Short Communication

What is most appropriate number of repetitions of the sit-to-stand test in older adults: a reliability study

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Abstract

The most frequently employed versions of the sit-to-stand test (STST) are the 5 times STST and the 30 seconds STST. However, it is not known whether a variation with different number of repetitions or time could be more appropriate for older adults. The objective of this study was to investigate the reliability of STST at different time points and number of repetitions. The test was performed in 33 older adults (73±6.1 years) for 40 seconds. The participants performed the procedure twice with a day interval between the sessions. The test was video-taped and the data were processed by two examiners. The highest test-retest reliability was found for the 4th (ICC=0.73, SEM=1.48, SDD=1.68), 5th (ICC=0.76, SEM=1.73, SDD=1.97) and 6th repetition (ICC=0.78, SEM=1.78, SDD=2.03). The inter-rater reliability was excellent independently of the number of trials (ICC>0.9). The correlation of the time at the 4th and 6th repetition with the time at the traditionally selected 5th repetition was excellent (r>0.9). The termination of the STST at the 4th repetition seems to provide equally reliable and valid estimations with the termination at the 5th repetition. Future studies should examine a 4 times STST since the reduction of the number of repetitions may be less tiring and safer for older adults.

Keywords: Older adults, Reliability, Sit to stand test

The ability to rise from sitting to standing is critical to an individual's functional independence and quality of life and it is one of the most biomechanically demanding functional tasks, also being essential for patient independence[1]. Limitations to standing up from a chair means low levels of body strength, resulting in inactivity, balance problems, falls, accidental death and injury in the older population[2-4].

The sit-to-stand test (STST) investigates the ability to stand up from a sitting position. It is a simple and widely used assessment tool among older people, investigating functionality and lower limb strength[5-8]. Several variations of the STST exist, including the maximum number of times a subject can stand up and sit down on a regular chair in a given period of time, usually 30-seconds or 1-minute[7,9] or the time taken to perform a given number of sit-to-stand maneuvers[7]. Most researchers select the performance of the 5 times STST and the 30-second STST[10]. The 5 times STST, records the amount of time to complete five repetitions of the test[11].The 30-second STST records the number of stands a person can complete in 30-seconds[6]. According to our knowledge, there is no evidence to suggest that this is the appropriate number of repetitions and time to complete the test. The probability of completing tests at a different number of repetitions or time may give more reliable results while being safer and easier to use and less stressful. Therefore, the objectives of this study were to investigate: 1) the test-retest and inter-rater reliability of STST based on different number of repetitions and termination time and 2) the correlation between the performance at different time-

Characteristic	Mean	Standard Deviation
Age (years)	73	6.1
Height (cm)	158	7.8
Weight (kg)	62	6.4
Body Mass Index	24.3	5.2

Table 1. Participants' demographics.

Repetitions (n)	Participants (n)	GrandMean	ICC	95%CI	SEM	SDD
1	33	2.86	0.54	0.17-0.75	0.64	0.71
2	33	5.52	0.65	0.17 0.85	0.91	1.03
3	33	8.24	0.69	0.12-0.88	1.21	1.38
4	33	10.92	0.73	0.14-0.9	1.48	1.68
5	33	13.54	0.76	0.25-0.91	1.73	1.97
6	33	16.14	0.78	0.33-0.91	1.78	2.03
7	32	17.74	0.6	0.31-0.79	3	3.43
8	32	20.53	0.69	0.25-0.86	2.48	2.83
9	31	22.18	0.38	0.05-0.64	4.22	4.81
10	31	24.92	0.62	0.23-0.82	3.1	3.54

Table 2. Test-retest reliability of sit-to-stand test based on the number of repetitions.

points and number of repetitions with the performance at the usual selected termination at 5 repetitions or 30 seconds.

After the approval of Ethical Committee of the Technological Educational Institute of Western Greece, a convenience sample of 33 older adults was recruited from the second Open Centre for the Elderly of Patras. Inclusion required that participants, were ≥60 years of age, were able to walk without use of an assistive device, and had no heart, vascular, lung, or bone/joint problems that precluded their standing from a chair. All participants provided written informed consent before testing.

The process obtained first basic demographic and anthropometric data. Thereafter, a STST test was carried out and video recorded for 40 seconds. A straight backed armless chair with a hard seat was placed against a wall. Older adults folded their arms crossed against their chest, starting from the seated position and standing up (knee extension) and sitting down (buttocks touched the chair). Timing with a stop watch was started on the command "go" and stopped at 40 seconds[7,11,12]. The procedure of the test was repeated the following day by the same examiner.

