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Research article

Cognitive impairment is a risk factor for decreased physical performance in the elderly

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A R T I C L E I N F O

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SPPB
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A B S T R A C T

Background: This study aimed to show a 3-year trajectory of physical performance among Chinese elderly in Beijing communities and explore the associations between new adverse events during the 3-year follow-up period and decreased physical performance.
Methods: A longitudinal observational study included baseline data and transitional information of physical performance from 456 community elders (mean age 67.3 ± 4.9 years, female 43.2 %) at a 3-year follow-up. The Mini-Mental State Examination (MMSE) and the Short Physical Performance Battery (SPPB) were used to measure cognition and physical performance, respectively. The number of chronic diseases, cognitive impairment, malnutrition, depression, knee pain, falls, and frailty were the principal independent variables in multivariate logistic regression analysis.
Results: The proportion of the elderly with poor physical performance (26.97 %) increased to 42.11 % and the proportion of those with good physical performance (44.96 %) dropped to 30.48 % after the three-year follow-up. As for physical performance transitions, 39.47 % of the elderly progressed to a worsening physical status. After adjustment for covariates, only new onset cognitive impairment (OR: 5.17; 95%CI: 2.01–14.54; P = 0.001) was associated with physical performance deterioration.
Conclusion: Cognitive impairment is an independent risk factor for decreased physical performance in elderly people. Active interventions targeted at cognitive impairment could help promote healthy aging.

1. Introduction

Physical performance has been considered as a summary measurement of physical functional capabilities in the context of an

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individual's lifestyles, medical conditions and age-related physiologic changes. Previous studies have shown that poor physical performance has close relationships with poor physical health, bad quality of life and disability [1–3]. Physical performance is not a static state, but has a dynamic nature, indicating that people have continuous transitions between different physical fitness statuses. Identifying the risk factors for physical deterioration will allow clinicians to take early interventions for individuals at high risk of physical deterioration. The decline in physical performance is a dynamic process influenced by multiple factors, such as ageing, sarcopenia, obesity, nutritional status, cognitive impairment, depression, co-morbidities, frailty, and poor physical performance at baseline, etc. [4–6]. Due to those factors often overlap and co-occur in older adults, it is difficult to correctly identify the most important risk factors that lead to decreased physical performance when multiple risk factors coexist. Previous studies were mostly cross-sectional studies, and they only focused on the associations between baseline risk factors and decreased physical performance after several years of follow-up. The covariates were limited. The main risk factors might not be correctly identified in the analyses with poor control for confounders.

Although China has the largest elderly population in the world, few studies have measured the trajectories of physical performance in the Chinese elderly population. As a quick, easily administrable, and objective measure of physical performance, the short physical performance battery (SPPB) has been widely used in studies of older adults in various settings [7–9]. In this study, we used SPPB to measure the physical performance trajectories of the Chinese elderly in Beijing communities. Subsequently, we tracked the physical fitness status transition of the elderly during the 3-year follow-up, and analyzed the relationship between this transition and new onset adverse events.

2. Methods

2.1. Study design and participants

The data used in this longitudinal observational population-based study was from the 2019 National Free Physical Examination Program conducted in Beijing. All recruited participants were aged over 60 years old and followed up from January 2022. The exclusion criteria for the participants were as follows: (1) those who were lost to follow-up due to relocation or change of contact information; (2) those who were no longer willing to be followed up due to immobility, acute illness, hospitalization, or weakness; (3) those without sufficient baseline data of sociodemographic characteristics and clinical evaluation. According to the exclusion criteria, 456 participants with complete baseline and follow-up data were included in this study out of 652 participants. Written informed consent was obtained from all participants or their legal representatives. This study was approved by the Ethics Committee of Xuanwu Hospital, Capital Medical University (Clinical ethics approval [2021] No. 026).

2.2. Exposure measures and covariates

Demographic information, body mass index (BMI), the number of chronic diseases from medical records, self-reported information, cognitive status, nutrition, frailty, depression and activities of daily living (ADL) were collected by experienced neurologists. Chronic diseases mainly included tumors, cerebrovascular disease, coronary heart disease, kidney disease, hypertension, liver disease, diabetes, anemia, peptic ulcer or stomach disease, and chronic obstructive pulmonary disease. Self-reported information included falls $\geq$2 times in a year and knee pain in a month.

