


Clinically meaningful change for the chair stand test: monitoring mobility in integrated care for older people

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Abstract

Background Clinically meaningful changes in the five-repetition chair stand test are essential for monitoring mobility in integrated care for older people. Recommendations for the clinically meaningful change of the chair stand test are not well known. Our study aimed to estimate the absolute and relative clinically meaningful changes for older adults' five-repetition chair stand test.

Methods We applied distribution-based and anchor-based methods in addition to receiver operator characteristics analyses to a population-based study of community-dwelling adults (SAGE Mexico study, $n = 897$) to derive the clinically meaningful change in the chair stand test. We used three self-reported clinical anchors: moving around, vigorous activities, and walking 1 km. Our primary outcome was the incidence of disability for basic activities of daily living (ADL). Secondly, we examined our estimates of clinically meaningful change in a clinical trial population of healthy volunteers (MAPT, France, study $n = 1575$) concerning the risk of incident ADL disability.

Results The age of SAGE Mexico participants ranged from 60 to 96 years; mean (SD) = 69.0 (6.2); 54.4% were female. Their baseline chair stand time averaged 12.1 s (SD = 3 s). Forty-eight participants (5.6%) showed incident disability over 3 years. The absolute and relative clinically meaningful change cut points found over 3 years of follow-up were 2.6 s and 27.7%, respectively. Absolute clinically meaningful change ranged from 0.5 to 4.7 s, depending on the estimation method. Relative clinically meaningful change ranged from 9.6 to 46.2%. SAGE Mexico participants with absolute and relative clinically meaningful declines (increasing 2.6 s and 27.7% from baseline time, respectively) showed an increased risk of ADL disability [aRR = 1.93; $P = 0.0381$; 95% CI (1.05, 3.46) and aRR = 2.27; $P = 0.0157$; 95% CI (1.22, 4.10)], respectively, compared with those without a clinically meaningful decline. MAPT participants [age range = 70–94; mean (SD) = 75.3 (4.4); 64.8% female; incident ADL disability over 5 years = 145 (14.8%)] with a relative clinically meaningful decline ($\geq 27.7\%$ from baseline over 3 years) had a 74% higher risk of incident ADL disability than their counterparts [aHR = 1.74; $P = 0.016$; CI95% (1.11, 2.72); mean follow-up of 58 months].

Conclusions Community-dwelling older adults with an increase of 3 s or 28% in chair stand test performance over 3 years (approximately 1 s or 10% per year) could be the target of interventions to enhance mobility and prevent incident disability.

Keywords Physical functional performance; Five-repetition chair stand test; Clinically meaningful change; Older adults

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Introduction

Clinically meaningful changes (also known as clinically relevant changes) are essential in the context of the integrated care for older people (ICOPE) strategy¹ to stratify individuals at risk for care dependency. Indeed, the ICOPE care model is being used to monitor older adults' five intrinsic capacity domains to detect early declines and prevent disability.² Locomotion is a crucial indicator of independence during ageing.^{3,4} It is assessed in the ICOPE model using the five-repetition chair stand test. During their clinical follow-up, older adults are expected to show variations in chair stand test performance⁵; nevertheless, the clinically meaningful change for the five-repetition chair stand test has not been established yet.

Compared with previously reported cut points for cross-sectional locomotion assessment,^{6,7} the clinically meaningful change has an added value during clinical monitoring when repeated measures of the chair stand test are obtained over time. Clinical staff might be empowered to detect substantial declines in older adults' locomotion domain even before crossing the conventional cut point.

