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Original Article

The Modified-30-Seconds-Chair-Stand-Test: A Practical and Reproducible Tool to Assess Muscle Strength in Acutely Ill Hospitalized Geriatric Patients

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Abstract

Objectives: Acutely ill hospitalized geriatric patients with sarcopenia have a poor clinical outcome. The European Working Group on Sarcopenia in Older People-2 (EWGSOP-2) recommends measuring handgrip strength (HGS) or the 5-times-repeated-Chair-Stand-Test (5t-CST) to assess muscle strength. The modified-thirty-seconds-Chair-Stand-Test (m-30s-CST) is expected to be more feasible than the 5t-CST and probably a better proxy for physical function compared to HGS. The aim of the study is to test the feasibility and reliability of the m-30s-CST in these patients. **Methods**: 92 patients (aged 84±6 y, mean GFI score of 6.1± 2.9, 53.5% female) participated. The m-30s-CST was performed at 3 different occasions. Feasibility was measured at admission and test-retest reliability at the day before and of discharge. Additionally Short Physical Performance Battery (SPPB), ADL-Barthel-Index (ADL-BI) and HGS were assessed. **Results**: The m-30s-CST is a significant more feasible test compared to the 5t-CST (n=92; 76.1% versus 20.1%; P<0.001), with a intraclass correlation coefficient (ICC) of 0.954 (n=59; CI-95%:0.921-0.973; P<0.001). The m-30s-CST has compared to HGS a significant better correlation with the ADL-BI and with the SPPB. **Conclusion**: The m-30s-CST is a feasible and reliable method to assess muscle strength and is compared to HGS a better proxy for physical performance in geriatric patients.

Keywords: Chair Stand Test, Muscle Strength, Handgrip Strength, Physical Performance, Sarcopenia

Introduction

Skeletal muscle mass and strength are strong prognostic factors for the functional decline, morbidity, and mortality of older patients[1]. Low skeletal muscle mass and poor physical performance are highly prevalent in hospitalized geriatric patients[2-5]. Muscle strength, muscle mass and muscle function are needed to perform basic daily activities and remain independently mobility. Clinical outcome following acute illness is generally poor in these geriatric patients with low skeletal muscle mass and strength[6]. Consequently, it is recommended to assess skeletal muscle mass and strength in patients admitted to the acute care geriatric ward[7]. The European Working Group Sarcopenia Older Peoples-2 (EWGSOP-2) recommends to measure handgrip strength (HGS) or to perform the 5 times repeated Chair Stand Test (5t-CST) as proxy for muscle strength[8]. The 5t-CST is preferred over HGS in clinical practice because, besides testing lower body strength, it also gives an indication of physical performance and mobility[9].

The CST measures the time it takes to stand fully upright[10]. Different versions of the CST test with the "5 times repeated Chair Stand Test" (5t-CST) have been validated for older adults and are recommended by the EWGSOP-2[8]. However, the 5t-CST is not validated for hospitalized geriatric patients.

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The 5t-CST prohibit the use of the armrests, which make it not feasible as measuring instruments when executed by acutely ill hospitalized geriatric patients. Most geriatric patients are too limited in terms of physical capacity or coordination to stand up from a chair without the use of the armrests, especially when muscle strength is compromised, as is the case in the acutely ill[11,12]. Furthermore, there is a floor effect found when executing multiple Chair-Stand-Tests in consecutive order[11,12]. The "30 seconds Chair Stand Test" (30s-CST) was developed to overcome the floor effect of the 5t-CST by counting the repetitions performed within 30 seconds. The 30s-CST is therefore more feasible in those who are physically more limited[2-4]. While the 30s-CST overcomes the part of the floor effect of the 5t-CST, it does not make it more feasible to perform this test, because of restricted physical capacity of these geriatric patients[5]. Therefore, the "Modified Thirty Seconds Chair Stand Test" (m-30s-CST) was introduced[3,13]. The m-30s-CST allows the use of the armrests, which makes it a more feasible test for the acutely ill hospitalized geriatric patients. McAllister and coworkers found a good test-retest reliability of the m-30s-CST in an older adults living in assisted living community[13]. However, the m-30s-CST has not been tested in the acutely ill hospitalized geriatric population. In the present study we therefore aimed to assess the feasibility and reproducibility of the m-30s-CST in acutely ill hospitalized geriatric patients.

Materials and Methods

The m-30s-CST was assessed within 3 days after hospital admission and on the day before and at hospital discharge. To study the feasibility the first measurement of m-30s-CST was chosen. To study the test-retest reliability the m-30s-CST from the day before and the day of hospital discharge was chosen. Finally, to study the relation between m-30s-CST and physical performance, self-reliance and handgrip strength (as proxy for overall muscle strength), respectively Short Physical Performance Battery (SPPB), ADL-Barthel Index (ADL-BI) and HGS were assessed.

Study sample

All geriatric patients admitted to the acute geriatric ward of the Zuyderland general hospital (the Netherlands) were asked to participate in the study. Recruitment took place over two periods of three months in March 2021 and November 2022. A total of 92 patients were included in the study after admission to the acute care geriatric hospital ward. Inclusion criteria were patients age above 70 years, a Groningen Frailty Indicator (GFI) score of 4 or greater indicating frailty and having independent mobility (with or without walking aid) before hospital admission[14]. All participants or representatives signed an informed consent form before the start of the research and received written information about the study. Exclusion criteria were being terminal illness with very limited life expectancy, wheelchair bound before hospital admission, being bedridden pre-admission, an inability to sit in a normal chair with armrest, not being instructible for performing the tests for any reason or no consent given by patient or representative.