For participants with different years of education, cognitive impairment is defined as an MMSE(Chinese version) score$<$17 (for illiterate people), an MMSE score$<$20 (for those with less than or equal to 6 years of education), an MMSE score$<$24 (for those with more than 6 years of education) [10]. Participants with a Geriatric Depression Scale (GDS-15) score $\geq$8 [11]were considered as having depression. Participants with a Mini Nutrition Assessment-Brief Table (MNA-SF) [12] score $<$8 were deemed to have malnutrition. Frailty status was determined based on FRAIL Scale, and participants with a score of > 3 were deemed frail [13]. The ADL status was measured by the Barthel Index which includes 10 activities of daily living14. ADL status: 0 means completely self-care in daily life; 1 means mild functional dependence; 2 means moderate functional dependence; and 3 means severe functional dependence [14].

New onset adverse events were defined as adverse health events that did not exist at baseline but were diagnosed at the follow-up, including cognitive impairment, malnutrition, depression, knee pain, falls and frailty.

2.3. Outcome measures

The SPPB was used to assesses physical performance. In brief, the SPPB is made up of three tests, including the repeated chair sit-to-stand test, the standing balance test, and walking speed test [15]. The SPPB total score, which is the sum of the three subtest scores, ranges from 0 (worst performance) to 12 points (best performance). In our study, the physical performance was classified based on the SPPB total score as poor performance (0–6 points), moderate performance (7–9 points), and good performance (10–12 points) [16].

Performance transitions were divided into two categories: (1) Deterioration: transition from good performance to moderate/poor performance, or transition from moderate performance to poor performance; (2) Non-deterioration: no change, a slight physical decline within the same-level performance, or improvements.

2.4. Statistical analysis

Continuous variables were described as mean with standard deviation (SD) or median with interquartile range, and categorical variables were presented as number and percentage. Wilcoxon test and Kruskal-Wallis test were used to compare non-parametric variables, and Chi-squared test and Fisher's Exact test were used for categorical variables. A Sankey-diagram was used to describe the trajectories of the subjects' physical performance over the three years. Multivariate logistic regression models were used to analyze the associations of new onset adverse events with performance transitions. Model 1 was adjusted for age, gender, marital status, education and BMI, the number of chronic diseases, baseline ADL status and SPPB score; and Model 2 was additionally adjusted for baseline cognitive impairment, malnutrition, frailty, fall, pain and depression. The results were presented as odds ratio (OR) and 95 % confidence interval (CI). A two-tailed P-value <0.05 was considered statistically significant. All statistical analyses were performed with R software, version 3.4.4 (http://R-project.org/).

3. Results

1 Baseline characteristics of the participants

At baseline, the 456 participants included in the study were stratified by their baseline SPPB scores, consisting of 123 (26.97 %) in the poor performance group, 128 (28.07 %) in the moderate performance group, and 205 (44.96 %) in the good performance group. The overall characteristics of these three groups were presented in Table 1. Participants with baseline poor performance tended to older. They had higher ADL status, a greater number of chronic diseases, and higher proportions of participants with cognitive impairment, malnutrition, fall, pain, frailty and depression, compared with the other two groups.

2 The trajectories of physical performance

At the 3-year follow-up, there were 192 (42.11 %) elderly participants with poor performance, 125 (27.41 %) with moderate performance, and 139 (30.48 %) with good performance, as shown in Fig. 1.

As for physical fitness status transition, in the baseline poor performance group, 75 (60.98 %) were still poor, 24 (19.51 %) had mild physical improvement (poor to moderate), and 24 (19.51 %) had significant physical improvement (poor to good); in the baseline moderate performance group, 38 (29.68 %) remained stable, 56 (43.75 %) deteriorated, and 34 (26.56 %) improved; and in the baseline good performance group, 81 (39.51 %) remained stable, 63 (30.73 %) had a mild decline (good to moderate), and 61 (29.76 %) had an obvious drop (good to poor). See Fig. 2 for details.

3 The associations between new onset adverse events and physical performance deterioration

According to performance transitions, participants were divided into the deterioration and non-deterioration groups. A comparison of the characteristics between the two groups was shown in Table 2. Compared with non-deterioration group, the deterioration group were younger, and they had lower ADL status, a lower number of chronic diseases, lower proportions of participants with cognitive impairment, malnutrition, fall, pain, frailty, and depression at baseline, and a lower SPPB score at the 3-year follow-up. For new onset adverse events, the deterioration group had higher proportions of those with new onset cognitive impairment, malnutrition, fall, and

Table 1
Baseline characteristics of the participants.