Clinical significance can be operationalized using (i) distribution-based interpretations, statistically driven, like the standard error of measurement (SEM), and (ii) anchor-based interpretations, comparing the results in the outcome of interest to other clinical changes or 'anchors'.^{8–10} The relevance of clinically meaningful change for performance measures in the geriatric clinical and research settings has been recently highlighted by the International Conference of Frailty and Sarcopenia Research Task Force.¹¹ In mobility/locomotion, previous reports have integrated distribution-based and anchor-based methods to provide overall recommendations for meaningful change of gait speed, short physical performance battery (SPPB) score, and 6-min distance walk for older adults. Still, they did not include estimates and recommendations for the chair stand test.^{12,13}

Among the studies approaching the clinically meaningful mobility performance changes, we did not find any reporting data for the chair stand test.^{13–15} There is a knowledge gap about the magnitude of the clinically meaningful change that could be applied to the chair stand test to monitor the locomotion in older adults. Given the increasing international implementation of ICOPE, understanding the clinically meaningful amount of decline in chair stand test becomes crucial to inform timely interventions and decrease the risk of disability. Therefore, our study aimed to derive recommendations for absolute and relative (percent) clinically meaningful change for the chair stand test in older adults.

Methods

We used data from a population-based study: the World Health Organization (WHO) Study on global AGEing and adult

health in Mexico, also known as SAGE Mexico. Based on previous reports,¹¹ we derived the clinically meaningful absolute and relative changes in the chair stand test that could warn clinicians of older adults' higher risk of becoming disabled for basic activities of daily living (ADL). Absolute clinically meaningful change was defined as the difference in seconds (s) between the baseline and follow-up measurements of the chair stand time. Relative clinically meaningful change (%) was defined as the percentage change between baseline and follow-up measures. We used distribution methods, which are based on the statistical distribution of the chair stand test. Anchor-based methods were also applied, which are 'anchored' to patient-reported mobility outcomes (e.g. 'how much difficulty did you have in walking a long distance such as a kilometre?').

Finally, we tested if participants with clinically meaningful absolute and relative declines were at significantly higher risk of incident ADL disability using data from the Multidomain Alzheimer Preventive Trial (MAPT).

Data sources

SAGE Mexico

We used the second and third waves (3-year apart from each other) of SAGE Mexico, given that the first wave of this study did not assess the chair stand test. Briefly, the WHO Study on global AGEing and adult health in Mexico, also known as SAGE Mexico, is a prospective cohort study with a multi-stage, stratified, and clustered sample designed to represent non-institutionalized older adults at the national level. Data were collected at the participant's lodgement by standardized trained staff using electronic records (CAPI). All participants provided their informed consent, and the scientific board of the National Institute of Public Health approved the SAGE Mexico study. In this study, we included participants aged 60 and older. Further information on study design can be found elsewhere.¹⁶

MAPT

We used data from the MAPT randomized controlled trial, which methodology has been described elsewhere.^{17,18} In brief, MAPT was a 3-year randomized controlled trial among community-dwelling adults aged 70 years and older examining the effects on cognitive function of a multidomain intervention (nutritional and physical activity counselling, cognitive training, and annual preventive consultations for the management of cardiovascular risk factors) with and without supplementation of omega-three polyunsaturated fatty acids. After the intervention, an additional 2-year observational period was carried out (total period: 2008–2016). The trial protocol (ClinicalTrials.gov identifier: NCT00672685) was approved by the French Ethical Committee located in Toulouse (CPP SOOM II) and

was authorized by the French Health Authority. All participants signed their consent forms before any study assessment. Inclusion criteria were meeting at least one of (i) spontaneous memory complaints, (ii) limitation in one instrumental activity of daily living, or (iii) slow gait speed (≤ 0.8 m/s). Exclusion criteria comprised Mini-Mental State Examination score < 24 , diagnosis of dementia, limitation in ADLs, and taking polyunsaturated fatty acid supplements at baseline. MAPT study provided data for several time points (baseline, 6, 12, 24, 36, 48, and 60 months).