More than half of the geriatric patients had problems in the musculoskeletal system (osteoarthritis, previous fractures and rheumatoid arthritis), about half had heart failure and more than a third of the study population had a neurological disorder (stroke, polyneuropathy or parkinsonism), all of which had a greater or lesser impact on mobility and ability on chair raising (Supplementary Table 1). Pneumonia, delirium, heart failure were the most reported diagnosis at hospital admission (Supplementary Table 2).

Sample size is calculated using the intraclass correlation coefficient (ICC) from Walter et al.[15]. Additional information that is used in the sample size calculation includes an expected ICC/reliability of 0.8, power 80% (which makes beta 0.20), desired significance level of 0.05, the use of a two-tailed test and a minimal ICC/reliability of 0.6. Expected loss-to-follow up is 10% and we strive to do a minimum of two assessments (n). This makes the estimated required number of patients 55 for the test-retest reliability.

Patients' characteristics

Patient characteristics were retrieved from the medical and nursing files. These included sex, age, diagnosis at hospital admission, medical history, body mass index, nutritional status, frailty score and the acute illness that led to hospital admission. Carlsson Comorbidity Index (CCI) is a validated tool to predict 10-year survival in patients with multiple comorbidities and is used to categorize the comorbidities[13]. The CCI was assessed by a resident of the geriatric department based on the information in the electronic medical file. Bodyweight was measured on a sitting weight scale (SECA, Model 959). Malnutrition was measured using the Short Nutritional Assessment Questionnaire (SNAQ), which is a validated screening instrument for malnutrition. Scores range from 0 to 5; a score of 3 or higher indicates that the patient is malnourished[16]. The frailty score was assessed according to the Groningen Frailty Indicator (GFI) criteria, which ranges from 0 to 15: a score of 4 or higher indicates frailty[17].

The ADL Barthel-Index (ADL-BI), m-30s-CST, handgrip strength (HGS) and Short Physical Performance Battery (SPPB) were assessed on the day of inclusion and at most within 72 hours after hospital admission and on the day before discharge. The tests were assessed by the involved researcher, ward resident, physiotherapist or the involved medical student. The tests were carried out in the patients allocated hospital room.

Modified thirty-seconds chair stand test (m-30s-CST)

When the modified thirty-seconds chair stand test (m-30s-CST) was performed, the patient was asked to sit in a chair with armrests. The same chair was used for these tests and had a seat placement of 45.2 cm

