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RESEARCH PAPER

Physical performance trajectories and mortality among nursing home residents: results of the SENIOR cohort

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Abstract

Background: Previous studies have shown that older people can experience a considerable change in their physical performance (PP) over time.
Objectives: To identify PP trajectories and their association with mortality among nursing home residents who were followed up for 3 years.
Design: Three-year longitudinal observational study.
Setting: Subjects of the SENIOR cohort.
Subjects: Six hundred and four nursing home residents with a mean age of 82.9 ± 9.1 years.
Methods: Baseline characteristics and the date of death were collected from the medical records. PP was assessed annually by the short physical performance battery (SPPB) test. Multiple imputations were performed to manage the missing data. PP trajectory groups were estimated using latent growth curve analysis. Cox proportional hazard regression models were applied to examine the risk of mortality according to the PP trajectory groups.
Results: Three PP trajectory groups were identified: slow decline ($N = 96$), moderate decline ($N = 234$) and fast decline ($N = 274$). After adjustments for potential confounding variables and the baseline SPPB scores, the residents in the fast decline and moderate decline trajectory groups had an increased risk of mortality compared to those in the slow decline trajectory group, with hazard ratio values of 1.78 (95% confidence interval [CI] = 1.34–2.26) and 1.37 (95% CI = 1.10–1.66), respectively.
Conclusions: PP trajectories provide value-added information to baseline geriatric assessments and could be used for predicting 3-year mortality among nursing home residents. It may be important to regularly monitor the SPPB score and signal an alert when a fast decline in PP is detected in older people.

Keywords: *trajectory*, *decline*, *mortality*, *nursing home*, *physical performance*, *short physical performance battery*

Key points

- Three different physical performance trajectories were identified among nursing home residents.
- The fast decline trajectory group was associated with higher risk of mortality compared to the slow or moderate decline group.
- Regular monitoring of the SPPB score would be useful in clinical practice.

Introduction

Physical performance (PP) measures are useful parameters for detecting declines in autonomy in older adults in clinical settings; furthermore, they may be good predictors of adverse health outcomes [1,3]. However, observations have indicated mobility heterogeneity in the older population and have highlighted the dynamic nature of changes in PP [4,5]. Furthermore, life course epidemiology models show the importance of physiological or functional measures that change over time [6].

To date, few empirical investigations on the health trajectories of the nursing home population have been conducted. Recently, a study of the trajectories of nutrition, cognitive function and autonomy over time and their impact on 5-year mortality in a French cohort of nursing home residents showed that these trajectories were better predictors of mortality than a single measurement of these parameters [7]. Several studies also examined the activities of daily living (ADL) disability trajectories in nursing homes and have suggested that there was considerable heterogeneity in disability trajectories, that the deterioration in ADL was not irreversible but was a predictor of short-term mortality [8,9].

Surprisingly, the PP trajectories among nursing home residents have not yet been closely examined. Indeed, most studies of the PP trajectories have been carried out in community-dwelling older people. In this population, a recent study identified three PP trajectories (i.e. stable trajectory, gradual functional decline and rapid decline) associated with marital status, multiple chronic conditions and age [10]. Other studies investigated the association between PP trajectories and mortality, and showed that the rapid-decline PP trajectory groups had a high mortality risk [11–14].

The nursing home resident population increasing each year around the world is particularly frail, dependent and with specific needs [15]. It is thus essential to improve knowledge on this topic to better their care and management. Therefore, this paper serves as a major contribution to research on PP trajectories in nursing homes. The main purposes of this paper are (i) to identify PP trajectories over time, (ii) to study the influence of baseline characteristics on PP trajectories and (iii) to examine the relationship between PP trajectories and 3-year mortality.

Methods

Population

We used the data from four waves in the SENIOR (Sample of Elderly Nursing home Individuals: an Observational Research) cohort, including the baseline assessment and the 3 years of follow-up. Subjects who met the selection criteria (i.e. residing in a nursing home, being mobile with or without walking aid, being able to sign an informed consent form and having a sound understanding) were recruited between 2013 and 2015, which corresponds to the first wave of the study. At baseline, the total number of included residents was 662. The residents were followed and underwent testing annually for 3 years. A detailed description of this cohort was published by Buckinx *et al.* [16] in 2016.