Video-recordings by the same physiotherapist (rater) on two different days (24 hours interval) were used for further analysis with Kinovea software (htpp/kinovea.org)[13]. For each participant the time needed for the completion of trials

was recorded. This time was recorded cumulatively for each trial (the time of the previous trials was added) so that the test to be considered as a continuous process. Furthermore, the number of the completed trials at 5, 10, 15, 20, 25, 30, 35 and 40 sec was additionally recorded. Therefore, the STST was examined both as a time-dependent (similarly to the 5 times STST) and a trial-dependent test (similarly to the 30-second test). The examination and data processing of the videos were performed by two physiotherapists-examiners blind to each other.

Data analysis was conducted using the Statistical Package for Social Sciences (SPSS) version 20.0. Standard descriptive statistics were calculated for participants' demographics and anthropometrics. Test-retest and inter-rater reliability between the two sessions was examined by calculating Intraclass Correlation Coefficients ($ICC_{2.1}$), Smallest Detectable Change (SDD) and Standard Error of Measurement (SEM). Pearson correlation coefficients were used for examining the correlations between the different time-points and number of repetitions with the termination of the test at 30 seconds and 5 repetitions. Significance level was set at P=0.05.

Thirty-three (33) participants performed the STST. Table 1 shows the characteristics of the participants. Table 2 shows the results of the test-retest reliability based on the

Time (seconds)	Participants (n)	GrandMean	ICC	95%CI	SEM	SDD
5 sec	33	1.6	0.47	0.05-0.73	0.43	0.48
10 sec	33	3.68	0.62	0.06-0.84	0.55	0.61
15 sec	33	5.69	0.61	0.14-0.82	0.89	1.01
20 sec	33	7.84	0.65	0.27-0.83	1.15	1.2
25 sec	33	9.84	0.68	0.27-0.85	1.33	1.52
30 sec	33	12.03	0.67	0.35-0.84	1.68	1.87
35 sec	33	14.06	0.71	0.39-0.86	1.83	2.09
40 sec (31)	31	15.9	0.67	0.31-0.84	2.06	2.35

Table 3. Test-retest reliability of sit-to-stand test based on time.

Repetitions (n)	Participants (n)	GrandMean	ICC	95%CI	SEM	SDD
1	33	1.97	0.98	0.75-0.99	0.46	0.65
2	33	3.82	0.95	0.53-0.99	0.45	0.63
3	33	5.87	0.96	0.91-0.99	0.53	0.74
4	33	7.83	0.98	0.89-0.99	0.6	0.84
5	33	9.7	0.99	0.95-0.99	0.72	1.01
6	33	11.6	0.99	0.98-0.99	0.85	1.2
7	32	13.49	0.99	0.97-0.99	0.92	1.3
8	32	15.25	0.99	0.97-0.99	0.97	1.37
9	31	16.95	0.99	0.96-0.99	1.07	1.51
10	31	18.72	0.99	0.97-0.99	1.13	1.59

Table 4. Inter-rater reliability of sit to stand test based on the number of repetitions.

number of repetitions. Reliability was higher for the 4th (ICC 0.73 95% CI 0.14-0.9), 5th (ICC 0.76 95% CI 0.25-9.91) and 6th repetition (ICC 0.78 95% CI 0.33-0.91).

Table 3 shows the results of the test-retest reliability based on time. Reliability was higher for 35 seconds (ICC 0.71 95% CI 0.39-0.86) followed by the 25 seconds (ICC 0.68).

Table 4 and Table 5 show the inter-rater reliability for the sit-to-stand test based on the number of repetitions and for the sit-to-stand test based on time. Results show excellent inter-rater reliability for the 5 times STST (ICC range: 0.96-0.99). Results for the 30 seconds STST vary from ICC 0.56 to ICC 0.99. Table 6 shows the Pearson correlation coefficients between the scores obtained at different time-points and repetitions and the scores obtained at the 5th repetition and 30th second. The correlation between the scores at the 30th second and the 5th trial was excellent (r=0.92).

