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Normative data for three physical frailty parameters in an aging, rural Indian population

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Abstract

Introduction: Physical frailty is associated with multiple adverse health outcomes. Since physical characteristics markedly vary with different populations, population-specific norms for physical frailty parameters are necessary. Such norms are lacking for the Indian population, especially for older, rural Indians. We aimed to develop normative values for three quantitative, frailty parameters—handgrip strength, "Timed Up-and-Go" (TUG) test time, and physical activity in an aging, rural Indian population.

Methods: The study sample is from an ongoing, prospective, cohort (Srinivaspura NeuoSenescence and COGnition, SANSCOG) comprised of rural, community-dwelling, cognitively healthy, aging Indians. Subjects are recruited through area sampling strategy, from villages of Srinivaspura, Kolar district, Karnataka state, India. Three physical frailty parameters of Fried's phenotype—handgrip strength ($n = 1787$), TUG time ($n = 1863$), and physical activity ($n = 1640$) were assessed using digital hand dynamometry, TUG test, and General Physical Activity Questionnaire (GPAQ), respectively.

Results: The 10th, 25th, 50th, 75th, 90th percentiles for the three frailty parameters were: right-hand grip strength (kg): males—13.9, 18.6, 23.8, 28.7, 33.7 and females—7.8, 10.6, 14.2, 17.9, 21.3; left-hand grip strength (kg): males—13.3, 18.3, 23.6, 28.9, 32.9 and females—7.9, 10.5, 14.3, 17.8, 21.2; TUG time (s): males—9.1, 10.1, 11.4, 13.4, 15.5 and females—9.5, 10.7, 12.4, 14.5, 16.6; physical activity (MET-minutes/week): males—1680; 4320; 8880; 15,840; 23,352 and females—1680; 4320; 9240; 15,120; 20,160.

Discussion: Our findings show that from 45 years onwards, overall grip strength decreases and TUG time increases, with women performing significantly poorer than men across all age groups, except >75 years, where no differences were seen. Physical activity did not show any consistent trend according to age or gender. Reference values for this aging, rural Indian population were substantially lower for grip strength and higher for TUG time than aging populations in several Western and other Asian countries.

KEYWORDS
frailty, functional mobility, handgrip strength, physical activity, Timed Up-and-Go (TUG)

1 | INTRODUCTION

Frailty is a pervasive yet inevitable problem that aging individuals encounter. Frailty can be broadly conceptualized as a condition associated with aging that is characterized by decreased reserve or resilience and increased vulnerability to adverse health outcomes.[1] Frailty has also been viewed as a state of physiological and functional decline owing to an accumulating burden of deficits.[2] Frailty has been established beyond doubt to be associated with a variety of adverse outcomes, such as multimorbidity,[3] hospitalizations,[4] increased costs of care,[5] disability,[6] social isolation,[7] and mortality.[8]

The phenomenon of population aging that is taking place across the world is conspicuous in India.[9] According to the last population census, India is home to over 104 million older persons aged 60 years and above. Further, considering the current demographic trend, this number is projected to increase drastically in the coming years (projected 353 million in 2050).[10] This makes frailty among older Indians a major health and socioeconomic challenge to be reckoned with in the coming decades.

Varied perspectives on this complex concept of frailty have resulted in the evolution of multiple dimensions.[11] This challenge has been compounded when the impact of (physical) frailty on cognitive,[12] sensory,[13] and psychosocial[14] domains is to be considered. This complexity is reflected in the fact that scores of proposed frailty assessment tools are available (67 different instruments[15] in a recent review), each weighing differentially on the varied dimensions. The *frailty phenotype* model by Fried et al.[16] is one of the most widely accepted models of frailty, which includes five components, namely, weak grip strength, slow walking speed, low physical activity, unintentional weight loss, and self-reported exhaustion. Among these, the first three components are quantitative parameters and have been used individually as vital screening tools, since they predict a plethora of adverse outcomes.

