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Original Research

Low relative sit-to-stand power in Colombian older adults: Cut-off points and associations with frailty and functional decline

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ABSTRACT

Objectives: To examine the association between relative sit-to-stand (STS) power and age, establish sex-specific cut-off points, and evaluate their associations with adverse outcomes in Colombian older adults.
Design: Cross-sectional, population-based study.
Setting: Health, Well-being, and Aging Study (SABE-Colombia, 2014–2015).
Participants: 3051 community-dwelling adults aged ≥60 years (56.6 % women; mean age 68.6 ± 6.4 years).
Measurements: Relative STS power ($W \cdot kg^{-1}$) was estimated using a validated equation. Quantile regression examined age-related changes across percentiles (Q10–Q90). Receiver operating characteristic (ROC) curves with the Youden index determined cut-off points. Age-adjusted logistic regression tested associations with frailty, functionality as gait speed and handgrip strength (HGS), and depression.
Results: Optimal cut-offs for low relative STS power were 2.11 $W \cdot kg^{-1}$ for men and 1.63 $W \cdot kg^{-1}$ for women. Prevalence of low STS power was 34.3 % in men and 34.8 % in women, increasing with age in both sexes. Quantile regression revealed steeper age-related declines at higher percentiles, particularly among men. Low relative STS power was significantly associated with frailty and low functionality.
Conclusion: Relative STS power is a simple, clinically feasible biomarker to identify functional impairment in older adults. The sex-specific thresholds reported for Colombian populations reflect demographic differences in muscle physiology and decline. Their integration into geriatric practice may enhance early detection, guide preventive interventions, and ultimately improve health outcomes in aging populations.

1. Introduction

In aging populations, reduced muscle function and physical performance are strongly associated with adverse outcomes and chronic conditions—such as dementia, sarcopenia, and frailty—that often lead to progressive disability [1–3] Functional tests include gait speed, grip strength, Time Up and Go, Short Physical Performance Battery, and the 5-Repetition Sit-to-Stand (5-rep STS), the latter noted for clinical feasibility and predictive validity [4]. The STS measures physical performance of the lower-limb by timing five sit-to-stand cycles without arm support. Recent methods developed by Alcazar et al. [4] allow estimating lower-limb power using a physics-based equation that considers body mass, participant height, chair height, and trial time, thereby accounting for both force and velocity components.

Normalizing power to body mass (expressed as $W \cdot kg^{-1}$) enhances the assessment of muscle efficiency compared to time-based metrics, allowing more precise monitoring and tailored intervention [5–7]. Moreover, relative STS power has been shown to predict functional

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outcomes and frailty more accurately than traditional STS performance measures (time or repetitions), supporting its use as a clinically meaningful biomarker [4]. In a previous study from our group using the same SABE-Colombia dataset [8], we established normative reference values and associations of STS power with a wide range of adverse outcomes. The present analysis builds on that work by deriving sex-specific cut-off points through ROC analysis and focusing specifically on clinically actionable thresholds for frailty, gait speed, muscle strength, and depression.

However, despite the strong association between low relative STS power and multiple adverse health conditions, and the widespread use of the 5-rep STS test in older adults, no previous research in Latin American populations has established cut-off points for low relative STS power using the 5-rep STS version, nor examined its potential relationship with adverse outcomes. To address this gap, the present study aimed to (1) examine the association between relative STS power and age to better characterize age-related trajectories of muscle function, (2) identify optimal cut-offs for relative muscle power during the STS test, and (3) evaluate their associations with frailty, functionality and depression in a cohort of community-dwelling older adults in Colombia.

2. Material and methods

2.1. Study design and participants

This study is part of the 2015 Survey on Health, Well-being, and Aging in Latin America and the Caribbean (SABE study), a multicenter initiative supported by the National Health Ministry in Bogotá, Colombia (https://www.minsalud.gov.co). Detailed rationale and methodology have been published elsewhere [8]. The final sample included 3051 participants who completed both adverse health outcomes assessment and the five-repetition STS test, as shown in **Supplementary Figure S1**.

