Title

Prevalence and factors associated with poor performance in the 5-chair stand test: findings from the Cognitive Function and Ageing Study II (CFAS II) and proposed Newcastle protocol for use in the assessment of sarcopenia

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Keywords

Sarcopenia; chair stand test, physical performance; gait speed; geriatric assessment

1 **Abbreviations**

CFAS II	Cognitive Function and Ageing Study II
5-CST	5-chair stand test
EWGSOP2	European Working Group on Sarcopenia in Older People 2

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Abstract

Background

Poor performance in the 5-chair stand test (5-CST) indicates reduced lower limb muscle strength. The 5-CST has been recommended for use in the initial assessment of sarcopenia, the accelerated loss of muscle strength and mass. In order to facilitate the use of the 5-CST in sarcopenia assessment, our aims were to (1) describe the prevalence and factors associated with poor performance in the 5-CST, (2) examine the relationship between the 5-CST and gait speed and (3) propose a protocol for using the 5-CST.

Methods

The population-based study Cognitive Function and Ageing Study II (CFAS II) recruited people aged 65 years and over from defined geographical localities in Cambridgeshire, Newcastle and Nottingham. The study collected data for assessment of functional ability during home visits, including the 5-CST and gait speed. We used multinomial logistic regression to assess the associations between factors including the SARC-F questionnaire and the category of 5-CST performance: fast (< 12 s), intermediate (12-15 s), slow (> 15 s) or unable, with slow/unable classed as poor performance. We reviewed previous studies on the protocol used to carry out the 5-CST.

Results

A total of 7,190 participants aged 65+ from the three diverse localities of CFAS II were included (54.1% female). The proportion of those with poor performance in the 5-CST increased with age, from 34.3% at age 65-69 to 89.7% at age 90+. Factors independently associated with poor performance included positive responses to the SARC-F questionnaire, physical inactivity, depression, impaired cognition and multimorbidity (all $P < 0.005$). Most people with poor performance also had slow gait speed (57.8%) or were unable to complete

the gait speed test (18.4%). We found variation in the 5-CST protocol used, for example timing until a participant stood up for the fifth time or until they sat down afterwards.

Conclusions

Poor performance in the 5-CST is increasingly common with age and is associated with a cluster of other factors that characterise risk for poor ageing such as physical inactivity, impaired cognition and multimorbidity. We recommend a low threshold for performing the 5-CST in clinical settings and provide a protocol for its use.

Introduction

The 5-chair stand test (5-CST) is a measure of the strength of the lower limb muscles, and involves a participant being asked to stand up from a chair and sit back down as quickly as possible five times [1]. The 5-CST has been included in cohort studies where poor performance has been linked to subsequent disability [2,3], falls [4], fractures [5] and mortality [2,6]. The 5-CST has also been evaluated in a range of different clinical settings. These include as an outcome measure following hip and knee replacement [7], in the care of patients with chronic obstructive pulmonary disease [8,9] and following discharge from intensive care [10]. Across these settings there is evidence that the 5-CST is reliable and that it is a valid measure of lower limb strength.

These characteristics have led to the 5-CST being recommended for use in the initial assessment of sarcopenia, the accelerated loss of muscle strength and mass. The European Working Group on Sarcopenia in Older People 2 (EWGSOP2) consensus definition [11] advised that the 5-CST or hand grip tests should be used to identify those with low muscle strength: if either are present, this is a basis on which to investigate causes and begin treatment. Clinically relevant questions regarding the 5-CST arising from the EWGSOP2 definition include an understanding of which groups are likely to have poor performance, the relationship with other components of the EWGSOP2 definition and guidance on the protocol to use.

The Cognitive Function and Ageing Studies are a suite of population-based studies in different geographical localities, recruited through general practice with population representativeness known and including care home settings. Their aims have been to integrate physical, mental, and cognitive domains to describe contemporary populations, including

frailty and dementia. In the most recent generational study in Cambridgeshire, Newcastle and Nottingham the Cognitive Function and Ageing Study II (CFAS II) incorporated the 5-CST and gait speed of a large sample of community-dwelling older people. Here we draw on data from CFAS II to describe the prevalence and factors associated with poor performance in the 5-CST, and to examine the relationship between the 5-CST and gait speed. We used our findings and a literature review to propose a protocol for using the 5-CST.

Methods

Participants and ethical approval

The study design for CFAS II has been described in detail previously [12]. In brief, people aged 65 years and above living in three geographic areas in England (Newcastle, Nottingham and Cambridgeshire) were recruited from general practitioner lists including those resident in care settings. The fieldwork for the first wave, as used in the present study, was carried out between 2008 and 2011, with participants visited at home by a trained researcher who completed a detailed questionnaire covering sociodemographic information, social engagement, activities of daily living, mental and physical health conditions, medication and cognitive measures, along with physical and cognitive assessments. Ethical approval was granted by the Cambridgeshire 4 Research Ethics Committee as well as relevant local research ethics committees. Study assessments were carried out only after written informed consent was obtained, with consent sought from a consultee if a participant lacked capacity to consent.

Assessment of chair stand test and gait speed

For the 5-CST, a firm straight back chair that was available in the participant's home such as a dining chair was used. The height of the chair used therefore varied. Each participant was asked if they would feel safe to sit on a firm straight backed chair with their feet on the floor and their arms folded across their chest, before standing up without using their arms. Those participants who completed a single chair stand without using their arms were then asked if they would feel safe to repeat the procedure but standing up five times as quickly as possible. The time taken to complete five rises was recorded, timed from when they were seated and asked to start until when they had stood up straight for the fifth time. The researcher recorded a reason in the event a participant felt safe to attempt but did not complete the 5-CST.