Handgrip strength (an indicator of muscle mass and strength), measured by dynamometry, has been found to have good clinical and prognostic value,[17] with low grip strength shown to be associated with premature mortality, disability, and prolonged hospital stay.[18] The Timed Up-and-Go (TUG) test is a simple test for gait and balance that reflects functional mobility. Several eminent professional bodies[19,20] have recommended routine screening for the risk of falls in older adults. Moreover, slower speed in the TUG test has been associated with multiple morbidities and mortality.[21] The significance of poor physical activity cannot be overstated due to its well-known association with cardiovascular and cerebrovascular disease.

However, to date, robust data on the norms for physical frailty parameters in the aging, Indian population is unavailable. Since physical characteristics including those that reflect frailty can differ significantly between different populations, cut-offs used in Western countries (that are mostly derived from studies done in Caucasian populations) may not be able to accurately estimate frailty among the South Asian, particularly Indian population. For example, body mass index and waist circumference cut-offs are different for Asian Indians, and calls are on for deriving population-specific norms for other physical health parameters, such as blood pressure, and so forth. Therefore, deriving normative data for individual frailty parameters for the Indian population is vital to accurately estimate the prevalence of frailty in this population.

The Centre for Brain Research, Indian Institute of Science, Bangalore, India is conducting a large-scale, community-based, prospective, cohort study among aging, rural Indians (projected $n = 10{,}000$) that is primarily aimed at studying the trajectories of aging and thereby, identifying the risk and protective factors for aging-related cognitive disorders, such as dementia. In this study, namely Srinivaspura NeuoSenescence, and COGnition (SANSCOG) study, cognitively healthy subjects aged 45 years and above are recruited from a rural community in Srinivaspura, in the southern Indian state of Karnataka. They undergo periodic, detailed, and multimodal evaluations that include clinical, cognitive, biochemical, genetic, and neuroimaging assessments that are performed by a multi-disciplinary team of clinicians, psychologists, social workers, brain imaging experts, and geneticists.

In this manuscript, we have used the baseline visit clinical data of SANSCOG subjects to develop normative values for three quantitative frailty parameters, namely handgrip strength (kilograms), TUG time (seconds) and total physical activity (MET-minutes/week; assessed using the Global Physical Activity Questionnaire [GPAQ]), in an aging population hailing from a rural area in Karnataka, a state in southern India. The other two parameters of Fried's phenotype, namely, unintentional weight loss and self-reported exhaustion were not included as they are qualitative variables, and we did not have reliable data on these from our clinical assessments

2 | METHODS

2.1 | Study design

A cross-sectional study design was employed for this particular study, wherein, data from baseline (first visit) clinical assessments of SANSCOG subjects was used.

2.2 | Setting

Rural, community setting in southern India—villages falling under the administrative area of Srinivaspura "taluk" (equivalent to a subdistrict) in the district of Kolar in the state of Karnataka.

2.3 | Subjects

In all, 1863 SANSCOG study subjects (870 males, 993 females), aged ≥45 years, who had completed their first (baseline) assessment visit. Among these, TUG time data was available for all subjects, handgrip strength data was available for 1787 subjects (823 males, 964 females), and 1640 subjects (771 males, 869 females) had available data for physical activity. Subjects were recruited into the SANSCOG study through an area sampling strategy, from the villages of Srinivaspura "taluk."

Inclusion criteria were as follows:

1. Age 45 years and above.
2. Resident of the study site in Srinivaspura.
3. Recruited into the SANSCOG cohort and completed baseline clinical assessments.

Exclusion criteria were as follows:

1. Diagnosis of neurodegenerative disorders such as dementia.
2. Diagnosis of psychosis, bipolar disorder, substance dependence (except nicotine).
3. Severe medical illness likely to interfere with study participation.
4. Significant hearing or vision impairment limiting the study evaluation.
5. Medications having a significant effect on cognitive function (e.g anticholinergic drugs, anti-Parkinsonian drugs, etc.).

These subjects form a relatively homogenous population, who have settled in this area for a few generations and have not been exposed much to the rapidly changing lifestyle seen in the urban parts of India. The majority of them belong to a low socioeconomic background and are engaged in agriculture. They have low education and limited access to healthcare and modernization.

2.4 | Ethics clearance and informed consent

SANSCOG study has been cleared by the Institutional Ethics Committee of the Centre for Brain Research, Indian Institute of Science, and its collaborating institutions. Written, informed consent is obtained from all subjects before recruitment into the study.