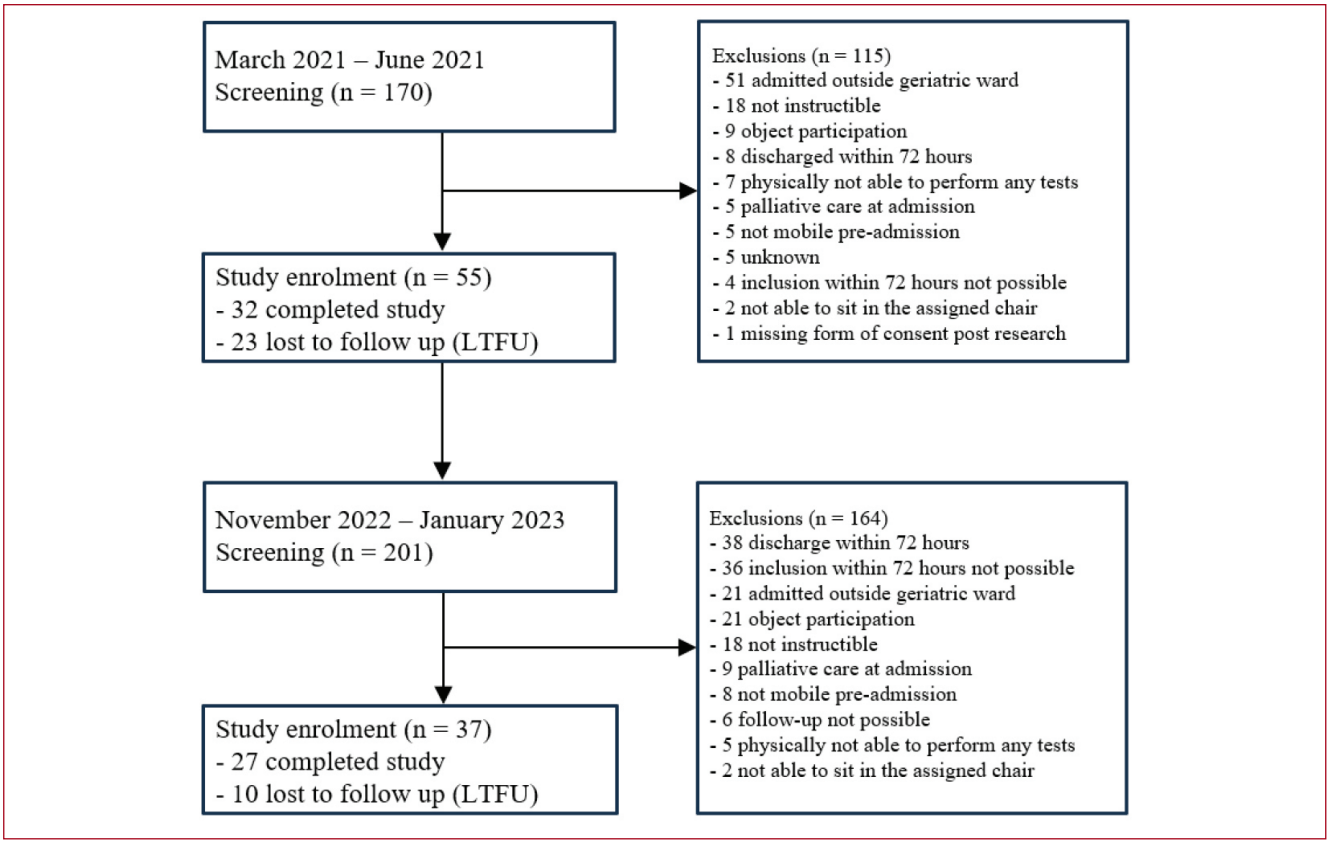

Figure 1. Flowchart describing patient recruitment.

above the floor. Patients must wear footwear or non-skid socks. When the m-30s-CST starts, the patient tries to rise up from the chair into a full standing position and sit back down again as many times as possible within 30 seconds. The patient is instructed to place both hands on the armrests and to start at the signal to go. If the patient is still rising to a standing position when the times runs out, the point counts if the movement was at least halfway done. The test was carried out within 72 hours after admission day before discharge and on the morning of the discharge from the hospital. The m-30s-CST may be subject to several sources of error that could affect its reliability. These sources include factors related to participants' physical condition, variations in test administration, measurement error, and participant-related factors such as motivation and learning effects. To minimize these potential sources of error, efforts were made to ensure that participants were in similar physical condition during each test administration, that the test was administered consistently across all participants and test administrations, that standardized instruments were used, and that participants were adequately motivated and engaged in the test.

Short Physical Performance Battery (SPPB)

The Short Physical Performance Battery (SPPB) is a validated test for the elderly population, which gives insight into the degree of mobility and can be used as a predictor for health outcomes[18]. The SPPB has a point system ranging from zero (worst performance) to twelve (best performance) points. The SPPB consists of a balance test (zero to four points), a walking test (zero to four points) and the 5t-CST. The 5t-CST has the following scale system: four points for a time <11.20 seconds, three points for a time between 11.20 -13.69, two points for a time between 13.70-16.69, one point for 16.70- 60 seconds and zero points for a time >60 seconds or when the patient is unable to perform the test. The SPPB was performed within 72 hours after hospitalization and the day before discharge.

ADL Barthel Index (ADL-BI)

The ADL Barthel Index (ADL-BI) gives a rating on the ability to be self-reliant, to perform basic daily needs without the help of others[19]. It consists of ten items and gives out a score depending on the degree of (in)dependence when performing those tasks in the last 24 hours, with a maximum

Variable	Male (n=43, 46.7%)	n	Female (n=59, 53.3%)	n	P-value
Age, frailty, and comorbidity at admission					
Age in years, median (IQR)	84 (80-88)	43	86 (81-89)	49	0.240
BMI, mean +SD (kg/m^2)	24,6 ± 3,0	43	24,8 ± 4,0	49	0.743
GFI, median n (IQR)	6,7 ± 3,2	43	5,6 ± 2,5	49	0.086
CCI, median n (IQR)	6.9 (5-8)	43	5,8 (5-7)	49	0.024*
SNAQ, median n (IQR)	1,8 ±1,8	43	1,6 ± 1,7	49	0.846
Physical performance at admission					
SPPB, mean +SD	3,2 ± 2,7	43	2,4 ± 2,1	49	0.105
ADL-BI, mean +SD	12,4 ± 4,7	43	12,5 ± 4,1	49	0.136
Muscle strength					
HGS admission (kg), mean +SD	22,4 ± 9,0	43	11,3 ± 5,0	49	0.023*
5t-CST admission (IQR)	0.6 (0-1)	43	0.2 (0-0)	49	<0.001*
m-30s-CST admission, mean + SD	5,1 ± 4,0	43	3,6 ± 3,3	49	0.025*
m-30s-CST day before discharge	5,8 ± 4,3	37	4,7 ± 3,2	38	0.488
m-30s-CST day of discharge	5,3 ± 3,3	28	4,8 ± 3,1	33	0.679

Data are represented as mean (SD) or median (QR). IQR = Interquartile range; SD = standard deviation; BMI = Body Mass Index; GFI = Groningen Frailty Index; CCI = Charlson Comorbidity Index; SNAQ = Short Nutritional Assessment Questionnaire; SPPB= Shorth Physical Performance Battery; ADL-BI = Activity of Daily Living Barthel score; HGS= handgrip strength; 5t-CST = 5 times repeated chair stand test, scored according to the SPPB categories; m-30s-CST= modified 30 seconds chair stand test. * Significance proven with p< 0.05.

Table 1. Patient characteristics (n=92).

of twenty points (which corresponds with a high level of independency). The Barthel Index was calculated within 72 hours after hospitalization and the day before discharge. This was done by observation, in consultation with nurses and/or physiotherapists and by accessing daily reports written by nurses.

