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Establishing sex- and age-specific normative values for the Senior Fitness Test among community-dwelling elderly aged 70 and older in Eastern China: a community-based study

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Abstract

Background The preservation of physical health is of crucial importance for the overall well-being of the ageing population, a concern that is particularly relevant in the context of rapidly ageing societies such as China. The Senior Fitness Test has emerged as an instrument for evaluating and monitoring the physical fitness of elderly individuals. However, there is a lack of data regarding the normative values of physical fitness among community-dwelling elderly people aged 70 years and older in China.

Objective This study aims to propose sex- and age-specific normative values for the components of the Senior Fitness Test in a large-based sample of Chinese aged over 70, thus contributing to the development of more tailored interventions addressing the aging trends.

Methods A total of 21,305 community-dwelling elderly individuals aged over 70 (53.02% female) were evaluated using the Senior Fitness Test in Hangzhou, China. Sex- and age-specific normative values for each component were computed, ranging from the 5th to the 95th percentile, with increments of the 5th percentile.

Results The results showed that the normative values vary by gender and age, declining with age in both males and females. Males exhibit superior strength, endurance, and dynamic balance, while females tend to have greater flexibility.

Conclusion This study established sex- and age-specific normative values for selected components of the Senior Fitness Test among elderly individuals in China. The study's findings provided performance standards for clinically assessing the physical fitness of Chinese seniors and could serve as valuable insights for future research endeavors.

Keywords Ageing, Senior Fitness Test, Normative values, Physical fitness, China

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Introduction

In China, the demographic landscape has witnessed a significant shift, with the elderly population surpassing 14% by 2021 [1]. This demographic transition portends a range of challenges for the healthcare system, necessitating proactive strategies to manage the impending burden. In response, the Chinese government has unveiled a national strategy called Healthy China 2030, to relieve the ever-increasing demand for healthcare services [2]. Healthy China 2030 emphasizes the importance of fostering individual agency in health management and promoting widespread participation in sports activities to enhance fitness and well-being, in concert with the World Health Organization's (WHO) vision of healthy aging. Physical fitness is crucial for overall health, especially for the elderly, as it is directly related to their ability to perform daily activities, maintain functional independence, and improve quality of life. When conducting a comprehensive health assessment for aging individuals, it is important to consider the components of physical fitness, including aerobic endurance, strength, flexibility, and balance, as these are essential for preserving mobility and reducing the risk of falls. To realize this vision, it is imperative to establish normative values and performance standards of physical fitness that are tailored to the unique needs of China's elderly population. The development of such standards will be instrumental in underpinning evidence-based policies that support functional independence among the elderly, thereby ensuring that they are equipped with the resources necessary to preserve their quality of life.

The Senior Fitness Test (SFT) is regarded as a critical instrument for evaluating the physical fitness of older adults. It was developed in 1999 by Rikli and Jones as a practical and cost-effective means of assessing functional fitness parameters [3, 4]. This comprehensive battery of tests encompasses the key fitness components pertinent to the elderly, including strength, aerobic endurance, flexibility, and dynamic balance, thereby sketching the level of physical capabilities essential for the performance of daily tasks in advanced age. Initially, the performance standards for the SFT were established and validated against the American population [3, 45], with subsequent studies generating normative values for various older adult populations in Taiwan [6], Spain [7, 8], Portugal [9], Hong Kong [10], Chile [11], Poland [12], and Germany [13]. Normative values derived from physical fitness tests offer a valuable metric for tracking the health and functional status of individuals as they advance in age. Moreover, these results facilitate comparative analyses of the aging process across diverse populations, providing insights into the variability of aging patterns and the effectiveness of various health and wellness interventions. Despite this global proliferation of research, there remains a paucity of data regarding the normative values of physical fitness among community-dwelling elderly people aged 70 years and older in China. Addressing this void is the primary objective of the current study, which aims to establish the first sex- and age-specific normative values for the components of the Senior Fitness Test within the population of China.

Methods

This cross-sectional study was conducted in Hangzhou, a large city in the eastern region of China and the provincial capital of Zhejiang. As of 2021, Hangzhou's resident population exceeded 12.204 million, with 17.3% of this population being aged 60 years and older [14]. A total of 21,305 community-dwelling elderly individuals aged over 70 were enrolled in the study through the annual health physical examination administered at local community health centers. Participants included in the analysis were functionally independent, able to walk without the use of assistive devices or any other form of external aid, and free from any medical, physical, or cognitive conditions that would prevent them from following instructions to complete the senior fitness tests. Before participating, all individuals gave their informed consent. Those who had any reservation or chose not to participate in the study were not required to undergo the SFT. The research protocol was reviewed and approved by the Ethics Committee of Zhejiang Hospital.

All participants underwent measurements for the following six components of the Senior Fitness Test. For the 30-second Chair Stand Test to assess lower body strength, participants were instructed to rise from a seated to a standing position and then return to the chair with arms folded across the chest as often as possible within 30 s. The number of full stands completed was recorded. For the 30-second Arm Curl Test to assess upper body strength, participants performed bicep curls with a specified weight (5-pound dumbbell for women and 8-pound dumbbell for men) for 30 s, and the total number of curls was counted. For the 2-minute Step Test to assess aerobic endurance, participants were asked to raise each knee to a point midway between the patella (kneecap) and iliac crest (top hip bone) as soon as possible for 2 min, the number of times the right knee reaches the required height was recorded. For the Chair Sit-and-Reach Test to assess lower body flexibility, participants sat on the edge of a chair with one leg extended and hands reached toward the toes, measuring the distance between the extended fingers and the tip of the toes. For the Back Scratch Test to assess upper body flexibility, participants were asked to reach one hand over the shoulder and the other behind the back to try and touch the fingers together. The distance between the fingers was measured. For the 2.4-Meter Up-and-Go Test to assess dynamic balance, participants were timed as they rose from a chair, walked 8 feet, turned around, returned to the chair, and sat down. Trained assessors conducted all tests with precision, adhering strictly to the guidelines provided in the second edition of the Senior Fitness Test Manual [4]. Participants were provided with test instructions along with a consent form. They were asked to practice each test before the formal assessment. Only one trial was allowed for the 30-second chair stand, 30-second arm curl, 2-minute step, and 2.4 m up-and-go test. For the back scratch and chair sit-and-reach test, two trials were administered, and the best score was recorded. Data collection for this study spanned from September 2021 through December 2021.

Prior to data analysis, a dedicated database was constructed using Navicat Premium 15. The data processing was carried out with Python 3.9.12, following a series of steps: the removal of entries with missing data, the deletion or correction of extreme values falling outside physiologically plausible ranges, and ensuring that all data entries with units are standardized by converting them to uniform units of measurement.Outliers, defined as data points exceeding three standard deviations from the mean, were subjected to a rigorous verification process. This process involved a thorough review of the original data entries to rectify any transcription or recording errors. For values exceeding five standard deviations, which were more likely to result from significant measurement errors or anomalies in test administration, they were removed from the dataset. However, outliers between three and five standard deviations were retained, as they were considered to potentially represent true extremes of performance.