SAGE Mexico and MAPT studies have been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Measures

Chair stand test

Both SAGE Mexico and MAPT measured the time in seconds the participant took to perform five chair stands at maximum speed with their arms folded across their chest. The protocol started by the interviewer by asking the question: 'Do you think it would be safe for you to try to stand up from a chair five times without using your arms?' The interviewer then demonstrated and explained the test using the chair usually employed by the participant placed with its back against a wall. Following, the interviewer indicated: 'Please stand up straight as quickly as you can five times, without stopping in between. After standing up each time, sit down and then stand up again. Keep your arms folded across your chest. I'll be timing you with a stopwatch'. Trained assessors measured time from the starting sitting position to the end of the fifth stand.¹⁹

The test was stopped if the participants became tired or short of breath during repeated chair stands; used their arms; after 1 minute, had not yet completed five rises; or at the interviewers' discretion, if concerned for their safety.

Disability for the basic ADL

The incidence of ADL disability (Katz scale)²⁰ was the outcome for elaborating the clinically meaningful change cut point. Scores on this scale vary from 0 (*total disability*) to 6 (*no disability*). Participants with the event at baseline (Katz < 6) were excluded from this analysis, and incidence was defined as reporting disability for one or more ADLs. We applied the exact definition in SAGE Mexico and MAPT.

Anchor measures

We used three items from the self-reported activities questionnaire in SAGE Mexico. These items were chosen because they are closely related to the locomotion domain.

Item 1: Overall, in the last 30 days, how much difficulty did you have with moving around?

Item 2: Overall, in the last 30 days, how much difficulty did you have in vigorous activities? ('vigorous activities' require hard physical effort and cause significant increases in breathing or heart rate)

Item 3: Overall, in the last 30 days, how much difficulty did you have in walking a long distance such as a kilometre?

These items were initially scored by self-reported difficulty levels using a Likert-type scale from 1 to 5. For our study, and following literature,⁸ we re-coded them in four strata: no change, small meaningful worsening (those who worsened within the mild–moderate difficulty), substantial, meaningful worsening (those who declined to severe and extreme difficulty), and no possibility of worsening (extreme difficulty at baseline or observed improving at follow-up).

Data analysis

Overview

The relative clinically meaningful difference was calculated using $(\Delta \text{ chair-stand-time} \times 100 / \text{baseline chair-stand-time})$. The absolute and relative clinically meaningful changes were obtained by (i) applying distribution-based (effect size and standard error of measurement SEM), (ii) anchor-based approaches (comparison of means between those who did and did not self-report decline in mobility items), and (iii) receiver operator characteristics (ROC)-derived Youden's index. We verified that these clinically meaningful changes were lower than the mean decline observed in participants with incident ADL disability (marginal means).

Next, we computed the adjusted risk ratios of incident disability for ADLs based on those participants with clinically meaningful declines in SAGE Mexico and MAPT using a logistic model adjusted for age, sex, and baseline chair stand time. Finally, we estimated the hazard ratio for incident disability for MAPT participants with clinically meaningful declines using Cox models adjusted for age, sex, education level, MAPT allocation group, and baseline chair stand time. The proportional hazards assumption was confirmed by Schoenfeld residuals and by time-varying covariates. All analyses were performed using STATA® 17.

Meaningful change according to effect size

Using the effect size formula ($\delta = (\mu_1 - \mu_2) / \sigma_1$) and conventional definitions of small and moderate effect,^{21–23} we calculated the small and moderate meaningful changes as $0.2 \times \sigma_1$ and $0.5 \times \delta_1$, respectively. μ_1 and μ_2 accounted for the mean chair stand test times at baseline and follow-up, respectively, and σ_1 was the standard deviation of the chair stand test performance (seconds) at baseline. Thus, the meaningful changes were estimated by solving for $(\mu_1 - \mu_2)$ in the effect size formula.

