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30 Seconds Sit-to-Stand Test: Reference Values for the Chilean Population

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Prueba de sentarse a levantarse en 30 segundos: Valores de referencia para la población chilena

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RESUMEN

La evaluación de la capacidad funcional es esencial para identificar problemas de movilidad y adaptar estrategias de rehabilitación. La prueba de levantarse y sentarse en 30 segundos (30s-STST) es válida y confiable para evaluar la musculatura de las extremidades inferiores. ***Objetivo:*** *Establecer valores de referencia para la 30s-STST en adultos de 18 a 80 años de la población chilena.* ***Métodos:*** *Se realizó un estudio transversal en seis centros en Chile, de los cuales tres eran Universidades y los otros tres eran centros de atención primaria. Se registraron las variables antropométricas, los niveles de actividad física, tabaquismo y el número de repeticiones durante el 30s-STST. Para establecer los valores de referencia, se calcularon los percentiles normativos específicos por sexo y edad (2,5, 10, 25, 50, 75, 90 y 97,5) para seis grupos etarios distintos. Además, se realizaron análisis de regresión lineal múltiple por separado para hombres y mujeres, utilizando el desempeño en el 30s-STST como variable dependiente y la edad, la estatura y el peso como predictores.*

Resultados: *Se incluyeron 499 personas en el estudio (57.5% mujeres). La mediana (percentil 25-75) del número de repeticiones en mujeres fue: 18-29 años: 19 (17-24), 30-39 años: 20 (18-23), 40-49 años: 17 (15-20), 50-59 años: 16 (14-20), 60-69 años: 15 (12-19), 70-80 años: 13 (11-18). En los hombres fue: 18-29 años: 19 (16-24), 30-39 años: 21 (18-27), 40-49 años: 16 (15-24), 50-59 años: 18 (16-21), 60-69 años: 14 (12-15), 70-80 años: 11 (10-13). Las ecuaciones predictivas son las siguientes: Hombres: 30s-STST= 25.364 - (edad años * 0.158); Mu-*

*jeres: 30s-STST= 39.264 - (edad años * 0.136) - (altura cm * 0.095).* ***Conclusiones:*** *Este estudio logró establecer valores de referencia para la población adulta chilena, los cuales pueden ser utilizados como referencia en otras poblaciones del Cono Sur, dada las características regionales compartidas.*
Palabras clave: *Capacidad Funcional; Ejercicio Físico; Fuerza Muscular; Limitación de la Movilidad; Valores de Referencia.*

ABSTRACT

Assessment of functional capacity is essential for identifying mobility issues and tailoring rehabilitation strategies. The 30-seconds sit-to-stand test (30s-STST) is valid and reliable for evaluating lower limb muscle. ***Aim:*** *To establish reference values for the 30s-STST in adults aged 18-80 years in the Chilean population.* ***Methods:*** *A cross-sectional study was conducted across six centers in Chile, three were universities and the other three were family health centers. The anthropometric variables, levels of physical activity, smoking status, and the number of repetitions during the 30s-STST were recorded. To establish the reference values, we calculated sex- and age-specific normative percentiles (2.5th, 10th, 25th, 50th, 75th, 90th, and 97.5th) for six different age groups. Additionally, multiple linear regression analyses were performed separately for men and women, with performance in the 30s-STST as the dependent variable and age, height, and weight as predictors.* ***Results:*** *Four hundred ninety-nine individuals were included in the study (57.5% women). The median (25th-75th percentile) number of repetitions in women was: 18-29 years: 19 (17-24), 30-39 years: 20 (18-23), 40-49 years: 17 (15-20), 50-59 years: 16 (14-20), 60-69 years: 15 (12-19), 70-80 years: 13 (11-18). While in men it was: 18-29 years: 19 (16-24), 30-39 years: 21 (18-27), 40-49 years: 16 (15-24), 50-59 years: 18 (16-21), 60-69 years: 14 (12-15), 70-80 years: 11 (10-13). The predictive equations are as follows: Men: 30s-STST= 25.364 - (age years * 0.158); Women: 30s-STST= 39.264 - (age years * 0.136) - (height cm * 0.095).* ***Conclusions:*** *This study successfully established reference values for the adult Chilean population, which can be used as a reference in other Southern Cone populations, given the shared regional characteristics.*
Keywords: *Functional Capacity; Mobility Limitation; Muscle Strength; Physical Activity; Reference Values.*

Functional capacity refers to the ability to perform daily tasks with enough energy to enjoy leisure-time activities and meet periods of unusual strain or disease[1] being an important indicator of current health[2]. It encompasses various aspects such as strength, endurance, flexibility, and speed, all of which influence one's physical performance and overall health[3].

