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Reference Values for the Five-Repetition Sit-to-Stand Test in the Adult Chilean Population

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Valores de referencia para la prueba de pararse y sentarse de cinco repeticiones en población adulta chilena

ABSTRACT

The five-repetition STS test (5-STS) is a field test utilized for evaluating physical function, primarily assessing the risk of falls, and is also included as a component in other assessments, such as the Short Physical Performance Battery (SPPB). This test proves to be easily implementable and of significant clinical utility; however, no reference values are currently available for the Chilean population. ***Aim:*** *To establish reference values for the 5-STS in the adult Chilean population.* ***Methods:*** *A multicenter cross-sectional study encompassed data acquisition from five distinct sites across Chile. Healthy adults aged between 18 and 80 were enrolled as participants. Anthropometric measures, physical activity levels, smoking history, Borg scale assessments, and the time to complete five repetitions were registered. Reference values were subsequently established based on sex and specific age categories.* ***Results:*** *463 subjects were included in the study, comprising 269 women. The median (and LIN) of time of 5 repetitions in women was: 18-29 years: 7.4 (10.6), 30-39 years: 7.7 (11.4), 40-49 years: 8.5 (13.1), 50-59 years: 9.2 (14.0), 60-69 years: 9.7 (15.3) and 70-80 years: 11.3 (17.7). While in men it was: 18-29 years: 7.8 (10.3), 30-39 years: 6.5 (11.4), 40-49 years: 8.1 (11.5), 50-59 years: 9.8 (15.1), 60-69 years: 11 (15.8), 70-80 years: 13 (18.5). The predictive equations are as follows: Men: 5-STS= 4.698 + (age(y) * 0.096); Women: 5-STS= -3.185 + (age(y) *0.074) + (height(cm) *0.055).* ***Conclusion:*** *This*

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study successfully established reference values for the adult Chilean population, providing essential data for the accurate assessment of the physical capacity of the people when using the 5-STS.
Keywords: *Exercise Test; Functional Status; Physical Fitness; Reference Values.*

RESUMEN
La prueba de pararse y sentarse de cinco repeticiones (5-STS) es un test de campo utilizado para evaluar la función física, principalmente relacionado con el riesgo de caídas, y se incluye también como componente en otras evaluaciones, como la batería corta de rendimiento físico (SPPB). Esta prueba es de fácil implementación y tiene una significativa utilidad clínica; sin embargo, actualmente no existen valores de referencia disponibles para la población chilena. ***Objetivo:*** *Establecer valores de referencia para el 5-STS en la población adulta chilena.* ***Métodos:*** *Estudio multicéntrico transversal, que abarcó la recopilación de datos en cinco sitios diferentes de Chile. Se incluyeron adultos saludables de entre 18 y 80 años. Se registraron medidas antropométricas, niveles de actividad física, historia de tabaquismo, evaluaciones con la escala de Borg y el tiempo requerido para completar las 5 repeticiones. Posteriormente, se establecieron valores de referencia según el sexo y categorías específicas de edad.* ***Resultados:*** *Se incluyeron 463 participantes en el estudio, de los cuales 269 eran mujeres. La mediana (y LIN) del tiempo para las 5 repeticiones en mujeres fue: 18-29 años: 7.4 (10.6), 30-39 años: 7.7 (11.4), 40-49 años: 8.5 (13.1), 50-59 años: 9.2 (14.0), 60-69 años: 9.7 (15.3) y 70-80 años: 11.3 (17.7). Mientras que en hombres fue: 18-29 años: 7.8 (10.3), 30-39 años: 6.5 (11.4), 40-49 años: 8.1 (11.5), 50-59 años: 9.8 (15.1), 60-69 años: 11.0 (15.8), 70-80 años: 13.0 (18.5). Las ecuaciones predictivas son las siguientes: Hombres: 5-STS= 4.698 + (edad(a) * 0.096); Mujeres: 5-STS= -3.185 + (edad(a) * 0.074) + (altura(cm) * 0.055).* ***Conclusión:*** *Este estudio estableció con éxito valores de referencia para la población adulta chilena, proporcionando datos esenciales para la evaluación precisa de la capacidad física de las personas al utilizar el 5-STS.*
Palabras clave: *Aptitud Física; Estado Funcional; Prueba de Esfuerzo; Valores de Referencia.*

