Trends in the Decline in Gait and Motor Ability of Older Adults: A Case Study Based on SHARE Data

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Abstract. This study analyzed data from the SHARE study to compare the gait speed of older adults in European countries and China and to explore the association of gait speed with other physical abilities. Given that the motor development of children follows a cephalocaudal and proximodistal trend, the declining trend of older adults' physical abilities was also analyzed. The results showed that, on average, older adults in China walked faster than older adults in European countries. Slower gait speed and weaker grip strength were observed for older adults with worse motor abilities. Furthermore, this study found that the decline in motor abilities of older adults accelerated with age. The participants' lower-extremity abilities showed earlier and more rapid decline than the abilities of the upper extremities and hands. This study helps to better understand the health condition and aging process of older adults.

Keywords: Older adults · Gait · Motor ability · Decline trend

1 Introduction

Aging often leads to degeneration of both the cognition function and physical function of the elderly. It is well known that these two functions are inter-related, both playing roles in the decline in mobility in activities such as walking. The lower cognitive function and weak muscle power observed in older adults are associated with slower gait speed [1–6]. Gait speed is used to predict the risk of disability, cardiovascular disease, dementia and even mortality of older adults [7, 8].

The dynamic systems theory of motor development suggests that the behavior of walking is not a single motor skill. It is a dynamic system consisting of various single motor abilities like crawling, standing, arm-reaching movements and stepping [9]. Moreover, studies focused on the motor development of children found that the organization and direction of motor development in infants shows a significant cephalocaudal trend and proximodistal trend [10]. The cephalocaudal trend refers to earlier control of the head than the arms, and earlier control of the arms and torso than the legs. The proximodistal trend refers to earlier control of the head, torso and arms than coordination of the hands and fingers. This raises the interesting possibility that the decline in motor ability of older adults might follow a similar trend.

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Furthermore, cultural differences in infant-raising methods are also known to influence the development of motor skills [11–13]. Thus, we can assume that these cultural differences might also influence the gait speed of older adults. Therefore, this study aimed to (1) compare the gait speed of several European countries and China, (2) explore whether the relationship between gait speed and motor abilities differs due to changes in the abilities of different body parts, and (3) explore the declining trend in motor ability of older adults and identify when this decline begins to accelerate. The results from this study will provide a better understanding of the physiology and aging process of older adults.

2 Methodology

2.1 Study Population

The Survey of Health, Aging and Retirement in Europe (SHARE) collects data on the health, socioeconomic status and social and family networks of people aged over 50 years. The survey started in 2004, and five panel waves (waves 1, 2, 4, 5 and 6, shown in Table 1) [14–18] and one retrospective life history wave (wave 3) have been conducted, covering more than 120,000 individuals across 27 European countries and Israel. Computer-assisted personal interviewing (CAPI) was used for the main interviews, in addition to paper and pencil surveys for drop-offs. The CAPI questionnaire has remained almost the same over the subsequent waves. Detailed and rigorous instruction about the questionnaire and interviewing process guarantees the reliability of the data.

Table 1. Year, number of respondents and data collected in SHARE study waves 1, 2, 4, 5 and 6.

	Wave 1	Wave 2	Wave 4	Wave 5	Wave 6
Year	2004	2006	2011	2013	2015
Number of respondents	30,434	37,174	58,184	66,221	68,231
Gait speed	√	√			
Chair stand		√		√	
Grip strength	√	√	√	√	√
Motor ability	√	√	√	√	√

Note: √ indicates that the module was measured in the wave.

To analyze the gait speed of participants from different countries, the data from wave 2 was used. Individuals from the only non-European country, Israel, were excluded. A total of 3479 individuals aged 50 or older from 13 countries who successfully finished the walking test were included in the analysis sample. The gait speed data of older Chinese adults was obtained from a study by [19], which included 50 adults aged over 50 years from Beijing. For analysis of the declining trend, individuals who did not participate in the follow-up waves were excluded from the baseline wave 1 when corresponding factors were analyzed.