This is the first study, to assess the reliability of the sit-to-stand activity at different time-points and repetitions

in older adults. The results provide a strong rationale for future research about the development and examination of a 4 times STST in older people. The true value of this study highlights the finding that the completion of the STST at 4 repetitions has high reliability and low SEM. The completion of the test after 4 repetitions provides comparable estimations with the conventional termination at the 5th repetition, but additionally provides recordings with smallest measurement error. A shorter version of the STST has clinical importance for muscle strength and functional assessment in older people[14]. The short versions of the STST seem relevant to evaluate leg strength, while the longer versions seem suitable for the evaluation of exercise tolerance[12] revealing often the characteristic fatigue the end of the test[15]. Furthermore, clinically the completion of the test in fewer repetitions seems to be safer because of the less fatigue or potential rare but existent complications such as loss of balance. Further research is also needed in order to investigate if a shorter test is more appropriate for muscle strength and/or

Time (seconds)	Participants (n)	GrandMean	ICC	95%CI	SEM	SDD
5 sec	33	2	0.99	0.98-0.99	0.25	0.35
10 sec	33	5	0.86	0.04-0.99	0.47	0.66
15 sec	33	7.6	0.61	0.34-0.98	0.64	0.9
20 sec	33	10.25	0.7	0.45-0.97	0.64	0.9
25 sec	33	13.25	0.99	0.98-0.99	0.85	1.2
30 sec	33	16.29	0.99	0.99-0.99	0.85	1.2
35 sec	33	18.62	0.56	0.62-0.96	0.85	1.2
40 sec	31	21.33	0.99	0.98-0.99	0.86	1.21

Table 5. Inter-rater reliability of sit to stand test based on time.

Correlations at different number of repetitions (time-based)			Correlations at different time-points (repetitions-based)		
Repetition	R5	30-sec	Time-point	R5	30-sec
R1	r=.84 n=33	r=-.8 n=33	5 sec	r=-72 n=33	r=.82 n=33
R2	r=.95 n=33	r=9 n=33	10 sec	r=.87 n=33	r=.9 n=33
R3	r=.98 n=33	r=91 n=33	15 sec	r=.89 n=33	r=.96 n=33
R4	r=.99 n=33	r=.91 n=33	20 sec	r=.91 n=33	r=.98 n=33
R5	r=1 n=33	r=.92 n=33	25 sec	r=.91 n=33	r=.99 n=33
R6	r=.99 n=33	r=.92 n=33	30 sec	r=.92 n=33	r=1 n=33
R7	r=.86 n=32	r=.77 n=32	35 sec	r=.9 n=33	r=.99 n=33
R8	r=.98 n=32	r=.96 n=32	40 sec	r=.89 n=31	r=.98 n=31
R9	r=.97 n=31	r=.97 n=31			
R10	r=.96 n=31	r=.96 n=31			
n=participants					

Table 6. Correlations between the scores at different time-points and repetitions with the scores at the 5th repletion and 30th second.

functional lower limb endurance assessment.

In addition, the ability to do a sit-to-stand movement is strongly influenced by different parameters such as the height of the chair seat, use of armrests, foot position[16], use of upper extremities[3], anthropometric parameters of older adults, different pathologies etc. In the present study, the well-defined assessment protocol with standardized use of instructions[17] and equipment reduced variations in measurements, contributing to the standardization of the measurement procedure and therefore the validity of the findings. Further research should take into account more physiological and psychological parameters such as use of upper extremities and trunk, anthropometric characteristics (e.g. muscle mass) etc[3].

Test-retest reliability for STST based on time and on number of repetitions was poor to moderate. The results

are indirectly supported by previous research in healthy older adults and in patients with stroke or diabetes 2[18,19]. The results also revealed moderate to excellent inter-rater reliability among the two examiners and this is in agreement with other studies[18,20-22].

However, some limitations of the study should be considered. Participants were asked to perform the test as many times as possible, affecting their response in comparison with their performance when they would be instructed to perform a specific number of repetitions or to perform the test for a specific amount of time[12]. Furthermore, the participants of the study were not impaired. Although the conclusion of the study regarding future research direction towards the establishment of a shorter test would be apparently beneficial for them, its validity and reliability should be additionally investigated for this population.

In conclusion, the present study demonstrated the reliability of the STST at different time-points and number of repetitions. There are clear indications that the termination of the test after 4 repetitions may be a reliable equivalent of the traditional termination of the test at 5 repetitions or 30 seconds. Considering the easier and potentially safer nature of a shorter test in older population, future research is suggested to be directed towards the development and validation of a 4 times STST in this population. Its validation by future researchers could lead to its additional examination and application in other high-risk clinical populations who may benefit from a test of shorter duration.

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