Participants were categorized into five age groups: AG70 (70–74 years), AG75 (75–79 years), AG80 (80–84 years), AG85 (85–89 years), and AG90 (90 years and older). The construction of the percentile norms involved the application of 19 different percentiles (5th, 10th, 15th, 20th, 25th, 30th, 35th, 40th, 45th, 50th, 55th, 60th, 65th, 70th, 75th, 80th, 85th, 90th, 95th). To determine these values, the data were sorted in ascending order, and the cumulative percentiles were calculated accordingly. This process yielded the values corresponding to each specified percentile.

Data analysis was carried out using SPSS 26. Measurement data were statistically described using mean ± standard deviation, and enumeration data were represented by frequency and percentages. The comparison of gender differences within the same age group was conducted using two independent sample t-tests. And one-way ANOVA was adopted in detecting multiple-group (e.g., different age groups) differences. The significance level was set at $\alpha = 0.05$ for two-tailed tests, with P-values less than 0.05 deemed statistically significant. GraphPad Prism 9.5.0 was utilized for the creation of graphical representations and data analysis as well.

Additional quantile regression analyses were conducted to assess the impact of age, height, weight, and BMI on each physical fitness test. This approach was designed to understand the effects on both lower-performing (5th percentile) and higher-performing (95th percentile) individuals, as well as the median performance (50th percentile). Separate models were estimated for male and female participants to capture potential gender differences in the relationships between physical characteristics and performance outcomes. The analyses were carried out using SPSS 26, employing its built-in quantile regression procedures.

Results

In total, this study included 21,305 community-dwelling elderly people aged over 70 years living in Hangzhou, China. Of which, 11,295 were women (53.02%), 10,010 were men (46.98%). A significant portion of the participants, 8,643 individuals (40.57%), were aged 80 and over. Participants were categorized into five age groups, and the distribution of participants in each group by gender is detailed Table 1. The mean and standard deviation (SD) for selected components in the Senior Fitness Test are displayed as well. Additionally, the table calculates and presents percentage of difference by sex in each test component, facilitating a comparative analysis.

Differences in Senior Fitness Test components between males and females

In the current study, we conducted a comparative analysis of specific components of the SFT across genders among different age groups. These findings revealed pronounced gender-based differences in all SFT test items, with statistical significance at $p < 0.01$. Females tended to achieve higher values in both upper body (the Back Scratch Test) and lower body (the Chair Sit-and-Reach Test) flexibility tests, while males excelled in the upper body strength test (the 30-Second Arm Curl Test), lower body strength test (the 30-Second Chair Stand Test), aerobic endurance test (the 2-Minute Step Test), and dynamic balance test (the 2.4-Meter Up-and-Go Test). These gender differences are particularly striking in the domain of flexibility, with men exhibiting average lower limb flexibility that was 54.93% less than that of women, and upper limb flexibility that was 23.64% lower.

These gender differences persist after age stratification. However, each component demonstrates a distinct ageing pattern. Regarding flexibility, as age increases, the gender gap gradually narrows. In the AG70 group, male lower limb flexibility is 341.46% inferior to that of females, while in the AG90 group, males are only 11.59% less flexible than females (Table 2). Meanwhile, for strength

Table 1 Number of participants by sex and age and mean and standard deviation (SD) for selected components in Senior Fitness Test by sex

	Total	Women	Men	Percentage of difference by sex
	n (%)	n (%)	n (%)	
Age groups	21,305(100%)	11,295(53.02%)	10,010(46.98%)	
70–74 (AG70)	5413(25.41%)	2897(13.6%)	2516(11.81%)	
75–79 (AG75)	7249(34.02%)	3812(17.89%)	3437(16.13%)	
80–84 (AG80)	4259(19.99%)	2270(10.65%)	1989(9.34%)	
85–89 (AG85)	3119(14.64%)	1686(7.91%)	1433(6.73%)	
90 and above (AG90)	1265(5.94%)	630(2.96%)	635(2.98%)	
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	**%**
Height (cm)	161.49(8.25)	156.03(5.69)***	167.65(6.06)***	7.45%
Weight (kg)	59.3(11.28)	55.12(10)***	64.03(10.77)***	16.16%
Body Mass Index(kg/m^2)	22.68(3.65)	22.61(3.77)**	22.76(3.5)**	0.66%
30-Second Chair Stand Test (n in 30s)	16.22(4.36)	16.01(4.33)***	16.47(4.38)***	2.87%
30-Second Arm Curl Test (n in 30s)	18.03(4.99)	17.7(4.93)***	18.39(5.04)***	3.90%
2-Minute Step Test (n in 2 min)	71.87(20.48)	67.53(18.84)***	76.76(21.15)***	13.67%
Chair Sit-and-Reach Test (cm)	-2.68(7.71)	-2.13(7.36)***	-3.3(8.04)***	54.93%
Back Scratch Test (cm)	-9.4(9.48)	-8.46(9.25)***	-10.46(9.62)***	23.64%
2.4-Meter Up-and-Go Test (s)	6.26(1.9)	6.37(1.94)***	6.13(1.84)***	-3.77%

***P-Value Less Than 0.001

** P-Value Less Than 0.01

*P-Value Less Than 0.05

components, as age advances, the gender gap widens. In the AG70 group, men outperform women by 1.72% in the 30-Second Chair Stand Test, whereas in the AG90 group, men perform 4.60% better.

Normative values for selected components in Senior Fitness Test

Sex- and age-specific normative values were calculated for the 5th, 10th, 15th, 20th, 25th, 30th, 35th, 40th, 45th, 50th, 55th, 60th, 65th, 70th, 75th, 80th, 85th, 90th, and 95th percentiles. These values are presented in Table 3. These percentile values provide 4 aspects of functional fitness, including strength (upper and lower body), aerobic endurance, flexibility (upper and lower body), and dynamic balance, enabling the assessment of an individual's functional fitness in comparison to others within their age group and gender.

Age group comparisons and distribution characteristics

The average performance of each test component declined with increasing age (Table 2). The changing trajectories and the distributions of data values vary in different test components. And graphical representations are depicted in Figs. 1 and 2. The means of all adjacent age groups were compared pairwise and p-values were displayed, and One-way ANOVA was adopted in detecting multiple-group differences.

In Fig. 1, we observed notable declines in the 2-Minute Step Test for AG85 in females and AG75 in males compared to previous age groups, suggesting potential differences in age-related decline in physical ability between genders. In both the 30-Second Chair Stand Test and the 30-Second Arm Curl Test, different from other age groups, the data distribution of AG90 tends to have multiple clusters. This suggests greater variability among individuals in the oldest age group.