The literature has demonstrated that functional limitations pose a higher mortality risk than multimorbidity[1]. Additionally, they are linked to increased costs related to falls and hospitalization[2,3]. The functional limitations can be assessed with the sit-to-stand (STS) test[4,5] This assessment is a straightforward, quick, and widely adopted functional performance

assessment[6]. It entails measuring the time it takes to stand up from a seated position a specific number of times or recording the number of repetitions completed within a set timeframe[6]. This test requires minimal space, material, and time[6].

The STS movement is a fundamental movement performed by individuals of all ages[7]. The significance of this motion lies in its pivotal role as a determining factor for physical function and independence[8]. The STS manoeuvre is a common activity in daily life[7], relying significantly on the function of lower limb muscles and balance[9,10].

The five-repetition STS test (5-STS), designed to measure the time taken to stand five times from a sitting position as quickly as possible, is extensively documented as the most comprehensive STS for older adults[11,12,13]. This test not only assesses physical function individually but is also a component of multidimensional evaluations, such as the SPPB (Short Physical Performance Battery), which is particularly important for assessing the functionality of older adults[14].

When using functional tests like the 5-STS, reference values are essential to interpret the results in the appropriate context[15]. These reference values provide points of comparison to determine whether an individual's performance falls within normal ranges for their age group and specific conditions[15]. Currently, no reference values are available for our population. Therefore, clinicians and researchers must rely on reference values from other countries with people having different anthropometric, cultural, and genetic characteristics.

Although existing reference values can serve as a starting point, it is essential to consider the variability among local populations and contexts. Various factors can influence test outcomes, including age, sex, physical activity levels, and specific health conditions[15]. Hence, establishing local reference values and objectives will allow a more accurate and personalized evaluation of physical function and patient progress in their specific environment. We aimed to determine 5-STS reference values for the Chilean population between 18 to 80 years.

Methods

Study design and participants

A cross-sectional study was conducted concurrently in five centers in various geographical regions of Chile (Quillota, Villa Alemana, Santiago, Talca, Puerto Montt) between June 2019 to June 2023. This study was approved by the Ethics Committee of the Eastern Metropolitan Health Service (June 2019). All subjects gave written consent. This study was performed following the "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE) Guidelines[16].

Participants were recruited from the general population using a uniform strategy across all participating centers. This involved using posters on social media and within the center´s facilities and sending recruitment emails to their staff and secondary contacts. The inclusion criteria were adults aged between 18 and 80 years who self-reported as healthy, defined as an individual without any known significant illnesses relevant to the proposed study, who falls within the normal range of body measurements, such as weight, and whose mental state allows them to understand and provide valid consent for participation in the study[17], born in Chile, and self-reported ability to stand up from a chair without using their arms for assistance. This criterion was confirmed verbally by trained assessors to ensure correct understanding of the task. Exclusion criteria comprised individuals with a BMI ≥35, chronic or acute respiratory disease within the last 30 days, acute or chronic musculoskeletal injury (affecting the lower limbs or lumbar region, or any other condition that, in the evaluator's judgment, could significantly limit the safe execution of the test), concurrent cardiac, cerebral, or neuromuscular disorders that hindered test performance, or individuals with difficulty understanding instructions.

Measurements

Each participant underwent a comprehensive assessment during a single visit, following a standardized order of procedures. Initially, anthropometric and demographic data were collected. Regarding smoking status, participants were asked to categorize themselves as 'never smoker', 'ex-smoker', or 'former smoker'. To gauge the level of physical activity (PA), the abbreviated version of the International Physical Activity Questionnaire-Short Form (IPAQ-SF) was utilized, and participants were classified into low, moderate, or high levels of PA[18].

