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ORIGINAL RESEARCH

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Higher levels of physical activity is associated with better walking ability and fall-related fitness of older adults during COVID-19 in China

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Abstract

This study analyzed the relationship of physical activity levels with walking ability and fall-related fitness in older adults in the Henan Provence, China. Physical activity levels of 288 older adults were assessed using the short form of the International Physical Activity Questionnaire. The participants were divided into low (LPAG, n = 81), moderate (MPAG, n = 106), and high physical activity groups (HPAG, n = 101). The 10-m walking test (10MWT), 3-m backward walking (3MBW), and Berg Balance Scale (BBS) were used to evaluate walking ability. Thirty seconds Sit to Stand Test (30SST), Time up and Go Test (TUGT), and figure-of-8 walk test (8WT) were evaluated for fall-related fitness. One-way ANOVA was used to detect between group differences, whilst Pearson's correlation was used to evaluate the relationship between total physical activity level and the measured variables. Logistic regression analyses were used to compute the odds ratios (ORs) of LPAG and MPAG relative to HPAG. There were significant differences between the groups for walking ability, 10MWT ($p < 0.01$), 3MBW, and BBS ($p < 0.01$), and also for variables of fall-related fitness, TUGT ($p < 0.01$), and 8WT ($p < 0.01$). Total physical activity levels had significant correlations with all variables except 30SST. In the walking ability, OR for 10MWT was 2.42 and 2.53 times for the LPAG compared to that for HPAG by model 1 and model 2. OR for BBS was 3.24 and 3.54 times for the LPAG and 9.31 and 9.65 times for the MPAG compared to for the HPAG by model 1 and model 2. In the fall-related fitness, OR for 8WT was 14.09 and 16.76 times for the LPAG compared to that for HPAG. High levels of physical activity are positively correlated with good walking ability and fall-related fitness. Increasing physical activity levels can reduce the risks associated with impaired walking ability and fall-related fitness.

Keywords

Physical activity level; Older adults; Walking; Fall; China

1. Introduction

Adults aged 65 or older currently account for 13.5% of the total population in China [1]. Furthermore, it has been predicted that the older adult population will continue to increase at the rate of 1 million people per year until 2025 [2]. In China, 31.7% of the older adults are reported to have one or more of the four chronic diseases [3]. As increase in the population is closely related to increase in medical expenses [4], improving health outcomes, particularly among the older adults, is imperative in today's society.

Lack of physical activity is a key cause of health deterioration in the older adults [5] and is strongly related to the risk of chronic illness and death observed in this population [6, 7]. Such is the case in China, where results of a 9-year-long follow-up study conducted among Chinese people indicated that 6.8% of the total mortality was associated with lack of physical activity [8], and an increase in age was associated with a decrease in levels of physical activity. Therefore, the World Health Organization has put forth exercise guidelines for health maintenance among the older adults, which consists of a minimum of 150 to 300 min of moderate-intensity aerobic exercise or 75 to 150 min of high-intensity aerobic exercise per week [9]. However, one-third of older adults aged 70–79 and half of those aged 80 or older do not satisfy these recommendations [10]. Results of a survey conducted by the Chinese Center for Disease Control and Prevention reported that 71% of China's population aged 60 years or older do not participate in any moderate-to-high intensity physical or leisure activities [4].

Walking is executed through a complex mechanism that includes interactions between neural, perceptive, and cognitive functions [11]. Walking ability is particularly important as it reflects the capacity for physical activity and functional independence in the older adults and is used as an indicator of health and physiological decline [12]. The reported incidence for abnormal gait is 11% in people in their 60s, 37% for people in their 70s, and 61.7% for people in their 80s, indicating worsening of the problem with age [13]. In particular, walking speed, stride, and foot joint movement were reported to decrease with increased age [14]. Among the walking ability variables, walking speed is highly correlated with functional physical fitness [15], along with functional status and mortality rate [16]. Results of a study conducted in older Chinese population residing in Hong Kong indicated that decreases in walking speed and stride length are associated with increases in dependency, mortality rate, and admission to social welfare organizations [17]. Thus, previous research suggests that walking ability is a key health factor that affects health status and quality of life in the older population.

