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Validity and reliability of 30-second chair-stand test and modified 30-second chair-stand test in obese older adults

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Sit-to-stand;
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ABSTRACT

Obesity in older adults can negatively affect muscle strength and balance, putting them at a greater risk of falling and experiencing mobility limitations. While the 30-second chair-stand test (30sCST) is widely used to assess lower limb strength, its validity and reliability have not been well established in obese older individuals, who may face unique physical challenges. Additionally, a modified version of the test (m30sCST), which involves standing up from a foam surface with eyes closed, may help reveal more subtle balance impairments that are not captured by the standard version. However, this version has also not been properly validated by this population Assessing the reliability and validity of both tests in obese older adults is important to ensure whether these tools can accurately identify individuals at higher risk of falling—allowing for earlier, more targeted interventions to prevent falls and support safe aging. Therefore, this study aimed to examine the concurrent validity and reliability of 30sCST and m30sCST in obese older adults. Twenty-six community-dwelling obese older adults aged 60 years and over participated in this study. All participants completed the 30sCST and m30sCST, along with the Timed Up and Go (TUG) test and the modified Clinical Test of Sensory Interaction on Balance (m-CTSIB). Validity was assessed using Pearson's correlation coefficient to examine the relationship between 30sCST and m30sCST with TUG and m-CTSIB. Reliability was determined by administering the 30sCST and m30sCST twice, five days apart. Intra-rater reliability was assessed using the Intraclass Correlation Coefficient (ICC3,2). The results showed that both the 30sCST and the m30sCST were significantly correlated with the TUG (r = -0.54 and – 0.52) and m-CTSIB test (r = -0.53 and – 0.52). In addition, both 30sCST and m30sCST have good intra-rater reliability with an ICC of 0.98. The results suggest that both the 30sCST and m30sCST are reliable and valid tools for assessing balance in obese older adults. These findings highlight the potential of the 30sCST and m30sCST as practical balance assessment tools in clinical settings.

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Introduction

The aging population not only experiences fall problems, but also has an increase in obesity rates, which are multifaceted problems for healthcare professionals and public health programs[1]. Falls in older adults constitute a major public health issue, frequently leading to severe injuries, decreased quality of life, and heightened healthcare expenses[2]. Obesity, characterized by an excessive accumulation of body fat, is linked to numerous health issues, including cardiovascular diseases, diabetes, and musculoskeletal disorders[3]. Moreover, obesity increases the risk of falls by inducing physical limitations and diminishing functional independence, thus making older adults more susceptible[4]. A recent systematic review and meta-analysis found that older adults with obesity are 16% more likely to experience falls than those without obesity[4]. Several plausible biomechanical and physiological mechanisms may explain the increased risk of falls in obese older adults. Previous research suggests that obesity is associated with factors such as sedentary behavior, chronic health conditions, and polypharmacy[5], all of which can contribute to falling risk. More specifically, excess body weight may lead to biomechanical challenges, including impaired postural control[6], increased foot loading[7], and reduced lower-limb muscle quality[8]. Consequently, early identification of individuals at a greater risk of falling is essential for implementing specific programs to diminish fall incidence within this population.

The sit-to-stand (STS) task, one of the most mechanically demanding daily activities for transferring[9], has been identified as a significant predictor of fall risk in older community dwellers[10]. Previous studies reveal that the STS accounts for 12% of falls among older adults[11], while transfers, such as getting in or out of a bed or chair, contribute a substantial 41% of falls in nursing homes[12]. Since falls frequently occur during transitional movements such as rising from a chair, using performance-based assessments that mimic this movement pattern may enhance the ability to detect fall risk. Tests like the STS, which closely resemble real-life functional tasks, could therefore serve as practical tools not only for assessing fall risk but also for guiding preventive strategies tailored to high-risk individuals, particularly those with obesity.