We grouped participants into the following 5-CST categories: fast (quicker than 12 seconds, as previously found to distinguish those not experiencing two or more falls in a 12-month period from those who did [4]), intermediate (12 – 15 seconds), slow (greater than 15 seconds, as per the EWGSOP2 guidance [2,11]) and unable (grouped separately due to the associations with adverse health outcomes [5,13], including those who were not usually independently mobile indoors and those who did not feel safe to attempt the test). Going forward we refer to participants with a slow time or those who were unable as having poor performance in the 5-CST.

For the gait speed test, the researcher marked out a 2.4m course and asked the participant to walk along it at their usual speed, using a walking aid if they felt more comfortable to do so. The researcher timed from when the participant began walking to when one of their feet first crossed the line at the end. The walk was performed twice, and we used the average of the two times to calculate their gait speed. The researcher recorded a reason in the event a participant felt safe to attempt but did not complete the gait speed test. We categorised participants into the following gait speed outcomes: fast (=> 1 m/s, as per an earlier study [14]), intermediate (>0.8 and < 1 m/s), slow (<= 0.8 m/s, as per the EWGSOP2 guidance [11]) and unable (including those who were not usually independently mobile indoors).

Assessment of SARC-F score and other characteristics

The SARC-F questionnaire is recommended as a screening tool for sarcopenia in the EWGSOP2 definition [11]. It has five components, comprising: difficulty in walking across a room, number of falls in the last year, strength (difficulty with lifting or carrying a 10-pound weight), difficulty with chair or bed transfers and difficulty with climbing stairs. Each is

scored 0 – 2 in order of increasing difficulty, and a score of 4 or more suggesting the presence of sarcopenia [15]. We derived a SARC-F score from CFAS II as described in supplementary materials (S1).

In addition to the SARC-F questionnaire, we examined clinically relevant factors associated with the outcome of the 5-CST available from the interview with respondent. These were self-reported long-term conditions, based on a count of conditions from the following list: hypertension, low blood pressure, diabetes, stroke, angina, heart attack, cancer, chronic bronchitis, asthma, hearing impairment, vision impairment, Parkinson's disease, epilepsy, arthritis, peptic ulcer, pernicious anaemia and thyroid problems. We considered those with two or more to have multimorbidity. Depression was assessed in CFAS II using the geriatric mental state (GMS) examination and the automated geriatric examination for computer assisted taxonomy (AGECAT) algorithm, with neurosis and psychosis types of depression being included [16]. We categorised the Mini-Mental State Examination (MMSE) as 26-30 (normal), 22-25 (mild impairment) and 21 or below (severe impairment). We considered those who did not complete an MMSE but who had a diagnosis of dementia (from the AGECAT algorithm [12,16]) to have severe impairment for the purpose of analyses. Smoking history was recorded as current, previous, or never. Participants were asked a series of questions about different types of habitual physical activity as developed for use in the English Longitudinal Study of Ageing [17,18], and categorised by their highest level of activity performed regularly (at least once a month): vigorous (such a running or heavy gardening), moderate (such as heavy housework or walking at a moderate pace) and light (such as light housework) or no regular activity. Place of residence was categorised as living alone, living at home with others or living in a care home.

We also classified their socio-economic status using the Registrar General's Social Classification into five groups: I, II, IIINM, IIIM, IV and V. We grouped participants' number of years of full-time education into 0-9, 10-11 and 12+.

Statistical analyses

We restricted the sample to participants of the first wave of CFAS II with a result for the 5-CST (including those who were unable to complete the test), the SARC-F questionnaire and the clinically-relevant factors, as shown in Supplement 4. We examined the characteristics of the sample by sex, testing for differences using the chi-square test for categorical variables and the T-test for continuous variables. We described the prevalence of 5-CST categories by 5-year age and sex groups, grouping those aged 90+ together. We examined the prevalence of 5-CST categories by the score from the SARC-F questionnaire. We calculated the sensitivity and specificity of the previously proposed cut-point of a SARC-F score of four or more for poor performance in the 5-CST.

We investigated other factors associated with the different categories of the 5-CST. To model the full range of categories, and because we anticipated that these factors might have non-proportional effects between each pairs of categories, we used multinomial logistic regression models with chair stand category as the outcome variable. We firstly checked that each factor had a statistically significant association with the outcome in a model adjusted for age category and sex only (as shown in supplementary materials, S2). We then ran a model including all factors to test which of them had independent associations with the outcome. In sensitivity analyses we repeated the models, excluding (a) those with a SARC-F score of four or above and (b) those who lived in care homes.

Finally, we described the prevalence of categories of gait speed among those with poor performance in the 5-CST. All tests of means and proportions, and all multivariable models incorporated sampling weights to account for the CFAS II design and initial non-response [12]. We performed all analyses using Stata version 14.0 [19].

Literature search

We searched the MEDLINE database in October 2019 for articles relating to the protocol used to perform the 5-CST (also referred to as the chair rise or sit to stand test). For details of the search terms and number of articles retrieved, please see supplementary materials, S3. Two authors (AG and CH) screened the search for relevant articles and a third author (JM) summarised their findings. We used the findings from CFAS II and the literature search to propose a protocol for the 5-CST.

Results

Characteristics of the study population

Of the 7,796 participants in the first wave of CFAS II, 7,303 (93.7%) had a time for the 5-CST or were unable to complete the test, and 7,190 (92.2%) also had data on clinical factors (as shown in Supplement S4). Participants with missing data tended to be older (mean age with missing data 80 and 75 without, $p < 0.001$) and more likely to be women (58.5% with missing data and 54.1% without, $p=0.041$).

Women (54.1% of the sample) were on average older than the men, more likely to have multimorbidity, depression, cognitive impairment, to undertake light or no physical activity, to live alone, to have a SARC-F score of four or more, to have fewer than 10 years in full-time education and to be of lower socio-economic status, whereas men were more likely to be previous or current smokers, as shown in Table 1.