Functional capacity is also a strong predictor of mortality in health older people[4], and chronic diseases like cáncer[5], COPD[6], and heart disease[7].

Assessment of functional capacity, muscle strength, and endurance is crucial for examining mobility and identifying insufficient exercise capability in both healthy individuals and patients[8,9,10]. There are different methods for measuring functional capacity, some of which can be performed in a laboratory setting and others through field test[11]. Both methods have advantages and disadvantages: for example, the laboratory provides more precise and controlled measurements, such as gas and lactate analysis, while field tests are more practical and accessible for clinicians, measuring performance in more daily situations[12]. Field tests hold significant value, particularly when resources for laboratory evaluations are limited[13].

Between the field tests, the 6-minute walk test (6MWT) has been widely used as a standard to assess functional capacity in various populations due to its simplicity and effectiveness[13]. However, in situations where the 6MWT cannot be performed, for example, due to lack of a corridor with adequate length, the sit-to-stand test (STST) is a viable alternative[14].

There are several versions of the STST, such as the five sit-to-stand (5-STST), 30-seconds STST (30s-STST), and the 1-minute STST (1min-STST)[11,15,16,17]. These assessments measure strength, power, and dynamic balance in the case of 5-STST and 30s-STS, while muscular endurance is a critical physiological aspect for both 30s-STST and 1min-STST[18]. As a result, these tests provide insight into overall physical performance[18]. The STST can be conducted in any healthcare environment as it necessitates only basic equipment (a standard chair and a stopwatch) and is easy for most participants, requiring minimal time[11]. It's a reliable assessment, demonstrating strong associations with other measures of exercise capacity like the 6-minute walk test or stair climbing. It also provides valuable prognostic information[19,20].

In particular, the 30s-STST this test has been demonstrated to be a valid and reliable tool to assess peripheral muscle performance of the lower limbs[21,22]. A relationship has also been found between the values obtained in the 6-minute walk test and the 30s-STST in healthy people[23] and in people with chronic diseases (e.g. COPD)[20]. 30s-STST also became vitally important during the COVID-19 pandemic, emerging as an alternative when time and space resources were scarce[19]. For example, muscle power derived from 30s-STST was a useful tool for detecting global muscle wasting in both male and female COVID-19 survivors[19]. Furthermore, this test proved to be feasible and safe as a remote assessment to identify physical sequelae in long COVID patients[24], as well as changes following a telerehabilitation protocol[25].

In terms of the psychometric properties of the 30s-STST and other field tests, it is essential to ensure their validity and reliability. These properties refer to the test's ability to accurately and consistently measure an individual's functional capacity, which has been described as good in different populations with chronic pathologies[21].

Currently, reference values from 30-STST are from Tveter, et al. Warden et al. and Furlanetto, et al. are available for Norway, United States of America and Brazil, respectively[26,27,28]. These authors offers a compilation of normative data that can serve as a reference for interpreting results in different populations and clinical settings[26,27,28]. While existing reference values can serve as a starting point, it is crucial to consider the variability among local populations and contexts. Factors such as age, sex, level of physical activity, and specific health conditions may influence test results[29]. There are ethnic, anthropometric, sociocultural, and dietary reasons that can influence the differences in the results of physical capacity tests in different populations, which would be another reason to justify having our own reference values[30]. Therefore, the establishment of local reference values and targets will allow for a more accurate and personalized evaluation of functional capacity and patient progress in their specific environment. The aim of this study is to establish reference values for the 30s-STST in an adult Chilean population between 18 to 80 years of age.

Methods

Study design and participants

A cross-sectional study was carried out simultaneously in six centers, 3 of these centers were universities and the other 3 were family health centers, across different geographical regions of Chile (Villa Alemana, Quillota, Talagante, Santiago, Talca, Puerto Montt) from June 2019 to June 2023. This study was approved by the Ethics Committee of the Metropolitan Eastern Health Service (14-06-2019). All subjects gave written consent. This study was performed following the "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE) Guidelines[31].

