and predict future functional performances.[15] The investigators found nothing in the literature that examined whether the 30CST test could discriminate between younger adults who are physically fit from those who are not physically fit as has been shown previously in older adults.[6] In addition, a popular clinical test for assessing LE muscle strength is the Five Times Sit-to-Stand Test (5XSTS). Thus, the examination of 30CST with 5XSTS could inform the literature regarding concurrent and convergent validity of 30CST. Further credence that 30CST has good convergent validity would be if can be correlated with LE functional muscle strength tests such as the lateral step-up test (LSUT), since both of these tests use similar motor action. Thus, there is a critical need for establishing the validity of 30CST in young adults before using it in clinical populations such as those involved in sports and physical activity.

Another important aspect of any clinical test is the presence of normative data because normative data helps clinicians establish performance benchmarks, which allows them to track patient progress, determine prognosis, and set rehabilitation or training goals. Interestingly, normative data for 30CST among different age groups exist.[6,13,16] However, the investigators found several limitations such as a wide age ranges and the potential influence of physical fatigue[13] within the existing normative value data that might necessitate establishing young adults performance in 30CST. Thus, examination of the 30CST in young adults is warranted because it can provide reference data, which can be used to assess and compare functional LE strength and understand muscle performance in young adults involved in sports or physical activity.

Therefore, the primary aim of this study was to determine reference values of 30CST performance in young adults aged 18 to 35 years. Second, the investigators evaluated the concurrent and convergent validity of 30 CST by examining its relationship with the LSUT and 5XSTS in young adults. Finally, the investigators assessed the discriminant validity of the 30CST by comparing young adults who meet versus those who did not meet the Physical Activity Guidelines for Americans recommendations for physical activity.[17]

MATERIALS AND METHODS

PARTICIPANTS

The investigators recruited 81 healthy young adults for this cross-sectional study. The investigators found participants by posting fliers and word-of-mouth at a college campus. Participants were included in this study if they were between the ages of 18-35 years and ambulated independently. The investigators excluded potential participants from this study if they reported orthopedic, neurological, or cardiorespiratory conditions that affect exercise performance. During the consenting process, the investigators informed participants the benefits and risks of this study before individuals signed the consent form for this study. The University of Alabama at Birmingham Institutional Review Board approved this research protocol.

PROCEDURES

The data reported in this study are part of a larger study that investigated the interrelationships between PPT and neuromuscular performance (data not published). First, the investigators measured anthropometric measurements (body height, body mass, and body composition) and then participants performed balance tasks. Next, participants performed either jump task (outside the scope of aims of this study) or LE PPT randomly. Investigators randomized the order of the LE PPT: 30CST, 5-times sit-to-stand test (5xSTS), and lateral step-up test (LSUT). Participants performed two trials per test with a 60-second rest period between trials. For the LSUT, participants performed one trial of the standard test where they touch the ground with their full foot (standard LSUT), and another trial where they touched the ground with only their heel (modified LSUT). Participants completed the International Physical Activity Questionnaire-Long Format (IPAQ-LF). The investigators asked participants to complete this questionnaire during a 10-minute rest period between the LE PPT and balance tasks. Prior to collecting data, investigators practiced all tests and protocol prior to implementing the study. In addition to the pre-study training, one investigator, who was responsible for counting or timing all PPT in this study, has used these PPT in the clinic for over 30 years in his physical therapy practice.

ANTHROPOMETRIC MEASUREMENTS

The investigators measured body height (m) using a stadiometer (Charder HM200P Stadiometer, Taichung City, Taiwan) and body mass (kg) and body composition using a bioelectrical impedance analysis (BIA) machine (Tanita Body Composition Analyzer; TBF-300, Arlington Heights, Illinois, USA). The investigators derived body mass index (BMI) by dividing body mass (kg) by squared body height (m^2). Participants wore light clothes and removed their shoes and socks for all the anthropometric measurements.