2.2 Gait Speed

Participants in the SHARE study conducted two walking tests on the premise of walking without the help of another person or using support, as well as feeling safe to walk. The respondents walked 2.5 m two times in the condition of available space. The time taken to complete each walking test was recorded in seconds. Respondents whose time for any walking test was less than 1.5 s which might not be a comfortable speed [20] were excluded. The gait speed for each test was calculated by dividing the time by 2.5 m, and gait speed was expressed as meters per second. Participants in the study by [19] were instructed to walk 10 m at a comfortable speed while wearing a smart bracelet. The average gait speed under this condition was taken into consideration.

2.3 Measurement of Motor Abilities

Self-reported mobility difficulties while performing 10 activities were recorded (walking 100 m, sitting for about 4 h, getting up from a chair, climbing several flights of stairs, climbing one flight of stairs, stooping, reaching arms, pulling or pushing objects, lifting or carrying objects, and picking up a coin). Considering the motor development trends of children, the motor abilities of older adults were categorized into the abilities of the hands, upper extremities and lower extremities [21]. The upper-extremity ability was defined as a binomial variable where the respondent reported having no difficulty or difficulty in at least one of the following activities: reaching arms, pulling or pushing objects, lifting or carrying objects, and sitting for about 2 h. The lower-extremity ability was defined as the respondent having no difficulty or difficulty in at least one of the following activities: climbing several flights of stairs, climbing one flight of stairs, stooping, kneeling or crouching, getting up from a chair, and walking 100 m. The hand ability refers to whether the respondent reported difficulty in picking up a coin.

The grip strength was analyzed as a continuous variable, indicating the respondent's hand-related ability. Both hands of each respondent were measured two times using a handheld dynamometer. The maximum value from the four measurements was used in the analysis [22]. The chair stand activity, representing lower-extremity ability, was measured by instructing respondents to stand from a chair five times, and the total time was recorded in seconds.

2.4 Confounders

The demographic information of respondents, including age and gender, were treated as potential confounders. Age was classified into four groups based on the respondents' age range: 50–60, 61–70, 71–80, 81–90, and 91–100 years. In addition, the current health condition of participants, consisting of smoking, alcohol consumption and physical activity, was also included. The smoking status was classified into three levels: never, former, and current [7, 22]. Alcohol consumption was measured by asking respondents how often they had consumed any alcoholic drinks during the past 3 months, with seven levels of response: almost every day, five or six days a week, three or four days a week, once or twice a week, once or twice a month, less than once a month, not at all in the past 3 months. Physical activity was measured by asking the respondent how often they engage in vigorous physical activity such as sports, heavy housework or a job that involves physical labor, which was recorded in four levels: more than once a week, once a week, one to three times a month, and hardly ever or never [23, 24].

2.5 Statistical Analysis

Means and standard deviations were used to describe the gait speed and grip strength of respondents in wave 2. Factorial analysis of variance (ANOVA) was used to analyze differences between two measurements in groups with different characteristics. Three samples were extracted: the sample including 1272 individuals who completed the walking test in both wave 1 and wave 2, the sample including 9947 individuals who completed the chair stand measurements in both wave 2 and wave 5, and the sample including 5069 individuals who completed the grip strength measurement in all five waves. Factorial repeated-measures ANOVA was used to analyze the variation in gait speed, chair stand time, grip strength and motor abilities across waves for each age group. The variation in extremity abilities for each age group across waves was determined by comparing the proportion of respondents who reported difficulty in extremity ability relative to the total number of respondents in each group. All statistical analyses were performed using R 3.5.1 software.