2.5 | Measurements

As part of their clinical assessments, detailed information is collected on diet, lifestyle, medical comorbidities, neuro-psychiatric history, personal and social history; physical examination including detailed neurological examination as well as a functional assessment is also performed. Thus, this comprehensive clinical assessment includes data on the three frailty parameters that were analyzed in this study. All clinical assessments are performed in the morning at the fully-equipped project site office in Srinivaspura or at the local primary health centre, where our mobile unit visits; we bring subjects from their homes to the assessment site by cab and provide them breakfast before starting assessments. Further, subjects complete all their assessments before they start to work; we compensate them for their time and wages lost. The details of how these parameters were measured are given below:

2.5.1 | Handgrip strength

Handgrip strength is a reliable indicator of overall muscle strength.[22] In this study, handgrip strength was measured using an electronic hand dynamometer (Camry—EH101) based on the Southampton protocol.[23] The subject is seated comfortably in an armed chair with the wrist in a neutral position (with the thumb facing upwards) and resting just over the end of the chair's arm. The subject holds the instrument with the thumb around the top of the handle and the other four fingers around the bottom of the handle. The base of the dynamometer is rested parallelly on the hand of the examiner (to negate the effect of gravity) but without restricting its movement. The subject is asked to squeeze as hard and as long as possible and the grip strength readings are recorded in kilograms. In our study, considering subject burden, we give only two trials for each hand (as compared to the Southampton protocol, wherein three trials are recommended for each hand) and the higher of the two readings is taken to represent the maximum handgrip strength of the subject.

2.5.2 | Functional mobility

TUG test[24] was used to measure functional mobility, which in turn reflects gait and balance functioning. In this test, the subject is asked to get up from a stable stool, walk a distance of 3 m (measured and marked using tape) at a normal pace, turn around and return to the sitting position. Though the original TUG test stipulates an armed chair, variations exist with and without an armrest and with and without a backrest. In our setting, we used a height-adjustable, iron stool, which is stable when the subject gets up or sits down. The total time taken is measured in seconds, using a stopwatch.

2.5.3 | Physical activity

The General Physical Activity Questionnaire (GPAQ)[25] was used to collect data on physical activity. This is a self-reported questionnaire from the World Health Organization (WHO) that assesses physical activity in three domains, namely, work, travel, and recreational activities. Both the intensity (moderate or vigorous) and the duration of physical activities in these domains are captured. The intensity is further translated to the amount of energy expenditure that is represented as "metabolic equivalents" (METs), where 1 MET is the energy consumed while sitting quietly, equivalent to a caloric consumption of 1 kcal/kg/hr. Based on the WHO guidelines, moderate-intensity activities are assigned 4 METs and vigorous activities are assigned 8 METs. Taking into account the total time spent in a typical week spent in doing activities in all the above-mentioned domains, the total energy expenditure is represented as MET-minutes/week. In this study, physical activity (using GPAQ) was measured across three life periods, namely, early life (13–30 years), mid-life (31–55 years), and late-life (56 years and above). For the purpose of utilizing physical activity data as one of the components of Fried's phenotype, we have considered the most recent period of life as representative of the subject's current physical activity.

2.6 | Statistical analysis

Statistical analyses were conducted by using SPSS version 23.0. Socio-demographic parameters of the subjects were analyzed using descriptive statistics (mean, median, standard deviation). The entire sample was stratified, both by age (45–55, 56–65, and 66–75 and >75 years) and gender (male and female). Percentile norms were derived for handgrip strength (in kilograms), TUG time (in seconds), and total physical activity (in MET-minutes/week) as continuous variables. The 10th, 25th, 50th, 75th, and 90th percentiles were calculated. Differences between the mean values of these variables across age groups were done using analysis of variance (ANOVA) test with 45–55 years age group as reference age group. Gender differences were calculated using a *t* test.