One commonly used assessment is the 30-second chair-stand test (30sCST), which measures the maximum number of chair stands within 30 seconds[13]. This test has shown good to excellent test-retest reliability (intraclass correlation coefficient, ICC = 0.97) and moderate to good construct validity when compared with the Fullerton Advanced Balance Scale (r = 0.78) in community-dwelling older adults. Additionally, the test's area under the receiver operating characteristic curve is 0.77, indicating moderate accuracy in predicting fall risk in community-dwelling older adults[10]. Nonetheless, prior research[10,14] had been conducted predominantly among older adults with not considered body mass index (BMI). Research has demonstrated that individuals with obesity exhibit distinct movement patterns during the STS task compared to those with normal BMI[15]. Furthermore, when lower-limb strength is normalized to body mass, individuals with obesity demonstrate a reduced capacity relative to non-obese individuals[16]. These findings may suggest that the psychometric properties of the 30sCST in older obese adults may differ from those in their non-obese counterparts from the previous study. However, evidence regarding the psychometric properties of the 30sCST in older obese adults remains limited.

The body's ability to perform movements and maintain stability relies on a complex interaction of sensory inputs from multiple systems, which are cognitively processed to initiate muscular responses and maintain balance through the musculoskeletal system. Degenerative changes in sensory processing among older adults affect sensory reweighting, leading to postural instability during functional tasks[17]. A previous study found that in a standing position on an unstable surface, older adults with obesity exhibited greater body oscillation than those with normal weight[18]. Additionally, research suggests that obesity is associated with reduced lower-limb sensory function due to pressure exerted by excess body mass[19]. These sensory impairments may compromise the ability to respond effectively to environmental challenges that require rapid postural adjustments. Accordingly, a modified version of the 30sCST (m30sCST) has been developed, incorporating visual and somatosensory perturbations by having participants close their eyes and perform the test on a foam surface. These sensory challenges reflect real-life conditions where visual input may be limited (e.g., poor lighting or night-time mobility) and somatosensory feedback may be compromised (e.g., walking on soft, uneven, or slippery surfaces). This modified test has demonstrated good to excellent test-retest reliability (ICC = 0.96) and moderate to good construct validity with the Fullerton Advanced Balance Scale (r = 0.69) in community-dwelling older adults. Furthermore, the m30CST has shown a higher area under the ROC curve (0.91) compared to the 30sCST, suggesting improved accuracy in predicting fall risk among community-dwelling older adults[10]. Thus, modifying the 30sCST by altering visual and somatosensory conditions may enhance its predictive accuracy for falls in obese older adults.

In both research and clinical settings, it is essential to establish reliable and valid outcome measures for specific populations. However, the validity and reliability of the 30sCST and m30CST have not been examined in obese older adults. By confirming the psychometric properties of both the 30sCST and m30sCST in obese older adults, this study contributes practical tools for clinicians to better assess fall risk and functional status in this specific population. This can lead to more targeted interventions and improved fall prevention strategies tailored to the physical capabilities of individuals with obesity. Therefore, this study aims to assess the concurrent validity and intra-rater reliability of the 30sCST and m30sCST in this population. We hypothesize that (1) both tests demonstrate moderate validity in assessing physical function compared to the Timed Up and Go (TUG) test and the modified Clinical Test for Sensory Interaction on Balance (m-CTSIB), and (2) both tests will exhibit good intra-rater reliability.

Materials and methods

Study design and participants

A cross-sectional study was conducted to assess the concurrent validity and reliability of the 30sCST and the m30sCST in obese older adults. A convenience sample of twenty-six adults aged 60 years or older with obesity was recruited for this study through leaflet distribution at the university faculty and online postings on social media platforms. Participants were included if they 1) had a BMI greater than 25 kg/m^2, in accordance with the World Health Organization's (WHO) criteria for defining obesity in Asian populations[20], 2) had a waist-to-hip ratio of at least 0.90 for men or 0.85 for women, based on WHO guidelines for central obesity[21], 3) were able to independently perform an STS task, 4) had normal visual acuity, and 5) had no uncontrolled or unstable health conditions that affect the ability to stand up from a chair and maintain balance such as arthritis, and hypertension. Exclusion criteria included participants who had an incident impairing STS performance during the data collection period or who were unable to complete the procedures. The University Ethics Review Committee granted Human Projects Research ethical approval. All participants and/or their guardians provided written informed consent prior to the trial. The characteristics of the participants are shown in table 1.