The 5-STS was conducted based on the methodology described in the Vaidya study, which consists of the patient sitting from an upright position, adopting the bipedal position with their knees in maximum extension[19]. A standard 43-46 cm chair was used, with thoracolumbar support. Subjects sat upright on the chair against the wall with the knees and hips flexed at 90° and the feet flat on the floor wide apart[5]. The duration required to perform five complete cycles of sitting and standing on the chair was meticulously recorded. Participants were instructed to perform the sit-to-stand manoeuvre on the chair a few times to acquaint themselves with the procedure. They were directed to rise and sit down five times as quickly as possible. Employing a stopwatch, the duration of the five repetitions was measured from the initial command to the completion of the fifth repetition. The timing began immediately after the subject rose from the chair and ceased once she resumed the seated position. A repetition was considered complete when the individual stood up fully and sat back down. A repetition was deemed correct if the person stood with fully extended knees and hips, then sat down, touching the chair with their buttocks while keeping their back straight.

To standardize the measurements, training sessions were conducted, during which evaluators from various centers were instructed to record three videos demonstrating the execution of the 5-STS using a designated pilot test individual[5,20]. The purpose was to ascertain adherence to the study protocol. Once the validation of the three recorded evaluations was confirmed, authorization was granted to start the study measurements.

Statistical analysis

Data were analyzed using the statistical IBM SPSS version 25.0 (IBM Corporation, Armonk, NY, USA). The Kolmogorov-Smirnov test was employed to assess data distribution. Numerical variables were reported as median (interquartile range), while qualitative variables were presented as frequency and percentage. For the correlation analysis, quantitative variables such as age, weight, height, BMI, and Borg were examined in relation to the number of repetitions of the 5-STS. We used the following percentiles to establish the reference values: 2.5^{th}, 25^{th}, 50^{th}, 75^{th}, and 97.5^{th} percentile (LIN). Results of reference values are presented separately by sex and age groups (groups from 18 to 29, 30 to 39, 40 to 49, 50 to 59, 60 to 69, and 70 to 80 years old).

Multiple linear regression was performed for men and women to facilitate the calculation of reference values, with performance in the 5-STS as the dependent variable and age, height, and weight as predictors. The stepwise method was used to generate the predictive model. For each model, the coefficient of determination (R^2) and the root mean square error (RMSE) were also calculated to report the proportion of variance explained and the average prediction error, respectively.

To compare 5-STS performance based on PA level, a one-way ANOVA test was conducted.

The sample size calculation was conducted using the known population of Chile (approximately 19 million), a 95% confidence level, and a 5% margin of error. The resulting sample size was determined to be 385 subjects.

Results

Data was collected from 469 subjects. Six participants were excluded due to BMI >35m/kg^2. Ultimately, the records of 463 individuals were included in the analysis, comprising 269 women (58.1%). Among the participants, 71.4% reported having a low level of PA, and 24% declared themselves smokers. Further information on the population's characteristics can be found in Table 1.

Table 1. Characteristics of the Study Population.