In Fig. 2, in both the Chair Sit-and-Reach Test and the Back Scratch Test, larger clusters within the scatter plots are closer to the lower limit with increasing age, the value of which tends to lower than the average value, especially in AG 90. In the 2.4-Meter Up-and-Go Test, as age increases, data become more scattered, suggesting greater variability within older age group.

Impact of age, height, weight, and BMI on physical fitness tests

The quantile regression results presented in Table 4 reveal that age was consistently the main factor negatively associated with physical performance, particularly among low and high performers (5th and 95th percentiles). At the median quantile (50th percentile), the influence of age, height, weight, and BMI varied across different tests and gender groups. For instance, in the 30-Second Chair Stand Test, all these factors had significant impact. BMI demonstrated mixed effects, with positive associations

Table 2 Mean and standard deviation (SD) for selected components in Senior Fitness Test according to age and sex

	Age groups				
	AG70 (70–74) n = 5413	**AG75 (75–79) n = 7249**	**AG80 (80–84) n = 4259**	**AG85 (85–89) n = 3119**	**AG90 90 and above n = 1265**
Height	162.24(7.72)	162.06(8.19)	160.78(8.67)	160.2(8.22)	160.55(8.76)
Women	157.07(5.14)	156.54(5.57)	155.06(6.23)	154.96(5.41)	154.52(6.16)
Men	168.2(5.63)	168.19(5.97)	167.31(6.05)	166.37(6.5)	166.54(6.57)
percentage of difference by sex	7.09%	7.44%	7.90%	7.36%	7.78%
Weight	61.67(10.81)	59.68(11.13)	57.46(11.09)	57.24(11.81)	58.32(11.39)
Women	58.04(9.67)	55.75(9.88)	52.88(9.61)	52.49(10.04)	52.92(9.4)
Men	65.85(10.54)	64.04(10.8)	62.69(10.33)	62.84(11.27)	63.67(10.65)
percentage of difference by sex	13.46%	14.87%	18.55%	19.72%	20.31%
Body Mass Index	23.39(3.55)	22.68(3.65)	22.16(3.55)	22.22(3.79)	22.54(3.52)
Women	23.51(3.69)	22.73(3.76)	21.98(3.72)	21.82(3.74)	22.13(3.5)
Men	23.25(3.39)	22.62(3.52)	22.37(3.32)	22.69(3.8)	22.94(3.49)
percentage of difference by sex	-1.11%	-0.48%	1.77%	3.99%	3.66%
30-Second Chair Stand Test	17.54(4.28)	16.91(4.24)	15.66(4.03)	14.54(3.84)	12.67(4)
Women	17.4(4.28)	16.67(4.25)	15.39(3.96)	14.29(3.7)	12.38(3.88)
Men	17.7(4.27)	17.18(4.22)	15.96(4.1)	14.83(3.98)	12.95(4.11)
percentage of difference by sex	1.72%	3.06%	3.70%	3.78%	4.60%
30-Second Arm Curl Test	19.59(5.05)	18.77(4.85)	17.35(4.54)	16.11(4.44)	14.07(4.25)
Women	19.31(4.94)	18.4(4.82)	17.09(4.48)	15.7(4.36)	13.7(4.19)
Men	19.92(5.17)	19.2(4.85)	17.64(4.6)	16.58(4.48)	14.43(4.27)
percentage of difference by sex	3.16%	4.35%	3.22%	5.61%	5.33%
2-Minute Step Test	83.21(20.77)	76.71(17.92)	67.78(16.34)	55.98(13.11)	48.44(12.09)
Women	76.14(17.15)	74.24(17.07)	64.92(15.49)	50.51(9.71)	42.27(8.87)
Men	91.35(21.58)	79.46(18.45)	71.06(16.67)	62.43(13.65)	54.57(11.74)
percentage of difference by sex	19.98%	7.03%	9.46%	23.60%	29.10%
Chair Sit-and-Reach Test	-1.06(7.25)	-1.84(7.48)	-3.67(7.93)	-4.4(7.55)	-6.84(7.82)
Women	-0.41(6.79)	-1.33(7.11)	-3.15(7.57)	-3.93(7.26)	-6.47(7.64)
Men	-1.81(7.69)	-2.41(7.82)	-4.27(8.27)	-4.95(7.84)	-7.22(7.98)
percentage of difference by sex	341.46%	81.20%	35.56%	25.95%	11.59%
Back Scratch Test	-7.66(9.23)	-8.45(9.25)	-10.18(9.48)	-11.58(9.41)	-14.34(9.05)
Women	-6.53(8.81)	-7.47(8.95)	-9.21(9.48)	-10.93(9.02)	-14.02(8.81)
Men	-8.95(9.52)	-9.53(9.45)	-11.28(9.35)	-12.34(9.81)	-14.67(9.27)
percentage of difference by sex	37.06%	27.58%	22.48%	12.90%	4.64%
2.4-Meter Up-and-Go Test	5.65(1.42)	5.88(1.56)	6.56(1.93)	7.1(2.2)	7.95(2.51)
Women	5.74(1.44)	5.98(1.6)	6.71(2)	7.26(2.26)	8.08(2.48)
Men	5.55(1.39)	5.77(1.51)	6.38(1.84)	6.91(2.12)	7.83(2.53)
percentage of difference by sex	-3.31	-3.51%	-4.92%	-4.82%	-3.09%

in some tests at lower quantiles and negative effects at higher quantiles. These findings underscore the varying influence of age and BMI on physical fitness, depending on gender and performance level.

Discussion

This study constitutes the most comprehensive examination to date on the normative values of physical fitness among elderly individuals in China, with a notable proportion of participants exceeding 80 years of age. The research highlights pronounced gender-specific variations and a progressive decline in physical capabilities with advancing age across multiple functional parameters.

