Journals
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SCHOOL OF MEDICINE AND PUBLIC HEALTH

# Thirty second sit to stand test performance in community dwelling geriatric population: a cross-sectional study

# Desempenho do teste de sentar e levantar de trinta segundos na população geriátrica da comunidade: um estudo transversal

**Mehar Sheoran[1]** (ID)
**Hina Vaish[2]** (ID)

[1]MMIPR, Maharishi Markandeshwar Deemed to be University (Mullana-Ambala). Haryana, India. mehars1101@gmail.com
[2]Corresponding author. School of Health Sciences, Chhatrapati Shahu Ji Maharaj University (Kanpur). Uttar Pradesh, India. hina22vaish@gmail.com

**ABSTRACT | INTRODUCTION:** To find the reference values for the 30-second sit-to-stand test and study the correlation of anthropometric measures with the test in the community-dwelling geriatric Indian population. **MATERIAL AND METHODS:** 136 individuals aged >60 years were recruited in this cross-sectional observational study. The study was conducted in India. After the initial screening, anthropometric measurements were recorded. Then, the 30-second sit-to-stand test was conducted. **RESULTS:** Normal decade-wise values for the test were reported to be (mean ± SD): 60-70 years (10.2±3.6), 71-80 years (9.5±3.4), and 81-90 years (8.5±5.2). Age, height, waist circumference, and hip circumference were significantly associated with the 30-second sit-to-stand test values. **CONCLUSION:** Normal values for the test in the community-dwelling geriatric population were reported to be mean ± SD 10.0±3.7. Anthropometric factors should be taken into consideration when performing the 30-second sit-to-stand test in clinical settings.

**KEYWORDS**: Body mass index. Geriatric. Sit-to-stand test.

**RESUMO | INTRODUÇÃO:** Encontrar os valores de referência para o teste de sentar e levantar de 30 segundos e estudar a correlação das medidas antropométricas com o teste na população indiana geriátrica residente na comunidade. **MATERIAL E MÉTODOS:** 136 indivíduos com idade >60 anos foram recrutados neste estudo transversal e observacional. O estudo foi realizado na Índia. Após a triagem inicial, as medidas antropométricas foram registradas. Em seguida, foi realizado o teste de sentar e levantar de 30 segundos. **RESULTADOS:** Os valores normais da década para o teste foram relatados como (média±DP): 60-70 anos (10,2±3,6), 71-80 anos (9,5±3,4) e 81-90 anos (8,5±5,2). Idade, altura, circunferência da cintura e circunferência do quadril foram significativamente associadas aos valores do teste. **CONCLUSÃO:** Os valores normais para o teste de sentar e levantar de 30 segundos para a população geriátrica da comunidade foram relatados como média ± DP 10,0 ± 3,7. Os fatores antropométricos devem ser levados em consideração ao realizar o teste de sentar e levantar de 30 segundos em ambientes clínicos.

**PALAVRAS-CHAVE:** Índice de massa corporal. Geriátrico. Teste de sentar e levantar.

## Introduction

The occurrence of health conditions has accelerated over time in the geriatric population. The provision of health care for this population has always been an essential element for emerging nations. Ageing is impacted by both physical and psychological factors. Decreased walking speed, muscle weakness, difficulty getting up from a chair, etc., are some of the factors affecting function in geriatrics.[1]

Physiological impairments arise with advancing age, especially affecting the lower limbs. This affects their ability to perform basic tasks like standing up from a seated position, climbing stairs, and walking.[2]

To quantify the strength of muscles of the lower extremity, activation of muscles like quadriceps femoris, flexors and extensors of the hip, ankle plantar flexors are required. The sit-to-stand performance test is extensively used for assessing lower-extremity function, strength, and balance control in geriatrics.[3,4]

Several variations of the sit-to-stand test exist, including the five-repetitions sit-to-stand test, 10-repetitions, or the 30-second sit-to-stand test.[3] "30-second sit-to-stand test" is a time-based test.[7] The test evolved to overpower the floor effect of 5 or 10 repetition sit-to-stand test.[3-6]