Variable	All (n= 463)	Women (n= 269)	Men (n= 194)	p-value
Age group				
18-29 (%)	101 (21.8)	53 (19.7)	48 (24.7)	
30-39 (%)	67 (14.5)	33 (12.3)	34 (17.5)	
40-49 (%)	86 (18.6)	58 (21.6)	28 (14.4)	n.s
50-59 (%)	68 (14.7)	44 (16.4)	24 (12.4)	
60-69 (%)	71 (15.3)	45 (16.7)	26 (13.4)	
70-80 (%)	70 (15.1)	36 (13.4)	34 (17.5)	
Height (m), median (IQR)	1.63 (0.13)	1.58 (0.10)	1.70 (0.09)	<0.001
Weight (Kg), median (IQR)	73 (19.6)	68 (18)	80.1 (17.5)	<0.001
BMI (kg/m^2),	27.4±4.1	27.5±4.2	27.3±3.8	n.s
Physical activity level (IPAQ-SF)				
Low (%)	331 (71.5)	201 (74.6)	130 (67)	n.s
Moderate (%)	83 (17.9)	48 (17.7)	35 (18.1)	
High (%)	49 (10.6)	20 (7.7)	29 (14.8)	
Tobacco use				
Smoker (%)	103 (24)	67 (27)	36 (19.8)	n.s
Non smoker (%)	304 (70.7)	167 (67.3)	137 (75.3)	
Former smoker (%)	23 (5.3)	14 (5.6)	9 (4.9)	
Basal Borg, median (IQR)	0 (1)	0 (1)	0 (1)	n.s

The data have been presented as mean ± standard deviation, median (interquartile range), or frequency (percentage), as appropriate. BMI: Body Mass Index; IPAQ-SF: International Physical Activity Questionnaire - Short Form.

A Spearman correlation test was performed to assess the relationship between the 5-STS variable and age (r= 0.454; p= 0.0001), height (r= -0.024; p= 0.6), weight (r= -0.004; p= 0.9), BMI (r= 0.025; p= 0.6), and Borg (r= 0.212; p= 0.0001).

To examine the relationship between individual performances in the 5-STS and the age of the subjects, we constructed dispersion graphs depicting the performance distribution concerning age and sex (Figure 1 and Figure 2). These graphs visually represent how the 5-STS performance varies across different age groups and between male and female participants. A noticeable trend was observed in the increase in the execution time of the 5-STS compared to age.

The obtained results were stratified based on the quality of performance, and percentiles (p2.5, p25, p50, p75, and p97.5) were calculated for different age groups (18-29, 30-39, 40-49, 50-59, 60-69, and 70-80 years), while also considering sex as a factor for division. The detailed classification is presented in Table 2.

The predictive equations showed that age in men and age and height in women have a significant relationship with test completion time, explaining 33.4% (R^2= 0.334, RMSE= 2.47) and 19.2% (R^2= 0.192, RMSE= 2.46) of the variance, respectively. The specific equations for men and women are as follows:

- Men: 5-STS= 4.698 + (age(y) * 0.096)
- Women: 5-STS= -3.185 + (age(y) * 0.074) + (height(cm) * 0.055).

In these equations, age must be provided in years and height in centimeters. The RMSE represents the average error between the predicted times from the equation and the observed times. In this case, the RMSE values of 2.47 for men and 2.46 for women suggest that, on average, the predicted times may deviate by approximately 2.5 seconds from the observed times.

The low PA group had an average time of 9.11±2.9 seconds, the moderate PA group 8.86±2.8 seconds, and the high PA group 7.8±2.0 seconds (p= 0.03) (Figure 3).