The chair stand test in relation to age, sex and SARC-F score

Average performance in the 5-CST worsened with age, with poor performance (defined as needing more than 15 seconds or being unable to complete the test) present in 34.3% of those aged 65-69, increasing to 89.7% of those aged 90+, with a particular increase in the proportion of those unable to complete the test at older ages as shown in Figure 1. Women had worse performance than men, and this became more obvious with increasing age ($P < 0.01$ from a test of age-sex interaction for poor performance).

Performance in the 5-CST worsened with increasing SARC-F score, as shown in Figure 2. A SARC-F score of four or more (the cut-point recommended for the identification of sarcopenia) was seen in 1,364 (19.0%) participants. This cut-point identified a group with

severely impaired chair stand performance, with 83.0% unable to complete the test and 13.2% completing it with a slow time. There was reflected in a high specificity (98.7%) and low sensitivity (33.2%) of a SARC-F score of four or more for poor performance in the 5-CST.

The associations of the chair stand test with clinical factors

In multinomial logistic regression models adjusted for age and sex, all of the clinical factors tested (multimorbidity, depression, impaired cognition, current smoking, physical inactivity, living alone or in a care home and raised SARC-F score) were significantly associated with worse performance in the 5-CST as shown in supplementary materials (S2). In the multivariable model, all factors had an attenuated but still significant association with the 5-CST (Table 2).

Table 2 provides odds ratios in which clinical factors (e.g. multimorbidity) are stratified and then the odds ratio of being in a particular 5-CST performance group (as opposed to having intermediate performance) is compared between those with the presence or absence of the clinical factor shown. For example, compared to those without multimorbidity, those with had a 12% (95% CI: 2 – 22%) lower odds of fast 5-CST performance, a 23% (95% CI: 8 – 40%) higher odds of slower 5-CST performance and a 23% (95% CI: 4 – 45%) higher odds of being unable to complete the 5-CST. The highest odds ratios for poor performance were seen for one or more positive responses to the SARC-F questionnaire, notably for being unable to complete the test. In sensitivity analyses, exclusion of those participants living in care homes and those with a SARC-F score of four or more did not substantially alter the findings.

The combination of SARC-F, 5-chair stand test and gait speed

Using these population based empirical data we developed a modified version of the EWGSOP2 algorithm (shown in Figure 3). The above finding of a wide range of independent factors associated with poor performance suggests that clinicians should check the 5-CST wherever possible, including among those with a SARC-F score between 1 and 3.

We saw that approximately two-thirds of those with a slower chair rise time also had slow gait speed. By comparison, approximately half of those who were unable to complete the 5-CST had slow gait speed, and approximately one-third of those unable to complete the 5-CST were also unable to complete the gait speed test.

Existing literature regarding the protocol for the chair stand test

Other versions of the chair stand test include the 10-chair stand test which was originally developed to assess patients with myositis [20]. There is also a version based on the maximum number of stands that a person can complete in 30 seconds, with 8% of one sample completing fewer than five stands [21]. Of the different versions, the 5-CST has been most commonly used in research studies [22] and is the one recommended in the EWGSOP2 consensus definition [11].

We identified three references with detailed protocols for the 5-CST [2,23,24]. The protocol used by Cesari et al. [2] was similar to that in CFAS II, except that timing stopped when participants had sat down for the fifth time, instead of when they had stood up for the fifth time. We found examples of both timing until sitting down for the fifth time [25–27] and on standing for the fifth time [23,28,29], with the latter including the protocol by Guralnik et al. for the Short Physical Performance Battery [23].

The height of the chair used is another aspect of protocol that is recognised to vary between studies, for example between 40 and 46 cm, with evidence that lower chair heights reduce the likelihood of successfully completing the test [30,31]. There is therefore a need to standardise chair height especially if serial measurements are being considered [1] and a height of approximately 43cm has been recommended in the protocol by Bohannon [24]. As in CFAS II, it is recognised that if using a person's own chair at home then the height used will vary [32]. Finally one study found that a moderately cold environment (15ºC) reduced the sit-to-stand performance of women at mean age 78 years compared to a warm/normal environment (25ºC) [33]. We combined the protocol used in CFAS II, the findings from our analyses and the existing literature to propose a recommended protocol for the use of 5-CST as shown in Figure 4.

Discussion

Summary of findings

We investigated the prevalence and factors associated with poor performance in the 5-CST in a large representative sample of older people in three diverse localities of England. We found that performance declined with age, including an increasing proportion of those unable to complete the 5-CST. A SARC-F score of four or more was highly specific, but not sensitive, for poor performance in the 5-CST. A range of clinically relevant variables including multimorbidity, depression, impaired cognition and smoking was also independently associated with poor performance. A literature review revealed variation in the protocol for the 5-CST test, including the timing and the height of the chair used. We have used our findings to recommend a protocol for the use of the 5-CST in the assessment of sarcopenia, applicable in both clinical and research settings.

Strengths and limitations of the present study

We designed a study to address several clinically relevant questions regarding the 5-CST which arise from the EWGSOP2 sarcopenia consensus definition. We used data from the CFAS II, a large population-based sample from three geographical areas from the UK designed to estimate the prevalence of dementia [12]. We had information on the majority (92%) of this sample in terms of 5-CST performance and its associated factors. Those with missing data (8%) were older on average and more likely to be female. A limitation of the present study is that it did not assess BMI as a clinical factor, which has been linked to performance in the 5-CST [34]. We used a statistical technique (multinomial logistic regression) that allowed us to incorporate the full range of 5-CST performance in analyses, including those unable to complete the test which became increasingly prevalent at older ages.