Baseline characteristics

Age, sex, body mass index (BMI), residents' medical history and list of medications were retrieved from their medical records. The residents were asked about their marital status and years of education. Cognitive status was assessed by the Mini Mental State Examination (MMSE). Depressive symptoms were obtained from the self-reported EuroQol-5D using the item 'anxiety/depression'.

Physical performance

During each year of the follow-up period, the short physical performance battery (SPPB) was used to evaluate the PP of the residents [17]. The SPPB is composed of three tests: body balance test, gait speed test and a chair stand test. Each test is scored on a scale ranging from 0 to 4 points. If a subject is not able to perform one of the tasks, a score of 0 is assigned to him or her. The total score is a sum of the individual scores and ranges from 0 to 12 points. The score for body balance test is determined by instructing the subject to hold three stances for 10 seconds each: joined, semi-tandem and tandem. The residents' gait speed across 4 m is recorded using a stopwatch (the use of walking aid was permitted). For the chair stand test, the time needed to rise from a straight-backed chair five consecutive times, with arms folded across the chest, is recorded.

Mortality

The outcome of interest was the survival time after 3 years of follow-up. The date of death was recorded in their medical records. The survival times were calculated as the number of days from the baseline assessment until death or the end of the 3-year follow-up period (or until the last date of contact if the resident moved or was lost to follow-up).

Statistical methods

First, missing data (due to refusals, incapacity to consent or loss of follow-up) were handled with multiple imputations (by the Markov chain Monte Carlo method) [18]. We generated five imputed datasets, and the pooled results were recorded. To take into account all deaths during the 3 years of follow-up, we imputed zeros for the SPPB scores of the individuals who died after one year, instead of excluding them from our analyses [19].

Afterwards, we used the latent growth curve analysis adjusted for the baseline characteristics described above to

estimate the PP trajectory groups over 3 years [20]. We compared models with different numbers of trajectories and quadratic shapes. The best-fitting model was selected using the Bayesian information criterion (BIC). The model with the lowest BIC value was designated as the best model [21].

Then, a descriptive analysis was conducted to compare the baseline characteristics with the function of the PP trajectory groups using analysis of variance for the continuous variables and the chi-square tests for the categorical variables. Then, multinomial logistic regressions were performed to evaluate the relative risk ratios (RRRs) between the PP trajectory groups and baseline characteristics [22].

Finally, three Cox proportional hazards models were applied to evaluate the association between the PP trajectory groups and mortality. Model 1 was unadjusted. Model 2 was adjusted for all baseline characteristics described above. Model 3 was additionally adjusted for the baseline SPPB score.

All analyses were conducted using SAS software (SAS Institute Inc., Cary, NC) and SPSS software (IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp). We considered a P value less than 0.05 indicative of statistical significance.

Results

Study population

The baseline characteristics of the 604 included residents according to the trajectory groups are presented in Table 1. At baseline, the mean age of the residents was 82.9 ± 9.1 years, and 441 (73%) were women. At baseline, the residents in the fast decline trajectory group were more likely to be female, older and a widow(er). These patients also had a more involved medical history, took a higher number of medications, and had lower MMSE scores and lower baseline SPPB scores. There was no association between PP trajectories, depression or years of education.

PP trajectory groups

Our sample included 604 residents who met the conditions for multiple imputations. Indeed, 58 subjects were removed from the study because they were part of two nursing homes whose management refused to continue the study after the first year of follow-up (therefore the data were not missing randomly). A total of 12.13% of missing values were imputed. Using the SPPB scores over the four waves (i.e. baseline and years 1, 2 and 3), our analyses showed that a three-trajectory solution was the best model of all models tested. These trajectory groups were named the slow decline, moderate decline and fast decline groups. Figure 1 illustrates the percentage of change in the SPPB score for each trajectory group. Residents in the slow decline trajectory group ($N = 96$, 15.9%) initially had an SPPB score of 9.5 points, and the score showed a relative decline by 21.8% over a period of 3 years. The residents in the moderate decline trajectory group ($N = 234$, 38.7%) initially had an SPPB score of 7.1 points, and the score showed a relative decline by 35.9% over the 3-year follow-up. The residents in the fast decline trajectory group ($N = 274$, 35.4%) initially had an SPPB score of 3.2 points, and the score showed a relative decline by 43.4% over the 3-year period. Therefore, we found that for residents with a low SPPB score at baseline, the score tended to decline more rapidly.