	Poor (n = 123)	Moderate (n = 128)	Good (n = 205)	*P*
BMI (Kg/m2)	24.44 (±3.61)	24.61 (±3.22)	24.90 (±3.27)	0.457
Age (year)	77.84 (±6.62)	69.48 (±5.59)	67.67 (±4.82)	<0.001
Male, n (%)	70 (56.91 %)	79 (61.72 %)	110 (53.66 %)	0.352
Live alone, n (%)	43 (34.96 %)	45 (35.16 %)	67 (32.68 %%)	0.867
High school or above, n (%)	97 (78.86 %)	97 (75.78 %)	150 (73.17 %)	0.508
Number of chronic diseases	3.00 [2.00, 4.00]	2.00 [2.00, 3.00]	2.00 [1.00, 3.00]	<0.001
ADL status	3.00 [2.00, 3.00]	1.00 [0.00, 1.00]	0.00 [0.00, 0.00]	<0.001
Baseline				
SPPB score	4.00 [3.00, 6.00]	9.00 [8.00, 9.00]	11.00 [10.00, 12.00]	<0.001
Walk speed (m/s)	2.33 [1.67, 3.17]	1.29 [1.00, 1.33]	0.83 [0.67, 1.00]	<0.001
Standing balance test score	2.00 [1.00, 2.00]	4.00 [3.00, 4.00]	4.00 [4.00, 4.00]	<0.001
Repeated chair sit-to-stand test score	1.00 [1.00, 1.00]	1.00 [1.00, 2.00]	4.00 [3.00, 4.00]	<0.001
Cognitive impairment, n (%)	65 (52.85 %)	32 (25.00 %)	39 (19.02 %)	<0.001
Malnutrition, n (%)	20 (16.26 %)	8 (6.25 %)	5 (2.44 %)	<0.001
Fall, n (%)	40 (32.52 %)	7 (5.47 %)	5 (2.44 %)	<0.001
Pain, n (%)	71 (57.72 %)	25 (19.53 %)	5 (2.44 %)	<0.001
Frailty, n (%)	80 (65.04 %)	19 (14.84 %)	23 (11.22 %)	<0.001
Depression, n (%)	58 (47.15 %)	22 (17.19 %)	30 (14.63 %)	<0.001
After 3 years				
SPPB score	5.00 [4.00, 9.00]	7.50 [5.00, 10.00]	9.00 [6.00, 11.00]	<0.001
walk speed (m/s)	2.00 [1.50, 3.33]	1.50 [1.17, 2.33]	1.37 [1.13, 2.00]	<0.001
Standing balance test score	2.00 [2.00, 4.00]	4.00 [3.00, 4.00]	4.00 [3.00, 4.00]	<0.001
Repeated chair sit-to-stand test score	1.00 [1.00, 2.00]	1.00 [1.00, 2.25]	2.00 [1.00, 3.00]	<0.001

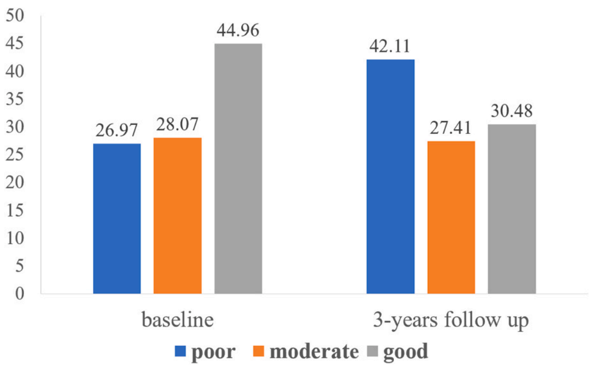

Fig. 1. The percentage of three SPPB groups at baseline and 3-years follow up.

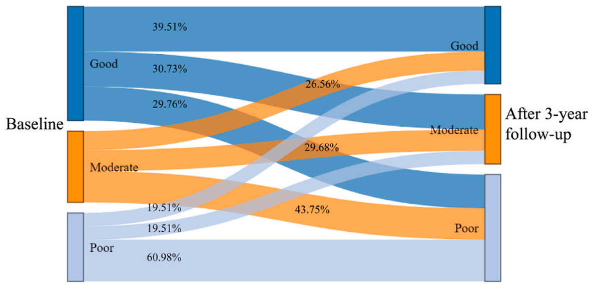

Fig. 2. The physical performance transitions between baseline and 3-year follow-up.

Table 2
The comparison of characteristics between worsened and non-worsened groups.