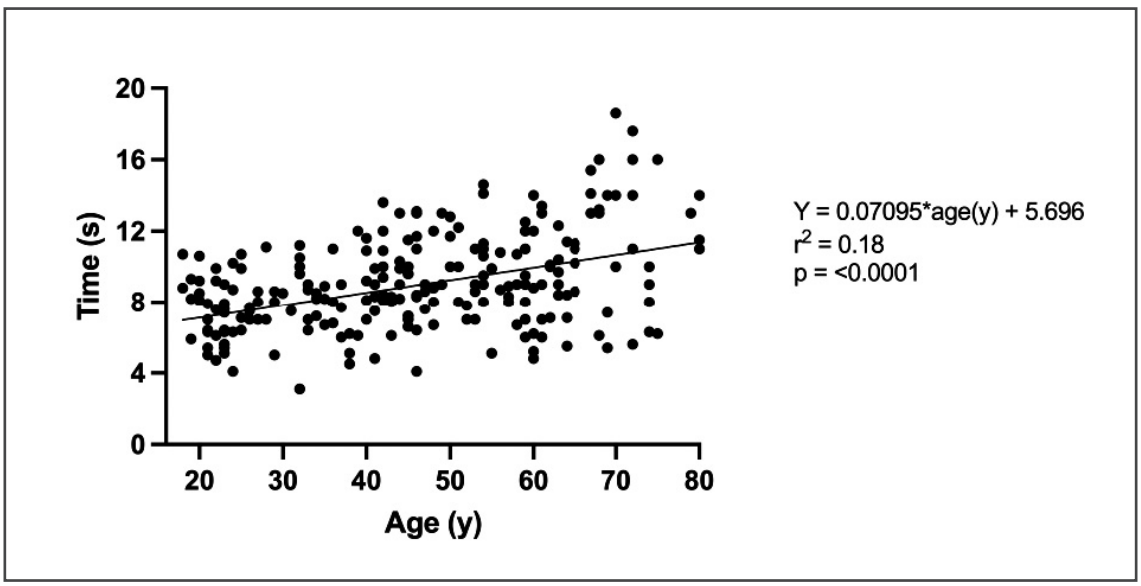

Figure 1: *Correlation between the 5-STS and age in Women.Scatter plot showing the relationship between age (years) and the time (seconds) to complete the 5-repetition sit-to-stand test (5-STS). The regression line indicates a positive association (Y= 0.07095 * age + 5.696), with an explained variance of r^2= 0.18 and a statistically significant p-value <0.0001.*

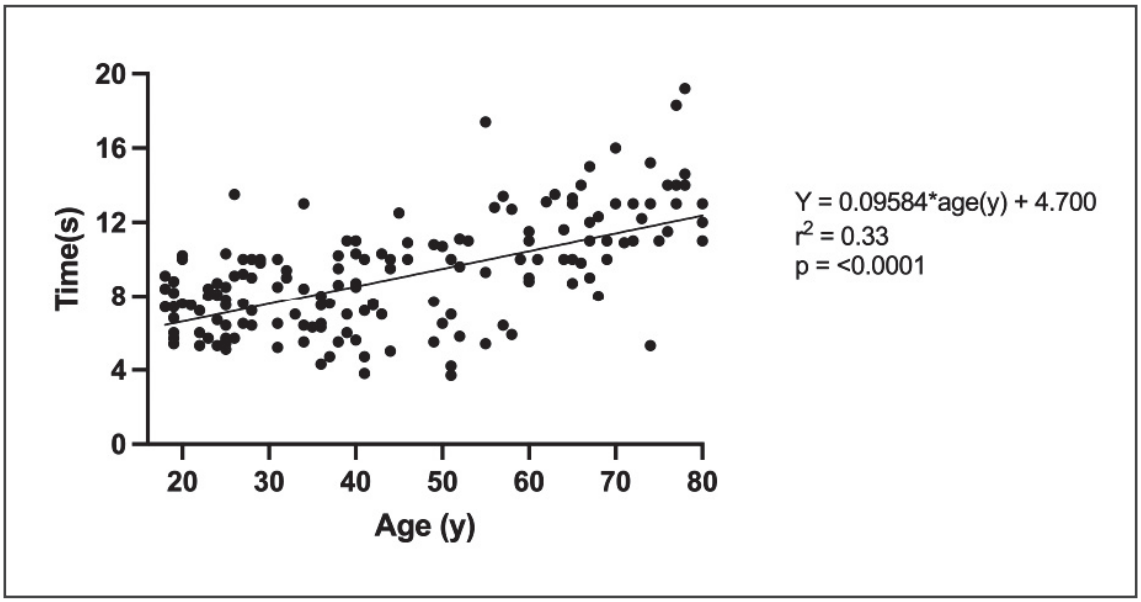

Figure 2: *Correlation between the 5-STS and age in Men. Scatter plot showing the relationship between age (years) and the time (seconds) to complete the 5-repetition sit-to-stand test (5-STS). The regression line indicates a positive association (Y= 0.09584 * age + 4.700), with an explained variance of r^2= 0.33 and a statistically significant p-value <0.0001*

Table 2. Age-specific percentiles of relative 5-STS.