The 30-second sit-to-stand test reflects daily activities that require the usage of lower limb muscles.[8] The participants have to give their maximal efforts within 30-second, and the number of sit-to-stands is counted manually within this time.[9] This test is reported to be feasible in the community living ad hospitalized geriatric population.[7,8] The 30-second sit-to-stand test has also been used to evaluate functional fitness levels and for rehabilitation. This test has been performed in various health conditions like knee replacements, COPD (Chronic Obstructive Pulmonary Disease), and rehabilitation programs, etc.[6,9] Researchers have investigated the applicability of the test in different populations, testing the validity, and reliability, thus, establishing reference values to interpret the test results.[2,5,9,10]

Reference norms in the absence of pathology allow the magnitude of an individual's functional limitation to be quantified. Ethnic and geographic variations have been reported as some of the factors affecting the physical test performance.[11,12] Anthropometric characteristics of subjects may also differ, as Asians have lower BMI (body mass index) but a higher percentage of body fat than Caucasians.[13] An association between lower limb strength and sit-to-stand test performance exists, however, others researchers have demonstrated that sit-to-stand test performance is dependent on other factors as well.[14,15]

Anthropometric measures such as height and body stature have been studied in relation to the sit-to-stand test.[3] To evaluate the prognosis of acute and chronic diseases and for the guidance of medical interventions, anthropometrics are good indicators in geriatrics. A study on the five-repetition sit-to-stand test has reported that age, body weight, and stature also influence the test performance and should be considered when interpreting it.[3]

There is a scarcity of literature on the reference norms for sit-to-stand tests for Indian individuals. Additionally, much of the research on the 30-second sit-to-stand test had just focused on reference values[2,5,9,10], and has not accounted for the possible contribution of anthropometric factors such as body weight, height, waist, and hip circumference influencing the test result. Thus, the present study aimed to measure the 30-second sit-to-stand normal values and to study the correlation of anthropometric measures with the test in the community-dwelling geriatric Indian population.

## Materials and Methods

A total of 136 asymptomatic community-dwelling geriatric participants volunteered to participate in this cross-sectional study. The study was approved by the ethics committee of the institute MM Institute of Medical Science and Research with the number

IEC 11 and was conducted in accordance with the Declaration of Helsinki (Revised 2013) and National Ethical Guidelines for Biomedical and Health Research involving human participants' guidelines laid by the Indian Council of Medical Research (2017).

The sample size for this correlational study was calculated by using the G power software version 3.1.97, in which the level of significance was set as 5% to 90% power of study with the coefficient of determination considered as 0.076.[3] The minimum required sample size was 133. We recruited 136 participants by purposive sampling method. The sample was selected from among individuals accompanying patients, those visiting the institute and the hospital, and nearby community dwellings. Participants aged > 60 years were included. The age of the participants was confirmed by their identity cards. All were non-smokers, and none were involved in any form of sports activity. Participants included were asymptomatic Indian geriatric adults of male and female gender with normal health status, defined as being asymptomatic with stable vitals, lifetime non-smokers and absence of any acute disease in 6 weeks preceding the study, walking independently without any assistive device and were able to stand from the chair without using any external support.

Exclusion criteria were: any recent surgeries during the last six months, any use of medications or documented conditions that may affect the study outcomes such as cardiovascular, musculoskeletal, neurological, metabolic, or impaired sensation, systolic blood pressure < 100 mmHg and > 139 mmHg and diastolic blood pressure < 60mmHg and > 89 mmHg, resting heart rate < 60 bpm and >100bpm, and participants who are unable to follow the commands or instructions properly.

The participants' systolic and diastolic blood pressure (Digital Sphygmomanometer, Omron HEM-71211J, India) were recorded. Use of medication, smoking habits and physical activities, history of diabetes mellitus, stroke, cardiac disorder, or history of heart, lung, or any surgery were self-reported.

The participants who fulfilled the selection criteria of the study and were willing to participate were selected. All the participants provided written informed consent regarding the study. The individuals were explained about the test procedures in the language that was best understood by them (Hindi/ English or Punjabi). The demographic details, history, practice demonstration, and basic information of the test were well shown to the participants for a better understanding of the procedure and to ensure its proper form on the first day of enrolment. Instructions were also given prior to the test to wear comfortable clothing, and no consumption of meals should be taken 2 hours before the test.