THIRTY SECONDS CHAIR-TO-STAND TEST (30CST)

The investigators provided instructions, demonstration, and a10-second practice for each participant prior to testing. The investigators instructed the participants to stand up and sit down fully, using both lower extremities, after an investigator said, "go" and to perform as many cycles of sit-to-stand-to-sit as possible in 30 seconds. The investigators instructed participant to exert their maximum performance during the test. Participants started this test sitting in the middle of the chair, feet positioned on the floor, and arms crossed on an armless chair with a seat height of 45-cm positioned against a wall. One investigator blocked the chair from moving by placing one foot in front of the chair leg to maintain the back of the chair against the wall during the test. In addition, the same investigator guarded and encouraged the participant during the test. Another investigator counted the number of cycles and monitored the stopwatch. The same investigator counted/timed and recorded the number of repetitions for all measures throughout the study. At the end of 30-seconds, the investigator who was counting the number of cycles also determined if the participant completed more than half a cycle. If the participant did complete more than half a cycle at the end of the test, the investigators counted this incomplete cycle as one repetition.[16] Participants performed two trials with a 60-second rest period between trials. In addition, the investigators allowed a short rest period of 30 seconds between the familiarization trial and first trial for all the participants. Previous investigators have established that the 30CST is a reliable[6,8,9] and valid[6,8] test to measure LE strength in adults and older adults.

FIVE TIMES SIT-TO-STAND TEST (5XSTS)

The 5xSTS test is another PPT that examines functional LE strength.[7] Like the 30CST, participants performed sit-to-stand–to-sit (using bilateral lower extremities) from the same chair positioned against the wall, with the same investigator blocking the front of the chair leg and guarding the participant. Participants started in the same 30CST position on the chair. In addition, the investigators instructed participants to fully stand up and sit down five times as fast as they could. Time started when the same investigator, who monitored the time and counted the 30CST cycles started the stopwatch and said, "Go." This investigator stopped the stopwatch when the participant's buttock touched the chair for the fifth time. Participants rested for 60 seconds between two data collection trials. Participants also rested for 20-30 seconds between the practice and first data collection trial. Investigators have reported that this test to be reliable[7,18] and valid.[7]

LATERAL STEP-UP TEST (STANDARD AND MODIFIED LSUT)

The LSUT also assesses the functional LE strength of the single leg that remains on the step throughout the 15-second test period. Prior to instruction and demonstration of this test, the investigators determined the participant's dominant leg by asking the individual, "If I rolled a ball in front of you, which leg would you kick it with?" The investigators selected the non-dominant leg as the limb to be studied limb. Thus, the non-dominated leg remained on the 20-cm height step in this study. The investigators instructed the participant to fully touch the floor with their dominant foot but not bear weight and then return the same foot to the top of the step (standard LSUT). One repetition equaled one cycle of step-to-floor-to-step. Participants performed this test again after a 60-second rest but instead of touching the floor fully with their dominant foot, they touched the floor only with their heel (modified LSUT). Like the LSUT the modified LSUT tests unilaterally; the leg that remains on the step receives the score for the test. The investigators choose to perform this modification to determine if the inability to use the plantarflexors affect performance and association between this test and the other functional strength test assessed in this study. Participants performed several familiarization cycles of both the standard and modified LSUT with a 30-second rest break before the data collection trials. The same investigator kept time with a stopwatch and guarded the participant during this test. The other investigator counted the number of complete cycles while holding on the step for participant safety. The same investigator measured and recorded the outcomes for each test in this study. Investigators have also reported this test to be reliable[19] and valid[20] to assess motor function.