Decreases in walking ability can be caused by decrease in lower extremity muscle strength and a decline in coordination, ultimately leading to injuries from falls [18]. A longitudinal population-based study indicated that slow walkers showed greater risk of indoor falls and tended to be less active [19]. Furthermore, a systematic review concluded that gait speed was found to be a consistent risk factor for falls and disability [20]. However, over 30% of the older adult population aged ≥65 years suffers from one or more falls annually [21], despite suggestions of fall risk prevention measures, such as the maintenance of appropriate physical activity levels or promotion of physical activity levels [22]. Related studies have indicated that high levels of physical activity above 22 METs can reduce fall risk by up to 50% [23]. Furthermore, an investigation of the effect of physical exercise intervention for fall prevention indicated that improvement of knee strength leads to fall risk reduction [24]. In reality, older adults who experience a decline in their balance ability suffer from more falls compared to people without such issues, which shows that muscular strength and balance are crucial factors that prevent falls in this population [25].

In summary of the evidence thus far, physical fitness is closely related to walking ability and fall risk. Moreover, it has been shown that both limitations in walking ability and fall risk are lower when physical activity levels are higher. However, there is little research to date on physical activity levels among the older adult population residing in China, even at a regional level. Therefore, this study aimed to investigate physical activity levels among the older adults in China's Henan Province as well as the correlation of physical activity with walking ability and fall-related fitness in this region.

2. Materials and methods

2.1 Participants

This study included 300 racially similar men and women aged 65 years or older residing in Henan Province, China. Participants were recruited by a word-of-mouth recruitment drive conducted through an elementary school in Henan province, China. Healthy and >65-year-old grandparents of the school students were recruited. Those who were unable to walk at normal pace due to orthopedic problems or behavior/cognitive disorders such as depression and impaired cognition were excluded. A total of 288 people (139 men, 149 women) were included in the final analysis. Surveys and fitness tests were conducted at the indoor basketball court of the elementary school after acquiring written consent from all participants.

2.2 Measurements

All measurements were conducted by seven well-trained instructors from the University. Measurement methods were reviewed and practiced to enhance intra-reliability.

2.2.1 Physical characteristics

The participants' height (cm) and weight (kg) were measured (MG001, Meilen, China) once and body mass index (BMI, kg/m^2) was calculated based on these values.

2.2.2 Physical activity level

The Chinese version of the short form of the International Physical Activity Questionnaire (IPAQ) was used to determine the physical activity levels of participants [26]. Participants were instructed to recall their physical activities from the past 7 days to complete the survey. To help with the participants' understanding of the questions, a researcher provided an explanation for each item before instructing the participants to write down their answers. The IPAQ consisted of survey items asking participants to report the frequency (days/week) of physical activity, such as low (walking), moderate-intensity, and high-intensity physical activity, and the average duration (min/day) of each physical activity. The amount of physical activity for each intensity (low, moderate, high) was calculated using a formula, and the total amount of physical activity was computed as the sum (MET-min/week) of the amount of physical activity for each intensity [27]. Participants with a total amount of physical activity exceeding 3000 MET-min/week were assigned to the high physical activity group (HPAG), those who exceeded 600 but were below 3000 MET-min/week were assigned to the moderate physical activity group (MPAG), and those below 600 MET-min/week were assigned to the low physical activity group (LPAG) [28]. The IPAQ has been reported to be appropriate, valid, and reliable for use in the older adult population aged 65 or older [29].

2.2.3 Walking capacity

2.2.3.1 Ten-minute walk test

The 10-m walk test (10MWT), which is the most widely used and recommended method, was conducted to evaluate walking speed [30, 31]. To prevent acceleration and deceleration at the start- and finish-lines from interfering with the results, 2-m buffers were added to both, which meant the participants walked a total of 14 m using their regular gait. The time taken to walk 10 m at a normal pace was recorded in seconds. Walking speed was calculated as distance/time (m/s). The test was repeated twice, and the average value from the two measurements was used [32].