Comparison with existing studies

We saw an increase in the average time taken to complete the 5-CST with increasing age (Figure 1). A previous meta-analysis of 14 studies of the 5-CST also showed an increase with age but of a lower magnitude than in the present study, with a pooled time for both women and men of 11.4 seconds in those aged 60-69 increasing to 12.7 in those aged 80-89 [35]; the faster 5-CST times than those seen in our study may reflect the inclusion of convenience samples, whereas CFAS II is a population-based study carried out in three diverse geographical localities. We also saw a sharp increase with age in the proportion of participants unable to complete the CST, rising above 50% in the 85-89 age group. We are not aware of other studies that have reported the prevalence of being unable to complete the 5-CST by age group, although previous work suggests that the likelihood of being unable to complete the 5-CST [5] and a single chair stand [36] increases with age.

A higher SARC-F score was also associated with worse performance in the 5-CST (Figure 2 and Table 2). A SARC-F score of four or more had high specificity but low sensitivity for poor performance in the 5-CST, as described previously in relation to sarcopenia in general [37,38]. This highlights the need for other ways to identify people likely to have probable sarcopenia, referred to as clinical suspicion in the EWGSOP2 guidance [11]. We have previously showed that multimorbidity, any positive SARC-F responses, polypharmacy, lower body osteoarthritis and physical inactivity were factors associated with probable sarcopenia at age 69 [39,40]. In the present study we found that impaired cognition, current smoking and living in a care home were also associated with poor performance.

From a literature review we found that the 5-CST has been widely applied and is the most commonly used type of chair stand test. The 5-CST also forms part of the short physical performance battery, in combination with the standing balance and gait speed tests [23]. We found variation in the protocol used, in terms of chair height and the point at which timing is stopped, both of which have the potential to affect the result obtained. We proposed a protocol to facilitate the use of the 5-CST in the context of suspected sarcopenia (Figure 4).

Implications for clinical practice and future research

The EWGSOP2 definition recommends the use of grip strength or the 5-CST to identify patients with probable sarcopenia. Our findings highlight that with increasing age there is a sharp increase in the proportion of individuals who are unable to complete the test. There is evidence that this proportion is even greater among medical inpatients [41]. In contrast, grip strength is feasible both in the very old and among inpatients [42,43]. We also saw that the majority of those with poor performance in the 5-CST also had poor performance in the gait speed test. Poor performance in the 5-CST, especially non-completion, may therefore highlight individuals who would be categorised as having severe sarcopenia according the EWGSOP2 definition and hence should be prioritised for further assessment. Performance in the 5-CST has also been shown to depend on sensation and balance, and hence poor performance in the 5-CST should also prompt clinical assessment of these factors [44].

We found that participants who were unable to complete the 5-CST had a range of adverse health and lifestyle factors including functional impairment on the SARC-F questionnaire, multimorbidity, impaired cognition, low mood, current smoking and low physical activity. Being unable to complete the 5-CST has also been linked to hip fracture [5] and increased all-cause mortality rates [13]. This all suggests that as well as an indication to carry out further

assessment of sarcopenia, being unable to complete the 5-CST is an indication to undertake a comprehensive geriatric assessment such as recommended for older adults living with frailty [45]. Our findings also highlight that capturing non-completion of the 5-CST, and the reasons for it, is important in research studies related to sarcopenia. This is especially relevant in clinical trials where individuals may become unable to complete the 5-CST during follow-up, as also recognised when using physical performance measures in trials of frailty prevention [46].

Conclusions

Poor performance (being slow or unable) in the 5-CST is already prevalent at age 65-69, with approximately one-third affected, and becomes increasingly common at older ages. A wide range of independent factors including any positive SARC-F responses, multimorbidity, depression and impaired cognition identify individuals who are likely to have poor performance, suggesting that clinicians should have a low threshold for attempting the test. We have proposed a protocol for the 5-CST which should facilitate its use in the assessment of suspected sarcopenia.

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The authors of this manuscript certify that they comply with the guidelines of ethical authorship and publishing in the Journal of Cachexia, Sarcopenia and Muscle [47].

Conflicts of interest

All authors confirm that they have no conflicts of interest.

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1 **Table 1: Characteristics of the sample, by sex**

Characteristic (n (%) unless shown otherwise)	Male (n=3,297)	Female (n=3,893)	P-value**
Age (y) mean (SD)	74.7 (6.69)	75.8 (7.22)	< 0.001
Age group			< 0.001
65-69	925 (28.06)	936 (24.04)	
70-74	850 (25.78)	928 (23.84)	
75-79	716 (21.72)	818 (21.01)	
80-84	560 (16.99)	777 (19.96)	
85-89	177 (5.37)	279 (7.17)	
90+	69 (2.09)	155 (3.98)	
Number of long-term conditions			< 0.001
0	295 (8.95)	238 (6.11)	
1	607 (18.41)	613 (15.75)	
2+	2395 (72.64)	3042 (78.14)	
Depression	148 (4.49)	334 (8.58)	< 0.001
Cognition (MMSE)			< 0.001
Normal (26-30)	2639 (80.04)	2873 (73.80)	
Mild impairment (22-25)	478 (14.50)	744 (19.11)	
Severe impairment (≤ 21)	180 (5.46)	276 (7.09)	
Smoking history			< 0.001
Never smoker	885 (26.84)	1881 (48.32)	
Previous smoker	2024 (61.39)	1622 (41.66)	
Current smoker	388 (11.77)	390 (10.02)	
Physical activity			< 0.001
Vigorous	1396 (42.34)	930 (23.89)	
Moderate	1362 (41.31)	1940 (49.83)	
Light/None	539 (16.35)	1023 (26.28)	
Place of residence			< 0.001
Living alone	780 (23.66)	1853 (47.60)	
Living at home with others	2493 (75.61)	1989 (51.09)	
Living in a care home	24 (0.73)	51 (1.31)	
SARC-F score			< 0.001
0	1875 (56.87)	1309 (33.62)	
1	488 (14.80)	732 (18.80)	
2	289 (8.77)	551 (14.15)	
3	186 (5.64)	396 (10.17)	
4+	459 (13.92)	905 (23.25)	
5-CST category			<0.001
Fast (< 12 s)	1048 (31.79)	865 (22.22)	
Intermediate (12 – 15 s)	747 (22.66)	797 (20.47)	
Slow (> 15 s)	725 (21.99)	1001 (25.71)	
Unable	777 (23.57)	1230 (31.60)	
5-CST time (s) mean (SD)*	14.2 (5.72)	15.4 (5.92)	< 0.001
Years in full-time education (n=7,147)			0.008