2.2. Procedures

Height was measured using a stadiometer to the nearest 0.1 cm; body mass was measured by the nearest 0.1 kg; and body mass index (BMI) was calculated as the ratio between body mass and height squared ($kg{\cdot}m^{-2}$). Lower-limb muscle power was evaluated using the five-repetition STS test [9] and the Alcazar equation [4]. This test evaluates the time needed to complete five repetitions of the sit-to-stand movement using a standardized armless chair (0.45 m height). Participants started by sitting on a chair with their feet parallel, legs not touching the chair, and hip width apart. Their arms either hung loosely on their sides or were placed on their hips. To ensure that they understood the movement, they first performed two practice trials. After that, a trained technician instructed them to complete five repetitions "as quickly as possible." Each repetition required full standing (complete knee extension) and sitting down until the buttocks touched the chair. The time was recorded to the nearest 0.01 s using a stopwatch, starting from the initial seated position until they reached the final standing position on the fifth repetition. The trials were not counted when the participant did not complete or perform repetitions incorrectly. The relative STS power (normalized by body mass) was calculated using a previously validated equation [4]:

$$Relative\ STS\ power = 0.9\ x\ g\ x\ \frac{(Height\ x\ 0.5 - Chair\ Height)}{Five\ STS\ time\ x\ 0.1}$$

2.3. Measurements

Frailty was assessed using the Fried frailty phenotype (FFP) [10], which includes five criteria: self-reported exhaustion, unintentional weight loss, weakness (BMI- and sex-adjusted cutoffs), slowness (lowest quintile of gait speed: men <0.594 m/s; women <0.497 m/s), and low physical activity. Participants were classified as robust (0 criteria), pre-frail (1–2), or frail (3–5), and later dichotomized into robust + pre-frail and frail groups. For the purpose of analyses, the latter group (FFP $\geq$ 3) was considered frail.

Functionality was assessed through gait speed and HGS. Gait speed was measured over 3 m at a normal pace; the best of two trials was recorded, with <0.8 m/s considered low [11]. HGS was assessed using a Takei dynamometer (Takei Scientific Instruments Co., Tokyo, Japan). Before testing, the dynamometer was calibrated to ensure accurate measurement. Each participant performed three attempts per hand, alternating hands between each trial. The test was performed with the elbow fully extended and the average value of all attempts was recorded as the final score. In accordance with the EWGSOP2 criteria, HGS was defined as <16 kg in women and <27 kg in men, thresholds that were used to identify individuals at high risk of probable sarcopenia [12]. Depression levels were evaluated using the Geriatric Depression Scale (GDS) short form with a score of $\geq$5 points indicating the presence of depressive symptoms [13].

2.4. Statistical analysis

Statistical analyses were performed using the R software (version 4.4.2) for Windows. Descriptive statistics were used to characterize the participants. We conducted quantile regression analysis with age as the independent variable and relative STS power ($W{\cdot}kg^{-1}$) as the dependent variable using the 'quantreg' package. Separate models were fitted for both men and women in five quantiles: Q10, Q25, Q50, Q75, and Q90, to explore age-related changes across different levels of STS power using bootstrapping with 5000 replications, which provided smoothed coefficient estimates and confidence intervals. The relationship between relative STS power and frailty (FFP) was examined using bivariate correlation. ROC curves were generated and analyzed with 'pROC' package to compute the area under the curve (AUC) and determine the optimal cut-off point based on the Youden index to identify the optimal trade-off between sensitivity and specificity of relative STS power ($W{\cdot}kg^{-1}$) for classifying frailty status using FFP. Next, we examined the differences in the prevalence of low relative STS power between men and women across different age groups using the χ^2 test. To reduce the risk of optimism bias, internal validation was conducted using bootstrap resampling procedures (1,000 iterations). Cut-off stability was evaluated across resamples. The 'ggplot2' package was used to plot the data. Finally, we conducted age-adjusted binary logistic regression analyses to examine the associations between low relative STS power and adverse outcomes, including low HGS, low gait speed, frailty, and depressive symptoms.

3. Results

The characteristics of the study participants are shown separately for

Table 1
Baseline characteristics of study participants.