Handgrip Strength (HGS)

Hand-grip strength (HGS) was measured with the Jamar Handgrip strength according to the South-Hampton protocol. This handheld dynamometer measures the maximum hand grip strength, which gives an estimation of the overall muscle mass and function[20]. The handgrip strength was carried out within 72 hours after admission to the hospital and the day before discharge on the dominant hand.

Statistical Analysis

Data analyses were done using IBM SPSS Statistics version 29 for descriptive, covariate and reliability analyses. Descriptive statistics was used for patient characteristics with means and corresponding standard deviations for continuous variables and percentages for categorical variables. Differences in feasibility between the m-30s-CST and the 5t-CST were assessed with a McNemar test of proportions. Normal distribution of data was observed with histograms including skewness and kurtosis and tested using Kolmogorov-Smirnov (KS) test of normality.

Test retest reliability of the m-30s-CST was analyzed by a two-way random model using intraclass correlation coefficient (ICC). Standard error of means (SEM) and minimal detectable change (MDC) were calculated using single measurement and absolute agreement of consistency[21]. Convergent validity of the m-30s-CST was done by analyzing correlations with a Pearson between the m-30s-CST and the SPPB, ADL-BI and HGS respectively, since there was found to be a normal distribution of data when analyzed with the KS-test for each sex.

Results

Study sample

A total of 92 patients were included in the study. Patient recruitment and exclusion with reasons are shown in the flow chart (Figure 1).

Patients' characteristics

Of the 92 patients that participated in this study, with a mean age of 84±6 y and a mean GFI score of 6.1± 2.9SD. A

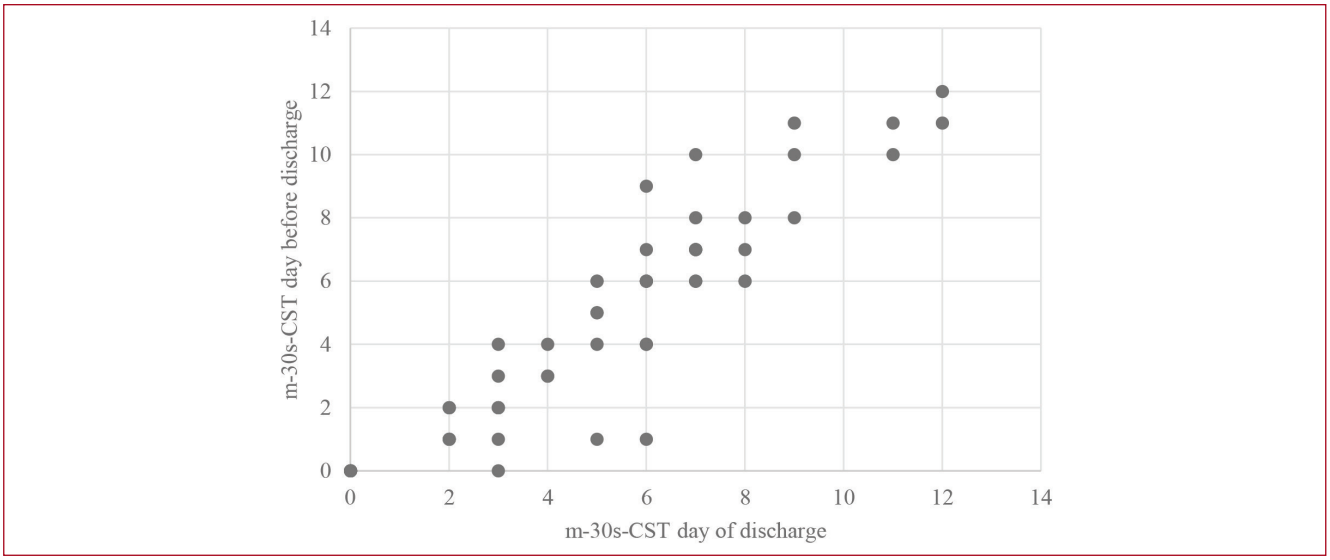

Figure 2. Distribution of the correlation between m-30s-CST in acutely ill geriatric patients (n=59) measured at the day before discharge and at the day of hospital discharge.

total of 49 (53.3%) patients were female.

The patient characteristics, including age, BMI, GFI score, CCI score, and SNAQ score, were analyzed for differences between men and women using various statistical tests. The patient characteristics table (Table 1) shows the mean, standard deviation and statistical test results for each characteristic by sex. If there was an abnormal distribution of data, the table shows the median and interquartile range (IQR, percentile 25-75).

There was no association between the m-30s-CST and comorbid diseases according the CCI (ρ=0.012; P=0.911). The results indicated that the CCI score was significantly higher in men (7, 5-8) compared to women (6, 5-7). The Chi-square test of GFI indicating frailty (a score of 4 or higher) between women and men proved not to be significant with a p-value of 0.860. There were no significant differences in age, BMI, SNAQ score or ADL-BI between men and women.

Feasibility Chair Stand Tests

Feasibility of the variants of the chair stand test was established at day after hospital admission. Seventy patients (76.1%) were able to perform the m-30s-CST, while only 19 patients (20.1%) were able to perform the 5t-CST. The Chi-square test gives a statistically significant difference in proportions (P <0.001).