0-9	785 (23.98)	1053 (27.19)	
10-11	1744 (53.27)	1970 (50.86)	
12+	745 (22.76)	850 (21.95)	
Socio-economic status (n=6,937)			< 0.001
I	285 (8.73)	65 (1.77)	
II	724 (22.17)	796 (21.68)	
III (M)	1473 (45.10)	502 (13.67)	
III (NM)	410 (12.55)	1395 (38.00)	
IV	271 (8.30)	687 (18.71)	
V	103 (3.15)	226 (6.16)	

1 * Among those able to complete five chair stands. 5-CST, 5-chair stand test.
2 **: p-values obtained from appropriate tests using sampling weights

Figure 1: Categories of the 5-chair stand test and mean time taken by age and sex

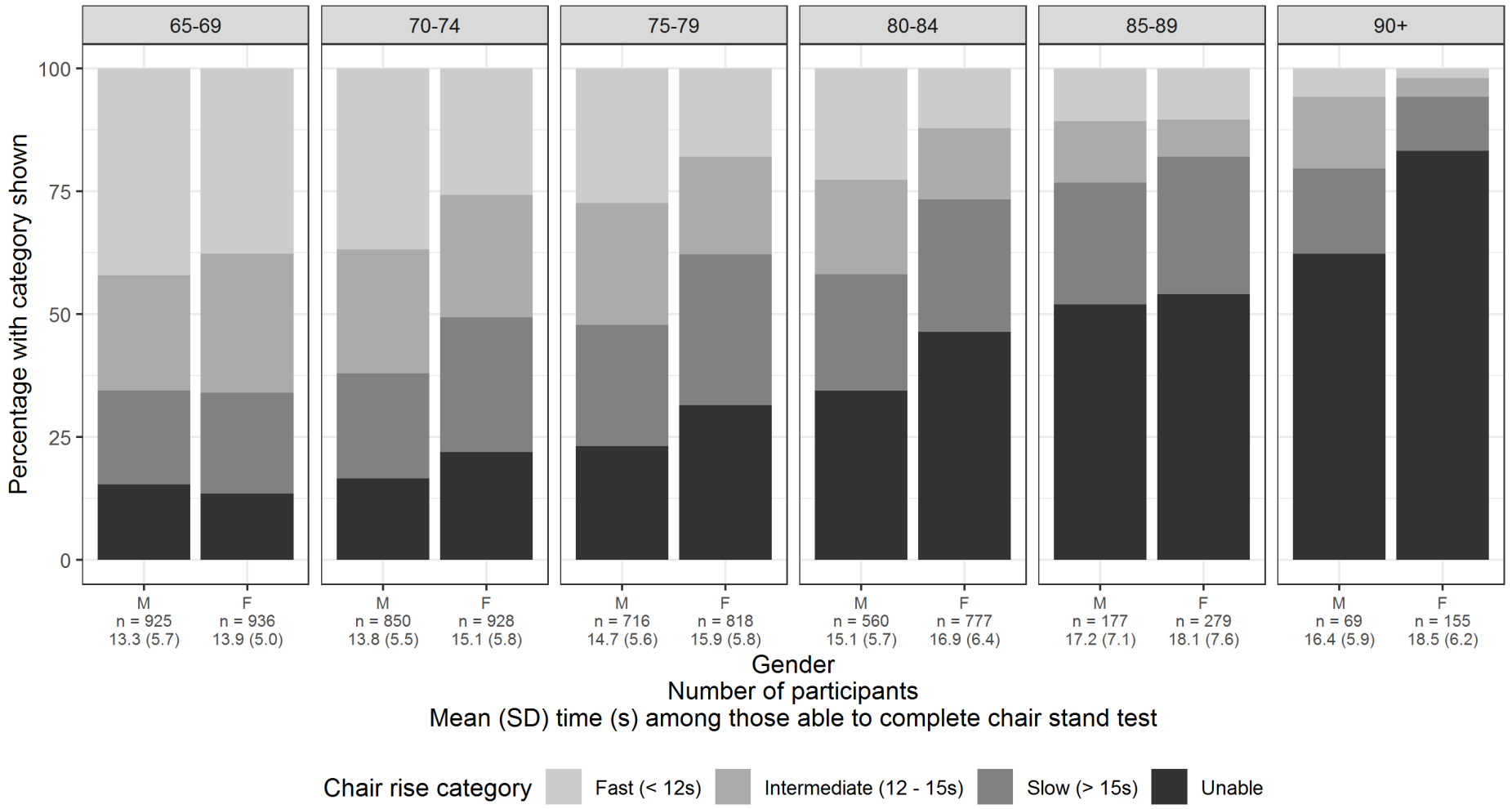


Figure 2: Categories of the 5-chair stand test and mean time taken, by SARC-F score