On the second day, anthropometric measures: height, weight, hip circumference, waist circumference, waist-to-hip ratio, and BMI were measured. For height measurement, individuals were asked to remove shoes and the distance from the bottom of their feet to the top of their heads was taken as the reference. The participants were asked to stand with buttocks, scapula, and heels resting against the wall, the neck was held in the natural non-stretched position, and the heels were touching each other, standing in an erect position. For measuring body weight, individuals were asked to remove the shoes and heavy clothing prior to weighing, and the weight was taken in kilograms (kg). Body weight was recorded using a beam balance scale ((Equinox EQ-EQ-9400, India) that was calibrated every month, and BMI was calculated using the formula weight (kg) / height$^2$ (m$^2$).

The waist and hip circumference were measured using the non-elastic, flexible measuring tape.[16] The individuals were asked to stand with arms resting by the sides and feet together. The waist circumference was measured by passing the measuring tape through the midway between the lowest costal margin at the mid-clavicle line and the anterior superior iliac spine at the end of normal expiration. The measurement of hip circumference was conducted standing up straight and wrapping a tape measure around the level of the widest part of the hip, at the level of the greater trochanter. Then, the waist-hip ratio (WHR) was calculated (WHR= Waist circumference/ hip circumference).

**30-second sit-to-stand test procedure**

On the second day, the 30-second sit-to-stand test was performed using a chair with a height of 42 cm.[2] The chair was stabilized against the wall during the performance to ensure stability and safety and to prevent the chair from moving during the performance. As instructed on the first day, likewise, the test began with participants sitting on the chair with their backs in an upright position. The feet were kept approximately shoulder width apart and placed on the floor by the angle forming that is slightly back from the knees.

The test commenced with the assessor instructing the participant to look straight forward and then rise from the chair, keeping the body erect after the "1,2,3, go" command in the language best understood by them (Hindi/English/ Punjabi), on their own preferred speed with arms folding across their chest, then retaining back to the initial sitting position. There were two trials with similar ambient conditions using the same chair. The participants were encouraged to achieve as many full stands and sit as possible within a time of 30-second. The participants were given the instruction to be fully seated after each stand. While performing the test, the examiner supervised the individual's performance to ensure its proper form and silently counted the completion of each of the correct stands.

The best value from the two trials of the test was considered. The correctly performed stands were considered, and the values of the test were noted. All tests were conducted by the same assessor between 9:00 am and 1:00 pm to avoid intra-day variability.

**Statistical analyses**

Statistical analyses were performed using SPSS software, version 16 (Statistical Package for the Social Sciences Inc., Chicago, IL, USA). The data were normally distributed as assessed by the Kolmogorov-Smirnov test. Correlations were estimated using Pearson's coefficient of correlation for parametric data. Comparisons between male and female 30-second sit-to-stand test values were made by independent t-test. Stepwise multiple regression analysis was used to develop the reference equation for the 30-second sit-to-stand test in community-dwelling geriatric Indian population. $P < 0.05$ was considered significant.

# Results

All the enrolled participants (N=136) completed the test, and there were no dropouts. The study flowchart is shown in Figure 1. The characteristics of the study population and correlations are summarised in Table 1.
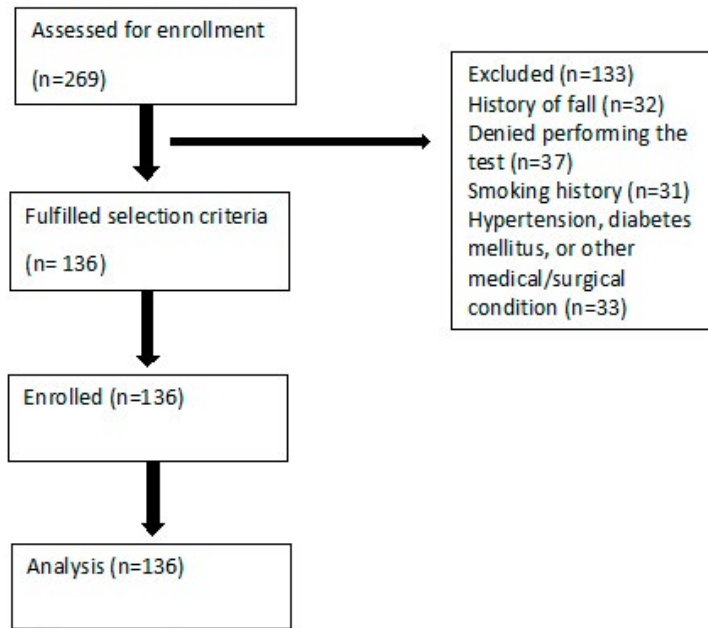
**Figure 1.** Study flowchart