Table 1 Characteristics of study participants (n = 26)

Characteristic	Findings
Gender; n (%)	
- Female	21 (80.8)
- Male	5 (19.2)
Age (years); mean ± SD	71.81 ± 4.83
Body mass index (kg/m²); mean ± SD	28.96 ± 3.21
Waist-to-Hip ratio; mean ± SD	0.92 ± 0.05
Timed Up and Go test (s); mean ± SD	12.43 ± 3.40
Modified Clinical Test for Sensory Interaction on Balance (stability index); mean ± SD	2.68 ± 0.45
30-second chair-stand test; mean ± SD	9.54 ± 2.65
Modified 30-second chair-stand test; mean ± SD	8.25 ± 3.04
Fall history within one year; n (%)	
- Yes	14 (53.8)
- No	12 (46.2)

The sample size for this study was calculated using Wan nor Arifin's sample size calculator. The calculation was based on the minimum acceptable reliability of 0.7, the expected reliability of 0.9, a 0.05% significance level, and a power (1-ß) of 80%. Additionally, a 10% dropout rate was anticipated, and the test would be repeated twice for reliability assessments. After incorporating these factors, the final sample size was determined to be 26 participants.

Procedures

A licensed physiotherapist with clinical experience in geriatric assessment conducted all testing procedures. Prior to data collection, the tester was trained by the senior author, who has expertise in functional assessment and reliability research. The training process included detailed instruction, observation of pilot trials, and supervised practice sessions to ensure consistency and adherence to the standardized testing protocol. Participants underwent four tests on the first day, including 30sCST, m30sCST, TUG, and m-CTSIB tests. For the second day, only the 30sCST and m30sCST were repeated. The interval between two assessments was 5 days. The testing sequence was allocated to the participants by a simple random sampling method.

30-Second Chair-Stand Test

During the 30sCST, the procedure involved getting up and down from a chair as fast as possible with their arms folded across the chest. Each participant began in the same posture, with their feet flat on the floor and their hips and knee joints at the 90-degree angle. The chair surface level with the distance from the lateral knee joint line when the tibia was perpendicular to the floor with the barefoot in standing. The participants then rose from the chair with their arms folded across their chests. The assessor provided the participant with the following instructions: 'Look straight ahead and rise to a full stand, then return to a complete sitting position.' After the 'go' signal, the participant was instructed to repeat this task as many times as safely possible within 30 seconds. The assessor counted down '1, 2, 3, go' to initiate the test[10,13].

Modified 30-Second Chair-Stand Test

For a m30sCST, a foam pad (Airex®), made of polyurethane foam and measuring 16 × 20 × 2.5 inches, was used. A foam was placed on the floor in front of the adjustable chair, and opaque swimming goggles were used as blindfolds[10]. For the starting position and the instruction were the same as the 30sCST[10,13].

For both 30sCST and m30sCST, the number of repetitions was recorded in each condition, with full standing and sitting on a chair. In addition, if the participant's time ran out while they were moving up or down, it was counted as a repetition. Each test was repeated two times, and average performance was used for analysis. After every try, the participant took a minimum of two minutes for rest, or as much time as necessary, to avoid muscle fatigue and motor learning. Throughout the testing, safety was ensured by closely monitoring participants and providing physical support as necessary to prevent falls or injuries.

Timed Up and Go test

In the TUG test, participants were instructed to sit in a chair at the starting location, stand, walk forward 3 meters as swiftly and safely as possible, turn at a traffic cone, walk back, and sit down at the starting position. The task was performed at a self-selected, comfortable walking speed rather than a rapid one[22]. The times were recorded, and two of the times were repeated. The average of these times was used for analysis.

Modified Clinical Test for Sensory Interaction on Balance

For the m-CTSIB test, the Biodex Balance System™ SD (Biodex Medical Systems, Inc.) was used to assess m-CTSIB. Participants were asked to stand at the center of the balance system platform with their feet shoulder-width apart and placed their hands on their iliac crests during the 4 different conditions. The conditions were 1) eyes opened, firm surface, 2) eyes closed, firm surface, 3) eyes opened, foam surface, and 4) eyes closed, foam surface. Each participant's feet were positioned on the platform using default values based on their individual height. The four conditions each lasted for 30 seconds, and all four conditions were performed twice, resulting in a total of eight trials. The overall stability index was calculated and was used for further analysis. A high score in this index, for instance, indicates poor balance.