Participants were recruited from the general population. A uniform recruitment strategy was employed across all center. It involved the dissemination of information through posters on the recruiters' social media platforms, physical posters placed both inside and outside the evaluation centers, and email outreach for individuals who voluntarily expressed interest in participating in the research who met the inclusion criteria, which were: Adults between 18 and 80 years of age self-reported as healthy, who stated that they were able to stand up and sit down in a chair. Exclusion criteria: A body mass index (BMI) ≥ 35, have a chronic or acute respiratory disease in the last 30 days, have an acute or chronic musculoskeletal injury, concomitant cardiac, cerebral, or neuromuscular disease that prevents you from performing the tests and/or presents an inability to understand instructions.

To calculate the sample size based on total population, we used a free University of Granada software. With a risk of type 1 error of 5% and confidence level of 95%. As a result, the final estimate determined a minimum of 471 participants.

Measurements

Each participant was assessed in one single visit using a standardized assessment order. Firstly, anthropometric and demographic characteristics were obtained. For smoking status, participants indicated if they were a ''never smoker'', ''ex-smoker'' or ''current smoker''. As a measure of the level of physical activity using the abbreviated version of the International Physical Activity Questionnaire (IPAQ-SF)[32]. It was classified as low, moderate, and high level.

The 30s-STST test consisted of a simple movement : standing up from a chair, adopting the bipedal position with their knees in maximum extensión[33] for 30 seconds. A standard 43-46 cm chair with thoracolumbar support was used[34]. Subjects sat upright on the chair against the wall with the knees and hips flexed and the feet flat on the floor wide apart (at the width of shoulders). The test's previous instruction stipulates that the subject must complete the maximum feasible number of repetitions within 30 seconds. The number of times fully seated and standing up in the chair during 30 seconds was recorded as the primary variable and only one 30s-STST measurement was performed[35]. In addition at the beginning and end of the test, the perception of effort was evaluated through the modified Borg CR10 scale[36].

To standardize the measurements, training sessions were conducted, during which all evaluators were instructed to record three videos demonstrating the execution of the 30s-STST using a designated pilot test individual. The purpose was to ascertain adherence to the study protocol. Once the validation of the three recorded evaluations was confirmed, authorization was granted to commence 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 used to verify data distribution and numerical variables were presented as mean and standard deviation (SD), and qualitative variables were presented as frequency and percentage. A correlation analysis was also performed using the Pearson's or Spearman's test, depending on the distribution of the data, for the quantitative variables (age, weight, height, BMI, initial Borg, and final Borg) with the 30s-STST results. To establish the reference values, we use the following categories already used previously[37]. Sex and age-specific normative percentiles (2.5th, 10th, 25th, 50th, 75th, 90th, and 97.5th) were generated.

To examine the relationship between individual performances in the 30s-STST test and the age of the subjects, we constructed dispersion graphs depicting the performance distribution concerning age and sex. To assess the impact of physical activity on 30secSTST performance, we compare the number of repetitions at different levels of physical activity, as measured by IPAQ-SF (low, medium, and high). This comparison was conducted using t-tests or Kruskal-Wallis tests.

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). The comparison was made between the measured values and the 50th percentile (p50) reported, according to sex and age range. In addition, a linear regression of these data was performed.

To facilitate the calculation of reference values, multiple linear regression was performed for men and women, with performance in the 30s-STST as the dependent variable and age, height, and weight as predictors. The stepwise method was used for generating the predictive model. To compare 30s-STST performance based on PA level, a one-way ANOVA test was conducted.

Results

Four hundred ninety-nine individuals were included in the study, comprising 287 women (57.5%) and 212 men (42.5%). Among the participants, 72.1% reported having a low level of physical activity, and 25.3% declared themselves smokers.

Table 1 provides detailed demographic information of the participants.

Table 2 shows the results stratified according to percentiles for different age and sex groups, constituting the reference values. The median (25th-75th percentile) number of repetitions in women was: 18-29 years: 19 (17-24), 30-39 years: 20 (18-23), 40-49 years: 17 (15-20), 50-59 years: 16 (14-20), 60-69 years: 15 (12-19), 70-80 years: 13 (11-18). While in men it was: 18-29 years: 19 (16-24), 30-39 years: 21 (18-27), 40-49 years: 16 (15-24), 50-59 years: 18 (16-21), 60-69 years: 14 (12-15), 70-80 years: 11 (10-13).