	Women (n= 269)						Men (n= 194)					
Age range	n	2.5	25	50	75	97.5 (LIN)	n	2.5	25	50	75	97.5 (LIN)
18-29	53	4.8	6.3	7.4	8.6	10.6	48	5.3	6.4	7.8	9.0	10.3
30-39	33	3.1	6.2	7.7	9.0	11.4	34	4.3	5.5	6.5	8.5	11.4
40-49	58	4.8	7.7	8.5	10.7	13.1	28	3.8	6.6	8.1	10.0	11.5
50-59	44	5.0	8.0	9.2	11.0	14.0	24	3.7	5.9	9.8	11.0	15.1
60-69	45	5.2	9.0	9.7	13.0	15.3	26	8.4	9.9	11.0	12.8	15.8
70-80	36	6.1	10	11.3	14.0	17.7	34	9.5	11.1	13.0	14.0	18.5

Percentile values (2.5, 25, 50, 75, and 97.5) for both men and women, stratified by age groups ranging from 18 to 80 years. Data are presented separately for men (n= 194) and women (n= 269), showing the distribution of the selected variable across the specified percentiles. Results are expressed in seconds. LIN: lower limit of normal.

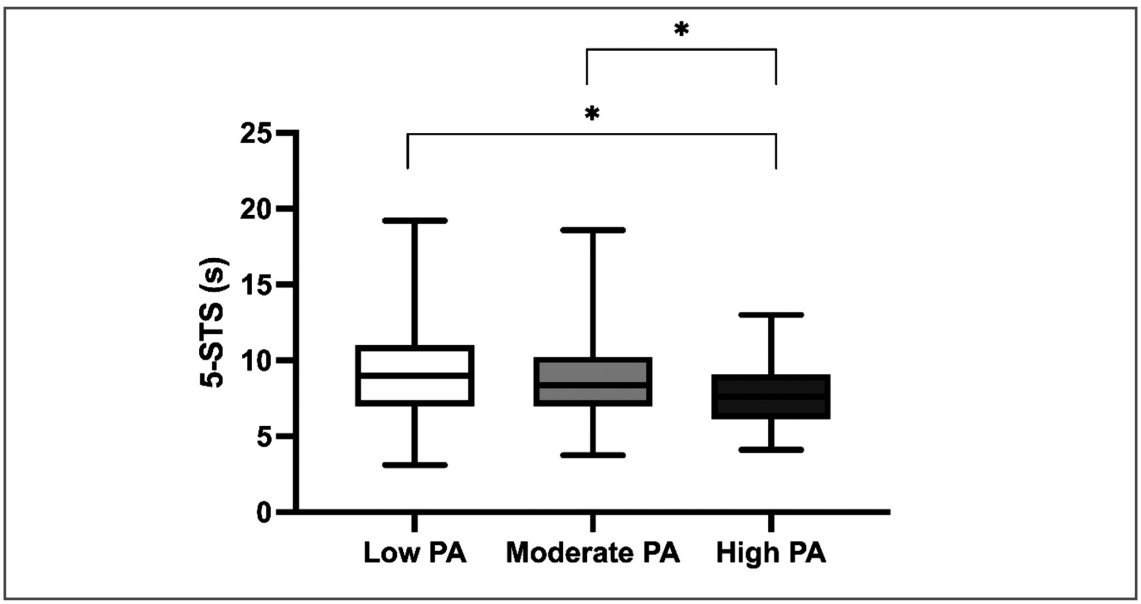

Figure 3: *Comparison of 5-STS by physical activity level. Boxplot illustrating the time (in seconds) required to perform the 5-STS across physical activity levels (Low PA, Moderate PA, High PA). Boxes represent interquartile ranges, horizontal lines indicate median values, and whiskers denote the range. *p<0.05, **p<0.01.*