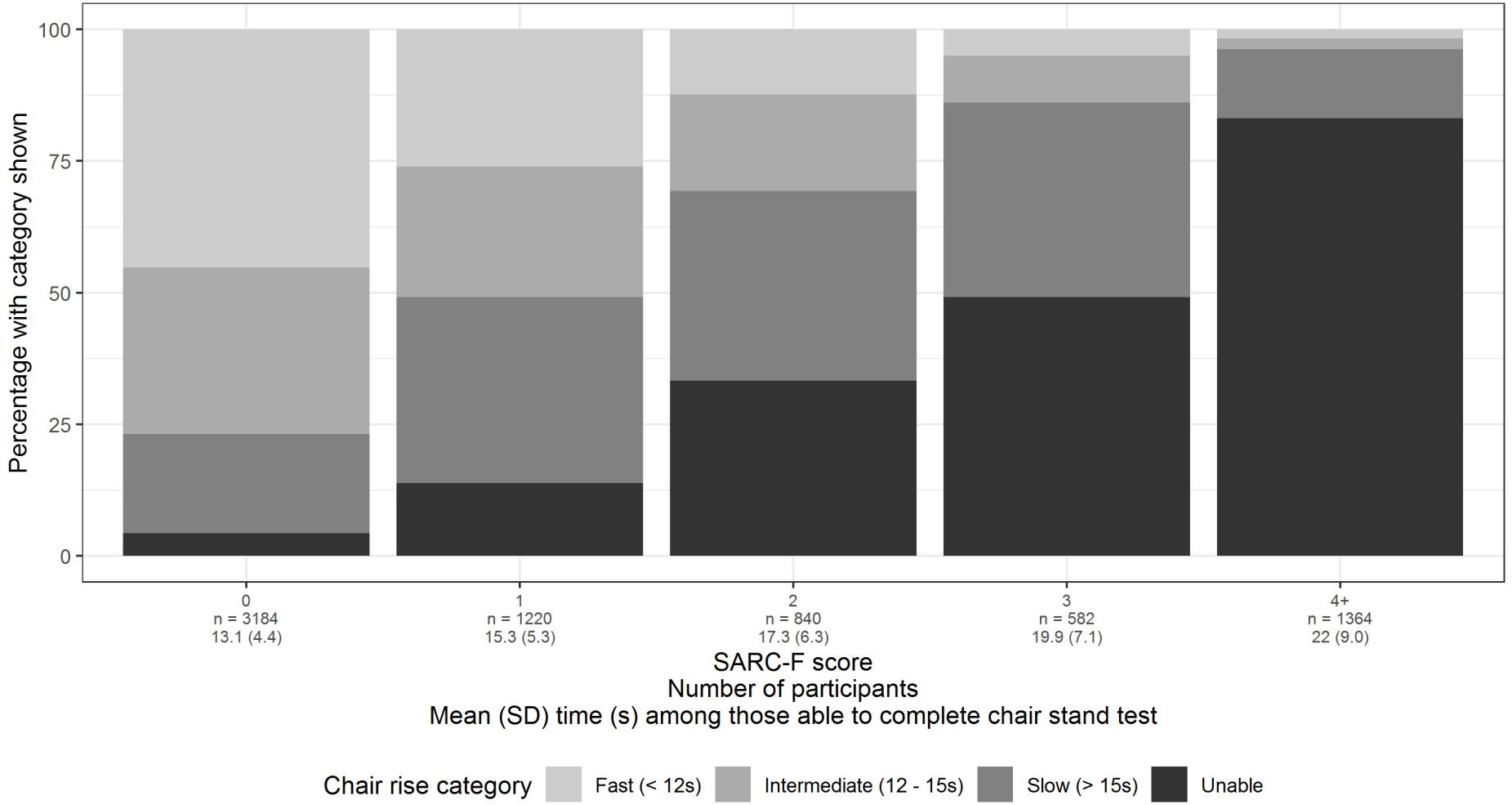


Table 2: Multivariable multinomial logistic regression model for 5-chair stand test category

Clinical factor	Odds ratio* [95% CI] compared to intermediate 5-CST			P-value**
	Fast 5-CST	Slow 5-CST	Unable to do 5-CST	
Multimorbidity: Present	0.88 [0.78, 0.98]	1.23 [1.08, 1.40]	1.23 [1.04, 1.45]	< 0.001
Depression: Present	1.25 [0.96, 1.64]	1.54 [1.20, 1.98]	1.24 [0.94, 1.63]	0.004
MMSE category (*Reference: Normal*)				< 0.001
Mild impairment	0.93 [0.79, 1.09]	1.07 [0.92, 1.24]	1.34 [1.13, 1.59]	
Severe impairment	0.86 [0.60, 1.24]	1.71 [1.26, 2.32]	2.97 [2.17, 4.05]	
Smoking history (*Reference: Never smoker*)				< 0.001
Past smoker	0.89 [0.80, 1.00]	1.00 [0.89, 1.12]	0.90 [0.79, 1.04]	
Current smoker	0.77 [0.64, 0.93]	1.25 [1.03, 1.50]	1.28 [1.03, 1.59]	
Physical activity (*Reference: Vigorous*)				< 0.001
Moderate	0.78 [0.70, 0.87]	1.23 [1.09, 1.39]	1.31 [1.11, 1.55]	
Light/None	0.72 [0.56, 0.93]	1.79 [1.44, 2.21]	3.52 [2.79, 4.45]	
Place of residence (*Reference: Living at home with others*)				< 0.001
Living alone	1.01 [0.90, 1.14]	1.08 [0.96, 1.22]	1.36 [1.18, 1.56]	
Living in a care home	0.36 [0.08, 1.76]	1.10 [0.46, 2.62]	1.43 [0.61, 3.36]	
SARC-F score (*Reference: 0*)				< 0.001
1	0.83 [0.72, 0.95]	2.15 [1.87, 2.47]	3.34 [2.73, 4.07]	
2	0.56 [0.46, 0.68]	2.77 [2.34, 3.29]	9.97 [8.10, 12.27]	
3	0.49 [0.35, 0.70]	5.31 [4.16, 6.77]	23.88 [18.27, 31.22]	
4+	0.79 [0.52, 1.19]	6.57 [4.82, 8.97]	113.66 [82.79, 156.04]	