3 | RESULTS

The mean age for subjects who underwent assessments for handgrip strength ($n = 1787$), TUG time ($n = 1863$), and physical activity ($n = 1640$) was 58.4 ± 10.1 years, 58.5 ± 10.1 years, and 57.3 ± 10.1 years, respectively. Similarly, corresponding gender distributions were 46%, 46.7%, and 47%, respectively. The 10th, 25th, 50th, 75th, and 90th percentiles for right-hand grip strength among right-handed individuals and left-hand grip strength among right-handed individuals are presented gender-wise in Table 1. Similarly, the

TABLE 1 Age and gender-stratified percentile norms for right and left handgrip strength (in kg)

	Total		45–55 years		56–65 years		66–75 years		>75 years	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
N	823	964	330	480	268	306	165	142	60	36
Right-hand grip strength in right-handed individuals										
Mean	23.8	14.5	26.9	15.2	22.8	14.8	21.6	12.7	17.8	11.2
SD	7.7	5.4	8.3	5.2	6.6	5.7	6.8	4.8	5.7	4.0
p value	<0.0001*		<0.0001*		<0.0001*		<0.0001*		<0.0001*	
Percentile										
10th	13.9	7.8	16.8	8.6	13.9	7.7	13.4	6.09	10.4	5.3
25th	18.6	10.6	21.4	11.1	18.2	11.3	16.8	9.3	13.8	8.8
50th	23.8	14.2	26.9	14.9	23.2	14.5	21.7	12.7	17.9	10.8
75th	28.7	17.9	32.5	19	27.2	17.8	25.8	16.0	21.7	12.9
90th	33.7	21.3	36.2	22.1	30.7	21.2	29.7	19.4	25.0	17.5
Left-hand grip strength in right-handed individuals										
Mean	23.4	14.4	26.5	15.3	22.9	14.36	20.6	12.7	17.5	11.4
SD	7.6	5.4	7.8	5.5	6.9	5.4	6.6	4.7	5.8	4.4
p value	<0.0001*		<0.0001*		<0.0001*		<0.0001*		<0.0001*	
Percentile										
10th	13.3	7.9	15.8	8.7	13.6	8.0	11.4	6.7	9.9	5.9
25th	18.3	10.5	20.9	11.1	18.5	10.6	16.1	9.1	13.5	8.0
50th	23.6	14.3	27.7	15	23.7	14.3	20.6	12.9	17.3	11.2
75th	28.9	17.8	31.6	18.7	27.7	17.3	24.9	16.0	21.4	14.1
90th	32.9	21.2	35.6	22.4	30.9	20.4	28.7	19	24.7	18.3

*$p < 0.05$ was considered significant.

gender-stratified normative values according to age groups 45–55 years, 56–65 years, 66–75 years, and >75 years are also shown (Table 1).

Mean right-hand grip strength among right-handed individuals was found to be significantly higher in males than in females on *t* test ($p < 0.0001$), both overall and within each age group (Table 1). Comparison of means of right-hand grip strength in right-handed individuals using one-way ANOVA between different age groups revealed significant difference ($p < 0.0001$) as portrayed in Figure 1A. Similarly, for left-hand grip strength among right-handed individuals, males performed significantly better than females ($p < 0.0001$), both overall and within each age group, as depicted in Table 1. One-way ANOVA of means of different age groups showed significant differences ($p < 0.0001$, Figure 1B). We could not perform an analysis of handgrip strength in left-handed individuals due to the small sample size.

For functional mobility measured using the TUG test, gender-stratified normative values, both overall and for each age group are depicted in Table 2. On age-stratification, the mean time taken progressively increased with age and these differences were statistically significant ($p < 0.0001$) as shown in Figure 2. We observed that males had significantly lower mean TUG time than females, both overall ($p < 0.0001$) and in the age-groups 45–55 years ($p < 0.0001$), 56–65 years ($p < 0.0001$), and 66–75 years ($p < 0.0001$) but not in the age group >75 years ($p = 0.11$) as represented in Table 2.