Discussion

This study has established normative reference values to predict the performance of the 5-STS. These values were derived from a diverse multicentric sample of individuals aged 18 to 80 in a developing country with characteristics similar to other Latin American populations. Including such a varied and representative population enables the potential application of these reference values in contexts lacking local normative data. By providing these reference values, the research aims to offer valuable insights and guidance for evaluating 5-STS performance in populations with similar demographic characteristics. This can assist healthcare professionals and researchers in assessing functional abilities more contextually relevantly.

The significance of adapting reference values to the local population cannot be emphasized enough[15]. Utilizing standardized values derived from data in other populations when assessing health parameters and physical abilities may not adequately capture the distinct characteristics and diversities of the Chilean population. Genetic background, lifestyle choices, cultural practices, and environmental factors play a pivotal role in influencing the health and performance of individuals[22,23]. As a result, it becomes imperative to establish precise reference values specifically developed to the demographics of a particular region or population to look for the optimal assessment[23].

In the last years, various normative data for the 5-STST in adults from diverse countries have been published[24,25,26,27,28]. Nevertheless, reference values specific to the Chilean adult population have not been previously documented for the 5-STS. The current findings align with previous studies, suggesting that performance on the 5-STST declines with age[27].

There are scarce reports on the sit-to-stand performance in Latin America. One of the available reference studies is that of Furlanetto, et al. who assessed the 5-STS in 296 volunteers aged between 20 and 80[27]. Our data closely resemble those obtained from the Brazilian population, even

in females aged 18 to 29 (7.4 vs. 7.3 seconds) and 70 to 80 years (11.3 vs. 11.4 seconds), where the time taken is practically identical. This pattern is also replicated in males, particularly within the age ranges of 18 to 20 years (7.8 vs. 8.1 seconds) and 60 to 69 years (11 vs. 10.6 seconds), exhibiting a similar behavior. These resemblances allow us to propose that these data may have at least regional relevance within the South American context.

Although the 5-STS is commonly used in older adults and geriatric assessments[11,29], recent evidence supports its application across a broader age range, including adolescents and younger adults. Farías-Valenzuela, et al. (2024) demonstrated that the 5-STS is a valid and reliable measure of lower limb strength and functional capacity in adolescents and adults aged 12 to 26 years with intellectual disabilities, showing significant correlations with handgrip strength, countermovement jump, agility, and balance[30]. Similarly, Møller, et al. (2012) validated the 5-STS in adults aged 20 to 55 with multiple sclerosis, establishing its relationship with lower limb muscle strength and balance performance[31]. In addition, Ferrari, et al. (2022) highlighted the 5-STS as a practical and cost-effective method to estimate lower limb muscle power in field settings, provided that appropriate assumptions are used[32]. Their results reinforce the utility of the 5-STS as a functional assessment tool that bridges laboratory-based measures with real-world clinical and community applications. These findings indicate that the 5-STS is not limited to older adults but can be used as a meaningful and straightforward functional assessment tool in young and middle-aged populations. Its ability to reflect lower limb strength, movement speed, and balance makes it suitable for monitoring functional performance in various health and exercise settings across the lifespan. In clinical practice, the 5-STS is widely recognized as part of the SPPB, a validated tool for assessing frailty and stratifying fall risk in older adults[14]. Its role in this multidimensional assessment highlights its clinical value in identifying individuals at increased risk of adverse outcomes such as falls, hospitalization, and functional decline. Therefore, while our findings support its broader application across different age groups, its most established and clinically endorsed use remains for frailty screening and fall risk evaluation in older adults.