**Table 1.** Participant characteristics and correlates of 30-second sit-to-stand test values

| Characteristics | Mean | ±SD | r | P |
|---|---|---|---|---|
| Age (years) | 67.98 | 6.98 | -0.216 | 0.012* |
| Ht (metres) | 1.65 | 0.11 | -0.170 | 0.048* |
| Wt (kilograms) | 70.28 | 15.39 | -0.116 | 0.178 |
| BMI (kg/m$^2$) | 25.73 | 4.60 | -0.051 | 0.557 |
| WC (centimetre) | 98.60 | 14.22 | -0.195 | 0.023* |
| HC (centimetre) | 1.05 | 12.16 | -0.196 | 0.022* |

Ht = height, Wt = weight, WC = weight circumference, HC = hip circumference, BMI = body mass index, WHR = waist hip ratio, SD = standard deviation
r = correlation coefficient
*P< 0.05 considered significant
Source: Authors (2021)

The 30-second sit-to-stand test values are summarized in Table 2. There was no significant difference in the test values of males and females. There were significant correlations between 30-second sit-to-stand test values and age (Figure2), height (Figure 3), waist circumference (Figure 4), and hip circumference (Figure 5).

**Table 2.** 30-second sit-to-stand values in community-dwelling geriatric Indian population

| Population (N) | Mean | $\pm$SD | Minimum | Maximum |
|---|---|---|---|---|
| Total population (136) | 10.0 | 3.7 | 2.0 | 20.0 |
| Females (42) | 10.0 | 2.9 | 2.0 | 20.0 |
| Males (94) | 9.8 | 4.0 | 2.0 | 20.0 |
| 60-70 years (94) | 10.2 | 3.6 | 2.0 | 20.0 |
| 71-80 years (33) | 9.5 | 3.4 | 4.0 | 18.0 |
| 81-90 years (8) | 8.5 | 5.2 | 3.0 | 17.0 |

N= number of participants, SD= standard deviation
Source: Authors (2021).

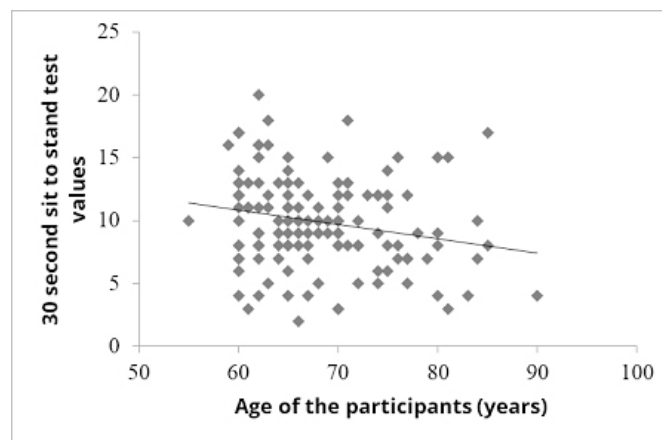**Figure 2.** Representing correlation of 30-second sit-to-stand test values with age (years)