The correlations between the values of 30s-STST and age revealed a moderated negative relationship (r= -0.486; p= 0.0001) and a low correlation with Borg pre (r= -0.252; p= 0.0001). There was no correlation with weight (r= -0.0063; p= 0.171), height (r= 0.025; p= 0.578) and BMI (r= -0.068; p= 0.134).

The relationship between individual performances in the 30s-STST test and the age of the subjects is presented in Figure 1 y Figure 2. These graphs visually represent how the 30s-STST performance varies across different age groups and between male and female participants.

The predictive equations showed that age in men, and age and height in women, have a significant relationship with the number of repetitions in the 30s-STST, explaining 23.6% (R^2= 0.236, RMSE= 5.494) and 18.4% (R^2= 0.184, RMSE= 4.958) of the variance, respectively. The specific equations are as follows:

- Men: 30s-STST= 25.364-(age* 0.158).
- Women: 30s-STST= 39.264-(age* 0.136)-(height* 0.095)

In these equations, age is in years and height is in centimeters. RMSE values (5.494 for men and 4.958 for women) indicate that the predicted repetitions may deviate by approximately 5 repetitions from the observed values.

In the analysis by level of physical activity according to IPAQ-SF, we found difference between high level of physical activity and low and moderate, being statistically significant (p<0.05) (Figure 3).

Table 1. Characteristics of the Study Population. 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. 30s-STST: 30 seconds sit-to-stand test.

Variable	All (n= 499)	Women (n= 287)	Men (n= 212)
N by age group (%)			
- 18-29	132 (26.5)	67 (23.3)	65 (30.7)
- 30-39	70 (14.0)	35 (12.2)	35 (16.5)
- 40-49	89 (17.8)	61 (21.3)	28 (13.2)
- 50-59	67 (13.4)	43 (15)	24 (11.3)
- 60-69	72 (14.4)	45 (15.7)	27 (12.7)
- 70-80	69 (8.2)	36 (12.5)	33 (15.6)
Height(m), median (IR)	1.63 (0.14)	1.58 (0.10)	1.70 (0.10)
Weight (kg), median (IR)	72.8 (20)	67.5 (18)	80 (17.6)
BMI (kg/m^2), mean (SD)	27.3 ± 4.1	27.3 ± 4.2	27.2 ± 3.9
Physical activity level (IPAQ-SF)			
Low (%)	360 (72.1)	216 (75.3)	144 (67.9)
Moderate (%)	91 (18.2)	51 (17.8)	40 (18.9)
High (%)	48 (9.6)	20 (7.0)	28 (13.2)
Tobacco use			
Smoker (%)	126 (25.3)	81 (28.2)	45 (21.2)
Non smoker (%)	349 (69.9)	192 (66.9)	157 (74.1)
Former smoker (%)	24 (4.8)	14 (4.9)	10 (4.7)
Leg Fatigue pre 30-STST (Borg scale), median (IR)	0 (1)	0 (1)	0 (1)

Table 2. The percentiles are presented based on sex and age categories, along with the delineation of cut-off values and the value denoting normality. The table presents the 2.5th, 25th, 50th, 75th, and 97.5th percentiles for men and women, as well as the lower and upper limits of normal (LLN and ULN). These cut-off values help identify individuals whose performance falls below or within the normal range, based on their sex and age group.

Age group (years)	Number of STS repetitions									
	Women (n= 287)					Men (n= 212)				
	p2.5	p25	p50	p75	p97.5	p2.5	p25	p50	P75	p97.5
18-29	13	17	19	24	31	13	16	19	24	30
30-39	14	18	20	23	39	14	18	21	27	30
40-49	11	15	17	20	25	13	15	16	24	37
50-59	10	14	16	20	29	11	16	18	21	34
60-69	9	12	15	19	25	9	12	14	15	19
70-80	9	11	13	18	24	8	10	11	13	19

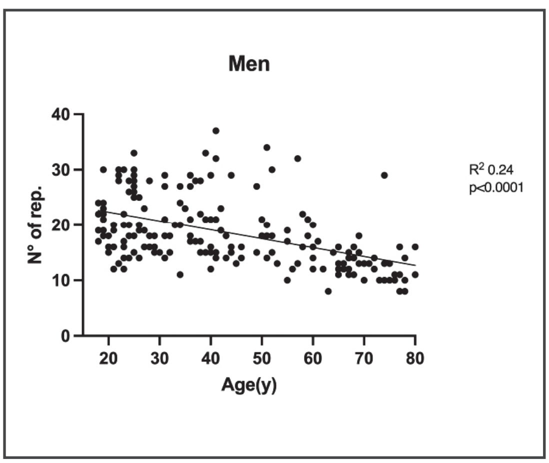

Figure 1: Correlation between the number of repetitions in the 30-seconds sit-to-stand test (30s-STST) and age in men. The scatter plot shows a significant negative correlation, indicating a decline in performance with increasing age.