	Non-deterioration (n = 276)	Deterioration (n = 180)	*P*
BMI (Kg/m2)	24.65 (±3.42)	24.76 (±3.25)	0.742
Age (year)	72.59 (±7.53)	68.37 (±5.19)	<0.001
Male, n (%)	157 (56.88 %)	102 (56.67 %)	1.000
Live alone, n (%)	97 (35.14 %)	58 (32.22 %)	0.587
High school or above, n (%)	214 (77.54 %)	130 (72.22 %)	0.239
Number of chronic diseases	2.00 [2.00, 3.00]	2.00 [1.00, 3.00]	<0.001
ADL status	1.00 [0.00, 3.00]	0.00 [0.00, 1.00]	<0.001
Baseline			
SPPB score	8.00 [5.00, 10.00]	10.00 [9.00, 11.00]	<0.001
walk speed (m/s)	1.33 [0.80, 2.33]	1.00 [0.80, 1.25]	<0.001
Standing balance test score	3.00 [2.00, 4.00]	4.00 [3.00, 4.00]	<0.001
Repeated chair sit-to-stand test score	1.00 [1.00, 3.00]	3.00 [2.00, 4.00]	<0.001
Cognitive impairment, n (%)	79 (35.14 %)	39 (21.67 %)	0.003
Malnutrition, n (%)	25 (9.06 %)	8 (4.44 %)	0.094
Fall, n (%)	44 (15.94 %)	8 (4.44 %)	<0.001
Pain, n (%)	85 (30.80 %)	16 (8.89 %)	<0.001
Frailty, n (%)	97 (35.14 %)	25 (13.89 %)	<0.001
Depression, n (%)	77 (27.90 %)	33 (18.33 %)	0.026
After 3 years			
SPPB score	10.00 [6.00, 11.00]	6.00 [5.00, 8.00]	<0.001
walk speed (m/s)	1.30 [1.00, 2.00]	2.17 [1.50, 2.54]	<0.001
Standing balance test score	4.00 [3.00, 4.00]	3.00 [3.00, 4.00]	<0.001
Repeated chair sit-to-stand test score	2.00 [1.00, 3.00]	1.00 [1.00, 1.00]	<0.001
New onset adverse events			
Cognitive impairment, n (%)	10 (3.62 %)	23 (12.78 %)	<0.001
Malnutrition, n (%)	11 (3.99 %)	16 (8.89 %)	0.049
Fall, n (%)	7 (2.54 %)	15 (8.33 %)	0.009
Pain, n (%)	8 (2.90 %)	11 (6.11 %)	0.15
Frailty, n (%)	8 (2.90 %)	22 (12.22 %)	<0.001
Depression, n (%)	17 (6.16 %)	14 (7.78 %)	0.631

frailty.

As shown in Table 3, new onset cognitive impairment (OR: 3.90; 95 % CI: 1.86–8.77; $P < 0.001$), malnutrition (OR: 2.35; 95%CI: 1.07–5.33; $P = 0.034$), fall (OR:3.49; 95%CI: 1.44–9.31; $P = 0.008$), and frailty (OR: 4.66; 95%CI: 2.11–11.39; $P < 0.001$) were significantly associated with physical performance deterioration in unadjusted model. However, only the association for new onset cognitive impairment remained statistically significant after adjustment for the covariates in model 1(OR: 5.17; 95%CI: 2.01–14.54; $P = 0.001$) and model 2 (OR: 6.14; 95%CI: 2.27–18.32; $P < 0.001$).

4. Discussion

In our study, almost 60.49 % of the older adults showed a decline in physical performance at 3-year follow-up. Although deterioration in physical performance was much more common than improvements, 39.02 % of participants with baseline poor performance had improvements after 3 years. In our analysis of the associations between new-onset adverse events and physical performance transitions over the past three years, only new onset cognitive impairment was independently associated with physical performance deterioration.

Our result strengthened the finding from previous studies that cognition was associated with physical function. For example, two Japanese studies, including a cross-sectional study using the activities of daily living (ADL) and instrumental activities of daily living (IADL) [17] and a longitudinal study using basic activities of daily living (BADL) [18], have shown an association between cognitive performance and decreased physical function. Another study has also shown that global cognition and executive function predict declines in gait speed [19]. Moreover, a longitudinal study of 764 participants showed that cognitive impairment was a stronger predictor of physical decline [20]. Some explanations for the association between cognitive impairment and decreased physical performance are as follows. Maintenance of body balance, an efficient gait, and completion of specific instructions may require specific cognitive capacities. Memory, visuospatial skills, sustaining attention, and execution ability may be differentially important to the planning, initiating, and maintaining of walking. Moreover, the apathy behavior of elderly individuals with cognitive impairment during the scale evaluation process may reduce the evaluation scores [21,22]. Taken together, a decline in physical performance may have a cognitive component. Early prevention and intervention of cognitive impairment could slow the decline of physical function and health status.