2.2.3.2 Three-minute backward walking

The 3-m backward walking test (3MBW) is a tool for assessing difficulty with daily activities in older adult populations or in cases of disability [33]. For this evaluation, safety cones were placed at 3-m intervals and the participants were instructed to walk backwards from the starting point until their heel passed the finishing point. The time taken to complete the test was measured and recorded in seconds.

2.2.3.3 Berg balance scale

The Berg Balance Scale (BBS), a tool to predict probability of independent walking capacity in daily life, is used to evaluate fall risk. The reliability of this tool has been reported to be 0.96 or higher [34]. This test consists of a total of 14 items relating to functional activities executed in everyday life, with each item being scored on a scale ranging from 0 to 4 points. The total score of all items was 56 points and was interpreted as follows: those scoring 40 points or higher were considered capable of independent walking, those scoring 20–40 points were considered to be needing some form of walking assistance, and those with a score of 20 points or less were considered to be incapable of walking. The reliability and validity of this test has been reported [35]. The Berg balance scale score was measured by well-trained instructors.

2.2.4 Fall-related fitness

2.2.4.1 Thirty-seconds sit to stand test

Thirty-seconds Sit to Stand Test (30SST) was conducted to evaluate lower extremity muscle strength. Participants were instructed to sit in the center of a chair with a backrest with their arms crossed in front of their chest. On the start signal, the participants were then instructed to stand up completely and sit down, which was measured as 1 count, and to repeat this as many times as possible. The number of repetitions completed in 30 s was recorded [36, 37].

2.2.4.2 Timed up and go test

Timed Up and Go Test (TUGT) was conducted to evaluate active balance ability. Starting from a sitting position, participants were instructed to stand up from their chair, walk around a cone placed 3 m away, and come back and sit back down, as fast as possible. The test was performed twice, and the better of the two times, recorded in seconds, was selected for use [38, 39].

2.2.4.3 Figure-of 8 walk test

Figure-of 8 walk test (8WT) was conducted to evaluate coordination ability. A rectangle of 3.6 m length and 1.6 m width was marked with safety cones placed at the corners, and a chair placed 2.4 m away from both points on either side of the rectangle. After placing safety cones at either side of the chair in the center, the participants were instructed to sit in one chair, and on the start signal, go around the cone to the right rear and sit in the opposite chair. Participants were then instructed to stand and go around the cone to the left rear and return to sit in the original chair. The time taken to complete this test was recorded in seconds. The inter-rater reliability and inter-measurement reliability of this test method has been reported to be 0.90 and 0.84, respectively. The inter-rater reliability and inter-measurement reliability of the number of steps has been reported to be 0.92 and 0.82, respectively [40].

2.3 Statistical analysis

Data obtained from the current study were analyzed using the SPSS 22.0 (IBM Corp., Chicago, IL, USA) statistical analysis software. Based on the results of the IPAQ [28], the participants were assigned to one of the following groups: low physical activity group (LPAG, n = 81), moderate physical activity group (MPAG, n = 106), and high physical activity group (HPAG, n = 101). To compare differences in walking ability (10MWT, 3MBW, and BBS) and fall-related fitness (30SST, TUGT, and 8WT) among the groups by physical activity levels (LPAG, MPAG, HPAG), one-way analysis of variance and the Scheffé test were used. Pearson's correlation was used to investigate the relationship between total amount of physical activity and the measured variables. Logistic regression analysis was used to compute the odds ratio of all variables related to walking ability and fall-related fitness according to physical activity levels, using the HPAG as reference. Having poor physical function was defined as either taking <1.0 m/s for the 10MWT [41] or scoring <40 points for the BBS [42]. The cut-off points for the fall-related fitness variables were based on evaluation standards provided in the National Fitness Award [35] for the age group of interest and used Low Class 3 (percentile rank 30) for 30SST, TUGT, and 8WT. Participants higher than Class 3 were evaluated as lower risk. Two logistic regression models were used: Model 1, which was computed without adjusting for gender, age, and BMI, and Model 2, which was calculated with adjustments for these variables. Statistical significance was set at $p < 0.05$.