Baseline characteristics and PP trajectory groups

The results of the multinomial logistic regression are summarised in Table 2. Considering that the slow decline trajectory group was the reference group, the older residents had a greater risk of being grouped in the fast decline (RRR = 1.16, confidence interval [CI] 95% = 1.12–1.20) or moderate decline (RRR = 1.08, 95% CI = 1.05–1.11) trajectory group. Women had increased risk of being in the fast decline (RRR = 0.18, 95% CI = 0.11–0.31) or moderate decline (RRR = 0.42, 95% CI = 0.26–0.70) trajectory group relative to that of men. A lower BMI increased the risk of being in the moderate decline trajectory group (RRR = 0.95, 95% CI = 0.91–0.98). Having a more involved medical history increased the risk of being in the fast decline trajectory group (RRR = 1.16, 95% CI = 1.09–1.24). Taking a higher number of medications increased the risk of being grouped in the fast decline (RRR = 1.12, 95% CI = 1.06–1.17) or moderate decline (RRR = 1.09, 95% CI = 1.03–1.15) trajectory group. Widow(er)s had an increased risk of being in the fast decline trajectory group (RRR = 4.60, 95% CI = 2.25–9.45). The residents with lower MMSE scores were more likely to be classified in the fast decline (RRR = 0.86, 95% CI = 0.80–0.92) or moderate decline trajectory group (RRR = 0.52, 95% CI = 0.45–0.61). The residents with lower baseline SPPB scores had a greater risk of being grouped in the fast decline (RRR = 0.25, 95% CI = 0.21–0.31) or moderate decline trajectory group (RRR = 0.52, 95% CI = 0.45–0.61).

Mortality

During the 3-year follow-up period, 231 deaths occurred, and the mean survival duration was 2.6 ± 1.1 years. Table 3 provides the results obtained from the Cox proportional hazards models. These results suggested that there was an association between the PP trajectory groups and 3-year mortality. The unadjusted model indicated that the fast decline trajectory group was associated with a hazard ratio (HR) of 2.29 (95% CI = 2.04–2.55), and the moderate decline trajectory group was associated with an HR of 1.71 (95% CI = 1.46–1.96) compared with the low decline trajectory group. Model 2 revealed that with adjustments for the baseline characteristics, this association remained significant. In addition, Model 3, which was adjusted for the

Table 1. Baseline characteristics by the SPPB trajectory groups.

Baseline characteristics	SPPB trajectory groups						*P* value
	Fast decline		Moderate decline		Slow decline		
	N	%	*N*	%	*N*	%	
	274	45.4	234	38.7	96	15.9	
Age (years)	87.88 ± 8.31		84.76 ± 8.64		75.97 ± 10.35		**<0.001**
Sex							**<0.001**
Women	230	83.9	162	69.2	49	51.0	
Men	44	16.1	72	30.8	47	49.0	
BMI (kg/m^2)	26.53 ± 6.32		25.59 ± 5.06		26.84 ± 4.28		**0.04**
Medical history (number of events)	6 (3–9)		5 (3–7)		5 (3–7)		**0.02**
Medication (number)	10 (6–14)		10 (6–14)		8 (4–12)		**0.02**
Civil status							**<0.001**
Married	24	8.8	25	10.7	18	18.7	
Divorced	18	6.6	28	12.0	23	24.0	
Widowed	210	76.6	159	67.9	37	38.5	
Single	22	8.0	22	9.4	18	18.8	
Education							
<7 years	147	53.6	113	48.3	42	43.7	0.22
>7 years	127	46.4	121	51.7	54	56.3	
MMSE score (/30)	23.27 ± 4.99		24.44 ± 4.45		26.11 ± 3.82		**<0.001**
Depression							0.09
Yes	141	51.5	139	59.4	58	60.4	
No	133	48.5	95	40.6	38	39.6	
Baseline SPPB score	3.07 ± 2.06		6.89 ± 2.22		9.51 ± 1.81		**<0.001**

Significant values are in bold (*P* value < 0.05).