Meaningful change according to the SEM

The SEM provides a sort of ‘bottom line’ of the minimum change we would need to observe to discard it is not due to measurement error. The meaningful intra-individual change was calculated using the SEM, defined as $\sigma_1\sqrt{1-r}$.^{21,23,24} Reliability estimates for the chair stand test time were taken from a published source.²⁵

Meaningful change according to the comparison of means

We estimated the mean changes for the chair stand test time for those SAGE Mexico participants with self-reported small and substantial deterioration of the mobility items adjusted by age, sex, and baseline chair stand time. The definitions of small and substantial worsening were given under the ‘Anchor measures’ section. In line with previous literature,¹¹ those who could not worsen because of extreme difficulty at baseline or observed improving at follow-up were omitted from these estimations to reduce bias. These comparisons were estimated for the absolute and relative changes.

Meaningful change derived from ROC analyses

The Youden’s index was applied in ROC curves to derive the cut point of the absolute and relative change in the chair stand test times to better classify the participants according to their probability of incident ADL disability.²⁶

study than those lost during the follow-up (-0.30 s, $P = 0.0016$).

Summary of clinically meaningful changes for the five-repetition chair stand test

Please find a graphic summary of the absolute and relative clinically meaningful changes in *Figure 1*.

As shown in *Figure 1*, there is consistency across methodologies. The smallest is the SEM, followed by the clinically meaningful change according to the effect size and the clinically meaningful change derived from the ROC analyses. Subsequently, there is the anchor-based clinically meaningful change based on the changes in the mobility items, and the largest is the marginal means of the time changes observed in those older adults with incident ADL disability.

SAGE Mexico participants with an absolute clinically meaningful decline showed a 93% increase in the risk of ADL disability [aRR = 1.93; $P = 0.0381$; 95% CI (1.05, 3.46)], and the risk for those with a relative decline was 2.27 times higher [aRR = 2.27; $p = 0.0157$; 95% CI (1.22, 4.10)] compared with those without a clinically meaningful decline. See *Table S1*.

Results

Participants of SAGE Mexico and MAPT included in these analyses are described in *Table 1*. Further characterizations have been published elsewhere.^{16,17} Briefly, the majority of SAGE Mexico participants included in this study were younger than 75 [age range = 60–96; mean (SD) = 69.0 (6.2)] and female (54.4%); 23% of them had achieved secondary school or higher. Their baseline time averaged 12.1 s (SD = 3 s) and 14.7 s (SD = 4.9 s) after 3 years of follow-up. The chair stand test time increased (thus locomotion capacities diminished) for 68.8% of the study sample, and the opposite was true for 31.1%. The mean chair stand performance was slightly better for those who remained in the

Meaningful change according to effect size

The small and moderate effects for the absolute decline were 0.7 and 1.7 s, respectively. The small and moderate effects for the relative decline were 12.1 and 30.4%, respectively.

Meaningful change according to the SEM

The standard error of measurement was 0.5 s and 9.6% for the absolute and relative declines, respectively.

Table 1 Description of the study populations of SAGE Mexico and MAPT

Mean (SD) unless shown otherwise	SAGE Mexico		MAPT	
	<i>n</i> = 897		<i>n</i> = 1575	
Age (years)	69.0	(6.2)	75.3	(4.4)
Participants aged 80+, <i>n</i> (%)	57	(6.4)	278	(17.7)
Female, <i>n</i> (%)	488	(54.4)	1,021	(64.8)
Five-repetition chair stand time at baseline	12.1	(3.4)	11.6	(3.5)
Five-repetition chair stand time at baseline at 3-year follow-up	14.7	(4.9)	11.7	(3.5)
Mean absolute change in the chair stand time	2.6	(4.9)	0.2	(3.5)
Mean relative change in the chair stand time	29.0	(60.7)	6.2	(30.7)
Incidence of ADL disability, <i>n</i> (%) ^a	48	(5.6)	145	(14.8)

^a3-year follow-up for SAGE Mexico, 5-year follow-up for MAPT.