Test-retest reliability of the m-30s-CST

Mean m-30s-CST was 5.8 ±4.3 in men and 4.7± 3.2 in women at the day before discharge and respectively 5.3 ±3.3 and 4.8 ± 3.1 at the day of hospital discharge (Table 1). No systematic differences in mean m-30s-CST were observed between these measurements (male: n=28 P=0.075 and female n=31 P=0.169). Two patients were excluded from analysis after they were found to be wrongfully included in the study (age below 70 years old). Test-retest reliability for these two measurements of the m-30s-CST in 59 geriatric patients was shown to be high with an ICC of 0.954 (95% CI: 0.921-0.973; P<0.001) (Figure 2).

The Standard Error of Measurement (SEM) was 0.428 - 0.404 and was calculated using the average measures ICC. The Minimal detectable change (MDC) was calculated as 1.142, which gave a MDC of 1 repetition of the m30sCST.

Combination	Correlation (ρ)	P-value
m-30s-CST and ADL-BI	0.577	<0.001
m-30s-CST and SPPB	0.802	<0.001
HGS and ADL-BI	0.214	0.040
HGS and SPPB	0.260	0.012
m-30s-CST and HGS	0.350	<0.001

m-30s-CST = modified 30 seconds chair stand test, ADL-BI = Barthel-index, SPPB= Short Physical Performance Battery; HGS = Handgrip strength.

Table 2. Correlation between strength tests and physical performance at baseline in 92 acutely ill hospitalized geriatric patients.

Physical performance and strength tests

The m-30s-CST showed a moderate positive correlation with the ADL-Barthel Index, with a ρ=0.577 (P<0.001) and strong correlation with the SPPB ρ=0.802 (P<0.001) (Table 2). Handgrip strength showed a negligible positive correlation with the ADL-BI, ρ=0.214 (P=0.040) and a very weak positive correlation with SPPB ρ=0.260 (P=0.012). Furthermore, we found a very weak positive correlation between the m-30s-CST and HGS (ρ=0.350; P<0.001).

Discussion

This study demonstrates that measuring muscle strength using the m-30s-CST in acute ill hospitalized geriatric patients is a more feasible and reliable method and gives a better indication about physical performance and self-reliance compared with the 5t-CST and HGS. Despite limited capacities of these 92 physical compromised patients 76% was able to perform at least one repetition of the m-30s-CST while only 20% was able to perform the 5t-CST. We demonstrated a high test-retest reliability for measuring the m-30s-CST (ICC 0.95; P<0.001) with a minimal detectable change (MDC) of 1 repetition in 59 physical compromised acutely ill geriatric patients. Although handgrip strength measurement is easy to perform, the m-30s-CST shows a better correlation with physical performance (SPPB with respectively: ρ=0.260; P=0.012 and ρ=0.802; P<0.001) and self-reliance (ADL-BI with respectively: ρ=0.214; P=0.040 and ρ=0.577; P<0.001).

Other studies also describe the advantages of lower body strength testing compared to handgrip strength. Geriatric patients with low skeletal muscle mass and strength generally have a poor clinical outcome following acute illness[22,23]. Measuring handgrip strength or chair stand test are advised by the EWGSOP-2. While handgrip strength is a predictor of morbidity and mortality, lower extremity strength may be better associated with functional activities in comparison to handgrip strength[24]. Harris-Love and coworkers found in their research that handgrip strength was not a proxy measure of lower extremity strength and found that lower extremity muscle strength values had the strongest associations with participant functional performance. Lower extremity strength testing may provide additional value as an endpoint measure in the assessment and clinical management of sarcopenia[9].

Improving and retaining self-reliance and overall condition is one of the main goals of acutely ill geriatric hospitalized patients[25]. Prioritizing these patient goals underlines the importance of measurements that provide information about functioning and not just about mortality risk. A chair stand test as a measure of muscle strength in the legs is therefore relevant in acutely ill hospitalized geriatric patients.

As mentioned earlier, the 5t-CST is recommended by EWGSOP-2 but is not very suitable for the acutely ill geriatric patient as it is feasible in only 20% of patients and there is a floor effect. The m-30s-CST appears to be feasible in the majority of patients (76.1%) despite their limitations with good test-retest reliability. This is consistent with previous, albeit very limited, research examining the m-30s CST. To our best knowledge there was only one study done by McAllister et al which tested the reliability of the m-30s-CST in older rehabilitating patients who were unable to perform the other sit-to-stand tests (CTS, 5t-CST, 30s-CST)[13]. The study involved seven participants with a mean age of 85 years and an average of 2 primary diagnosis and 5.2 comorbidities, with a baseline performance on the m-30s-CST a mean (±SD) of 2.8 ±2.7 repetitions and after rehabilitation a mean of 4.8 ±5.5 repetitions. McAllister and coworkers showed a high test-retest intra-rater reliability (ICC: 0.987; P≤ 0.001) which is accordance with our research with an ICC of 0.954 (95% CI: 0.921-0.973; P<0.001).