**Figure 3.** Representing correlation of 30-second sit-to-stand test values with height (metres)
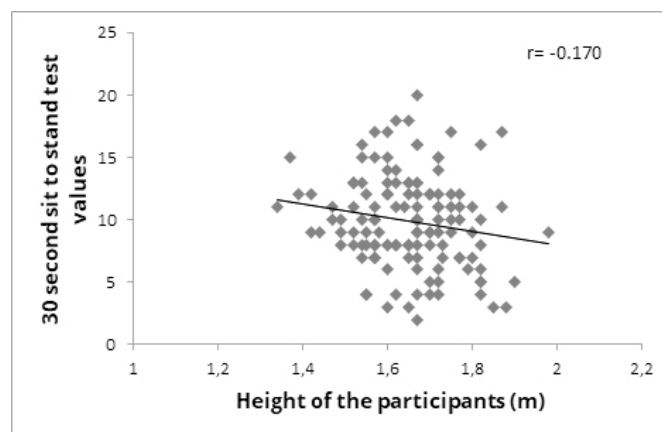
**Figure 4.** Representing correlation of 30-second sit-to-stand test values with waist circumference (centimetres)
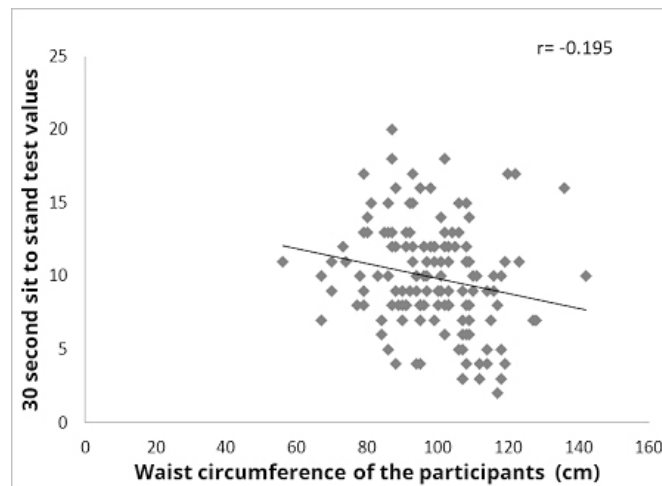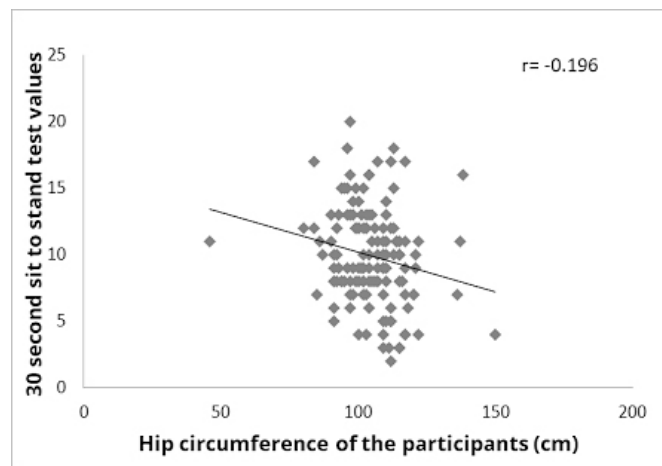


**Figure 5.** Representing correlation of 30-second sit-to-stand test values with hip circumference (centimetre)



Based on the results of correlation and regression analysis, the 30-second sit-to-stand test in the community-dwelling geriatric Indian population can be determined as follows:

30-second sit-to-stand test (predicted) = 22.783- 0.104 × age (years) – 0.055 × hip circumference (cm) (table 3)

**Table 3.** Predicting model for 30-second sit-to-stand test values

| Independent variable (n=136) $r^2 = 0.66^{\#}$ | Coefficients | SE | P |
|---|---|---|---|
| Constant | 22.783 | 3.813 | 0.0001* |
| Age (years) | -0.104 | 0.044 | 0.020* |
| Hip circumference (cm) | -0.055 | 0.025 | 0.031* |

#Variance, SE = standard error.
*P< 0.05 is considered significant
Source: Authors (2021).

## Discussion

To our knowledge, this is the first study to determine 30-second sit-to-stand test values in the community-dwelling geriatric Indian population. In addition, we studied the correlation of anthropometric measures with the test values in the same community.

**Reference values for the 30-second sit-to-stand test**

The 30-second sit-to-stand test values determined in the study were found to be substantially lower than previously reported values.[5,14] We conducted test in healthy adults over the age of 60 years who were free from any documented pathologies. We encouraged participants to complete as many full stands as they could in 30-second; however, participants were also instructed to perform the sit-to-stand test as fast as possible in some studies.[5] We instructed participants about the test and also conducted a demonstration on the first day and then conducted the test on the second day, in line with the other authors.[5]