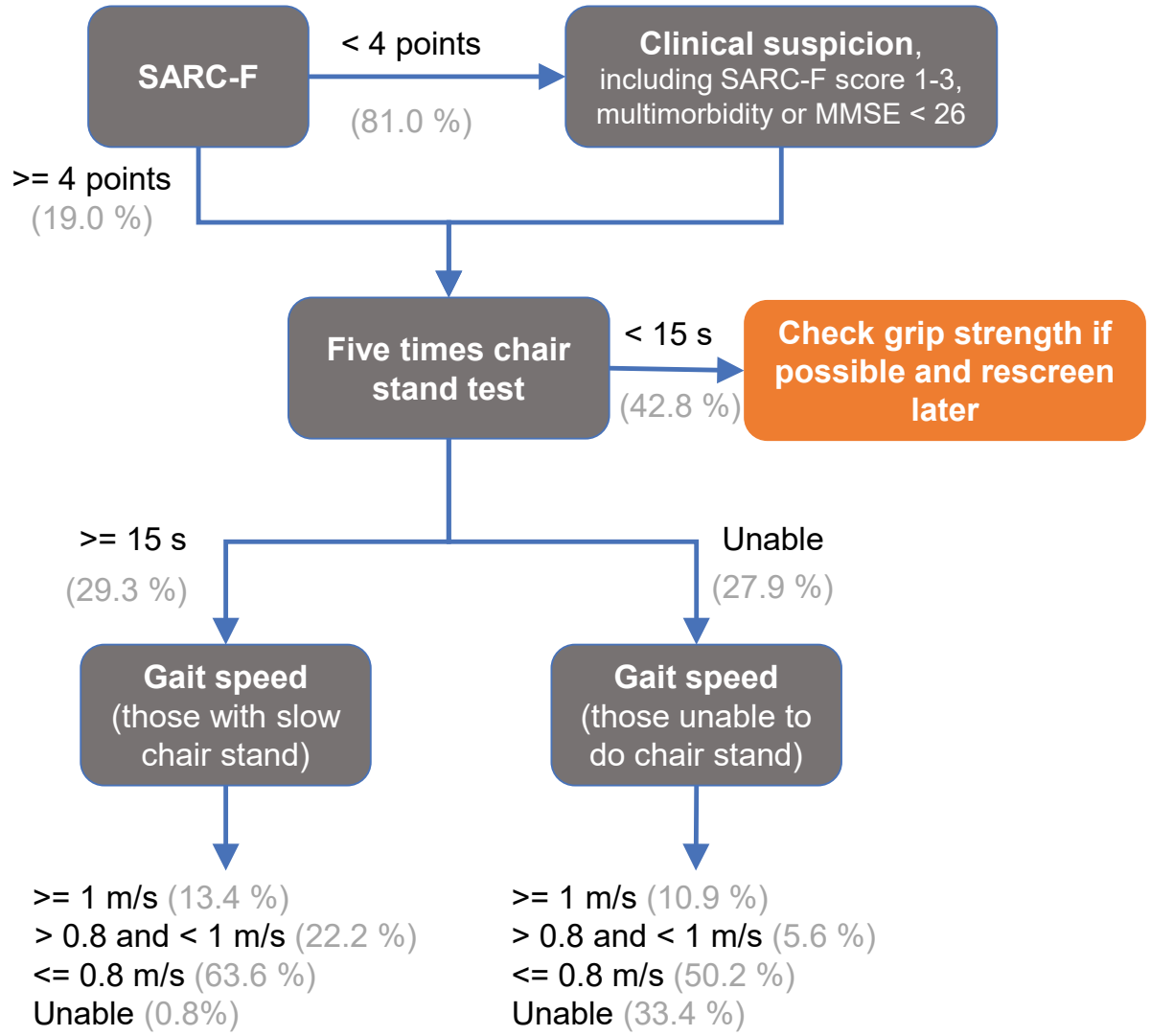
Model also includes sex and age category (not shown). N=7,190.

5-CST, 5-chair stand test.

* The odds ratio of being in a particular 5-CST performance group compared to intermediate performance are tested given presence or absence of the clinical factor shown. An odds ratio greater than one indicates greater odds of being in 5-CST performance category shown as opposed to having intermediate performance, compared between the level of the clinical factor shown and the reference level.

** P-value for the significance comparing a multivariable model with and without the clinical factor shown.

Figure 3: Illustration of findings using modified EWGSOP2 algorithm



N=7,190.

Figure 4: Newcastle protocol for assessment of chair stand test in suspected sarcopenia

We recommend that clinicians have a low threshold for attempting the 5-CST (5-chair stand test) as a wide range of factors are associated with poor performance.

1. Use a firm straight-backed chair placed against a wall. Record the height of the chair used (height of approximately 43cm is recommended).

2. Stop at any point if you or participant feel that the test is unsafe.

3. Begin by explaining and demonstrating the procedure. *"I am going to measure how fast you can stand up and sit back down 5 times one after another. I would like you to stand up straight as fast as you can, then sit down before standing again, keep going until you have stood five times. Please keep your arms folded across your chest at all times."* Demonstrate the procedure now.

4. Check if participant feels safe to stand up completely from the chair with their feet on the floor in comfortable shoes and their arms folded across the chest. *"Now I would like you to try to stand up once, then sit back down afterwards to familiarise yourself with the movement, do you feel safe to do this?"*. If so, proceed.