3 Results and Discussion

3.1 Comparison of Gait Speed Between Countries

The average age of respondents in wave 2 was 79.65 years (SD = 4.17), and the average gait speed was 0.68 m/s (SD = 0.30). As shown in Table 1, the gait speed differed significantly across countries ($F_{(13,3465)} = 27.855$, $p < 0.001$). Moreover, post hoc tests revealed potential regional differences [25]. The gait speed in three southern European countries, Italy, Spain and Greece, did not show any significant differences (Spain-Italy, $t = -3.233$, $p = 0.054$; Spain-Greece, $t = -1.574$, $p < 0.001$; Italy-Greece, $t = 1.784$, $p < 0.001$). However, the gait speed of respondents from these countries was lower than those in Germany, which is in central Europe (Germany-Italy, $t = 2.633$, $p = 0.32$; Germany-Spain, $t = 5.483$, $p < 0.001$; Germany-Greece, $t = 4.27$, $p < 0.01$), and the gait speed of participants in Germany was slower than those in Denmark and Sweden, which are northern European countries (Germany-Denmark, $t = -5.234$, $p < 0.001$; Germany-Sweden, $t = -4.289$, $p < 0.01$). The gait speed of older adults in Beijing, China, was faster than all European countries. Another two studies that measured the average gait speed of older adults in Hong Kong [26] and Chongqing [27] reported gait speeds of 0.78 m/s (SD = 0.214) and 0.86 m/s (SD = 0.14) respectively, which were also faster than most European countries evaluated in the SHARE study.

Table 2. Gait speed and grip strength according to the selected measure.

Selected measure	Gait speed (m/s)			Grip strength (kg)	
	N	Mean (SD)	p	Mean (SD)	p
Age (years)			<0.01		<0.01
58–70	4	0.65 (0.28)		28.75 (3.50)	
71–80	2231	0.71 (0.31)		28.96 (9.59)	
81–90	1187	0.63 (0.29)		25.63 (9.08)	
91–100	57	0.52 (0.29)		20.75 (7.55)	
Sex			<0.01		<0.01
Male	1637	0.71 (0.31)		34.52 (8.20)	
Female	1842	0.65 (0.30)		21.62 (5.96)	
Country			<0.01		<0.01
Austria	122	0.64 (0.32)			
Germany	157	0.67 (0.28)			
Sweden	365	0.78 (0.29)			
Netherlands	295	0.71 (0.29)			
Spain	251	0.51 (0.30)			
Italy	248	0.59 (0.25)			
France	313	0.71 (0.29)			
Denmark	349	0.81 (0.31)			
Greece	292	0.54 (0.31)			
Switzerland	195	0.76 (0.28)			
Belgium	412	0.70 (0.34)			
Czech Republic	213	0.71 (0.34)			
Poland	176	0.55 (0.25)			
Ireland	91	0.65 (0.30)			
China (Beijing)	50	1.33 (0.07)			
Lower-extremity ability			<0.01		<0.01
No difficulty	1405	0.76 (0.31)		30.46 (9.45)	
Difficulty in at least one activity	2074	0.62 (0.28)		25.82 (9.22)	
Upper-extremity ability			<0.01		<0.01
None difficulty	2105	0.74 (0.30)		30.22 (9.40)	
Difficulty in at least one activity	1374	0.59 (0.28)		23.81 (8.52)	
Hand ability			<0.01		<0.01
No difficulty	3332	0.68 (0.30)		27.92 (9.55)	
Difficulty	147	0.54 (0.27)		22.48 (8.94)	
Smoker			0.27		0.36
Former	305	0.70 (0.30)		30.26 (9.47)	
Current	363	0.68 (0.29)		30.17 (9.90)	
Never	2811	0.67 (0.30)		27.09 (9.47)	
Alcohol consumption			<0.01		<0.01
Almost every day	842	0.71 (0.30)		29.92 (9.47)	

(*continued*)

Table 2. (*continued*)