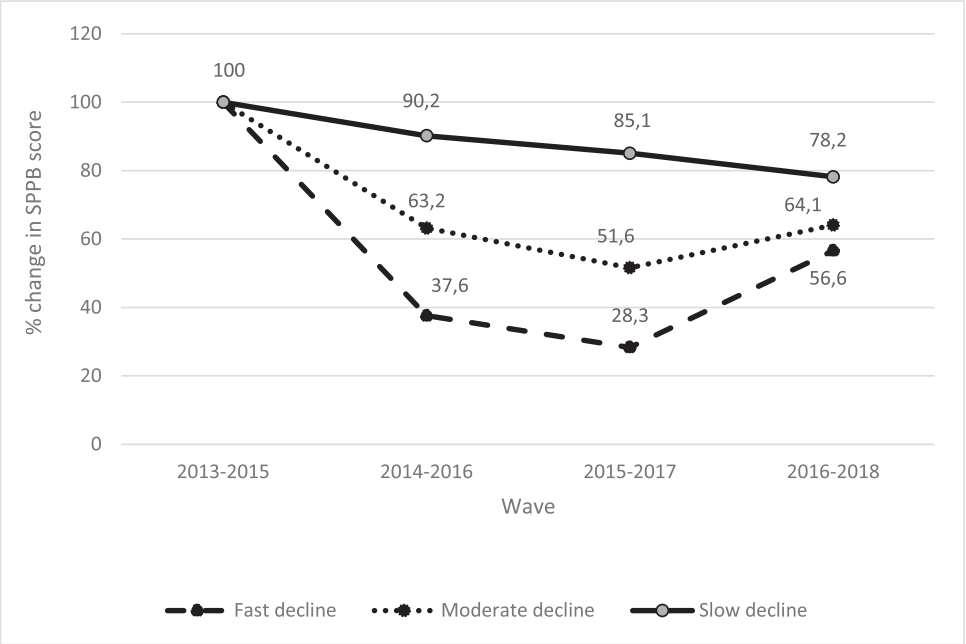

Figure 1. Percentage change in the SPPB score for each trajectory group from 2013 to 2018.

baseline characteristics and baseline SPPB score, indicated that the residents in the fast decline and moderate decline trajectory groups had a 1.78 (95% CI = 1.34–2.26) and 1.37 (95% CI = 1.10–1.66) times higher risk of mortality, respectively, relative to the slow decline trajectory group.

Discussion

In this work, we investigated the PP trajectories of 604 older residents included in the SENIOR cohort and the association of these trajectories with baseline characteristics and mortality. This study identified three PP

Table 2. Association of the residents' baseline characteristics with the SPPB trajectory groups.

Baseline characteristics	Fast decline[a]				Moderate decline[a]			
	RRR	95% CI		*P* value	RRR	95% CI		*P* value
Age	1.16	1.12	1.20	<**0.001**	1.08	1.05	1.11	<**0.001**
Sex (ref.: women)								
Men	0.18	0.11	0.31	<**0.001**	0.42	0.26	0.70	**0.03**
BMI	0.99	0.95	1.03	0.44	0.95	0.91	0.98	**0.03**
Medical history	1.16	1.09	1.24	**0.01**	1.08	0.99	1.16	0.19
Medication	1.12	1.06	1.17	<**0.001**	1.09	1.03	1.15	**0.01**
Civil status (ref.: single)								
Married	1.21	0.50	2.97	0.57	1.45	0.60	3.57	0.40
Divorced	0.63	0.26	1.48	0.30	1.11	0.48	2.57	0.40
Widowed	4.60	2.25	9.45	<**0.001**	3.83	1.85	7.96	0.36
Education (ref.: >7 years)								
<7 years	1.52	0.95	2.45	0.13	1.16	0.85	1.76	0.46
MMSE score	0.86	0.80	0.92	<**0.001**	0.91	0.67	0.97	**0.02**
Depression (ref.: Yes)								
No	0.72	0.45	1.16	0.24	1.07	0.66	1.75	0.44
Baseline SPPB score	0.25	0.21	0.31	<**0.001**	0.52	0.45	0.61	<**0.001**

[a]The slow decline trajectory was the reference group. The significant values are in bold (*P* value < 0.05).