The discrepancies in the values may have been due to geographic and ethnic variations, as they may influence physical fitness test performance.[17,18] Anthropometric characteristics of individuals may also differ.[13] There is a direct relationship between muscle strength and physical exercise; reduced physical activity frequently leads to alteration in muscle metabolism, decline in muscle mass, and lower physical capacity.[19] Possibly decreased outdoor exercises and declining physical activity patterns may also be the grounds for lower reference values in India. A study reported that 57% of the population has failed to comply with the World Health Organization (WHO) regimen for physical activity.[20]

**Association of age with 30-second sit-to-stand test values**

The study findings revealed a significant negative correlation between age and 30-second sit-to-stand performance. Age was the predominant variable in the regression equation as well. The 30-second sit-to-stand values decreased in a linear fashion with respect to the increase in age. This may probably be due to the reduced strength in the knee muscle and hip extensors.[21] Although we included normal individuals in our study, this could be attributed to normal age-related changes in the musculoskeletal systems.

Furthermore, the declining usage of the propelling power due to reduced forward shift of pressure at the centre affects performance.[22]

Other age-related physiological changes, such as decreased nerve conduction velocity and increased passive tissue stiffness, also contribute to the decline in test performance.[23] The findings support those previous studies and indicate that older people exhibit decreased sit-to-stand test performance as age advances.[2,11]

**Association of height with 30-second sit-to-stand test values**

We found height to be correlated with the 30-second sit-to-stand values. As the height of the participant increases standing time from the chair causes larger trunk flexion. This imposes an increased burden on the lower limb, resulting in excessive production of force, eventually leading to decreased quickness of the movement that leads to a reduced number of stands in 30-second.[21]

**Association of weight, BMI, waist, and hip circumference with 30-second sit-to-stand test values**

The present study shows a negative correlation between waist circumference and the 30-second sit-to-stand test. The greater the waist circumference, the poorer will be the performance in the fitness test. Also, hip circumference in the study showed a negative correlation. Hip circumference was a predominant variable in the regression equation as well.

Weight, BMI, and WHR had a negative but not significant correlation. Participants with increased weight take more time to complete the sit-to-stand test as compared to those with normal weight.[3] The higher the BMI, the poorer will be the sit-to-stand performance.

The participants included in our study were apparently healthy and did not have any major health issues. The participants in the present study might be normal, thus, no significant difference was exhibited in weight and BMI. Also, the mean values reflect that our population included individuals who were not obese. A varied weight category is needed to study the influence of weight and BMI on sit-to-stand performance. However, the differing results for the influence of sit-to-stand test outcomes

between the current and previous investigations require further evaluation.

## Association of gender with 30-second sit-to-stand test values

There was no significant difference in the 30-second sit-to-stand test values between males and females, and the probable reason could be a smaller number of females recruited in our study. The participants, both men and women, in our study were independent. Women generally perform the daily activities more than men, which can also exert an influence on their performance.[24] Thus, the influence of gender on sit-to-stand performance needs further exploration

## Regression analysis

Approximately 66% of the variability in 30-second sit-to-stand test values in the present study was explained by age and hip circumference. This indicates that anthropometrics is important in predicting sit-to-stand performance.

A proportional correlation exists between anthropometrics and the number of steps. Also, women present more body fat.[25] This proposes that the correlation of gender with sit-to-stand performance needs further exploration. Furthermore, an association between lower limb strength and sit-to-stand test performance exists.[5] Other possible factors influencing 30-second sit-to-stand performance may be the physical activity level of participants; other physiological factors; the appropriate bench height and its effect on the biomechanical efficiency of the participants, as well as their cardiorespiratory response, which could be studied in future research.

## Limitations

This study was limited by several factors. Less number of female participants were recruited in the present study. Also, we were able to enrol only a few participants between the age of 81-90 years due to the presence of several comorbidities. We had a non-random sampling but strict inclusion and exclusion criteria to prevent the risk of bias. Finally, we did not assess other potential variables that may have a limited physical function, such as peripheral muscle strength, body fat percentage, dietary habits, and psychological factors.

## Clinical implications

Information obtained from this study can be used by health professionals in clinical settings for assessment and rehabilitation purposes. Obtained reference values can be used for comparison with the pathological state of the individual for assessment and setting goals for rehabilitation. The disparity in values obtained from different populations emphasizes the need to generate population specific reference norms for a test of physical functions. The influence of anthropometric factors on the 30-second sit-to-stand test helps to understand the various factors affecting the test performance in the geriatric population.