Selected measure	Gait speed (m/s)			Grip strength (kg)	
	N	Mean (SD)	p	Mean (SD)	p
Five or six days a week	85	0.76 (0.35)		33.84 (10.12)	
Three or four days a week	197	0.77 (0.28)		31.76 (9.50)	
Once or twice a week	462	0.74 (0.30)		29.30 (9.78)	
Once or twice a month	338	0.72 (0.30)		28.03 (9.57)	
Less than once a month	329	0.66 (0.29)		26.25 (9.23)	
Not at all	1226	0.60 (0.29)		24.77 (8.68)	
Vigorous physical activity			<0.01		<0.01
More than once a week	680	0.76 (0.32)		30.75 (9.86)	
Once a week	346	0.76 (0.31)		29.69 (9.53)	
One to three times a month	336	0.69 (0.32)		29.22 (9.79)	
Hardly ever, or never	2117	0.63 (0.28)		26.14 (9.13)	

3.2 Gait Speed and Motor Ability

The differences in gait speed and grip strength according to the respondents' characteristics are shown in Table 2. The average grip strength was 26.68 kg (SD = 9.59). Older adults who reported no difficulty in upper-extremity, lower-extremity and hand abilities walked faster than those who reported at least one difficulty. Furthermore, an interaction of upper-extremity and lower-extremity abilities on gait speed was observed ($F_{(1,3166)} = 12.62$, $p < 0.001$). Older adults who reported no difficulty in both the upper and lower extremities had a faster gait speed (0.77 m/s, SD = 0.31) than those who reported at least one difficulty in any ability. Older adults who reported at least one difficulty in upper-extremity ability but no difficulty in lower-extremity ability (0.73 m/s, SD = 0.30) walked faster than those who reported no difficulty in upper-extremity ability but at least one difficulty in lower-extremity ability (0.69 m/s, SD = 0.28). However, superiority in gait speed was not reflected in grip strength. The former had weaker grip strength (25.53 kg, SD = 7.88) than the latter (28.83 kg, SD = 9.16), which indicated that difficulties in different extremities were related to changes in abilities. These benefits infer extremity-related abilities through gait and grip strength, thus further predicting physical limitation and risk of disability rather than predictions based only on measuring activities of daily living or instrumental activities of daily living (ADLs/IADLs) [2].

3.3 Declining Trend

Regarding the decline in gait speed, there was a significant effect of age group ($F_{(2,2538)} = 12.67$, $p < 0.001$) and wave ($F_{(1,2538)} = 57.81$, $p < 0.001$) on gait speed. As shown in Table 3, respondents in the older group had a slower gait speed. The decreased gait speed of the 71–75-year age group after 2 years was not significant when compared to the other age groups, which indicates that adults aged older than 76 experienced a significant decline in gait speed. However, the decreased gait speed in each age group did not significantly differ after 2 years ($F_{(4,1267)} = 0.474$, $p > 0.05$). The gait degeneration and age were negatively related ($r = -0.016$, $p > 0.05$), which indicates that gait slowed down, but that the change was slower with increasing age.

Table 3. Gait speed of wave 1 and wave 2

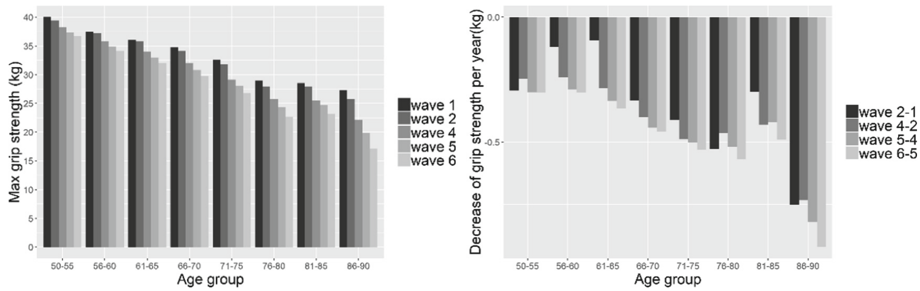
Gait speed (m/s)					
Age group (years)	N	Wave 1	Wave 2	Change	T-test
		Mean (SD)	Mean (SD)		
71–75	67	0.67 (0.26)	0.63 (0.28)	−0.04	t = −0.938, p = 0.352
76–80	739	0.75 (0.28)	0.68 (0.29)	−0.07	t = −0.883, p < 0.001
81–85	336	0.67 (0.26)	0.62 (0.28)	−0.05	t = −3.677, p < 0.001
86–90	105	0.61 (0.30)	0.53 (0.30)	−0.08	t = −3.270, p < 0.01
91–95	25	0.58 (0.26)	0.55 (0.31)	−0.03	
Sum	1272	0.71 (0.28)	0.65 (0.29)		