Although the absolute number of participants over 60 years was not the lowest among age groups, their representation remains a limitation, considering that older adults are the primary target population for the clinical application of the 5-STS, especially in frailty assessment and fall risk evaluation[29]. This pattern is recurrent in studies focused on reference values, particularly in Latin American countries[27,28]. Here, a sedentary way of life and the widespread occurrence of non-communicable ailments present obstacles in assembling a population deemed "healthy." The categorization of ostensibly healthy individuals was predicated upon self-reporting and the non-existence of diagnosed medical conditions. Nevertheless, it is noteworthy that incorporating subjects with undiagnosed conditions or illnesses constitutes a recurrent attribute in studies encompassing expansive population samples aimed at establishing reference benchmarks.

Different proposals exist on which percentile to define normality limits in the 5-STS. For example, Klukowska, et al.[26] used the 99th percentile to determine the upper limit of normality in their study with healthy individuals, while Furlanetto, et al.[27] used the 10th percentile for the lower limit. This reflects the lack of a clear consensus on which percentile is most appropriate in all situations. Given that our study presents several percentiles and a reference equation, we believe it is important for clinicians to decide which to apply based on the clinical context and evaluation goals. We do not adhere to a single value as an absolute truth, as different percentiles can be useful depending on whether the goal is to detect early functional decline or severe dysfunction, thus providing greater flexibility and adaptability in clinical practice. However, considering that longer completion times indicate poorer performance, we suggest that using intermediate percentiles, such as the 50th, may be more appropriate for the early identification of functional decline. In contrast, the 97.5th percentile should be reserved for identifying severe impairment.

The predictive model for the 5-STS demonstrated a moderate ability to predict completion times, with an R^2 of 0.334 for men and 0.19 for women, indicating that the variables considered explain 33% and 19% of the variability in times, respectively. However, the RMSE of 2.47 seconds for men and 2.46 seconds for women suggests a significant average deviation between predicted and observed times, especially considering that the test times range from 7 to 13 seconds. This error level implies a deviation of 19% to 36% of the total test time, which could have important clinical implications, particularly in detecting subtle differences in physical performance. While RMSE is a standard metric used in predictive model evaluation due to its sensitivity to larger errors[33], the values obtained in this study suggest that the model may require adjustments to improve accuracy, particularly in subjects with shorter times where the percentage error is higher. Despite this, the equations provide a useful framework for assessing functional performance, though clinicians should account for the margin of error when interpreting the results.

Although the 30-39 and 50-59 age groups had lower absolute numbers, the limited representation of adults over 60 years is particularly relevant from a clinical perspective, as this is the group for which the 5-STS holds the most excellent utility in frailty and fall risk assessment[34,35]. This may be because older adults tend to lead a more sedentary lifestyle and have a higher prevalence of non-communicable diseases, making it challenging to include a population considered "healthy." The categorization of apparently healthy individuals was determined through self-reporting and the absence of diagnosed medical conditions. Our study determined health status by self-report, a practical approach commonly used in population-based studies[17]. However, we acknowledge that this method may lead to the exclusion of older adults who perceive themselves as unhealthy, even when they have no formal diagnosis or present with mild or undetected conditions. This self-selection bias could partially explain our sample's limited representation of older adults. Future studies could benefit from incorporating standardized clinical assessments or objective screening tools to characterize health status better and reduce potential selection bias.

Nevertheless, it is worth noting that including individuals with undiagnosed conditions or diseases is a common feature in studies aimed at establishing reference parameters in large population samples. Furthermore, the sample in this study did not follow a probabilistic approach, which could have introduced selection bias, as participants who accepted the invitation may have differed in characteristics from those who did not participate. Another aspect not recorded in this study was the socioeconomic characterization of the participants, which could have influenced the results.

Conclusion

Reference values for the 5-STS were determined for the Chilean population aged 18 to 80 years. These values can be valuable for optimal assessments and determining the effects of interventions involving the evaluation of physical function through this test.

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