Notable declines in both upper and lower body strength and endurance with age across both genders were observed, with men demonstrating better performance. These findings on aging trends and gender differences are consistent with previous research [3, 9, 10, 12, 13, 15]. Compared to counterparts in the USA [3], Spain [7, 8], Poland [12], and other Chinese populations in Taiwan [6] and Hong Kong [10], stronger upper body strength were detected in the present study. The differences are particularly marked in Taiwan [6] and Hong Kong [10], where strength levels are noticeably lower. In

Table 3 Sex- and age-specific normative values for selected components in Senior Fitness Test

Percentiles	Female					Male				
	AG70 70–74	AG75 75–79	AG80 80–84	AG85 85–89	AG90 ≧ 90	AG70 70–74	AG75 75–79	AG80 80–84	AG85 85–89	AG90 ≧ 90
30-Second Chair Stand Test										
95	25	24	22	20	19	25	25	23	21	20
90	22	22	20	18	18	23	22	20	19	18
85	21	20	19	18	16	21	20	20	18	17
80	20	20	18	18	15	20	20	19	18	16
75	20	19	18	17	15	20	19	18	17	15
70	19	18	17	16	15	19	19	18	16	15
65	18	18	17	15	14	19	18	18	16	15
60	18	18	16	15	14	18	18	17	15	14
55	18	17	16	15	14	18	18	16	15	14
50	18	17	15	14	13	18	17	16	15	13
45	17	16	15	14	12	17	17	15	14	12
40	16	16	14	14	11	17	16	15	14	12
35	16	15	14	13	10	16	16	14	14	11
30	15	15	14	13	10	16	15	14	13	10
25	15	14	13	12	9	15	15	14	12	10
20	14	13	12	11	8	15	14	13	12	9
15	13	12	12	10	8	14	13	12	10	8
10	12	11	10	9	8	12	12	10	10	8
5	10	10	9	8	6	11	10	10	9	7
30-Second Arm Curl Test										
95	28	26	25	23	21	30	28	25	24	22
90	25	24	22	20	20	26	25	23	22	20
85	24	22	21	20	18	24	24	22	20	19
80	23	22	20	19	17	23	22	20	20	18
75	22	21	20	18	16	22	22	20	19	17
70	21	20	19	18	16	21	21	20	18	16
65	20	20	18	17	15	20	20	19	18	16
60	20	19	18	16	15	20	20	18	17	16
55	20	19	17	16	15	20	20	18	17	15
50	19	18	17	16	14	19	19	17	16	15
45	18	18	16	15	13	19	18	17	16	14
40	18	17	16	15	12	18	18	16	15	13
35	18	17	15	15	11	18	18	16	15	12
30	17	16	15	14	11	18	17	15	15	11
25	16	16	15	13	10	17	16	15	14	11
20	16	15	14	12	10	16	16	14	13	10
15	15	14	12	11	10	16	15	13	12	10
10	13	12	12	10	9	14	13	12	11	10
5	11	10	10	10	8	12	12	11	10	9
2-Minute Step Test										
95	106	103	95	67	58	124	112	100	86	76
90	101	99	89	63	56	121	107	96	84	71
85	97	96	84	61	54	119	102	92	80	67
80	94	92	80	60	52	116	98	88	78	66
75	91	89	76	58	49	111	94	85	74	64
70	88	86	72	56	47	106	91	82	70	61
65	84	82	68	55	46	101	88	79	66	60
60	81	79	65	54	44	97	84	74	64	59
55	77	74	63	51	43	94	81	70	61	56
50	73	71	61	50	42	91	78	67	60	54

Table 3 (continued)

Percentiles	Female					Male				
	AG70 70–74	AG75 75–79	AG80 80–84	AG85 85–89	AG90 ≧ 90	AG70 70–74	AG75 75–79	AG80 80–84	AG85 85–89	AG90 ≧ 90
45	70	68	60	48	40	87	73	64	58	52
40	67	65	59	47	39	84	70	62	56	50
35	64	62	57	45	38	80	68	61	55	48
30	62	61	56	44	35	77	65	60	53	46
25	61	60	54	43	33	73	63	58	51	45
20	60	59	52	41	33	70	62	56	50	43
15	59	58	50	40	32	68	60	55	48	42
10	58	56	46	38	31	65	60	53	46	41
5	55	51	43	37	31	59	56	47	44	39
Chair Sit-and-Reach Test										
95	8	7	6	6	6	7	7	6	6	6
90	6	6	6	5	4	6	6	6	5	4
85	6	6	5	4	2	6	6	5	3	2
80	5	5	3	2	1	5	5	3	2	1
75	4	3	2	1	0	4	3	2	1	-1
70	3	2	1	0	-2	3	2	0	0	-2
65	2	2	0	0	-3	2	1	0	-1	-3
60	2	1	0	-1	-5	1	0	-1	-2	-5
55	1	0	0	-2	-6	0	0	-2	-3	-6
50	0	0	-2	-3	-7	0	-1	-4	-5	-8
45	0	0	-3	-5	-8	-1	-2	-5	-5	-10
40	0	-2	-4	-5	-10	-2	-3	-6	-7	-10
35	-2	-3	-5	-7	-10	-3	-5	-7	-8	-12
30	-2	-4	-6	-8	-12	-5	-5	-9	-10	-12
25	-4	-5	-9	-10	-13	-6	-7	-10	-10	-14
20	-5	-7	-10	-10	-15	-8	-9	-10	-10	-15
15	-7	-10	-11	-11	-15	-10	-10	-12	-12	-15
10	-10	-10	-13	-13	-15	-12	-13	-15	-15	-16
5	-13	-14	-16	-15	-16	-16	-16	-19	-18	-18
Back Scratch Test										
95	4	4	3	2	1	3	3	2	2	0
90	3	2	2	0	-3	1	1	0	0	-2
85	2	1	0	-1	-5	0	0	-2	-3	-4
80	1	0	0	-3	-7	-1	-1	-3	-4	-7
75	0	0	-2	-4	-8	-3	-3	-4	-6	-9
70	0	-2	-3	-6	-10	-3	-3	-5	-7	-10
65	-2	-3	-4	-7	-12	-4	-5	-7	-9	-12
60	-3	-4	-6	-9	-12	-5	-6	-8	-10	-12
55	-4	-5	-7	-10	-13	-6	-7	-10	-11	-14
50	-5	-6	-8	-11	-15	-7	-8	-11	-12	-15
45	-6	-7	-10	-12	-16	-8	-10	-12	-12	-16
40	-7	-8	-12	-12	-17	-10	-10	-13	-13	-18
35	-8	-10	-12	-14	-19	-11	-12	-15	-15	-20
30	-10	-11	-14	-15	-20	-13	-15	-16	-16	-20
25	-12	-14	-15	-16	-20	-15	-16	-18	-19	-20
20	-15	-15	-18	-19	-20	-17	-18	-20	-20	-21
15	-16	-18	-20	-20	-22	-20	-20	-20	-23	-24
10	-20	-20	-22	-23	-25	-22	-22	-24	-25	-25
5	-23	-24	-25	-25	-26	-25	-25	-27	-29	-28
2.4-Meter Up-and-Go Test										
95	8.4	8.9	10.0	11.2	12.0	8.0	8.5	9.5	10.4	12.0

Table 3 (continued)