3. Results

3.1 Physical characteristics

The physical characteristics of the participants can be seen in Table 1. Number subjects of each group, mean age, and BMI were not significantly different between groups ($p < 0.05$).

3.2 Differences in walking ability based on level of physical activity

Results of the comparative analysis of the different walking abilities between groups based on levels of physical activity are shown in Table 2. 10MWT and BBS were positively associated with significant difference between the groups by level of physical activity ($p < 0.01$). 3MBW was negatively associated with significant difference between the groups by level of physical activity ($p < 0.01$). Results of post-hoc analysis indicated significant differences in 10MWT, 3MBW, and BBS in the LPAG than in the MPAG and HPAG ($p < 0.01$).

3.3 Differences in fall-related fitness based on level of physical activity

Results of the comparative analysis of fall-related fitness between groups based on levels of physical activity are shown in Table 3. There were no significant between group differences regarding 30SST ($p > 0.05$). Results of post hoc analysis indicated significant differences in TUGT ($p < 0.01$) and 8WT ($p < 0.01$) in the LPAG compared to the MPAG and HPAG.

TABLE 1. General characteristics of the participants.

Variables	Gender	LPAG (n = 81)	MPAG (n = 106)	HPAG (n = 101)	*p*	Total (n = 288)
Gender						
	Male	39	44	56		139
	Female	42	62	45		149
	Total	81	106	101	0.13	
Age (years)						
	Male	70.15 ± 4.99	69.80 ± 4.70	69.95 ± 3.31		69.99 ± 4.04
	Female	71.48 ± 4.25	70.53 ± 5.27	68.80 ± 3.23		70.10 ± 4.71
	Total	70.69 ± 4.72	70.10 ± 4.95	69.45 ± 3.31	0.16	70.04 ± 4.39
BMI (kg/m^2)						
	Male	23.97 ± 3.50	24.15 ± 3.60	23.40 ± 3.03		23.57 ± 3.22
	Female	24.41 ± 4.33	24.85 ± 3.80	24.18 ± 3.68		24.67 ± 3.90
	Total	24.15 ± 3.84	24.46 ± 3.69	23.74 ± 3 .33	0.36	24.123 ± 3.61
Total Physical Activity (MET-min/week)						
	Male	660.99 ± 488.64	1796.79 ± 77.99	5477.91 ± 594.26		2938.44 ± 2211.01
	Female	594.16 ± 346.20	1704.50 ± 850.12	3919.11 ± 689.35		2070.22 ± 1477.12
	Total	637.99 ± 423.03	1743.67 ± 813.77	4798.83 ± 10.00	<0.01*	2501.32 ± 1924.21

Data are expressed as mean ± standard deviation.
BMI, body mass index; LPAG, low physical activity group; MPAG, moderate physical activity group; HPAG, high physical activity group.
**p < 0.05; tested using one-way ANOVA.*

TABLE 2. Walking ability differences between groups.

	LPA (n = 81)	MPAG (n = 106)	HPAG (n = 101)	F	*p*
10MWT (m/s)	0.10 ± 0.19 ^{ab}	1.14 ± 0.23	1.17 ± 0.23	14.86	<0.01*
3MBW (s)	5.79 ± 0.17 ^{ab}	4.66 ± 0.22	4.62 ± 0.12	38.39	<0.01*
BBS (score)	39.10 ± 1.16 ^{ab}	45.65 ± 0.66	47.01 ± 0.40	34.92	<0.01*

Data are expressed as mean ± standard deviation.
LPAG, low physical activity group; MPAG, moderate physical activity group; HPAG, high physical activity group; 10MWT, 10 minutes walking test; 3MBW, 3-meter backward walking test; BBS, Berg Balance Score.
**p < 0.05; tested using one-way ANOVA and Scheffé test.*
^{a} *p < 0.05 compared with the MLPAG.* ^{b} *p < 0.05 compared with the HPAG.*

TABLE 3. Fall-related fitness differences between groups.