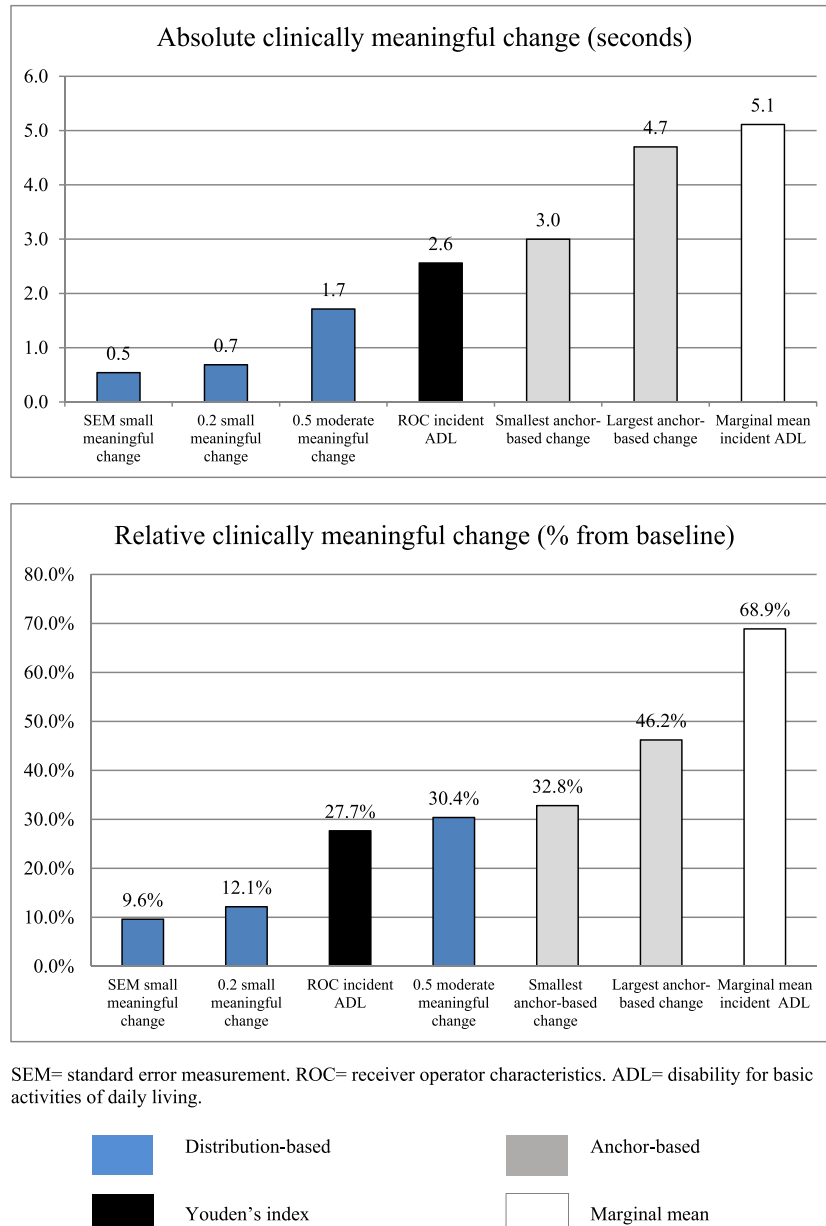


Figure 1 Sorted estimations of clinically meaningful changes in the time for performing the five-repetition chair stand test according to the estimation method. IADL, incident disability for basic activities of daily living; ROC, receiver operator characteristics; SEM, standard error measurement.

Meaningful change according to the comparison of means

Small meaningful changes according to anchor-based measurements averaged 3.1 s and 39%, respectively, for absolute and relative changes (range for absolute change = 3.0–3.2 s; range for relative change = 32.8–45.0%).

Moderate meaningful changes according to anchor-based measurements averaged 3.8 s and 39%, respectively, for ab-

solute and relative changes (range for absolute change = 3.1–4.7 s; range for relative change = 32.9–46.2%).

Meaningful change derived from ROC analyses

The absolute and relative changes found using Youden's index were 2.6 s and 27.7%.