Gender- and age-wise normative values for physical activity (MET-minutes/week) in represented as percentiles in Table 3. Overall mean physical activity, as measured by GPAQ, did not differ significantly by gender. Comparison of the mean physical activity between age groups using one-way ANOVA showed a significant difference ($p < 0.0001$) between the different age groups (Figure 3). On gender stratification within the different age groups, males had

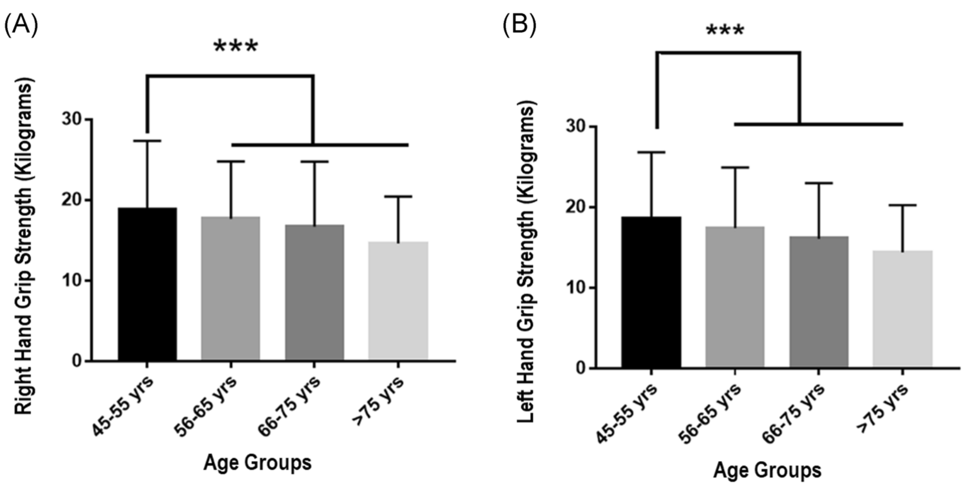

FIGURE 1 Comparison of mean handgrip strength (in kg) among different age groups. (A) Right grip strength in right-handed individuals and (B) left grip strength in right-handed individuals. ***$p < 0.001$

TABLE 2 Age and gender-stratified percentile norms for TUG time (in s)

	Total		45–55 years		56–65 years		66–75 years		>75 years	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
N	870	993	349	491	281	317	177	150	64	36
Mean	12.0	12.9	11.2	12.0	11.6	12.9	12.8	14.8	15.5	16.9
SD	2.8	3.1	2.1	2.4	2.3	2.8	3.0	3.7	4.4	4.0
p value	<0.0001*		<0.0001*		<0.0001*		<0.0001*		0.1124	
Percentile										
10th	9.1	9.5	8.7	9.1	8.9	9.8	9.7	10.9	10.7	12.2
25th	10.1	10.7	9.6	10.3	10	10.9	10.7	11.9	12.5	13.5
50th	11.4	12.4	10.9	11.7	11.3	12.5	12.0	14.3	14.8	16.2
75th	13.4	14.5	12.4	13.6	13	14.3	14.1	16.2	17.3	19.8
90th	15.5	16.6	14.1	15.2	14.8	16.7	17.1	19.1	22.7	22.4

*$p < 0.05$ was considered significant.

significantly higher physical activity than females in the age-group 45–55 years ($p = 0.0073$); however, this was reversed in the age-groups 56–65 years ($p = 0.0016$) and 66–75 years ($p = 0.0023$) We did not find any significant gender difference in physical activity in the subjects >75 years, as displayed in Table 3.

4 | DISCUSSION

This study presents gender- and age-wise normative data for three important, quantitative frailty parameters, namely handgrip strength (in kg) using digital hand dynamometry, functional mobility (in s) using TUG test, and total physical activity (in MET-minutes/week) using GPAQ, in a rural, aging population from southern India. This data is highly significant, considering that most of the currently available norms for various frailty parameters are from Western countries. The importance of using population-specific norms for the diagnosis of complex physical conditions such as frailty cannot be overstated.