	LPAG (n = 81)	MPAG (n = 106)	HPAG (n = 101)	F	*p*
30SST (freq./30 s)	11.89 ± 1.91	12.057 ± 2.44	12.46 ± 1.9	1.73	0.17
TUGT (s)	13.09 ± 0.33 ^{ab}	10.467 ± 0.23	10.24 ± 0.22	51.54	<0.01*
8WT (s)	22.29 ± 0.65 ^{ab}	19.32 ± 0.47	18.94 ± 0.34	20.64	<0.01*

Data are expressed as mean ± standard deviation.
LPAG, low physical activity group; MPAG, moderate physical activity group; HPAG, high physical activity group; 30SST, 30 seconds sit to stand test; TUGT, timed up and go test; 8WT, figure-of-8 walk test.
**p < 0.05; tested using one-way ANOVA and Scheffé.*
^{a} *p < 0.05 compared with the MPAG.* ^{b} *p < 0.05 compared with the HPAG.*

3.4 Relationships between total physical activity, walking ability, and fall-related fitness

Results of the correlational analysis of total physical activity with walking ability and fall-related fitness are shown in Table 4. Total physical activity was negatively correlated with 3MBW (r = –0.24, $p < 0.01$), TUGT (r = –0.30, $p < 0.01$), and 8WT (r = –0.19, $p < 0.01$) and was positively correlated with 10MWT (r = 0.21, $p < 0.01$) and BBS (r = 0.27, $p < 0.01$).

3.5 Comparison of odds ratios regarding walking ability and fall-related fitness risk between groups based on levels of physical activity

Results of the logistic regression analyses are shown in Table 5. In the field of walking abilities, the LPAG was 2.42 ($p < 0.01$) and 2.53 ($p = 0.01$) more likely to have slower walking speeds than those in the HPAG in model 1 and 2 respectively. The MPAG was not statistically significant for either Model 1 or Model 2. Furthermore, the MPAG was 3.24 and 3.54 more likely to have poorer BBS than the HPAG in model 1 and 2 respectively ($p < 0.01$). And the LPAG was 9.31 ($p < 0.01$) and 9.65 ($p < 0.01$) more likely to have poorer balance than those in the HPAG in model 1 and 2 respectively.

In the field of fall-related fitness, the LPAG was 14.09 ($p < 0.01$) and 16.76 ($p < 0.01$) more likely to have slower walking speed than those in the HPAG in model 1 and 2 respectively. However, 30SSCT and TUST, odds ratios for MPAG and LPAG were not statistically significant for Models 1 and 2, respectively.

4. Discussion

This study aimed to investigate the physical activity levels among older adults in Henan Province in China and to identify how physical activity levels correlated with walking ability and fall-related fitness. Major results indicated that higher levels of physical activity were positively associated with better walking ability and fall-related fitness. Furthermore, the LPAG had a higher risk of poor walking ability and fall-related fitness when compared to HPAG as the reference.

Our study demonstrated that high level of physical activity was positively associated with walking ability and fall-related fitness. Many previous studies have reported that lifestyle habits such as physical activity are considered a major factor of health. Lack of physical activity accounts for 12–19% of the risk for developing noncommunicable diseases [7]. However, in China, it has been reported that only 25.30–47.44% of the older adult population conforms to the levels of exercise recommended for their age group (a minimum of 30 min per day on 5 or more days per week) [43]. Our results emphasize the need to manage not only noncommunicable diseases, but also falls and muscle strength problems among older adults in China.

In view of this, it is crucial that the recommended amount of physical activity is undertaken by the older adults: however, factors such as walking ability and fall-related fitness are also important in this regard. This is because lack of physical activity in the older adults is related to decline in muscle strength and endurance [44] and is also related to falls, dependency, hospitalization, and mortality [44–46]. Physical inactivity can also have negative effects on domains such as speed of task completion and performance on tasks demanding mobility [46], which can lead to decreased quality of life due to loss of independence. Walking speed is a specific aspect of walking ability, a decline in which can be a marker of physical frailty in older adults [47, 48]. Decrease in walking speed is also a predictor for decline in cognitive function [49, 50] and a predictor of disability and mortality rates in older adults [51]; thus, it is considered a valid and reliable measure of health and functional status in this population [20, 52]. Hence, existing data indicates that the consideration of walking ability is crucial for health management in older adults and is influenced by factors such as levels of physical activity and cardiovascular fitness [53].