Chair rising assessed with the m-30s-CST showed a moderate correlation with self-reliance assessed with the ADL-BI (Spearman's rho = 0.577, P< 0.001). This indicates that the ability to perform the chair stand test quickly and effectively has an association with greater independence in activities of daily living. Our findings are consistent with former research done by McAllister and coworkers (2020) in a rehabilitation center for older adults, which included 33 patients for this analysis, found a correlation between the m-30s-CST and a modified Barthel-Index with a Spearman rho of 0.737 (P= 0.01). However, the ADL-BI in their study was modified to increase sensitivity to detecting change. They concluded that the correlation between the measure tools lends weight to the hypothesis that the m-30s-CST is a clinically relevant tool that can reflect improvements in functional performance. Despite the fact that our study did not aim specifically to investigate responsiveness we suggest that the m-30s-CST can be a useful tool for functional status. Further research on the responsiveness of the m-30s-CST over time and the relation with changes in the ADL-BI will be needed to prove this theory.

The weaker correlation between the m-30s-CST and the ADL-BI in our research compared to the finding of McAllister and coworkers could be due to several reasons. Firstly, our research used the original ADL-BI and did not modify the scoring system to increase the sensitivity to detect change. Secondly, hospitalized acutely ill geriatric patients need recovery time from acute illness and have more physical and cognitive limitations, which can affect the relation between the m-30s-CST and the ADL-BI. In hospitalized geriatric patients prevalence of cognitive problems is higher compared to patients in a rehabilitation setting. Contrary to the research from McAllister and coworkers, our research did not exclude patients diagnosed with dementia[26]. Finally the ADL-BI provides information about the patients functioning before hospitalization and the m-30s-CST is assessed during the acute illness during the hospitalization. This could lead to a weaker correlation between the two measures.

In accordance with the research from Harris-Love and coworkers we found that handgrip strength showed a very

weak correlation with functional performance (SPPB; ρ=0.260; P=0.012 and ADL-BI; ρ=0.214; P=0.040). Additionally Tietjen-Smith and coworkers reported no correlation between HGS and ADL-BI (ρ = 0.136; P> 0.05) in 102 older adults living in assisting living centers which is in line with our findings[27,28].

Our results also showed a very weak correlation between the m-30s-CST and the HGS (ρ = 0.350; P<0.001). To our knowledge no earlier research on the correlation between those two specific measurement tools has been done yet. Sawada and coworkers compared the 30s-CST with HGS in an aged population (74.7±7.2) of 678 participants and found a very weak correlation (ρ = 0.400; P<0.001). This finding is in accordance with our research findings[29]. These findings underline that handgrip strength and leg muscle strength assessed with the m-30s-CST are proxies for different outcomes.

Of the 374 screened patients, only 92 were ultimately included in the study. In view of the high number of patients that are excluded, there may be selection bias. However, we think the probability of this is low as the patient characteristics are similar (data not shown). However, more than 100 patients had already been discharged early, reasons for this were diverse, such as no indication for hospitalization, waiting for care, but also a quicker than expected recovery, resulting in discharge to home or another care institution. It may be that we missed patients who had relatively better physical capacities, but also worse. In theory, this could have influenced the feasibility of the 5t-CST and m-30s-CST in both directions, but we have no data on this.

Patient characteristics were found to be not significantly different between sexes except for the CCI. Since the purpose of the study was to investigate feasibility and test-retest reliability, this difference in CCI does not affect the results. Moreover, the measurements of the m-30s-CST to measure the test-retest reliability were done in a time frame of 2 days, so no impact of the difference on CCI score between the 2 sexes should be expected.

Possible limitations of the study are factors that could have impacted the patients ability to perform the m-30s-CST consistently across time: recovery of health throughout the hospitalization, fluctuations, cognitive functioning and physical energy throughout the day and external events that could have impacted the patients resilience[30]. To avoid this as much as possible, we took the two measurements when we expected the least amount of change in physical and mental conditions. We also tried to take the measurements at the same moment in the patients' daily schedule so results would not be impacted by fatigue from exercise or mental strain that could have occurred during the day.

As the focus of this study was on hospitalized acutely ill geriatric patients, thus concerning frail older patients with high care dependency and low physical performance capacities, caution should be taken when generalizing the findings to other populations. The strength of this study lies in the fact that it is a study performed in daily hospital practice with acutely ill geriatric patients. In addition, it is the first study that investigates the applicability and test-retest reliability of the m-30s-CST in these patients and in this setting demonstrating that it is feasible and reliable strength test and gives a better indication about physical function and self-reliance compared to hand grip strength.

In conclusion the m-30s-CST is a well-applicable and reliable tool in the acutely ill hospitalized geriatric population. It is an easy accessible test that quickly gives insight into the lower extremity muscle strength as well as functional status. The m-30s-CST is more feasible compared with the 5t-CST in the acutely ill hospitalized geriatric patients and is a better marker for physical performance and self-reliance compared with handgrip strength in these physical compromised frail patients. In treating hospitalized geriatric patients with high prevalence of sarcopenia and different patients' goals geriatricians should both assess handgrip strength and perform the m-30s-CST because they have different clinical relevant implications, respectively mortality and functionality.

More research is needed to access the responsiveness of the m-30s-CST compared to changes physical performance (SPPB) and self-reliance (ADL-BI) and in relation to possible impact of treatment.

Ethics approval

This study was approved by the Ethics Committee of Zuyderland and Zuyd Hogeschool, the Netherlands (METCZ20210028), and conducted in accordance with the 1964 Declaration of Helsinki and its later amendments.