Our data shows that from the age of 45 years onwards, grip strength gradually decreases as age increases. This was observed in both genders. However, women had significantly lower strength compared to men, across all age groups. The above findings are in line with prior research which shows that after the fourth decade, grip strength decreases with increasing age and that women have lower grip strength across different populations.[26]

We compared the normative data from our study population of rural Indians with that of populations of different age groups across the world—both in developed and developing countries. Comparison with reference values for handgrip strength derived from a European adult population ($n = 769$, aged 22–95 years)[27] revealed that our population had a substantially lower overall mean strength among both men (right hand: 23.80 vs. 49 kg) and women (right: 14.50 vs. 29 kg). However, in both the above studies, mean strength was roughly 40% lesser in women compared to men. Similarly, median handgrip strength in our study population was lower than that of a large ($n = 5250$), community-dwelling, older population from Chile,[28] among both men (right hand: 23.8 vs. 32.7 kg) and women (right: 14.2 vs. 19.3 kg). In 2019, the Asian Working Group for Sarcopenia (AWGS) used a pooled data set ($n = 26{,}344$) from eight cohort studies[29] among older adults (≥60 years) from seven Asian countries excluding India (Korea, Japan, Singapore, Taiwan, Thailand, China, and Hong Kong) and reported the mean handgrip strength as 34.1 kg in men and 21.9 kg in women, which was markedly higher than the corresponding means of aging adults (≥45 years) in our cohort. The same trend was also observed when comparing our results with two African studies among rural-dwelling older adults—in a Ghanian population (≥50 years, $n = 527$, mean grip strength: 46.9 kg in males and 29.3 kg in females)[30] and in a Malawian population (≥55 years, $n = 296$, mean grip strength: 28 kg in males and 21.7 in females).[31]

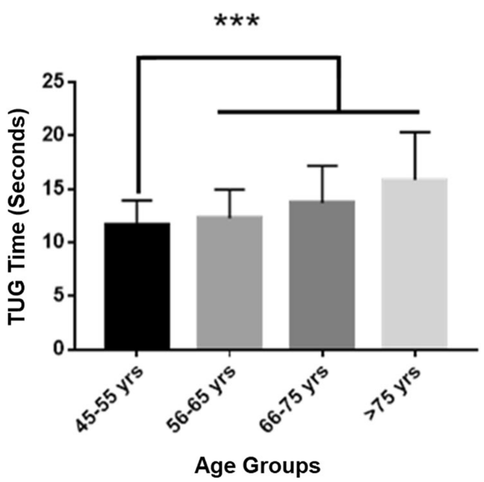

FIGURE 2 Comparison of mean TUG time (in seconds) among different age groups. TUG, Timed Up-and-Go. ***$p < 0.001$

TABLE 3 Age and gender-stratified percentile norms for total physical activity (in MET-minutes/week)

	Total		45–55 years		56–65 years		66–75 years		>75 years	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
N	771	869	366	492	206	239	138	110	51	27
Mean	11,515.7	11,061.7	14,057.2	12,370.0	9622.4	12,370.0	8918.7	12,370	9308.2	9311.1
SD	10,159.4	9284.4	10,170.3	8192.4	10,104.2	8192.4	9188.8	8192.4	9258.0	12,176.6
p value	0.3445		0.0073*		0.0016*		0.0023*		0.9991	
Percentile										
10th	1680	1680	2568	1680	1680	1440	1656	1680	1680	576
25th	4320	4320	6720	5580	3360	3360	3360	3360	3360	1680
50th	8880	9240	13,440	13,440	6720	6720	6720	6840	6720	5880
75th	15,840	15,120	18,480	16,800	11,760	11,760	11,580	11,760	11,760	10,920
90th	23,352	20,160	25,200	20,328	18,552	18,480	20,160	26,808	17,808	24,864

*$p < 0.05$ was considered significant.

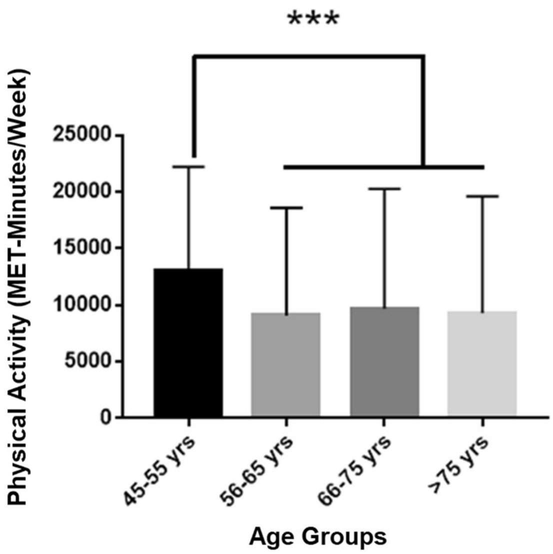

FIGURE 3 Comparison of total physical activity (in MET-minutes/week) among different age groups. MET, metabolic equivalents. ***$p < 0.001$