Percentiles	Female					Male				
	AG70 70–74	AG75 75–79	AG80 80–84	AG85 85–89	AG90 ≧ 90	AG70 70–74	AG75 75–79	AG80 80–84	AG85 85–89	AG90 ≧ 90
90	7.7	8.0	9.0	9.9	11.1	7.2	7.9	8.9	9.3	11.0
85	7.0	7.5	8.8	9.0	11.0	7.0	7.1	8.4	9.0	11.0
80	6.8	7.0	8.4	9.0	10.7	6.6	7.0	8.0	8.8	10.0
75	6.4	6.9	8.0	8.8	9.8	6.1	6.7	7.4	8.3	9.0
70	6.1	6.5	7.6	8.4	9.0	6.0	6.2	7.0	8.0	9.0
65	6.0	6.2	7.1	8.0	9.0	6.0	6.0	7.0	7.5	8.7
60	6.0	6.0	7.0	7.8	8.7	5.7	6.0	6.6	7.0	8.2
55	5.7	6.0	6.8	7.1	8.0	5.5	5.8	6.2	7.0	8.0
50	5.5	5.8	6.4	7.0	8.0	5.3	5.6	6.0	6.8	7.8
45	5.3	5.6	6.0	6.9	7.6	5.1	5.3	6.0	6.2	7.0
40	5.0	5.3	6.0	6.3	7.0	5.0	5.0	5.7	6.0	7.0
35	5.0	5.0	5.8	6.0	7.0	5.0	5.0	5.5	6.0	6.4
30	5.0	5.0	5.5	6.0	6.4	4.8	5.0	5.1	5.6	6.0
25	4.8	5.0	5.0	5.6	6.0	4.5	4.8	5.0	5.3	5.9
20	4.5	4.6	5.0	5.1	5.8	4.3	4.5	4.9	5.0	5.6
15	4.3	4.4	4.8	5.0	5.5	4.2	4.2	4.5	4.9	5.1
10	4.1	4.2	4.4	4.7	5.0	4.0	4.0	4.2	4.5	5.0
5	4.0	4.0	4.0	4.1	4.6	4.0	4.0	4.0	4.0	4.3

terms of lower body strength, performance in this test is very similar between Hangzhou, the USA [3], Spain [7, 8], and Poland [12], and slightly better when compared to Taiwan [6] and Hong Kong [10]. Older adults in Hangzhou exhibit lower cardiovascular endurance compared to those in the USA [3], Spain [7, 8], Poland [12], Taiwan [6], and Hong Kong [10], with the decline being more pronounced in Hangzhou. While Taiwan [6] and Hong Kong [10] perform better than mainland China, their levels still fall short of those observed in the USA [3] and Western Europe [7, 8, 12]. Furthermore, the annual decrease in muscle strength is approximately 1%, with the rate increasing to approximately 2% after age 85. Several other studies corroborate our observation that the loss of muscle strength accelerates in advanced age [16, 17]. A substantial difference was also noted in the 2-minute step test between adjacent age groups, indicating that age 85 may represent a turning point for the decline in endurance in women, while for men, this threshold appears to be around age 75.

Muscle strength is vital in various aspects of physical fitness, and its decline is associated with functional impairments [18]. Muscle weakness has been identified as an independent predictor for higher mortality rates among the elderly [19]. Furthermore, the present study detected greater variability among individuals in the oldest age group, with larger clusters far below the average value presents, suggesting a more pronounced trend of decline in those with lower functional abilities. This decline appears to be influenced by a confluence of factors, including not only the natural aging process but also the synergistic effects of reduced muscle mass, neurological and hormonal alterations, and physical inactivity [15, 20]. Actually, it is suggested in previous study that in this very elderly cohort, the musculoskeletal system remains responsive to progressive resistance training, with such interventions significantly enhancing functional mobility and the ability to perform daily activities [21]. It also explained the potential reason that a considerable proportion of participants exhibit outstanding physical fitness within the AG90 cohort. Future studies should further investigate the underlying mechanisms that drive these observed age-related changes, with the aim of identifying potential solutions to prevent functional decline in the very elderly population.

In flexibility tests, findings of the present study indicate that both upper and lower body flexibility are poorer compared to those observed in the USA [3], Spain [7, 8], Poland [12], Taiwan [6], and Hong Kong [10], with men showing particularly lower results. Women significantly outperformed men in both the Chair Sit-and-Reach and Back Scratch tests, with margins of 54.93% and 23.64% respectively, demonstrating superior flexibility across the trunk, upper, and lower body regions. These gender differences are consistent with findings reported in previous research [3, 9, 10, 12, 13, 15]. Additionally, this gender difference diminishes with age, decreasing from 341.46% in the AG 70 group to 11.59% in the AG 90 group for the Chair Sit-and-Reach test, and from 37.06% in the AG 70 group to 4.64% in the AG 90 group for the Back Scratch test. The reasons for these phenomena are multifaceted. Age-related changes in muscle-skeletal and soft tissue