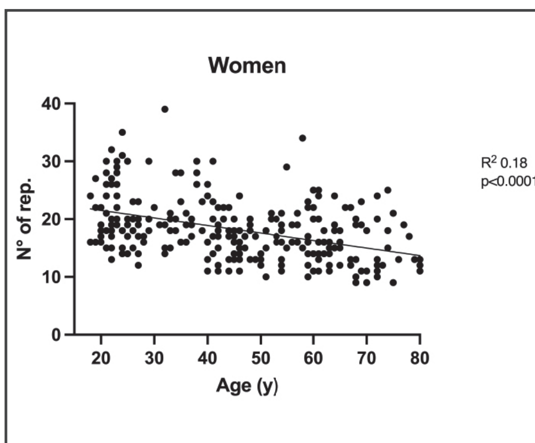

Figure 2: Correlation between the number of repetitions in the 30-seconds sit-to-stand test (30s-STST) and age in women. The scatter plot reveals a similar significant negative correlation, indicating a decline in performance with increasing age.

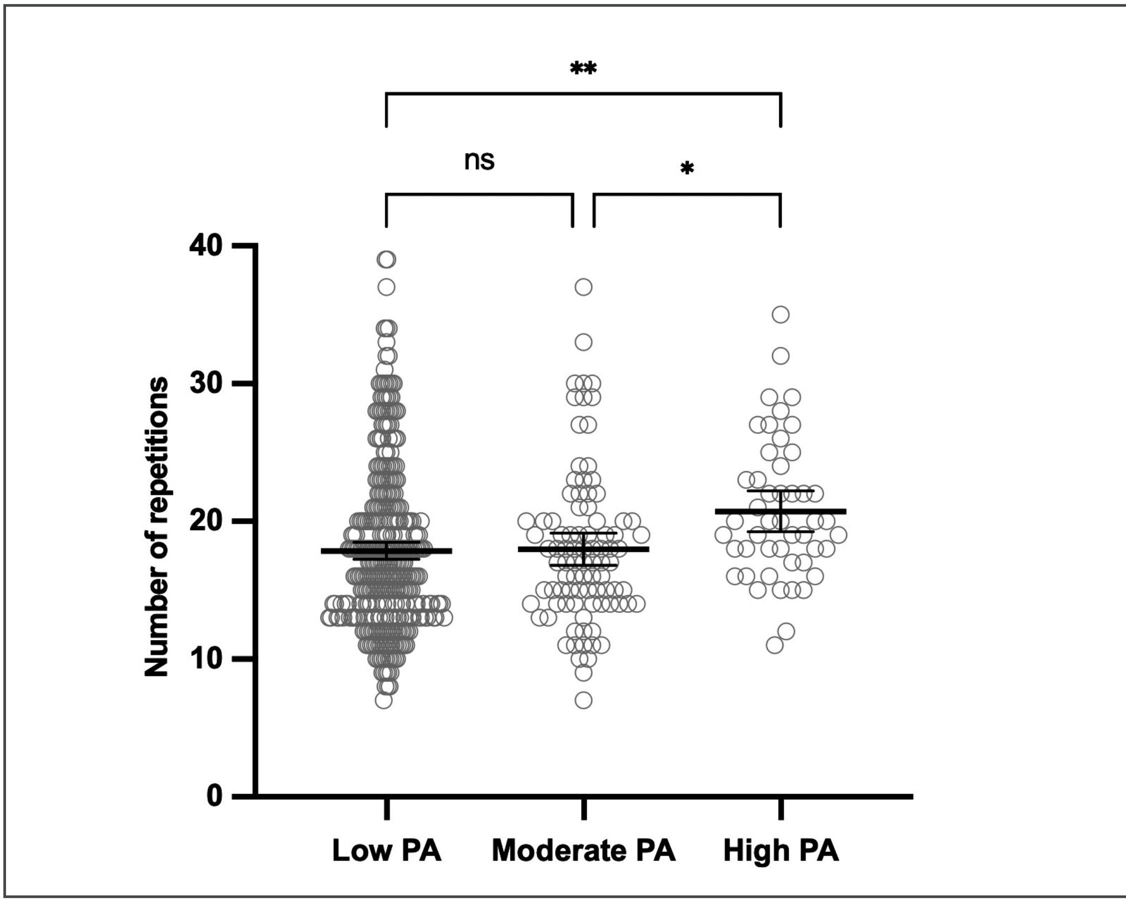

Figure 3: *Number of repetitions in the 30-seconds sit-to-stand test (30s-STST) across different physical activity levels (low, moderate, and high) in the Chilean population. The bars represent median values, with interquartile range. Significant differences between groups are indicated as *p < 0.05, **p < 0.01, while non-significant differences (ns) are shown between Low and Moderate PA groups. The data highlight an increasing trend in performance with higher levels of physical activity.*

Discussion

This study is the first that has established reference values to facilitate the comparative analysis of the 30s-STST performance in Chilean population, which will allow a guide to apply and interpret the results of this test in our population. This brings a series of benefits to our clinical context where many sectors do not have the ability to perform more complex exams or tests.

The importance of reference values adapting to the local population cannot be overstated[29]. When assessing various health parameters and physical capacity, using standardized values based on data from other populations may not accurately reflect the unique characteristics and diversities of the Latin American population. Factors such as genetics, lifestyle, culture, and environmental influences can significantly impact the health and performance of individuals[38,39]. Therefore, it becomes essential to establish specific reference values that are tailored to the demographics of a particular region or population[40].

Furthermore, applying standardized values from other populations might lead to misinterpretations, misdiagnoses, and inappropriate treatments and prognostic, as individual variations may not be adequately accounted for[41]. Numerous factors influence the reference values of a population, among which sex, age, anthropometry, and especially ethnicity stand out. Therefore, the ATS/ERS Statement recommend having reference values from the same people on which the procedures will be applied[40].

Our values are lower than those reported by Tveter, et al. (2014), who established reference values for the 30s-STST in the Norwegian population across most age intervals[26]. When compared with the results of Couto Furlanetto, et al. (2022), our values are higher in some intervals and similar in others[28]. Additionally, the values obtained in this study for the Chilean population are comparable to those found in the North American population[27].