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE-LONG FORMAT (IPAQ-LF)

This questionnaire measures six different domains but for this part of the study, the investigators only used the leisure domain, as researchers have suggested the use of this domain in public health intervention and surveillance.[21] The investigators followed the IPAQ scoring guidelines and calculated MET-minute/week. Participants completed the paper/pencil survey between the balance measurements and PPT, which allowed participants to rest for 10 minutes. The investigators helped provide clarification of items if individuals inquired. The IPAQ is a reliable and valid questionnaire to assess physical activity levels over the past week.[22,23] For IPAQ-LF, the investigators chose 1000 MET-minutes/week as the cut-off score to categorize participants into two groups of sufficiently active and insufficiently active based on leisure time score of IPAQ-LF. The investigators selected this value since it is a number at the higher end of physical activity level recommendation by the Physical Activity Guidelines for Americans.[17] The investigators chose this value since the variability of this data was wide in this study and previous researchers found that self-report for physical activity is inconsistent.[24]

DATA AND STATISTICAL ANALYSIS

Statistical Package for the Social Sciences software (SPSS; IBM Corp., Armonk, NY) v27.0 was used for statistical analyses. Means and standard deviations were calculated to describe all data from this sample except for race and sex where frequencies and percentages were determined. All PPT displayed normal distributions when tested for skewness and kurtosis. Pearson correlations analyses were used to determine the associations between 30CST and the other three PPT: 5xSTS, standard LSUT, and modified LSUT. Correlation coefficients were interpreted as follows: weak (0.1 – 0.3), moderate (>0.3 to 0.5), or a strong correlation (>0.5).[25] Independent t-tests were used to determine if 30CST could discriminate those individuals who met physical activity guideline recommendations from those who did not meet these guidelines. Pearson correlations were also used to determine discriminant validity of 30CST and IPAQ-LF leisure's domain score. Intraclass coefficients were determined between PPT performance trials to ensure adequate rest was provided between repetitions of each PPT. Alpha levels less than 0.05 were used to determine statistical differences.

RESULTS

Eighty-one participants completed this study, with the majority of the sample being female (58.0%) and Caucasian (66.7%) (Table 1). Approximately 62% of the participants met the upper limit of the physical activity guidelines for physical activity. Participants' age ranged from 18 to 35 years ($\bar{x}$ ± SD = 25.1 ± 3.4 years) with an average normal BMI ($\bar{x}$ ± SD = 24.8 ± 4.6). However, those who were classified as insufficiently active (n = 31; men = 18; women = 13) in this study would be considered overweight (BMI, $\bar{x}$ ± SD = 25.9 ± 4.9).[26] The sufficiently active groups' average body mass was significantly lower while the IPAQ-LF leisure domain score and 30CST were significantly greater than the insufficiently active groups ($p < .05$).

On average, participants performed 33.0 ± 5.4 repetitions of 30CST. There was a significant negative and strong association between 30 CST and 5xSTS (r = -0.78, p = 0.01) indicating that those who scored greater scores of 30CST took less time to complete five repetitions of sit-to-stand-to-sit (Table 2). The 30CST showed significant positive and strong correlations with the standard LSUT (r = 0.51, p = 0.01) and a positive and moderate modified LSUT (r = 0.47, p = 0.01). In addition, the sufficiently active group performed significantly greater repetitions of 30CST those in the insufficiently active group: t (2,79) = 2.09 (p = 0.04). There was no significant association between the 30CST and IPAQ-LF leisure time score (p > 0.05). Finally, good to excellent intraclass coefficients found between PPT trials: 0.93 (95%CI = 0.89 – 0.94) for 30CST trials, 0.94 (95%CI = 0.90 – 0.96) for 5xSTS, and 0.79 (95%CI = 0.69 – 0.86) for LSUT.

DISCUSSION

The study findings provide reference values for 30CST with good concurrent, convergent and discriminate validity for healthy young adults aged 18 to 35 years and not formally participating in athletics. Specifically, the investigators found that young adults aged 18 to 35 years performed on average 33.0 repetitions (SD = 5.4 repetitions). Based on these results, the 30CST may be a good test to use in healthy adults especially since it could discriminate between those young adults sufficiently active and insufficiently active. This study results are different from those previously reported mainly because the previous investigators reported normative data across a wide age range including a mix of young and middle-aged adults or a mix of pediatric and young adults.[13]