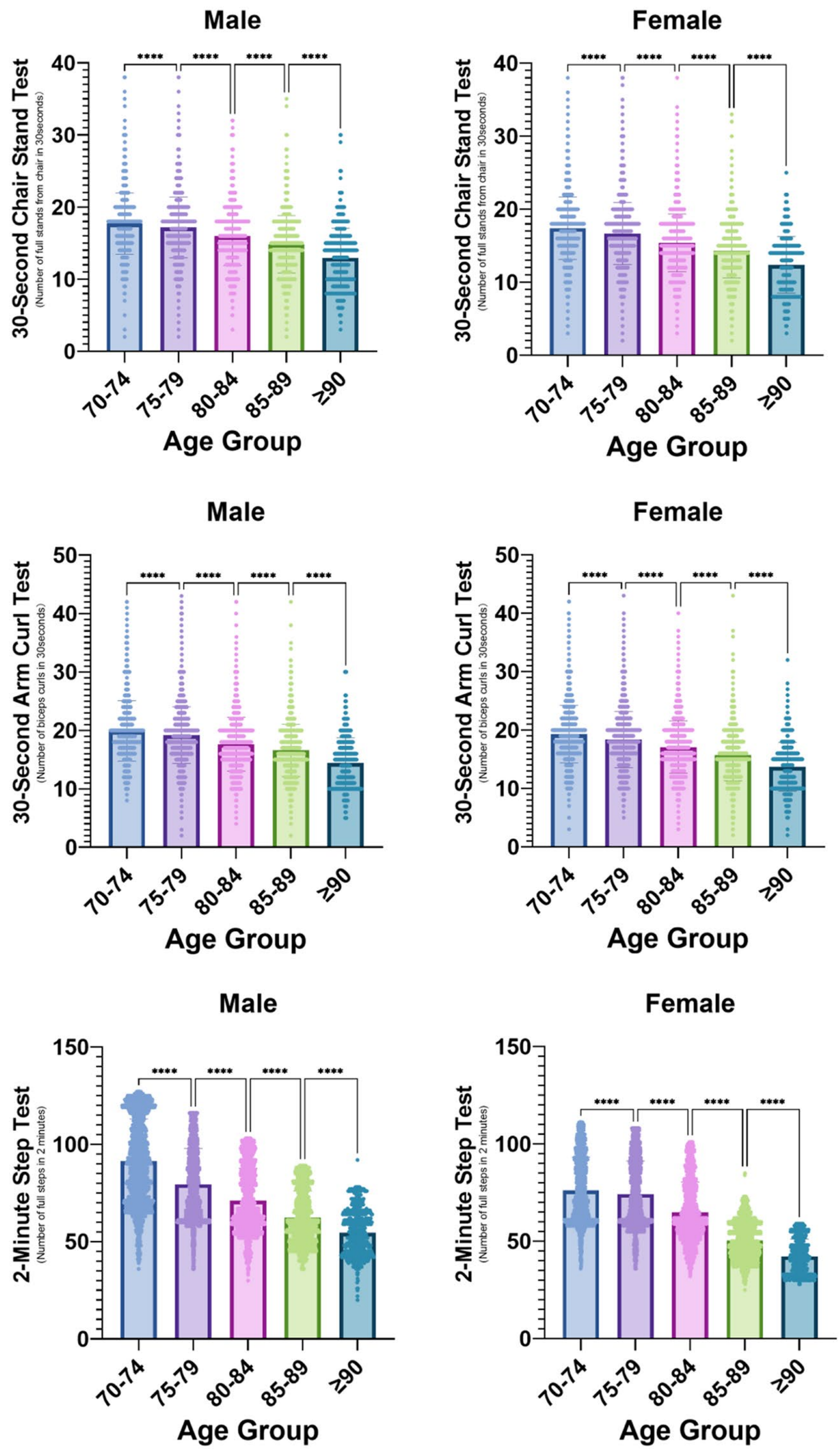

Fig. 1 Scatter plot with bar for 30-Second Chair Stand Test, 30-Second Arm Curl Test and 2-Minute Step Test

structures, as well as the onset of conditions such as osteoporosis and arthritis, contribute to the decline in flexibility. Women consistently exhibit greater flexibility than men across all age groups, indicating the influence of hormones on mechanical tissue structure. The narrowing gender difference with age suggests the involvement of other variables, such as lifestyle patterns [22, 23]. Further studies are needed to explore the mechanics of this gender difference. Even though the flexibility of upper and lower body declines gradually with age, unlike other functional fitness parameter, the upper and lower limits of the tests remain consistent across age groups,

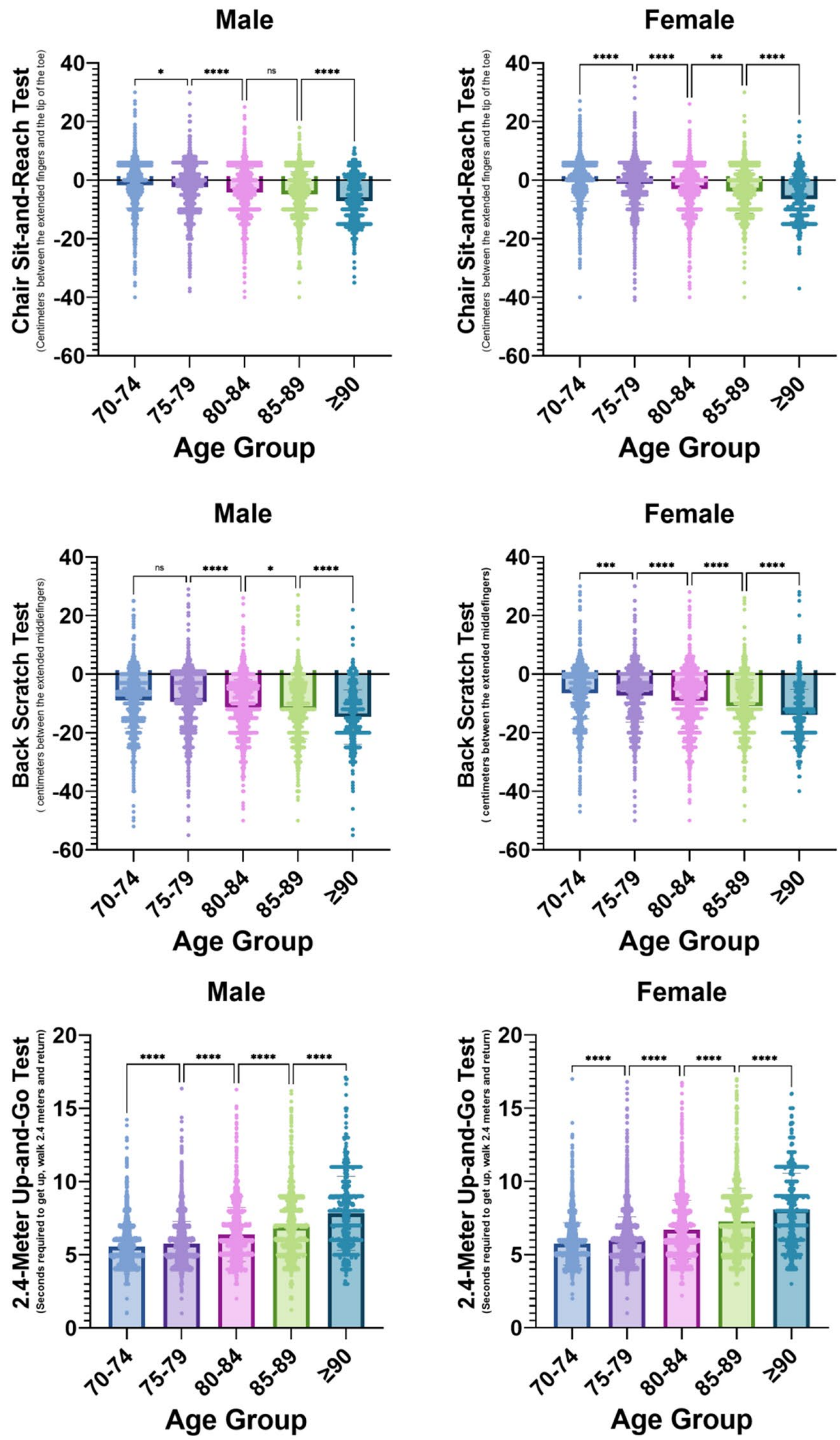

Fig. 2 Scatter plot with bar for Chair Sit-and Reach Test, Back Scratch Test and 2.4-Meter Up-and Go Test

suggesting that individuals with the highest and lowest flexibility levels are more homogeneous across different age groups. The homogeneity of the population with exceptional flexibility suggests that they may be more resilient to age-related flexibility loss. Flexibility training, such as stretching exercises, has been proven to increase joint range of motion and enhance functional outcomes [24]. Individuals with an active lifestyle, such as Tai Chi Chuan practitioners, are characterized by superior flexibility [25]. Further studies were needed to investigate the causal relationship between these factors and flexibility retention.