## Conclusion

Normal values for the 30-second sit-to-stand test for the community-dwelling geriatric Indian population were reported to be mean ± SD 10±3.7. Age, height, waist circumference, and hip circumference were significantly associated with the 30-second sit-to-stand in the community-dwelling geriatric Indian population. Anthropometric factors should be taken into consideration when performing the 30-second sit-to-stand test in clinical settings for assessment and rehabilitation purposes.

Source of Finding: Nil

### Authors' contributions

Sheoran M designed the experiment, collected the data, and wrote the manuscript. Vaish H designed the experiment, analyzed the data, contributed with critical intellectual content, and wrote the manuscript.

### Conflicts of interest

No financial, legal or political conflicts involving third parties (government, companies and private foundations, etc.) were declared for any aspect of the submitted work (including, but not limited to grants and funding, participation in an advisory board, study design, preparation manuscript, statistical analysis, etc.).

## Indexers

The Journal of Physiotherapy Research is indexed by EBSCO, DOAJ, LILACS e Scopus.

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## References

1. Beaudart C, Rolland Y, Cruz-Jentoft AJ, Bauer JM, Sieber C, Cooper C, et al. Assessment of Muscle Function and Physical Performance in Daily Clinical Practice. Calcif Tissue Int. 2019;105(1):1-14. https://doi.org/10.1007/s00223-019-00545-w

2. Goda A, Murata S, Nakano H, Matsuda H, Yokoe K, Mitsumoto H, et al. Temporal Patterns in Performance of the 30 Second Chair-Stand Test Evince Differences in Physical and Mental Characteristics Among Community-Dwelling Older Adults in Japan. Healthcare (Basel). 2020;8(2):146. https://doi.org/10.3390/healthcare8020146

3. Bohannon RW, Bubela DJ, Magasi SR, Wang YC, Gershon RC. Sit-to-stand test: Performance and determinants across the age-span. Isokinetic Exerc Sci. 2010;18(4):235-240. https://doi.org/10.3233/ies-2010-0389

4. Applebaum EV, Breton D, Feng ZW, Ta AT, Walsh K, Chassé K, et al. Modified 30-second Sit to Stand test predicts falls in a cohort of institutionalized older veterans. PLoS One. 2017;12(5):e0176946. https://doi.org/10.1371/journal.pone.0176946

5. Jones CJ, Rikli RE, Beam WC. A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. Res Q Exerc Sport. 1999;70(2):113-119. https://doi.org/10.1080/02701367.1999.10608028

6. Millor N, Lecumberri P, Gómez M, Martínez-Ramírez A, Izquierdo M. An evaluation of the 30-s chair stand test in older adults: frailty detection based on kinematic parameters from a single inertial unit. J Neuroeng Rehabil. 2013;10(86). https://doi.org/10.1186/1743-0003-10-86

7. Bodilsen AC, Juul-Larsen HG, Petersen J, Beyer N, Andersen O, Bandholm T. Feasibility and inter-rater reliability of physical performance measures in acutely admitted older medical patients. PLoS One. 2015;10(2):e0118248. https://doi.org/10.1371/journal.pone.0118248

8. McAllister LS, Palombaro KM. Modified 30-Second Sit-to-Stand Test: Reliability and Validity in Older Adults Unable to Complete Traditional Sit-to-Stand Testing. J Geriatr Phys Ther. 2020;43(3):153-158. https://doi.org/10.1519/jpt.0000000000000227

9. Vaidya T, Chambellan A, Bisschop C. Sit-to-stand tests for COPD: A literature review. Respir Med. 2017;128:70-77. https://doi.org/10.1016/j.rmed.2017.05.003

10. Le Berre M, Apap D, Babcock J, Bray S, Gareau E, Chassé K, et al. The Psychometric Properties of a Modified Sit-to-Stand Test with Use of the Upper Extremities in Institutionalized Older Adults. Percept Mot Skills. 2016;123(1):138-152. https://doi.org/10.1177/0031512516653388

11. Bohannon RW. Reference values for the five-repetition sit-to-stand test: a descriptive meta-analysis of data from elders. Percept Mot Skills. 2006;103(1):215-222. https://doi.org/10.2466/pms.103.1.215-222