A possible reason why 30CST repetitions were better in these subjects than the previously reported normative values,[13] is that the current investigators studied a well-defined age range (18-35 years) while the previous researchers studied different age groups, including individuals aged 20-59 years and 10-19 years.[13] These previously selected age ranges[13] likely contained individuals at either end of young adult age ranges who may possess large differences in muscle strength due to growing and aging processes that occur across the human lifespan. Muscle strength continuously increases through the first few decades of life with peak muscle strength occurring in the second or third decade of life.[14] Muscle strength starts to decrease in the fourth decade of life in both sexes[14,27] and could have metabolic implications.[28] Lower extremity strength is directly associated with 30CST in older adults.[6,8] Thus, we selected to study a group of individuals at a similar stage of muscle strength development which may explain the difference between the 30CST performances in this study compared to the reported by McKay and colleagues.[13]

The investigators minimized risk of fatigue by allowing the participants to rest between all study activities, which may be another factor explaining greater 30CST performance in this study. The previous normative study did not report a provision of rest interval between research activi-

Table 1. Clinical and Demographics Descriptive Statistics.

	Sufficiently Active (n = 50)	Insufficiently Active (n = 31)	p-values	Total
Age (years)	25.1 ± 3.3	24.8 ± 3.6	0.720	25.1 ± 3.4
Race, N (percent)	White 39 (78.0) Others 11 (22.0)	White 20 (64.5) Others 11 (35.5)	0.185	White 54 (66.7) Others 27 (33.3)
Sex, N (percent)	Males 16 (32.0) Females 34 (68.0)	Males 18 (58.1) Females 13 (41.9)	**NA**	Males 34 (42.0) Females 47 (58.0)
Body Mass (kg)	69.3 ± 14.6	77.7 ± 17.3	**0.021**	72.6 ± 16.1
Body Height (m)	1.7 ± 0.1	1.7 ± 0.9	0.122	1.7 ± 0.1
BMI (kg/m^2)	24.1 ± 4.3	25.9 ± 4.9	0.086	24.8 ± 4.6
IPAQ Leisure Domain (MET-minute/week)	2297.7 ± 1265.6	444.2 ± 325.1	**<0.001**	1588.3 ± 1357.4
30-CST (Repetitions)	34.0 ± 5.2	31.5 ± 5.5	**0.040**	33.0 ± 5.4
Five Times Sit-to-Stand (Seconds)	4.3 ± 0.6	4.5 ± 0.8	0.223	4.4 ± 0.7
Lateral Step-Down (Repetitions)	18.0 ± 2.1	18.1 ± 2.6	0.760	18.1 ± 2.3
Modified Lateral Step-Down (Repetitions)	15.2 ± 2.4	15.1 ± 3.1	0.881	15.2 ± 2.6

BMI: Body Mass Index; IPAQ: International Physical Activity Questionnaire; MET: Metabolic Equivalent of Tasks; 30-CST: 30-Second Chair-Stand Test.
Values are represented as means ± SD.

Table 2. Pearson Correlation Coefficients Among the Variables of Interest.

	30-Second Chair-Stand (Repetitions) Pearson Correlation/Partial Pearson Correlations#	IPAQ Leisure (MET –minute/week)	Body Mass (kg)	Body Height (m)
30-Second Chair-Stand (Repetitions)	-	0.110	0.086	**-0.261***
Five times sit-to-stand (Seconds)	**-0.778**/-0.762****	-0.129	0.039	**0.255***
Lateral Step-Down (Repetitions)	**0.512**/0.596****	0.039	0.032	0.200
Modified Lateral Step-Down (Repetitions)	**0.465**/.560****	0.164	-0.054	**0.234***