	Overall n = 3051 % = 100.0	Men n = 1325 % = 43.4	Women n = 1726 % = 56.6
Age (years)	68.58 (6.48)	69.04 (6.66)	68.24 (6.32)*
Height (m)	1.56 (0.08)	1.63 (0.06)	1.51 (0.06)*
Weight (kg)	65.76 (12.68)	68.65 (12.17)	63.54 (12.63)*
Body mass index (kg/m2)	27.49 (4.9)	26.31 (4.01)	28.39 (5.32)*
Handgrip strength (kg)	22.45 (8.51)	28.63 (7.83)	17.69 (5.37)*
Low HGS n (%)	1251 (41)	508 (38.3)	743 (43)*
Gait speed ($m{\cdot}s^{-1}$)	0.78 (0.25)	0.84 (0.27)	0.74 (0.23)*
Lower gait speed, n (%)	2001 (65.6)	757 (57.1)	1244 (72.1)*
Relative STS Power, ($W{\cdot}kg^{-1}$)	2.13 (0.67)	2.46 (0.69)	1.88 (0.54)*
Depression, n (%)	1617 (53)	724 (54.6)	893 (51.7)*
Frailty, n (%)	838 (27.5)	266 (20.1)	572 (33.1)*

* $p < 0.05$ indicates significant differences vs. men.

men and women in Table 1.

Fig. 1 presents the quantile regression analysis for the 10th, 25th, 50th, 75th, and 90th percentiles, showing the association between relative STS power and age in men (blue) and women (red). The results indicate that participants in the higher percentiles exhibited a steeper age-related decline in relative STS power compared with those in the lower percentiles. In women, the decline was less steep overall, with a distinct pattern observed at the 90th percentile, where the coefficient was less negative than expected.

Relative STS power showed a significant negative correlation with frailty, stronger in men ($r = -0.306$, $p < 0.001$; medium effect) than in women ($r = -0.211$, $p < 0.001$; small effect). ROC analysis revealed an AUC of 0.698 (95 % CI: 0.662–0.734) for men, with an optimal cutoff of 2.11 W·kg^{-1} (specificity 34 %, sensitivity 59 %), indicating modest discrimination. In women, AUC was lower (0.602; 95 % CI: 0.574–0.631), with a cut-off of 1.63 W·kg^{-1} (specificity 30 %, sensitivity 45 %), reflecting weaker predictive ability (Fig. 2A, B)

Considering the entire sample, the prevalence of low relative STS power was similar between men (34.3 %) and women (34.8 %). By age group (60–64, 65–69, 70–74, 75–79, 80–84, 85+ years), women showed significantly higher prevalence in the 60–64 (61 % vs. 39 %) and 65–69 (62 % vs. 38 %) groups ($p < 0.05$). However, men exhibited a steeper age-related increase, with prevalence rising from 39 % at age 60–64 to 54 % at age 85+, reaching comparable or higher levels than women in the older groups. Detailed values are provided in **Supplementary Table S1. Supplementary Table S2** shows that low relative STS power was significantly associated with frailty and functional decline in both sexes but not with depression.

4. Discussion

This study investigated the utility of the relative STS power test as a functional biomarker in older Colombian adults. Sex-specific thresholds for low relative STS power were identified (men: 2.11 W·kg^{-1}; women: 1.63 W·kg^{-1}), with men exhibiting a stronger association between low power and frailty compared to women. Reduced relative STS power was associated with adverse functional outcomes, particularly low HGS and slow gait speed, reinforcing its value as a practical tool in clinical evaluations of older adults when applying population-specific cut-offs. These findings mirror global patterns, confirming the association of low relative STS power with frailty and functional decline. Baltasar-Fernandez et al. [14] established comparable thresholds in Spanish cohorts, suggesting cross-cultural relevance. Notably, they found that low relative STS power was associated with slower gait speed, disability in