Further, mean grip strength in the oldest group (>75 years) in our study (men: 17.78 kg, women: 11.24 kg) was lower than in similarly aged populations from several countries; for example, in a large population-based study among individuals aged >75 years from Taiwan[32] (men: 23.2 kg, women: 13.9 kg). A Swiss population comprising of individuals aged 75–99 years ($n = 244$) had mean handgrip strength ranging from 37.7 kg to 29.6 kg in men and 22.2 to 16.5 kg in women.[33] Similarly, a meta-analysis[34] examining seven studies from the USA, Canada, and Australia ($n = 739$) showed that mean right-hand grip strength in individuals aged 75–99 years ranged from 31.1 to 18.8 kg in men and 21.6 to 15.2 kg in women. All of the above comparisons bring to light that older, rural Indians have lower handgrip strength compared to several other older populations worldwide: European, North American, South American, Canadian, Australian, Asian, and African.

Very few studies from India have provided normative data for handgrip strength in aging individuals. In a hospital-based, cross-sectional study[35] from northern India, among 723 subjects aged 60 years and above, mean handgrip strength in the age groups 60–65 years, 66–70 years, and >75 years was 27.31, 22.49, and 21.23 kg among males and 12.12, 11.38, and 10.40 kg among females, respectively. Another study,[36] which compared handgrip strength between rural and urban females in the northern Indian state of Haryana observed that rural women had a significantly higher mean handgrip strength than urban women (right hand 20.35 vs. 18.87 kg).

Our study revealed that mean time taken in the TUG test was significantly lesser in males as compared to females (11.98 vs. 12.86 s) and increased with age. Both the above trends have been demonstrated by prior studies among older populations across the world. As observed with the grip strength findings, mean TUG time in our aging study sample was higher than studies from other older populations—American[37] (50–59 years; 9.9 s), Polish[38] (60–74 years; 8.4 s), Spanish[39] (71–99 years; males: 9.3, females: 11.2 s), Norwegian[40] (60–84 years; males: 8.2–11.2 s, females: 7.8–11.2 s), Japanese[41] (≥60 years; 8.86 s), Singaporeans[42] (60–74 years; 9.80 s), Thai[43] (60–69 years; males: 9.2, females: 9.9 s, 70–79 years; males: 10.2, females: 11.3 s, ≥80 years; males: 11.9, females: 13.4 s), Koreans[44] (70–84 years; males: 10.3, females: 10.2 s). Further, a meta-analysis[45] of 21 studies, using data of older adults belonging to different countries, showed that the mean TUG time was only 9.4 s.

Normative data for functional mobility on the TUG test in the aging Indian population is scarce. In a study[46] from the state of Gujarat in India, a sample of individuals ($n = 520$) aged 40-70 years had lower TUG time (males: 8.29 and females 8.71 s) than our study subjects aged ≥45 years. However, a recent study[47] from Tamil Nadu in southern India reported higher mean TUG times (12.0 and 19.4 among subjects aged 51–60 and 61–70 years, respectively. Thus, Indians appear to have a higher TUG time compared to several other populations across the world.