Regarding the decline in chair stand ability, the main effect of age group ($F_{(4,9969)} = 58.12$, $p < 0.001$) and wave ($F_{(1,9969)} = 148.74$, $p < 0.001$) on the time to complete five chair stands were significant. Moreover, the increased time after 7 years of each age group differed with each other ($F_{(4,9969)} = 4.39$, $p < 0.01$). The increased time for the 66–70 age group was significantly higher than that of the 51–55 age group ($t = 2.861$, $p < 0.05$), and the increased time of the 71–75 age group was greater than that of the 51–55 ($t = 3.327$, $p < 0.01$) and 56–60 ($t = 2.986$, $p < 0.05$) age groups. Given that the increased time to complete the chair stands was positively related to age ($r = 0.042$, $p < 0.001$), it was speculated that for older adults, the time required to stand from a chair and the change per year was increased with advancing age, especially for those aged 66 years or older (Table 4).

Table 4. Time to perform five chair stands of respondents in wave 2 and wave 5.

Chair stands (s)					
Age group (years)	N	Wave 2	Wave 5	Change	T-test
		Mean (SD)	Mean (SD)		
51–55	2342	10.52 (6.40)	11.25 (7.51)	0.73	t = 3.793, p < 0.001
56–60	2730	10.81 (6.03)	11.69 (6.83)	0.88	t = 5.392, p < 0.001
61–65	2251	11.13 (6.16)	12.39 (6.97)	1.26	t = 6.926, p < 0.001
66–70	1747	11.98 (7.67)	13.56 (8.82)	1.58	t = 5.972, p < 0.001
71–75	904	12.36 (7.05)	14.32 (8.70)	1.96	t = 5.523, p < 0.001
Sum	9947	11.16 (6.58)	12.31 (7.65)		

When analyzing the decline in grip strength, there was a significant effect of age group ($F_{(7,25302)} = 343.23$, $p < 0.001$) and wave ($F_{(4,25302)} = 126.31$, $p < 0.001$). As expected, older adults had weaker grip strength, and their grip strength became weaker over time. We also observed that there were significant effects of age group ($F_{(7,21)} = 10.18$, $p < 0.001$) and wave ($F_{(3,21)} = 1102.75$, $p < 0.001$) on the decrease in grip strength between waves. As shown in Fig. 1, the grip strength of each age group did not decline equally, with a faster decline observed with increasing age. On average, the older age group showed a greater decrease in grip strength per year when compared to the younger age group, demonstrating an accelerated decline trend.



(a) (b)

Fig. 1. Grip strength of different age groups over subsequent study waves (a), and the decrease in grip strength between waves (b).

For analysis of motor ability decline, the upper-extremity ability, lower-extremity ability and hand ability were measured according to age group and wave number. Figure 2 shows the proportion by age groups and waves. In both the comparison between age groups and the comparison between waves, there was a larger proportion of respondents who had difficulty in motor ability with increasing age. In each age group, the proportion of older adults who had difficulties in their lower-extremity ability was highest, followed by the proportion of those who reported difficulty in their upper-extremity ability. When compared to upper- and lower-extremity abilities, very few older adults reported difficulty in their hand ability. On average, lower-extremity ability declined faster than upper-extremity ability, while hand ability declined the slowest. Although a small improvement was observed between two certain waves [27], the three kinds of motor abilities generally declined with age, especially from 66 years of age. The motor abilities of these older adults showed a faster decline between waves when compared to the younger age groups.