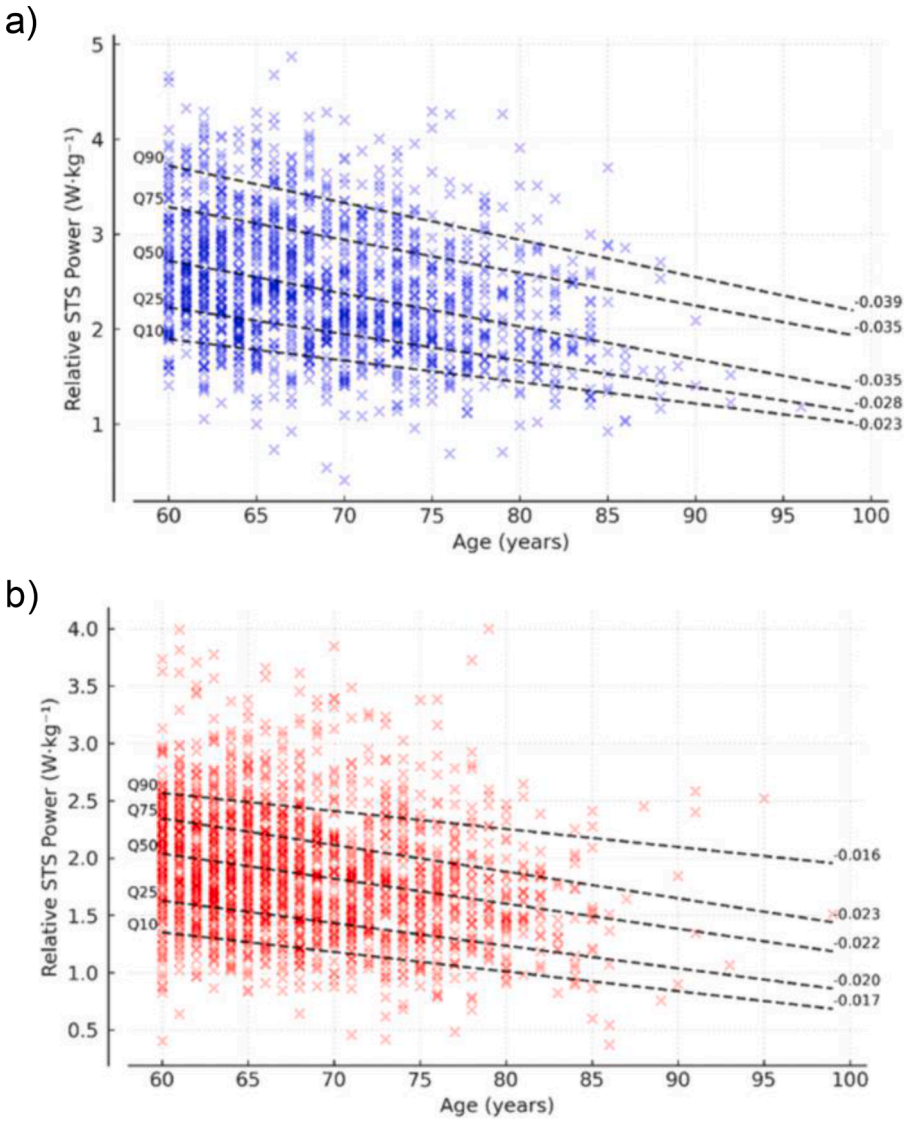


Fig. 1. Quantile regression analysis for the 10th (Q10), 25th (Q25), 50th (Q50), 75th (Q75), and 90th (Q90) percentiles showing the relationship between relative STS power and age for men (blue, panel a) and women (red, panel b). The regression coefficients are displayed on the right side of each quantile line.

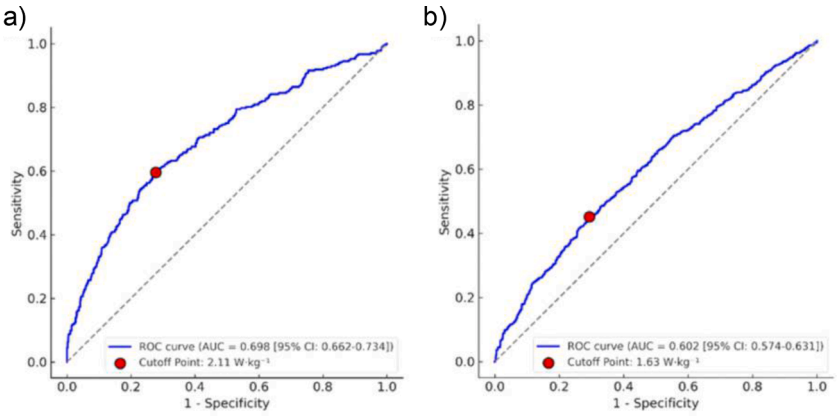


Fig. 2. Receiver operating characteristic (ROC) curve plots showing the ability of relative STS power to identify frailty (FFP $\geq$ 3) in older men (panel a) and women (panel b). 95 % CI refers to the 95 % confidence interval, and AUC represents the area under the curve.

activities of daily living, and reduced quality of life, reinforcing its prognostic value as a clinically meaningful biomarker.