The 2.4-Meter Up-and-Go Test serves as a measure of agility and dynamic balance and is also a robust predictor

Table 4 Quantile regression results by gender: parameter estimates for Quantile Level and 95% confidence interval

Male				Female		
Quantile	**5th Quantile**	**50th Quantile**	**95th Quantile**	**5th Quantile**	**50th Quantile**	**95th Quantile**
30-Second Chair stand test						
Intercept	5.733 (-22.178, 33.644)	33.251 (1.330, 65.171) ***	47.501 (10.877, 84.125) *	18.424 (6.261, 30.587)	15.120 (5.980, 24.260) ***	3.361 (-2.612, 9.334)
Age(years)	-0.193 (-0.220, -0.165) ***	-0.188 (-0.215, -0.161) ***	-0.230 (-0.259, -0.201) ***	-0.150 (-0.178, -0.123) ***	-0.128 (-0.152, -0.104) ***	-0.188 (-0.231, -0.145) ***
Height(cm)	0.064 (-0.103, 0.230)	-0.127 (-0.214, -0.039) ***	-0.107 (-0.176, -0.038) **	-0.033 (-0.190, 0.124)	-0.046 (-0.069, -0.023) **	0.173 (-0.151, 0.497)
Weight(kg)	-0.102 (-0.316, 0.111)	0.177 (0.134, 0.220) ***	0.148 (0.110, 0.186) **	0.039 (-0.181, 0.259)	0.067 (0.023, 0.111) **	-0.259 (-0.462, -0.056) *
BMI	0.731 (0.132, 1.330) *	0.345 (0.255, 0.435) ***	0.799 (0.712, 0.886) **	0.316 (-0.221, 0.853)	0.638 (0.525, 0.751) ***	1.252 (0.921, 1.583) **
30-Second Arm Curl Test						
Intercept	35.118 (6.351, 63.885) *	48.848 (35.471, 62.225) ***	57.861 (-4.118, 119.839)	13.340 (-12.669, 39.349)	17.526 (6.566, 28.486) ***	42.565 (-4.300, 89.430)
Age	-0.184 (-0.213, -0.155) ***	-0.226 (-0.239, -0.213) ***	-0.407 (-0.468, -0.345) ***	-0.172 (-0.201, -0.143) ***	-0.197 (-0.209, -0.185) ***	-0.326 (-0.378, -0.275) ***
Height	-0.108 (-0.279, 0.063)	-0.157 (-0.236, -0.077) ***	-0.080 (-0.449, 0.289)	0.013 (-0.152, 0.179)	0.016 (-0.054, 0.085)	-0.031 (-0.329, 0.267)
Weight	0.126 (-0.094, 0.346)	0.206 (0.104, 0.309) ***	0.137 (-0.338, 0.611)	-0.038 (-0.270, 0.194)	-0.022 (-0.120, 0.076)	-0.001 (-0.419, 0.417)
BMI	0.072 (-0.546, 0.689)	0.000 (-0.287, 0.287)	0.240 (-1.090, 1.571)	0.520 (-0.046, 1.085)	0.630 (0.392, 0.869) ***	0.591 (-0.429, 1.610)
2-Minute Step Test						
Intercept	98.259 (24.744, 171.773) *	187.905 (88.792, 287.018) ***	302.454 (231.544, 373.365) ***	117.569 (57.367, 177.772) ***	119.502 (53.253, 185.752) ***	221.187 (136.861, 305.513) ***
Age(years)	-1.116 (-1.190, -1.043) ***	-1.852 (-1.951, -1.753) ***	-2.392 (-2.463, -2.321) ***	-1.278 (-1.345, -1.212) ***	-1.620 (-1.693, -1.547) ***	-2.199 (-2.292, -2.106) ***
Height(cm)	0.146 (-0.292, 0.583)	0.204 (-0.386, 0.794)	-0.065 (-0.487, 0.357)	0.105 (-0.277, 0.488)	0.456 (0.035, 0.877) *	0.301 (-0.235, 0.838)
Weight(kg)	-0.097 (-0.660, 0.466)	-0.177 (-0.936, 0.582)	0.101 (-0.441, 0.644)	-0.090 (-0.627, 0.447)	-0.581 (-1.172, 0.010)	-0.316 (-1.069, 0.437)
BMI	1.065 (-0.513, 2.643)	0.464 (-1.664, 2.592)	-0.062 (-1.584, 1.461)	0.811 (-0.498, 2.121)	1.509 (0.068, 2.951) *	0.853 (-0.982, 2.687)
Chair sit and reach						
	5th Quantile	**50th Quantile**	**95th Quantile**	**5th Quantile**	**50th Quantile**	**95th Quantile**
Intercept	-55.597 (-142.478, 31.283)	34.846 (4.474, 65.219) *	37.101 (4.412, 69.791) *	-4.234 (-66.870, 58.403)	-1.417 (-24.622, 21.788)	13.994 (-16.122, 44.109)
Age(years)	-0.113 (-0.200, -0.026) *	-0.274 (-0.304, -0.244) ***	-0.121 (-0.153, -0.088) ***	-0.113 (-0.183, -0.044) ***	-0.245 (-0.270, -0.219) ***	-0.155 (-0.188, -0.122) ***
Height(cm)	0.209 (-0.308, 0.726)	-0.206 (-0.387, -0.025) *	-0.148 (-0.343, 0.046)	-0.099 (-0.497, 0.299)	0.027 (-0.120, 0.175)	-0.004 (-0.195, 0.187)
Weight(kg)	-0.299 (-0.964, 0.366)	0.287 (0.055, 0.519) *	0.167 (-0.083, 0.417)	0.154 (-0.405, 0.713)	-0.028 (-0.235, 0.179)	-0.005 (-0.273, 0.264)
BMI	1.406 (-0.459, 3.271)	0.012 (-0.640, 0.664)	-0.297 (-0.999, 0.405)	0.319 (-1.043, 1.682)	0.726 (0.221, 1.231) **	0.271 (-0.384, 0.926)
Back Scratch Test						
Intercept	-6.189 (-88.144, 75.766)	20.480 (1.222, 39.738) *	-5.497 (-60.564, 49.570)	1.239 (-63.158, 65.637)	-11.249 (-26.998, 4.499)	22.529 (-14.851, 59.908)
Age	-0.171 (-0.253, -0.089) ***	-0.238 (-0.258, -0.219) ***	-0.132 (-0.187, -0.077) ***	-0.172 (-0.243, -0.101) ***	-0.179 (-0.197, -0.162) ***	-0.142 (-0.183, -0.101) ***
Height	-0.180 (-0.668, 0.308)	-0.369 (-0.484, -0.255) ***	-0.006 (-0.334, 0.321)	-0.213 (-0.622, 0.197)	-0.175 (-0.275, -0.075) ***	-0.133 (-0.370, 0.105)
Weight	0.308 (-0.319, 0.936)	0.499 (0.352, 0.647) ***	0.005 (-0.417, 0.426)	0.301 (-0.274, 0.876)	0.251 (0.111, 0.392) ***	0.176 (-0.157, 0.510)
BMI	0.266 (-1.493, 2.026)	0.811 (0.398, 1.224) ***	0.770 (-0.412, 1.952)	0.331 (-1.070, 1.732)	1.374 (1.031, 1.716) ***	0.104 (-0.709, 0.917)
2.4-Meter Up-and-Go Test						
Intercept	1.724 (-1.074, 4.522)	2.083 (-4.000, 8.166)	17.519 (-0.419, 35.456)	4.642 (2.488, 6.796) ***	-1.541 (-7.331, 4.248)	-0.084 (-18.286, 18.118)
Age(years)	0.016 (0.013, 0.019) ***	0.098 (0.091, 0.104) ***	0.155 (0.137, 0.173) ***	0.012 (0.009, 0.014) ***	0.099 (0.092, 0.105) ***	0.177 (0.157, 0.197) ***
Height(cm)	0.012 (-0.005, 0.029)	-0.003 (-0.040, 0.033)	-0.101 (-0.208, 0.006)	-0.004 (-0.017, 0.010)	0.019 (-0.018, 0.056)	-0.009 (-0.125, 0.107)
Weight(kg)	-0.017 (-0.039, 0.004)	0.002 (-0.044, 0.049)	0.131 (-0.006, 0.269)	0.008 (-0.011, 0.027)	-0.022 (-0.073, 0.030)	0.019 (-0.143, 0.182)
BMI	0.008 (-0.052, 0.068)	-0.153 (-0.284, -0.023) *	-0.543 (-0.928, -0.158) **	-0.059 (-0.105, -0.012) *	-0.084 (-0.210, 0.042)	-0.185 (-0.581, 0.211)