Statistical analysis

Statistical analysis was conducted using SPSS version 29.0 (SPSS Inc., 233 S Wacker Dr, 11th Fl, Chicago, IL 60606). Pearson's correlation coefficient (r) was used to assess the concurrent validity of the 30sCST and m30sCST to the TUG and m-CTSIB tests. The strength of the correlation was classified as follows: little or none ($r < 0.25$), poor ($r = 0.25–0.50$), moderate ($r = 0.51–0.75$), and good to excellent ($r > 0.75$) [23].

To evaluate the intra-rater (ICC 3,2) reliability of the time to complete the 30sCST and m30sCST, the ICC with a 95% confidence interval was calculated. An ICC greater than 0.75 indicated good reliability, while an ICC between 0.5 and 0.75 suggested moderate reliability[23]. Furthermore, the standard error of measurement (SEM) and minimal detectable change (MDC) were computed to assess absolute reliability, using the following formulas:

$SEM = \text{Standard deviation (SD)} \times \sqrt{(1 - ICC)}$ and $MDC = 1.96 \times \sqrt{2} \times SEM$.

Results

For the concurrent validity analysis, both the 30sCST and the m30sCST were significantly correlated with the TUG and m-CTSIB tests. Analysis using Pearson's correlation coefficient revealed a moderately negative relationship between each test as shown in table 2.

Table 2 Correlation between the 30sCST, m30sCST, and TUG and m-CTSIB tests

Tests	TUG		m-CTSIB	
	r (95% CI)	*p*-value	r (95% CI)	*p*-value
30sCST	-0.54 (-0.76, -0.18)	0.005*	-0.53 (-0.76, -0.18)	0.006*
m30sCST	-0.52 (-0.75, -0.15)	0.008*	-0.52 (-0.75, -0.16)	0.008*

Abbreviations: 30sCST, 30-second chair-stand test; m30sCST, modified version of the 30-second chair-stand test; TUG, Timed Up and Go; m-CTSIB, modified Clinical Test for Sensory Interaction on Balance; CI, confident interval.

The means and standard deviations (SD) of the repetition to complete the 30sCST and m30sCST, which were used to determine reliability, are reported in table 3. The ICC of both tests exhibited good intra-rater reliability. The SEM and MDC of both tests are also shown in Table 3.

Table 3 The reliability and corresponding minimal detectable change (MDC) and standard error of measurement (SEM) of the 30sCST and m30sCST.

Variable	Repetition (mean ± SD)		$ICC_{3,2}$	95% CI	*p*-value	SEM	MDC
	First day	Second day					
30sCST	9.54 ± 2.65	9.42 ± 2.79	0.98	0.96 - 0.99	< 0.001	0.38	1.05
m30sCST	8.25 ± 3.04	7.98 ± 2.94	0.98	0.96 - 0.99	< 0.001	0.42	1.16

Abbreviations: 30sCST, 30-second chair-stand test; m30sCST, modified version of the 30-second chair-stand test; TUG, Timed Up and Go; m-CTSIB, modified Clinical Test for Sensory Interaction on Balance; CI, confident interval; ICC, Intraclass correlation coefficient.

Discussion

This study aimed to evaluate the concurrent validity and intra-rater reliability of the 30sCST and its modified version (m30sCST) in obese older adults. The findings indicate that both tests possess moderate concurrent validity when compared with the TUG test and the m-CTSIB. Additionally, both the 30sCST and m30sCST demonstrated good intra-rater reliability and low SEM and MDC values when used in obese older adults. In addition, throughout the study, no adverse events or safety concerns were reported during either the 30sCST or the m30sCST.

The 30sCST and m30sCST were moderately and negatively correlated with TUG and m-CTSIB tests when employed in older obese adults. The TUG test is an efficient, rapid, and often utilized instrument for evaluating mobility, balance, and functional ability in elderly individuals[24]. In addition, this test was recommended by the latest falls prevention and management as one of the screening tools in older adults[25]. For the m-CTSIB, this test is used for identifying sensory integration deficits affecting balance by isolating the contributions of visual and somatosensory[26]. The moderate negative correlation found in this study (r = -0.52 to -0.54) suggests that both 30sCST and m30sCST are in partial agreement with the functional balance and sensory integration balance assessment. These results are consistent with previous findings in non-obese older adults, demonstrating that the 30sCST and m30sCST showed a significant, moderate correlation (r = 0.73 and 0.69) with the Fullerton Advanced Balance Scale[10]. This slight reduction may be attributed to obesity-related factors such as altered movement patterns, impaired sensory processing, and reduced relative lower-limb strength, which are known to influence functional performance(15,16). However, unlike earlier studies that focused on clinical balance measures, our study aimed to validate the 30sCST and m30sCST against laboratory assessments, providing new insights into their applicability in objective balance evaluations. Although the m30sCST includes additional sensory challenges, the similar validity outcomes with the 30sCST may suggest that both tests primarily capture lower-limb functional capacity rather than uniquely assessing sensory integration. This could indicate a ceiling effect or limited variability in sensory challenge response among the participants. Given these findings, we suggest that the 30sCST and m30sCST be used in combination with other established assessments like the TUG or m-CTSIB rather than as standalone tools.