Age-related declines in relative STS power varied by sex and percentile distribution. Although women aged 60–69 years showed higher prevalence of low relative STS power, sex differences diminished after age 75 due to a steeper decline in men. This pattern is consistent with evidence from European cohorts, where men exhibited greater age-related losses in relative STS power compared with women. Such findings support the notion of accelerated neuromuscular deterioration and sarcopenia in men, whereas older women may retain metabolic resilience that helps preserve functional capacity. When comparing our findings with those from other populations, the cut-off points identified in Colombian older adults (2.11 W·kg^{-1} in men and 1.63 W·kg^{-1} in women) were lower than those reported in a large European cohort including more than 9000 older adults (2.6 and 2.0 W·kg^{-1}, respectively) [6]. These differences may be explained by anthropometric and sociodemographic characteristics, including shorter stature and lower muscle mass in Colombian participants, as well as the specific adverse outcomes used to derive cut-offs. Moreover, our results confirmed a steeper age-related decline in men, a pattern consistent with European evidence, although Colombian women exhibited relatively more stable trajectories beyond age 75. Compared with other populations, the rate of decline in Colombian older adults appeared greater than that reported in Spanish cohorts [14] and more closely resembled the trajectories observed in large European studies [6]. In contrast, Danish cohorts showed different age-related patterns, with men and women experiencing more gradual losses until advanced ages [15]. These findings highlight both shared biological processes underlying age-related muscle decline and context-specific differences, reinforcing the need for population-based reference values.

Our ROC analyses confirmed the predictive validity of relative STS power for frailty (men: AUC = 0.698; women: AUC = 0.602), though modest AUC values underscore the need for complementary assessments in clinical practice. Notably, specificity values were relatively low, indicating a considerable proportion of false positives. Therefore, relative STS power may be more appropriate as a screening indicator rather than a confirmatory diagnostic measure. This study has some limitations. First, although we investigated potential interactions between covariates and cut-off points for STS power, we did not find significant interactions. Second, it is important to acknowledge the selection bias resulting from the exclusion of older adults who did not provide data for the variables of interest. Additionally, if the missingness was informative (i.e., not missing at random), this could introduce bias, potentially influencing our findings. Finally, we considered only relevant variables from the literature known to influence adverse outcome events risk in Colombian older adults. However, this approach may have limited the study's ability to capture the full complexity of the investigated phenomenon, suggesting the need for future research to explore other potentially relevant variables.

This study also has several strengths. The use of logistic and quantile regression models ensured robust analysis of associations between variables and adverse outcomes. The representative sample of Colombian older adults provides key insights into aging in this population. Clinically, defining STS power cut-offs could aid early frailty detection in primary care, improve disability risk stratification when combined with gait speed, guide targeted lower-limb strengthening programs, and enable scalable, low-cost assessments using only a chair and stopwatch.

5. Conclusion

Relative STS power emerges as a pragmatic biomarker for identifying functional impairment in aging populations. The sex-specific cut-off points established for Colombian older adults reflect demographic variations in muscle physiology and age-related decline trajectories. Furthermore, these findings in adults aged $\geq$60 years complement the work of Ramírez-Vélez et al. [8] within the SABE Project in Colombia. Owing to its simplicity, predictive value, and compatibility with digital technologies, relative STS power represents a clinically relevant tool for early detection and intervention, with the potential to improve health outcomes in older adults.

Ethics approval statement and patient consent statement

The protocol was approved by the Institutional Review Boards of the University of Caldas (ID: CBCS-021-14) and the University of Valle (ID: 09-014 and O11-015). Informed consent was obtained from all subjects and/or their legal guardian(s), all methods were carried out in accordance with relevant guidelines and regulations.

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Data statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declaration of generative AI use

We declare no use of generative AI and AI-assisted technologies in scientific writing, and in figures, images, and artwork.

CRediT authorship contribution statement

Robinson Ramírez-Vélez: Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation. **Miguel Germán Borda:** Writing – original draft, Validation, Conceptualization. **Juan Carlos Calderón-González:** Visualization, Validation, Methodology, Investigation. **Albeiro Dávila-Grisales:** Visualization, Validation, Supervision. **Gonzalo Romero-Martínez:** Validation, Methodology, Conceptualization. **Mikel Izquierdo:** Writing – review & editing, Methodology, Investigation, Formal analysis. **Miguel A. Pérez-Sousa:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.tjfa.2026.100141.

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