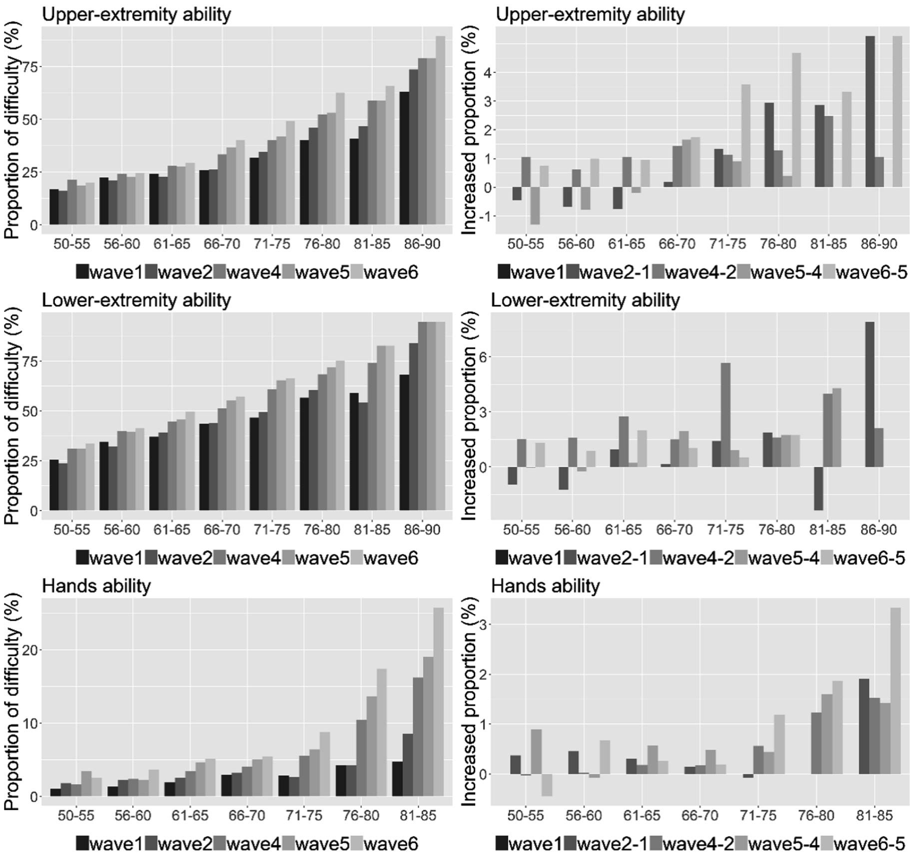


Fig. 2. The proportion of older adults with difficulties in upper-extremity, lower-extremity and hand abilities in each age group across waves and the increased proportion of older adults who had difficulties in the corresponding motor ability compared with last wave.

4 Conclusions

This study analyzed data from the SHARE study in order to compare the gait speed of participants in certain European countries and China. The results showed that older Chinese adults walked 0.31 m/s faster than older adults in Europe, and this difference in gait speed can reveal cultural and regional differences to a certain extent. This study divided the motor ability into upper-extremity ability, lower-extremity ability and hand ability, inspired by the motor development trend of children, and found that the gait speed of respondents differed significantly between those who reported at least one difficulty in upper-extremity ability and those who reported no difficulty. Slower gait speed was associated with worse upper-extremity ability, with a similar effect observed in lower-extremity ability and hand ability.

The longitudinal data for gait speed, chair stand time, grip strength and motor ability showed that the physical abilities of older adults not only declined, but declined at a faster rate after the age of 66 years. The older the participant, the more quickly their motor abilities degenerated. In addition, contrary to the cephalocaudal trend and proximodistal trend of motor development of children, older adults' lower-extremity ability declined sooner and more quickly than the decline in upper-extremity ability and hand ability.

Some limitations of this study should be noted. Firstly, the sample was not representative of older adults in China. Secondly, the methods of measuring gait were not exactly the same in all studies, therefore, the comparison of gait speed across countries requires more in-depth study.

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