Importantly, this study's reliability results were notably high, with intraclass correlation coefficients (ICC) of 0.98 for both the 30sCST and m30sCST. These findings are in line with or exceed previously reported values in community-dwelling older adults(10) and support the use of these tests as stable and consistent measures. The provision of practice sessions utilizing methods for the assessors prior to the beginning of data collection may have enhanced the good reliability outcomes shown in the current investigation. Moreover, explicit and standardized directives from the assessor may facilitate the participants' effective execution of the assigned task.

Understanding the measurement error is essential for determining whether a tool is sufficiently reliable for clinical decision-making. Previous studies have reported acceptable SEM values for the 30sCST in older adults (0.71)(10), older adults with osteoarthritis (1.97)(27), and for the m30sCST (0.96) in older adults(10). In the present study, the SEM values for both the 30sCST and m30sCST were found to be less than 0.5 repetitions, indicating very low variability in performance. This suggests that the measurements are highly consistent, and the error is minimal, making them reliable for use in older adults with obesity. Moreover, this study established MDC values for both the 30sCST and m30sCST, which are straightforward and easy-to-administer assessments. When comparing the MDC values from our study with those reported in previous research(10), we found that the MDC for the 30sCST in our sample of obese older adults was 1.05 repetitions, which is lower than the 1.96 repetitions reported in a prior study involving non-obese older adults. Similarly, the MDC for the m30sCST in our study was 1.16, compared to 2.67 in the previous research. These lower MDC values observed in obese older adults may suggest that even small changes in performance could reflect meaningful improvements, potentially making it easier to detect clinically relevant changes in this population. These MDC values provide a helpful standard for understanding results in different groups and assist in figuring out the smallest change needed to show a real improvement in obese older adults after treatment.

The study's strengths lie in the population it studied, particularly the obese older adults. This population is facing a risk of falling due to compounded effects of age-related and weight-related impairments in balance and mobility. In addition, using both clinical and instrumented balance assessments offers a well-rounded evaluation of balance. Despite these strengths, some limitations remain. First, the participants in this study were a convenience sample of obese older adults, mostly female, from one community, which may not reflect the overall older adult population. Second, this study only examined intra-rater reliability without assessing inter-rater reliability. Evaluating inter-rater reliability is crucial for determining whether the tests can produce consistent results across different evaluators, a key factor for their clinical applicability. Additionally, future studies should include an investigation of the other psychometric properties of the 30sCST and m30sCST, such as their accuracy in detecting falls in obese older adults.

Conclusion

The 30sCST and m30sCST are reliable and moderately valid functional evaluations for community-dwelling obese older adults. The 30sCST provides a quick and practical measure of lower-limb strength and mobility under normal conditions, while the m30sCST introduces sensory challenges that may better reveal subtle balance impairments related to sensory processing deficits. Clinically, these tests can be used together to gain a fuller picture of an individual's functional status and to help guide targeted interventions for fall prevention but should always complement other assessments rather than replace them.

Take home messages

The 30sCTS and its modified version are reliable and valid instruments for evaluating physical function and balance in obese elderly individuals, endorsing its application in fall risk assessment and rehabilitation strategy formulation.

Conflicts of interest

The authors declare no conflict of interest.

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Author contributions

Tanida Vajaradesa: Conceptualization, Methodology, Formal analysis Writing – Original draft.

Pawan Chaiparinya: Conceptualization, Writing – Review & Editing.

Duangporn Suriyaamarit: Conceptualization, Formal analysis, Resources, Writing – Review & Editing.

Data availability

Data available on request from the authors

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