The present study confirmed that higher levels of physical activity were positively associated with faster walking speeds. In particular, the difference in 10MWT between the LPAG and the MPAG/HPAG was significant, indicating that walking speed improved with increased physical activity. In addition, the total physical activity of all participants was significantly correlated with 10MWT. Specifically, the odds ratio for 10MWT was 2.42 times higher for the LPAG (Model 1) when using the HPAG as the standard with high levels of physical activity, which was also true while controlling for gender, age, and BMI (Model 2), where the odds ratio was 2.53 times higher for the LPAG. These results indicate that high level of physical activity is positively associated with faster walking speed and that the risk associated with slow walking speed is low.

Higher physical activity levels are associated with a higher probability of independent walking capacity and better dynamic balance ability. BBS is a major testing method used for evaluating mobility and fall risk in older adults [54]. Previous research on the amount of physical activity, BBS score, and TUGT factors indicated that BBS had positive correlations with physical activities of light to moderate intensities, while it had negative correlations with the outcomes of the TUGT, which is an evaluation of dynamic balance ability [55]. In particular, higher physical activity levels are associated with a higher probability of independent walking capacity and better dynamic balance ability. The results of BBS and 3MBW in the present study showed similar trends. Higher physical activity levels were associated with better BBS and 3MBW and with extension walking ability, as seen in the significant between group differences in the LPAG compared with the MPAG and HPAG. Such relationships were also supported by logistic regression analysis based on levels of physical activity; for BBS, the MPAG's odds ratio was 3.23 times higher, and the LPAG's odds ratio was 9.31 times higher compared to the HPAG (Model 1), while the LPAG had a 9.65 times higher odds ratio when the analysis was conducted controlling for certain variables (Model 2). These findings indicate that the relationship between levels of physical activity and walking ability appear to be similar for the older adult population in China to those described previously for other populations.

Our results revealed that the relationship between the

TABLE 4. Correlation of total physical activity and walking ability with fall-related fitness.

	Walking Ability			Fall-related fitness		
	10MWT	3MBW	BBS	30SST	TUGT	8WT
	(m/s)	(s)	(score)	(frequency)	(s)	(s)
Total Physical Activity (MET-min/week)	0.21*	–0.24*	0.27*	0.09	–0.30*	–0.19*

10MWT, 10 minutes walking test; 3MBW, 3-meter backward walking test; BBS, Berg Balance Score; 30SST, 30 seconds sit to stand test; TUGT, timed up and go test; 8WT, figure-of-8 walk test.
$^{*}p < 0.05$, tested using Pearson's correlation.

TABLE 5. Odds ratio of walking ability and fall-related fitness in relation to physical activity level.

Variables	Group	Model 1		Model 2	
		OR (95% CI)	*p*	OR (95% CI)	*p*
Walking ability					
10MWT (m/s)	HPAG	1 (reference)		1 (reference)	
	MPAG	0.98 (0.53–1.82)	0.96	0.999 (0.53–1.87)	0.10
	LPAG	2.42 (1.30–4.50)	<0.01*	2.53 (1.35–4.74)	0.01*
BBS (score)	HPAG	1 (reference)		1 (reference)	
	MPAG	3.24 (1.23–8.53)	0.02*	3.54 (1.33–9.46)	0.01*
	LPAG	9.31 (3.64–23.85)	<0.01*	9.65 (3.72–25.04)	<0.01*
Fall-related fitness					
30SST (freq./30 s)	HPAG	1 (reference)		1 (reference)	
	MPAG	0.88 (0.77–1.01)	0.08	0.88 (0.76–1.01)	0.08
	LPAG	0.98 (0.86–1.12)	0.76	0.97 (0.85–1.10)	0.63
TUGT (s)	HPAG	1 (reference)		1 (reference)	
	MPAG	0.05 (0.30–3.75)	0.94	1.39 (0.34–5.77)	0.65
	LPAG	2.06 (0.40–10.90)	0.40	3.69 (0.59–23.05)	0.16
8WT (s)	HPAG	1 (reference)		1 (reference)	
	MPAG	1.923 (0.17–21.54)	0.60	2.10 (0.18–23.85)	0.55
	LPAG	14.09 (1.76–112.52)	<0.01*	16.76 (2.07–135.75)	<0.01*