We did not observe any consistent trend in mean total physical activity (in MET-minutes/week) with increasing age. Further, no statistically significant overall gender difference was detected, and overall and no consistent trend in gender difference was seen, when sub-grouped according to age. A dearth of literature remains for physical activity norms on GPAQ (reported in MET-minutes/week), especially in the Indian population. In a recent study[48] in an adult population (≥30 years) from rural Karnataka in India, the mean total MET-minutes/week was 118,33.0 in males and 11,094.0 in females, which was similar to our findings. However, in this study, as age progressed, physical activity declined in the older age groups (≥50 years) and females had significantly less physical activity than men. As compared to Indian studies, mean MET-minutes/week from other studies were relatively lower. A large study from Thailand[49] observed that the mean to be 10,378.3 (10,100.1) in men and 5799.6 (7314.1) in women in the age group 40–49 years and decreased to 7372 (9288.6) and 4871.0 (6492.0), respectively, in the age group 60–69 years. According to the WHO, less than 600 MET-minutes/week is considered to be insufficient physical activity. In comparison to this, our rural study population's mean physical activity was very high, similar to the above-mentioned findings by Nooyi et al.[48] among rural Indians, where they also observed that 96.2% of their population fell in the category of very high physical activity (>1200 MET-minutes/week). Interestingly, a study from Punjab, India found that physical activity levels were higher in rural as compared to urban adults. The same trend was also reflected in a large multicentric survey in India.[50] Possible reasons for higher levels of physical activity in rural Indians may be due to predominantly agriculture-based work and limited transport facilities. Age-standardized prevalence of insufficient physical activity estimated from data from 168 countries was found to be 27·5%. However, in our study, we did not calculate the prevalence of insufficient physical activity since this was beyond the scope of this manuscript, which is focused only on presenting normative data.

Our findings that the above-studied frailty parameters are age- and gender-specific as well as population-specific, and our estimation of their normative values will enable clinicians to accurately identify frailty in aging Indians. The strengths of our study include a large sample population of aging adults with similar sociodemographic characteristics and lifestyle patterns. This is one of the few large-scale studies that provide normative data for a rural, aging Indian population. However, caution is needed when attempting to generalize these results to the large Indian population, in view of the massive socio-cultural differences that exist across the country. Limitations of the study include the usage of a seat without a back or armrest for the TUG test as the chair type could influence TUG time. Additionally, the total physical activity was calculated based on a self-reported questionnaire and hence, is prone to recall bias. Also, this data was not a direct measure of the current physical activity but obtained from the average physical activity during the subjects' most recent period of life. Further, GPAQ prespecifies only three life periods for assessment of physical activity namely, early life (13–30 years), mid-life (31–55 years), and late-life (56 years and above), whereas, we had stratified subjects in our study into four age groups (45–55, 56–65, 66–75, and >75 years. Thus, for subjects aged 45–55 years, physical activity data was obtained from GPAQs mid-life (31–55 years) period and for subjects in the age groups of 56–65, 66–75, and >75 years, physical activity data was obtained from GPAQs late-life (56 years and above) period. Thus, the age-wise differences in physical activity observed in our study need to be interpreted with caution.

In conclusion, our main findings suggest that our reference values for handgrip strength are lower and that for TUG time are higher than reported in populations from several other countries, including Asian countries. Poor nutritional status among marginalized, rural-dwelling individuals could be an underlying factor for this as shown by prior studies.[31,51] A recent study[52] in the same rural Indian population highlighted the high prevalence of micronutrient deficiencies in these older adults. Our rural study subjects reported high levels of physical activity as compared to other studies across the world.

Evidence is emerging on the possibility of preventing, delaying, or reversing frailty through primary care interventions, such as nutritional supplementation (including protein supplementation), exercise, and education.[53,54] In this scenario, having population-specific norms for the frailty parameters discussed above would be crucial in the early detection of frailty. As a next step, factors associated with frailty in the Indian population need to be studied in detail. This will facilitate the development of targeted, population-specific, and culturally appropriate public health strategies to delay or mitigate a premature decline in physical functioning, prevent disability, and thereby, substantially improve the quality of life among older adults. In addition, the study of frailty and its associated factors along with longitudinal monitoring of cognitive functioning will give vital clues on how frailty can be a risk factor for cognitive decline in later life.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS

Jonas S. Sundarakumar: conceptualization, investigation, methodology, supervision, validation, writing—original draft, writing—review & editing. **Karru V. Raviteja**: data curation, formal analysis, investigation, methodology, visualization, writing—review & editing. **Graciela Muniz-Terrera**: conceptualization, methodology, supervision, validation, writing—review & editing. **Vijayalakshmi Ravindranath**: conceptualization, investigation, methodology, project administration, resources, supervision, validation, writing—review & editing.

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