There is no doubt that the physical performance of the elderly is influenced by multiple factors. Previous studies have shown that elderly people with multiple chronic diseases, especially back pain, arthritis, and mental symptoms, are at greater risk of physical dysfunction and falls [23]. Other studies in different populations have also found musculoskeletal pain [24], depression [6], poor nutritional status [25], and three or more clinical conditions [26]were associated with severe deterioration of physical performance. However, after adjustment, these conventional risk factors that emerged within three years were not found to be associated with poor physical performance after three years. The reasons may be multifaceted. For example, most people are free from functional impairment or disability despite the presence of chronic disorders until age 80 and disability becomes common only in people over 85 years old [27,28]. This may indicate that the results vary depending on the age of the included participants, as our study population are younger than those in previous studies [26].

Previous studies on the association between physical deterioration and falls have been controversial. Some cohort studies showed that walk speed was significantly associated with falls in the community-dwelling elders [8,29,30], while some showed that physical deterioration had no relationship with the risk of future falls [16,31]. In our study, after the adjustment in model 1 and model 2, the significance of the association between new onset falls in the three-year follow-up and physical deterioration was lost.

Several studies have showed that depression elevates the subsequent risk of physical disability [32–35]. However, we found no association between depression and decreased physical performance. This inconsistency may be due to the different research methods. Most previous studies focused on the association of baseline depression with baseline physical performance scores or the future risk of physical deterioration. However, our study focused on new onset depression during the 3-year follow-up, and explored its association with physical deterioration over three years. Of course, the confounding effects due to different populations and different evaluation scales cannot be ruled out. The impact of depression on the physical performance of the elderly people might require longer periods of follow-up.

There are some limitations in our study. First, partial data used in the study were self-reported, including falls ≥ 2 times in a year and knee pain in a month, possibly leading to recall bias which affected clinical judgment. Second, the small sample sizes of the subgroups were relatively small, which might limit the generalizability of these findings. Third, the evaluation items of the SPPB scale are limited and several relevant confounding factors such as anthropometric data, diet, alcohol intake, sedentary behaviors, hygiene, infections, metabolic syndrome parameters, sleep patterns and APOE gene etc. were omitted from this study, which might lead to biases in our results.

5. Conclusions

This study focused on the physical performance trajectories and its transitions associated with multiple age-associated adverse outcomes over the three years in community-dwelling elders. Our study showed that age-related changes in physical performance in older adults were dynamic and diverse, and new onset cognitive impairment was strongly associated with physical performance deterioration. The elderly with cognitive impairment should be considered as the target group for improving physical performance. Since it depicts the alterations in the self-care potential of individuals, physical performance transition carries important quantitative and qualitative implications for autonomy, quality of life, and social interaction.

Table 3
The associations between performance transitions and new onset adverse events.

	Unadjusted		Model 1		Model2	
	OR (95%CI)	P	OR (95%CI)	P	OR (95%CI)	*P*
Cognitive impairment	3.90 (1.86–8.77)	<0.001	5.17 (2.01–14.54)	0.001	6.14 (2.27–18.32)	<0.001
Malnutrition	2.35 (1.07–5.33)	0.034	2.63 (0.78–8.85)	0.117	2.91 (0.84–10.03)	0.088
Fall	3.49 (1.44–9.31)	0.008	2.79 (0.82–10.26)	0.109	2.56 (0.72–9.89)	0.155
Pain	2.18 (0.87–5.74)	0.101	1.47 (0.45–4.88)	0.523	1.55 (0.46–5.33)	0.476
Frailty	4.66 (2.11–11.39)	<0.001	2.38 (0.74–8.41)	0.159	2.39 (0.72–8.65)	0.165
Depression	1.28 (0.61–2.67)	0.503	0.98 (0.28–3.22)	0.977	1.26 (0.34–4.43)	0.721

Model 1: adjusted for new onset adverse events as appropriate, age, sex, marital status, education and BMI, the number of chronic diseases, baseline ADL status and SPPB score.
Model 2: additionally adjusted for cognitive impairment, malnutrition, frailty and depression variables at baseline.

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Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics declarations

This study was reviewed and approved by the Ethics Committee of Xuanwu Hospital, Capital Medical University, with the approval number ChiCTR2200055707. All participants provided informed consent to participate in the study.

CRediT authorship contribution statement

Dan Su: Writing – review & editing, Writing – original draft, Funding acquisition, Data curation, Conceptualization. **Ying Liu:** Writing – original draft, Software, Methodology, Formal analysis. **Yangling Su:** Validation, Investigation. **Xiaojun Zhang:** Writing – review & editing, Data curation, Conceptualization. **Piu Chan:** Writing – review & editing, Project administration, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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