Table 4 (continued)

Male				Female		
Quantile	**5th Quantile**	**50th Quantile**	**95th Quantile**	**5th Quantile**	**50th Quantile**	**95th Quantile**

*** WALD test P-Value Less Than 0.001

** WALD test P-Value Less Than 0.01

* WALD test P-Value Less Than 0.05

of mortality [26, 27], with its use as a screening tool for the risk of falls being recommended in clinical practice [23, 28]. In our study, both men and women demonstrated similar patterns of decline with age, a trend that aligns with findings from previous research [3, 6–10, 12, 13, 15]. However, the differences between individuals within each age group increased with advancing age. The 2.4-Meter Up and Go test performances were similar across various regions within different age groups [3, 6–8, 10, 12], albeit with minor variations. Specifically, men in Taiwan demonstrated slightly better performance in the younger age groups (ages 70–74) [6], while women in Poland exhibited slightly superior performance within the same age bracket [12].The 2.4-Meter Up-and-Go Test encompasses multiple facets of strength, balance, and mobility. The test demands core and lower body strength to transition from sitting to standing, as well as proficiency in stepping, acceleration, deceleration, and turning. Studies have linked an increased time on the 2.4-Meter Up-and-Go Test to Alzheimer's disease, suggesting that optimal performance requires a combination of motor skills and cognitive function [29, 30]. The complexity of the skills required for the test may contribute to the observed increase in the variation within age groups as individuals age.

This study has uncovered substantial heterogeneity in physical functioning among the elderly as they age, particularly in domains such as strength and dynamic balance, where the data distribution among the oldest age group exhibits greater variability. The human ageing process is shaped by a complex interplay of lifestyle, physiology, environment, and disease factors, and it continuously regulates and modifies all processes throughout the entire lifespan [31], which can lead to the heterogeneity observed in the elderly population. This diversity underscores the imperative for personalized interventions that can effectively address the unique needs of each individual. While some elderly individuals may sustain high levels of physical function and continue to participate in activities such as travel and work, others may encounter declines in health and mobility, necessitating more comprehensive support and care. The World Health Organization (WHO) has characterized healthy ageing as a process that involves maintaining functional ability to ensure well-being in older age, encompassing both mental and physical capacities [31]. Recognizing and adapting to this heterogeneity is crucial for fostering healthy ageing and for ensuring the well-being of the elderly.

In summary, the current research offers critical insights into the physical fitness of Chinese seniors, serving as both a valuable benchmark for regional studies and a practical tool for clinicians. The Senior Fitness Test (SFT) is simple to administer, does not require complex equipment, and is suitable for use in both clinical and community settings. It assesses various fitness dimensions, enabling healthcare professionals to customize evaluations based on individual needs. Clinicians can opt for specific tests targeting strength, endurance, balance, or flexibility or conduct comprehensive tests for an overall fitness assessment. This method facilitates the identification of necessary interventions, supports ongoing progress tracking, and allows for benchmarking against established norms, streamlining the assessment process. These thorough evaluations are crucial for assessing fall risks, monitoring physical function decline, and creating personalized fitness programs that improve the quality of life for older adults, thereby helping to delay or prevent age-related physical decline.

Strength and limitations

The current study offers a robust foundation for understanding the physical fitness landscape of elderly Chinese populations, with its normative values derived from a substantial sample size (n=21,305) in Eastern China. Unlike statistical modeling, which was not utilized to estimate data distributions, the direct calculation of all percentiles from raw data ensures a transparent and accurate representation of the data.

A notable limitation of this study is its cross-sectional design, which, while valuable for providing a snapshot of physical fitness in the elderly, falls short of the insights that longitudinal studies could offer. Longitudinal studies would enable the tracking of natural changes in fitness over time. Despite this limitation, cross-sectional data, when accurately assessed and analyzed, holds significant value for the aging population. Furthermore, the study's focus on community-dwelling elderly individuals in Hangzhou, located in the more developed eastern part of China, limits the generalization of the findings to other regions of China. Expanding the sample to include a more diverse demographic is essential for advancing the representativeness of future research findings.

Conclusions

This study underscores the significance of addressing gender-specific differences and age-related declines in strength, endurance, flexibility, and dynamic balance to promote more individualized approach in realize healthy aging and enhance overall well-being. Recognizing the multifaceted nature of physical fitness in aging populations, the design of tailored interventions is imperative to support individuals in maintaining optimal physical fitness throughout their later years.

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Author contributions

Shulan Yang and Wanqi Yu wrote the main manuscript text and Shulan Yang prepared Figs. 1 and 2. Xiongang Huang designed the study, and Xiaoling Lv interpreted the data. All authors reviewed the manuscript.

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Data availability

All data are incorporated into the article.

Declarations

Ethical approval

Ethics approval for this project was provided by the Ethics Review Committee of Zhejiang Hospital with the approval number 2022LSD (121 K). All individuals gave their informed consent before participating.

Competing interests

The authors declare no competing interests.

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