5. If the single stand completed without use of arms, check if participant feels safe to stand five times in the same way as fast as they can. "*Please stand up straight as fast as you can five times. After standing up each time, sit down and then stand up again. Keep your arms folded across your chest. I will count each stand out loud as you perform the test. Do you feel safe to do this?".*

6. If so, start timing from when you ask the participant to begin by saying *"Ready? Go"* until they stand up straight for the fifth time. Count each stand out loud as the participant stands up straight each time. Stop the test if the participant uses their arms or appears unwell.

7. Record time taken (or reason 5-CST not completed). If participant's time above 15 seconds, or they are unable, manage as probable sarcopenia: measure muscle mass and check gait speed if possible. If time below 15 seconds, measure grip strength if possible and repeat 5-CST in the future.

Supplementary materials

S1: Derivation of SARC-F score

SARC-F component & question	Scoring	Assessment in CFASII
Strength How much difficulty do you have in lifting and carrying 10 pounds?	None = 0 Some = 1 A lot or unable = 2	Uses difficulty in carrying heavy shopping bags in place of "10 pounds".
Assistance in walking How much difficulty do you have walking across a room?	None = 0 Some = 1 A lot, uses aids, or unable = 2	If participant uses aids in the gait speed test then scores 2. Uses data available in English Longitudinal Study of Ageing (ELSA)[§] to determine scoring of 1 and 0.
Rise from a chair How much difficulty do you have transferring from a chair or bed?	None = 0 Some = 1 A lot or unable without help = 2	If participant is permanently bedfast or chairfast, scores 2. If neither but has difficulty starting to move then 1 is scored, else scored 0.
Climb stairs How much difficulty do you have climbing a flight of 10 stairs?	None = 0 Some = 1 A lot or unable = 2	Difficulty in going up and down flight of stairs is assessed. No difficulty scores 0, some scores 1 and inability/needing assistance scores 2.
Falls How many times have you fallen in the past year?	None = 0 1-3 falls = 1 4 or more falls = 2	Participants asked on tendency to fall. If multiple falls in previous month then score 2, otherwise 0. Unable to establish less frequent falls in previous year and so we could not score 1.

[§] Similarly aged participants in ELSA, the English Longitudinal Study of Ageing [1,2] complete a gait speed test and have outcome compared with a question asking if they have difficulty in walking across a room. Multiple thresholds of walk speed were investigated. Satisfactory sensitivity and specificity were observed at threshold of $\leq$ 0.5m/s in logistic regression model with difficulty the outcome assessed. In CFASII, we therefore assume those with walking speed $\leq$ 0.5m/s have "some difficulty" and score 1, else 0.

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S2: Findings from multinomial logistic regression models for chair stand test, with results shown adjusted for age and sex only

Clinical factor	Odds ratio* [95% CI] compared to intermediate 5-CST			P-value*
	Fast 5-CST	Slow 5-CST	Unable to do 5-CST	
Multimorbidity: Present	0.8 [0.72, 0.89]	1.76 [1.56, 1.99]	3.16 [2.76, 3.61]	< 0.001
Depression: Present	1.09 [0.83, 1.41]	2.19 [1.73, 2.78]	3.26 [2.6, 4.09]	< 0.001
MMSE category (*Reference: Normal*)				< 0.001
Mild impairment	0.86 [0.74, 1.01]	1.33 [1.15, 1.53]	2.35 [2.05, 2.70]	
Severe impairment	0.78 [0.55, 1.12]	2.16 [1.62, 2.89]	6.28 [4.82, 8.19]	
Smoking history (*Reference: Never smoker*)				< 0.001
Previous smoker	0.86 [0.77, 0.97]	1.10 [0.98, 1.23]	1.18 [1.06, 1.33]	
Current smoker	0.72 [0.60, 0.87]	1.50 [1.26, 1.80]	2.29 [1.92, 2.72]	
Physical activity (*Reference: Vigorous*)				< 0.001
Moderate	0.74 [0.66, 0.82]	1.52 [1.36, 1.71]	2.53 [2.20, 2.93]	
Light/none	0.57 [0.44, 0.72]	3.91 [3.21, 4.75]	28.26 [23.16, 34.48]	
Place of residence (*Reference: Living at home with others*)				< 0.001
Home alone	0.97 [0.87, 1.09]	1.17 [1.04, 1.31]	1.54 [1.38, 1.72]	
Living in a care home	0.24 [0.05, 1.14]	3.04 [1.32, 6.97]	12.07 [5.59, 26.03]	
SARC-F score (*Reference: 0*)				< 0.001
1	0.79 [0.69, 0.90]	2.31 [2.02, 2.65]	3.8 [3.13, 4.62]	
2	0.52 [0.42, 0.63]	3.16 [2.68, 3.73]	12.72 [10.40, 15.56]	
3	0.43 [0.30, 0.60]	6.63 [5.24, 8.40]	36.72 [28.37, 47.51]	
4+	0.66 [0.44, 0.98]	9.48 [7.05, 12.74]	245.28 [181.46, 331.57]	

Table reports results for separate models for each factor shown along with sex and age category. N=7,190 throughout.

5-CST, chair stand test.

* The odds ratio of being in a particular 5-CST performance group compared to intermediate performance are tested given presence or absence of the clinical factor shown. An odds ratio greater than one indicates greater odds of being in 5-CST performance category shown as opposed to having intermediate performance, compared between the level of the clinical factor shown and the reference level.

** P-value for the significance comparing a model with and without the clinical factor shown.

S3: Terms used in literature search

We searched the MEDLINE database in October 2019 using the following search terms: (chair stand or chair rise or sit to stand) and (protocol or reliability or measurement or validity). The search returned 610 papers. Two reviewers screened titles and abstracts, resulting in 61 papers which we then examined for (i) existing recommendations about the protocol to use in the 5-CST, (ii) the effect of different aspects of measurement protocol on the values obtained, and (iii) references to other relevant papers.

S4: Flow diagram showing analytical sample used