12. Nakazono T, Kamide N, Ando M. The Reference Values for the Chair Stand Test in Healthy Japanese Older People: Determination by Meta-analysis. J Phys Ther Sci. 2014;26(11):1729-1731. https://doi.org/10.1589/jpts.26.1729

13. Wang J, Thornton JC, Russell M, Burastero S, Heymsfield S, Pierson Jr RN. Asians have lower body mass index (BMI) but higher percent body fat than do whites: comparisons of anthropometric measurements. Am J Clin Nutr 1994;60(1):23-28. https://doi.org/10.1093/ajcn/60.1.23

14. McCarthy EK, Horvat MA, Holtsberg PA, Wisenbaker JM. Repeated chair stands as a measure of lower limb strength in sexagenarian women. J Gerontol A Biol Sci Med Sci. 2004;59(11):1207-1212. https://doi.org/10.1093/gerona/59.11.1207

15. Netz Y, Ayalon M, Dunsky A, Alexander N. 'The multiple-sit-to-stand' field test for older adults: what does it measure?. Gerontology. 2004;50(3):121-126. https://doi.org/10.1159/000076769

16. Woldegebriel AG, Fenta KA, Aregay AB, Aregay AD, Mamo NB, Wubayehu TW, et al. Effectiveness of Anthropometric Measurements for Identifying Diabetes and Prediabetes among Civil Servants in a Regional City of Northern Ethiopia: A Cross-Sectional Study. J Nutr Metab. 2020;2020:8425912. https://doi.org/10.1155/2020/8425912

17. Vaish H, Ahmed F, Singla R, Shukla DK. Reference equation for the 6-minute walk test in healthy North Indian adult males. Int J Tuberc Lung Dis. 2013;17(5):698-703. https://doi.org/10.5588/ijtld.12.0474

18. Whitrow MJ, Harding S. Ethnic differences in adolescent lung function: anthropometric, socioeconomic, and psychosocial factors. Am J Respir Crit Care Med. 2008;177(11):1262-1267. https://doi.org/10.1164%2Frccm.200706-867OC

19. Izquierdo M, Merchant RA, Morley JE, Anker SD, Aprahamian I, Arai H, et al. International Exercise Recommendations in Older Adults (ICFSR): Expert Consensus Guidelines. J Nutr Health Aging. 2021;25(7):824-853. https://doi.org/10.1007/s12603-021-1665-8

20. Podder V, Nagarathna R, Anand A, Patil SS, Singh AK, Nagendra HR. Physical Activity Patterns in India Stratified by Zones, Age, Region, BMI and Implications for COVID-19: A Nationwide Study. Ann Neurosci. 2020;27(3-4):193-203. https://doi.org/10.1177/0972753121998507

21. Demura S, Yamada T. Height of chair seat and movement characteristics in sit-to-stand by young and elderly adults. Percept Mot Skills. 2007;104(1):21-31. https://doi.org/10.2466/pms.104.1.21-31

22. Lockie RG, Ruvalcaba TR, Stierli M, Dulla JM, Dawes JJ, Orr RM. Waist Circumference and Waist-to-Hip Ratio in Law Enforcement Agency Recruits: Relationship to Performance in Physical Fitness Tests. J Strength Cond Res. 2020;34(6):1666-1675. https://doi.org/10.1519/jsc.0000000000002825

23. Palve SS, Palve SB. Impact of Aging on Nerve Conduction Velocities and Late Responses in Healthy Individuals. J Neurosci Rural Pract. 2018;9(1):112-116. https://doi.org/10.4103/jnrp.jnrp_323_17

24. Mohammed R, Basha ASK, Jungade S. Influence of Age, Gender, and Body Mass Index on Balance and Mobility Performance in Indian Community-Dwelling Older People. Phys Occup Ther Geriatr. 2021;39(2):144-156. https://doi.org/10.1080/02703181.2020.1818909

25. Schorr M, Dichtel LE, Gerweck AV, Valera RD, Torriani M, Miller KK, et al. Sex differences in body composition and association with cardiometabolic risk. Biol Sex Differ. 2018;9(28). https://doi.org/10.1186/s13293-018-0189-3