IPAQ: International Physical Activity Questionnaire
Controlling for body height
* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

ties.[13] In addition, they did not mention if they randomized the order of the PPT.[13] A previous systematic review has reported that fatigue, induced by LE exercise, affected PPT and balance performances including the speed and power of sit-to-stand-to-sit repetitions in older adults.[29] Furthermore, investigators reported that the quadriceps femoris muscle fatigue increased in young adult who performed greater repetitions of 30CST,[30] emphasizing the importance of rest interval between trials. Thus, the biasing effect of fatigue could have adversely affected the outcome measures based on the PPT order performed in the previously published normative values for individuals aged 10 to 19 years and 20 to 59 years.[13] Specifically, the researchers of previously published normative values of 30CST for adults used a comprehensive test battery of physical function such as the six minutes walking test, which may pose a fatiguing effect on 30CST if it followed multiple functional tests without rest breaks between tests. The investigators of the current study feel confident that they provided enough rest in this study due to the good to excellent intraclass coefficients found between PPT trials. Thus, one could infer that enough rest was allowed between and within PPT in this study. LSUT intraclass coefficient was not as strong as the sit-to-stand-to-sit but still good considering the modification the second trial of the LSUT.

The 30CST showed moderate to strong concurrent/convergent validity to assess LE muscle strength due to the moderate correlations found between the 5xSTS and LSUT tests. The 5xSTS[7] and LSUT[20] have previously been validated with LE resistive strength tests and functional tests in older adults. Jones et al[6] showed that 30CST had a strong correlation *(r* =0.77) with 1-repetition maximum (1RM) of a leg press. McCarthy[8] and colleagues found moderate association between 30CST and hip (*r* = 0.33) and knee (*r* = 0.44) extensor leg strength measured by a Cybex isokinetic dynamometer. In addition, McKay showed a moderate association between knee extensor strength and 30CST (*r* = 0.42) in adults 60 years and older.[13] Interestingly, the modified LSUT association with 30CST (*r* = 0.47), while significant, was less than the correlation between the standard LSUT and 30CST (*r* = 0.51). Previous authors reported that individuals use their plantarflexors during sit-to-stand activities,[8] which is also common during LSUT performance. However, the activation of the plantarflexors during the modified LSUT was minimized in the "moving leg" during the step down and up phases of this test. Thus, bilateral plantarflexors where being used in both phases of the LSUT but not the modified LSUT which would potentially be the reason why the LSUT association magnitude was greater than the modified LSUT association with 30CST.

The 30CST was also found to discriminate between those individuals that did not meet 1000 MET-minutes week and those who did, measured by leisure domain of IPAQ-LF. Previous researchers found that 30CST had good discriminant validity in distinguishing between older adults who exercised regularly from those who did not.[6] Thus, the 30CST may be a good test to discriminate between young adult athletes who are aerobically fit and those who are not, but further research needs to be done with athletes.

Several limitations existed in this study. First, the investigators did not have enough participants to determine if the 30CST test would be able to discriminate exercise level within males and females. Second, the investigators did not adjust the seat height of the chair dependent on body height or leg length despite previous researchers finding that seat height affects 30CST performance in older adults.[31] However, partial correlations to control body height showed significant moderate correlations between 30CST and the other PPT (Table 2). Third, concurrent and convergent validity were determined using functional strength test scores rather than a gold standard strength score as measured by an isokinetic dynamometer which may raise concerns. However, all three tests used in this study are reliable and valid to measure functional lower extremity strength, commonly used clinically, and showed moderate to strong correlation coefficients which should increase trust in these findings. Furthermore, McKay et al. showed that lower extremity muscle strength was associated with 30CST using a handheld dynamometer.[13] Finally, these results may not generalize well to athletes and other populations especially since most of the study participants were Caucasian, healthy, and young adults. Thus, this study should be repeated with athletes and different populations to ascertain that these findings are similar or different in these populations.

CONCLUSION

PPT's are often used in the evaluation of LE strength and performance in young adults[7,32] and athletes[2,3,5] due to the ease of administration, cost and portability.[2,4] The results of this study indicate that the 30CST has concurrent and convergent validity in assessing LE muscle strength and discriminate between sufficient and insufficient physical activity levels in young healthy adults. The 30CST could be a useful test to assess functional LE strength in young adults since this test is inexpensive, portable and easy to administer. Thus 30CST may be a good PPT to measure LE strength in athletes since it meets many of the measurement properties sought when selecting field-based strength tests.[4] However, this study should be replicated with athletes to ascertain that the findings of this study are found in athletes.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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