In SAGE Mexico, older adults with incident ADL disability had a mean decline of 5.1 s and 68.9% from baseline over 3 years.

External validation

As shown in *Table 2*, MAPT participants with a clinically meaningful absolute worsening of their chair stand time (≥ 2.6 s) during the first 3 years of follow-up had a 46% higher risk of incident ADL disability (aHR = 1.46; 95% CI 0.95, 2.25). Those with a clinically meaningful relative worsening of their chair stand time ($\geq 27.7\%$ from baseline) had a 74% higher risk of incident ADL disability (aHR = 1.74; 95% CI 1.11, 2.72) with a mean follow-up of 58 months.

Discussion

Using a population-based study (SAGE Mexico), we found that absolute meaningful changes for the five-repetition chair stand time ranged from 0.5 to 1.7 s and from 3.0 to 4.7 s applying distribution-based and anchor-based methods, respectively. Relative meaningful changes ranged from 9.6 to 30.4% using distribution-based and anchor-based methods, respectively. The results from the ROC analyses showed that ≥ 2.6 s and $\geq 27.7\%$ were coherent with distribution-based and anchor-based methods. Furthermore, we corroborated that older adults with a clinically meaningful decline in the chair stand time were at higher risk of incident ADL disability in an external population (the MAPT study).

A change ≥ 2.6 s (or 27.7%) from baseline over 3 years was clinically meaningful in our research. This amount could seem substantial for some clinicians, but bear in mind that we measured changes over 3 years. Yet, we found that changes as small as 0.5 s or 9.6% over 3 years are already meaningful from the statistical point of view. The SEM served as a 'bottom line' for the change attributed to other than measurement error. A change ≥ 2.6 s (or 27.7%) from baseline over 3 years is higher than the minimal detectable change estimated by $1.96 \times \text{SEM} \times \sqrt{2}$ in our data (1.5 s or 26.6%) and consistent with a previous study in older women.²⁷

To the best of our knowledge, no other study has estimated the clinically meaningful change for the five-repetition chair stand test using distribution-based and

anchor-based methods with a population-based sample. In this vein, our study builds on previously published works about the meaningful change for physical performance measures for older adults, with recommendations for clinically meaningful differences in gait speed and the SPPB through the distribution-based and anchor-based methods.^{12,13} Going beyond previous publications, in addition to distribution-based and anchor-based methods, we also used ROC analyses; this approach allowed us to make an objective choice for establishing recommendations on the most appropriate clinically meaningful decline across the range of results (*Figure 1*). Therefore, we defined the clinically meaningful change in the chair stand test using Youden's index (2.6 s and 27.7% for the absolute and relative, respectively) because it was coherent and located in an intermediate position between the distribution-based and anchor-based methods' results.

Our findings suggest that a difference of 1 s or 10% change *per year* in the five-repetition chair stand test would be clinically meaningful, assuming a linear trend. We did not find publications for the clinically meaningful decline in the chair stand test. Still, Onder *et al.* have reported average decreases of 2.2 s or 11.2% and 4.0 s or 21.1% from baseline to 1 and 3 years, respectively, for absolute and relative changes in the Women's Health and Aging study.²⁸ Our results are coherent with such rate of decline considering that we are using population-based data with no function-based selection criteria as the ones applied for the WHAS, which is also an older population [mean (SD) age = 78.9 (8.1)].²⁸ A slight decline of 0.5 s was reported over 7 years on high-functioning community-dwelling American adults aged 70–79 as part of the MacArthur study.²⁹ Also, Rosano *et al.* have reported an average decline of 0.5 s/y in people with severe white matter hyperintensities ($n = 2450$, mean age = 75 years).³⁰