Authors' Contributions

Isis Ensink was responsible for the second part of patients' inclusions and data collection, handled different aspects of data analysis and interpretation and drafted the majority of the manuscript. She prepared the manuscript for submission and ensured adherence to the journal guidelines. Martijn JA Rothbauer took part in the conceptualizing of the study, was responsible for the first half of the inclusions and data collection, assisted with initial data preparation, helped manage resources and reviewed and revised specific sections of the manuscript to enhance its quality. Shannon Röhlinger played a role in the data collection during the first part of the inclusions by conducting measurements and ensuring data accuracy and consistency. Audrey HH Merry contributed to parts of the data analysis and helped interpreting the data. She reviewed and revised sections of the results to enhance its quality. Walther MWH Sipers took part in the conceptualizing of the study, contributing to its design and the process. He supervised the execution of the research, data analysis, writing of the manuscript and ensuring regulatory compliance. He critically reviewed different versions of the manuscript to improve its clarity and quality to make it suitable for publications. All authors read and approved the final version of the manuscript.

References

1. Alexandre Tda S, Duarte YA, Santos JL, Wong R, Lebrão ML. Sarcopenia according to the European Working Group on Sarcopenia in Older People (EWGSOP) versus dynapenia as a risk factor for mortality In the elderly. J Nutr Health Aging, 2014;18(8);751-756.
2. Shirley Ryan Abilitylab. 30 Seconds Sit To Stand Test [online]. Sralab: Chicago; 2013 [Accessed 2 January 2023]. Available from: https://www.sralab.org
3. Le Berre M, Apap D, Babcock J, Bray S, Gareau E, Chasse K, et al. The Psychometric Properties of a Modified Sit-to-Stand Test With Use of the Upper Extremities in Institutionalized Older Adults. Percept Mot Skills 2016;123(1):138-152.
4. Jones CJ, RE Rikli, WC Beam. A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. Research quarterly for exercise and sport 1999;70(2):113-119.
5. Bodilsen AC, Juul-Larsen HG, Petersen J, Beyer N, Andersen O, Bandholm T. Feasibility and inter-rater reliability of physical performance measures in acutely admitted older medical patients. PLoS One [online] 2015;10(2): e0118248. [Accessed 6 February 2023]. Available from: https://journals.plos.org/plosone/
6. Cerri AP, Bellelli G, Mazzone A, Pittella F, Landi F, Zambon A, et al. Sarcopenia and malnutrition in acutely ill hospitalized elderly: Prevalence and outcomes. Clin Nutr 2015;34(4):745-751.
7. Cederholm T, Jensen GL, Correia M, Gonzalez MC, Fukushima R, Higashiguchi T, et al. GLIM criteria for the diagnosis of malnutrition - A consensus report from the global clinical nutrition community. Clin Nutr 2019;38(1):1-9.
8. Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, Cederholm T, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age and Ageing 2019;48(1):16-31.
9. Harris-Love MO, Benson K, Leasure E, Adams B, McIntosh V. The Influence of Upper and Lower Extremity Strength on Performance-Based Sarcopenia Assessment Tests. J Funct Morphol Kinesiol 2018;3(4):53.
10. Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, Cederholm T, et al. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age and Ageing 2010;39(4):412-423.
11. Mehmet H, Yang AWH, Robinson SR. What is the optimal chair stand test protocol for older adults? A systematic review. Disability and Rehabilitation 2020;42(20):2828-2835.
12. Csuka M, McCarty DJ. Simple method for measurement of lower extremity muscle strength. Am J Med 1985;78(1):77-81.
13. McAllister LS, Palombaro KM. Modified 30-second sit-to-stand test: reliability and validity in older adults unable to complete traditional sit-to-stand testing. Journal of geriatric physical therapy 2020;43(3):153-158.
14. Steverink N. Measuring frailty: developing and testing the GFI (Groningen Frailty Indicator). The gerontologist 2001;41:236.
15. Walter S, Eliasziw M, Donner A. Sample size and optimal designs for reliability studies. Statistics in medicine 1998;17(1):101-110.
16. Kruizenga HM, Seidell JC, de Vet HC, Wierdsma NJ, van Bokhorst-de van der Schueren MA. Development and validation of a hospital screening tool for malnutrition: the short nutritional assessment questionnaire (SNAQ). Clin Nutr 2005;24(1):75-82.
17. Bielderman A, van der Schans CP, van Lieshout MR, de Greef MH, Boersma F, Krijnen WP, et al. Multidimensional structure of the Groningen Frailty Indicator in community-dwelling older people. BMC Geriatr 2013;13:86.
18. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, et al. A short physical performance battery assessing lower extremity function: Association with self-reported disability and prediction of mortality and nursing home admission. Journal of Gerontology: Medical Sciences 1994;49:85–94.
19. Collin C, Wade DT, Davies S, Horne V. The Barthel ADL Index: A reliability study. International Disability Studies 1988;10(2): 61–63.
20. Benton MJ, Spicher JM, Silva-Smith AL. Validity and reliability of handgrip dynamometry in older adults: A comparison of two widely used dynamometers. PLoS One 2022;17(6).
21. Dontje ML, Dall PM, Skelton DA, Gill JM, Chastin SF, Team SU. Reliability, minimal detectable change and responsiveness to change: Indicators to select the best method to measure sedentary behaviour in older adults in different study designs. PloS one 2018;13(4):e0195424 [Accessed 23 February 2023]. Available from: https://journals.plos.org/plosone/
22. Gariballa S, Alessa A. Sarcopenia: prevalence and prognostic significance in hospitalized patients. Clinical Nutrition 2013; 32(5):772-776.
23. Vetrano DL, Landi F, Volpato S, Corsonello A, Meloni E, Bernabei R, et al. Association of sarcopenia with short-and long-term mortality in older adults admitted to acute care wards: results from the CRIME study. Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences 2014;69(9):1154-1161.
24. Lauretani F, Russo CR, Bandinelli S, Bartali B, Cavazzini C, Di Iorio A, et al. Age-associated changes in skeletal muscles and their effect on mobility: an operational diagnosis of sarcopenia. J Appl Physiol (1985) 2003;95(5):1851-1860.
25. van Munster BC, Boot GG, Festen S, de Rooij SE. Goals and outcomes of hospitalised older people: does the current hospital care match the needs of older people? Intern Med J 2022;52(5):770-775.
26. Landefeld CS, Palmer RM, Kresevic DM, Fortinsky RH, Kowal J. A randomized trial of care in a hospital medical unit especially designed to improve the functional outcomes of acutely ill older patients. New England Journal of Medicine 1995;332(20):1338-1344.
27. Tietjen-Smith T, Smith SW, Martin M, Henry R, Weeks S, Bryant A. Grip strength in relation to overall strength and functional capacity in very old and oldest old females. Physical & Occupational Therapy in Geriatrics 2006;24(4):63-78.
28. Di Monaco M, Castiglioni C, De Toma E, Gardin L, Giordano S, Tappero R. Handgrip strength is an independent predictor of functional outcome in hip-fracture women: a prospective study with 6-month follow-up. Medicine (Baltimore) 2015;94(6)e542 [Accessed 3 February 2023]. Available from: https://journals.lww.com/md-journal/pages/default.aspx
29. Sawada S, Ozaki H, Natsume T, Deng P, Yoshihara T, Nakagata T, et al. The 30-s chair stand test can be a useful tool for screening sarcopenia in elderly Japanese participants. BMC Musculoskeletal Disorders 2021;22:1-6.
30. Hesseberg K, Bentzen H, Bergland A. Reliability of the senior fitness test in Community-dwelling older people with cognitive impairment. Physiotherapy Research International 2015;20(1):37-44.