One limitation of our data is the smaller number of subjects recruited over 60. This is a common characteristic of reference value studies where a sedentary lifestyle and the prevalence of non-communicable diseases make it challenging to obtain a population considered "healthy". The categorization of apparently healthy individuals was determined through self-reporting and the absence of diagnosed medical conditions. Nonetheless, it is worth noting that including individuals with undiagnosed conditions or diseases is a prevailing feature in studies involving extensive population samples aimed at establishing reference parameters. Although the reference values obtained in this study may be particularly useful for older adults, we intentionally included younger adults in the sample, considering that various conditions-such as intensive care unit-acquired weakness, genetic diseases like cystic fibrosis, and vascular disorders including pulmonary hypertension-can significantly impact functional capacity in this population. Another limitation of this study is that the sampling did not have a probabilistic approach. This could have introduced a bias in the selection of the participants since those who accepted the invitation could differ in characteristics from those who did not participate. These results must be interpreted considering this limitation in the sampling methodology.

Importantly, these values were derived from a diverse multicentric sample of individuals ranging from 18 to 80 years old in a developing country with similar characteristics to other Latin American populations (e.g. Argentina, Perú, Bolivia, Uruguay, Paraguay), so they could be used with the same objectives in other countries besides Chile, with similar benefits.

Conclusion

Reference values for the 30s-STST were established for the Chilean population aged 18 to 80 years and can be used in Latin American population. The 30s-STST was found to be safe, easy to perform, and highly acceptable to the adults tested. It provides a simple and inexpensive means of measuring functional capacity. These values may be valuable for assessing and determining the effects of interventions that include functional capacity evaluation through this test.

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Abbreviations

- 30s-STST: 30 seconds sit-to-stand test
- 6MWT: 6-minute walk test
- BMI: Body mass index
- IPAQ: International Physical Activity Questionnaire
- LLN: Lower limit of normality
- ULN: Upper limit of normality

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