Model 1, un-adjusted; Model 2, adjusted for gender, age, body mass index. OR, odds ratio; CI, confidence interval; LPAG, low physical activity group; MPAG, moderate physical activity group; HPAG, high physical activity group; 10MWT, 10 minutes walking test; 3MBW, 3-meter backward walking test; BBS, Berg Balance Score; 30SST, 30 seconds sit to stand test; TUGT, timed up and go test; 8WT, figure-of-8 walk test.
$^{*}p < 0.05$ tested using logistic regression.

amount of physical activity and fall risk has various and specific cut-off points. A previous study has reported that fall risk is associated with low physical functions [56] and that decline in muscle strength of the upper and lower extremities, dynamic balance ability, aerobic endurance, and agility increase the risk of falls [57]. Additionally, it has been reported that physical activity levels, muscle strength, and coordination are factors that can predict fall risk [58]. Research on the relationship between the amount of physical activity and fall risk have reported various and specific cut-off points. According to our study, LPAG with activity values ≤600 MET/min was considered as a high-risk group: however, participants in the MPAG may have a high risk of falling. In the future, we need to develop a fall prediction physical activity cut-off for the Chinese population through large-scale studies.

Furthermore, the fitness variables of muscle strength and balance ability have been indicated as major factors related to fall risk [59], as well as coordination, which is a factor that inevitably declines with age and has significant relationships with walking speed [60]. In addition, a meta-analysis indicated that fall risk is also associated with gait problems and use of walking aids [61]. Such findings, in combination with those of the current study, indicate that muscle strength, balance, and coordination are key factors in reducing fall risk and preventing falls; therefore, it is necessary for older adults to receive training for specifically preventing declines in these areas. Since these factors are also related to the amount of physical activity, it is equally important to maintain an active lifestyle.

The comparative analysis of fall-related fitness based on levels of physical activity showed no between group differences for 30SST in current study. However, better balance and coordination relative to higher levels of physical activity were observed when comparing the LPAG with the MPAG and HPAG, but not when comparing the MPAG with the HPAG. Such results are similar to those of a study that falls and in particular fear of falling are important barriers to older people gaining health benefits of walking and MVPA [62]. In addition, the logistical regression analysis of the fall-related fitness factors indicated that those in the LPAG were 0.98 times more likely to have reduced 30SST and 14.09 times more likely to have reduced 8WT when compared to the HPAG, even when adjusted for age, gender, and BMI. These findings indicate that low levels of physical activity can have negative consequences on dynamic balance and coordination and that low levels of physical activity can increase the risks associated with poor fall-related fitness.

This study has several limitations. Analysis of environmental and economic factors that could affect the levels of physical activity among the participants was not included. In addition, the determination of physical activity levels through a survey may have reduced the accuracy of the physical activity measurements. However, considering the lack of research in China regarding physical activity levels and its effect on health in older adults [63], the findings of the current study can be utilized as meaningful foundational data for future studies. Further studies should use an objective physical activity measure and a more multi-faceted analysis approach including a comparative analysis of older adults in urban and rural settings and analyses of the social, environmental, and cultural factors and by age group that can affect individual physical activity levels.

5. Conclusions

Higher levels of physical activity were associated with better walking ability and fall-related fitness. The deployment of exercise interventions for improving specific aspects of walking ability, such as walking speed, and fall-related fitness, such as dynamic balance and coordination, along with the maintenance of high physical activity levels, are strategies that can improve health outcomes in older adults.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and analyzed in the current study are available upon reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

JC and SJK—designed the research study and methodology, wrote the manuscript. SK and SJK—contributed to formal analysis, contributed data curation, revised the manuscript, supervised the study. JC—were in charge of project administration. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved as a retrospective study by the Institutional Review Board of Sungkyunkwan University (approval number: SKKU 2022-10-029). All study participants provided written informed consent.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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