Defining clinically meaningful changes for the chair stand test can empower the healthcare professionals during the follow-up of older adults. Our results on the clinically meaningful changes add value to the cross-sectional cut points for the chair stand test in the context of ICOPE. For example, a clinician might find a patient has declined from 10 to 13 s in the five-repetition chair stand test over 3 years. This patient is below the 14 s cut point recommended by the ICOPE handbook.¹ However, the patient has already expressed a clinically meaningful change. Thus, clinicians might decide to implement interventions in a higher risk population even earlier. Furthermore, distribution-based meaningful changes

Table 2 Adjusted hazard ratio for incident ADL disability in MAPT participants with clinically meaningful decline in the five-repetition chair stand test

<i>n</i> = 872			
Events of incident ADL disability = 125			
Mean FU time = 58.6 months			
	aHR ^a	<i>P</i>	95% CI
\geq absolute clinically meaningful change	1.46	0.087	(0.95, 2.25)
\geq relative clinically meaningful change	1.74	0.016	(1.11, 2.72)

^aHazards ratio adjusted for age, sex, education level, MAPT allocation group, and baseline chair stand time.

might be applicable for monitoring meaningful changes in lower limb strength and power during/after clinical interventions. For example, improvements of 2.9 and 2.5 s have been reported after 6 weeks of pre-operative exercise training³¹ and after 3 months of total hip arthroplasty,³² respectively.

To further explore the trajectory of the chair rise time, we were not able to test if the test time changes in a linear or non-linear fashion because data were only available for two time points in SAGE Mexico. However, we used the chair stand test times available in MAPT for several time points, the trade-off being that it is not a population-based study. We modelled the time trajectory for those with and without incident ADL disability which best fitted a quadratic function (see *Figures S1 and S2*). Then, we retrospectively modelled the time trajectories for those participants who performed better or worse than our recommended clinically meaningful change for three 3-year follow-up. Participants with a clinically meaningful change went from 11 s at baseline to 12, 13, and 14.4 s after 6, 12, and 24 months of follow-up, respectively. MAPT participants with time differences lower than the clinically meaningful roughly maintained their performance throughout the 5-year follow-up.

Our study has several strengths; for instance, it is the first to provide recommendations for clinically meaningful change in community-dwelling older adults derived from population-based data. In addition to using the conventional methods reported by previous literature,^{11,12} we applied ROC analyses to obtain a data-driven cut point of the clinically meaningful change. Also, besides reporting the absolute changes like in previous papers,¹² we have also attained the relative meaningful changes expressed as a percentage of change. It is possible that relative meaningful changes (%) outperform absolute meaningful changes (seconds) in populations distinct to SAGE Mexico, depending on their distribution of the chair rise time and other markers of physical performance.

One limitation of our study is that the external validation was performed in MAPT, which is not a population-based study. MAPT was a randomized controlled trial not designed to test the clinically meaningful changes in the chair stand time. MAPT's population included relatively fit and well-educated older adults (see 'Data sources' section and *Andrieu et al.*¹⁸). Our results on the external validation may not be generalizable to other populations. This limitation concerns only the external validation process and is not related to the main results of our study. Despite this limitation, we were able to demonstrate the usefulness of the clinically meaningful change as a risk-stratifying feature in MAPT participants. Future external validation studies using a variety of populations are needed.

Our work fills the gap regarding the clinically meaningful change for older adults' chair stand test time. The mobility domain can be monitored using other means with established clinically meaningful change, the SPPB, for instance.¹⁹ Never-

theless, using the chair stand test brings advantages like shorter application time and feasibility even with spatial room constraints. Furthermore, it is reactive to acute conditions like self-reported dizziness or flu-like symptoms within weeks.³³ Offering recommendations for the clinically meaningful change in the chair stand test in older adults might lead to early detection of mobility declines and prevention of disability in older age.

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Online supplementary material

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Conflict of interest

Emmanuel Gonzalez-Bautista, Philippe de Souto Barreto, Aaron Salinas-Rodriguez, Betty Manrique Espinoza, Yves Roland, Sandrine Andrieu, and Bruno Vellas declare that they have no conflict of interest.

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