Supplementary Files

Supplementary Table 1. Case summary of the 3 most frequent co-morbid diseases according organ system category of the acutely hospitalized geriatric patients (n=92).

Cat.	Organ system	1st	n	2nd	n	3rd	n
1	Cardiac	Chronic heart failure	45	Coronary artery disease	41	Atrial Fibrillation	36
2	Hypertension	2 medications	31	3 medications	12	1 medication	7
3	Vascular	Anaemia	32	Peripheral vascular disease	13	DVT/PE	9
4	Respiratory	COPD	34	Pneumonia	13	Smoking	11
5	ENT	Presbyacusis	67	Cataract	46	Glaucoma/ macular degeneration	9
6	Upper GI	Proton Pump Inhibiter use	33	Reflux Esophagitis	14	Peptic Ulcer	7
7	Lower GI	Constipation	45	Diverticular disease	31	Colon cancer	2
8	Hepatic	Cholecystectomy	13	Cholecystolithiasis	4	Pancreatitis	2
9	Renal	Renal failure	47	Stones	6	Renal Cell Carcinoma	1
10	Other GU	Incontinence	39	Bladder retention	12	BPH/TURP	9
11	Musculoskeletal-Integumentary	Osteoarthritis	45	Fracture	18	Rheumatic arthritis	9
12	Neurological	Stroke/TIA	18	Parkinson(ism)	9	polyneuropathy	8
13	Endocrine/ metabolic	DM	27	Thyroid disease	21	Hypercholesterolemia	11
14	Psychiatric/ Behavioural	Delirium	41	Dementia	23	MCI	14

ENT: Ear, Nose, Throat; GI: Gastrointestinal; COPD: Chronic Obstructive Pulmonary Disease; TIA: Transient Ischaemic Attack; DM: Diabetes Mellitus; DVT: Deep Venous Thrombosis; PE: Pulmonary Embolism; BPH: Benign Prostatic Hypertrophy; TURP: Transurethral Resection of the Prostate; MCI: Mild Cognitive Impairment.

Supplementary Table 2. Case summary of main medical diagnosis at hospital admission of the acutely hospitalized geriatric patients (n=92).

Main medical diagnosis	Number
Pneumonia / pneumosepsis	20
Delirium	14
Decompensated heart failure	10
Complicated urinary tract infection	9
Falls/syncope	8
Hyponatremia symptomatic	5
Dehydration	4
Anaemia symptomatic	3
Medication intoxication	2
Diverticulitis	2
Erysipelas	2
Cancer	2
Other*	11

** Acute cholecystitis, endocarditis, gout arthritis, pulmonary embolism, acute renal failure, osteomyelitis, polymyalgia rheumatica, spondylodiscitis, subdural hematoma. All the geriatric patients had at least 5 other medical diagnosis/problems at hospital admission.*