Table 3. Cox proportional hazards regression model predicting the risk of mortality over 3 years as a function of the physical performance trajectory group.

Physical performance trajectory group	Model 1[a]				Model 2[a]				Model 3[a]			
	HR	95% CI		*P* value	Adjusted HR	95% CI		*P* value	Adjusted HR	95% CI		*P* value
Fast decline	2.29	2.04	2.55	<**0.001**	1.81	1.50	2.12	**0.002**	1.78	1.34	2.26	**0.002**
Moderate decline	1.71	1.46	1.96	<**0.001**	1.42	1.15	1.69	**0.02**	1.37	1.10	1.66	**0.02**

[a]The slow decline trajectory was the reference group. Model 1 was unadjusted. Model 2 was adjusted for age, sex, BMI, medical history, medication, civil status, educational attainment, MMSE score and depressive symptoms. Model 3 was adjusted for the same variables as Model 2 + the baseline SPPB score. The significant values are in bold (*P* value < 0.05).

trajectory groups using repeated measurements of SPPB scores over 3 years. Then, we observed an association between the baseline characteristics and the PP trajectory groups. These analyses suggest that the risk of mortality is higher in the fast decline and moderate decline groups relative to the slow decline group.

There are similarities among the three identified PP trajectory groups in this study and those described by previous studies in terms of the number of groups and the decline in PP over time [10,11,23]. In concordance with the previous analyses, the slow trajectory group experienced a slight decline over time. The fast decline group showed the largest decline during the first 2 years, with a small increase in the last year of the 3 years of follow-up. The same trajectory but with a less prominent decline was also observed for the moderate trajectory group. However, the quadratic curves of our three trajectory groups differ slightly from those of previous reports who were downhill or stable [10,11,23]. The most surprising aspect regarding the fast and moderate trajectory groups is in the slight improvement in the last year, which has not been reported in previous studies. Although surprising, this result might be due in part to the impact of the inclusion criteria and the attrition of the results. Indeed, some studies with controversial results regarding increases in the PP among nursing home residents have been reported in other studies [24]. The decrease in people over the years (because of mortality) could lead to the fittest staying in the study and thus underestimating the decline in functioning [25]. Moreover, during the life course of older people, there is a dynamic process of the physical frailty, characterised by transitions (improvement or worsening) over time [26].

Consistent with the literature, this research found that residents in the fast decline group were more likely to be older [10], female [11] and a widow(er) [23] and more likely to have a more involved medical history [11,23], have lower MMSE scores [11] and take a higher number of medications [11]. These findings suggest that careful attention to residents' anamnesis and medical conditions could be important for predicting the PP trajectory of individuals. However, we need to be cautious when interpreting these results because the studies with which we compared our results were carried out with community-dwelling older people. In contrast to earlier findings, however, no evidence of an association between depressive symptoms and PP trajectories was detected [10,11]. This inconsistency may be due to the self-reported nature of depressive symptoms in our study,

which is less accurate than those reported by a clinician for individuals with diagnosed depression [27].

The results regarding the association of the baseline SPPB score with the PP trajectory are broadly consistent with the earlier findings of LaCroix *et al.* [28]. The residents who had a low baseline SPPB score tended to have a fast decline trajectory over the 3 years of follow-up. The large differences between the baseline SPPB of the three groups are similar to those observed in Mutambudzi *et al.*'s study [11]. Moreover, most previous studies found an association between a single measurement of the SPPB and mortality [2,29].

In accordance with the present results, Mutambudzi *et al.* [11] demonstrated that there was an association between the SPPB trajectories and mortality. This association remained significant after adjustments for confounding variables and the baseline SPPB scores. Other studies found similar results regarding the prediction of PP trajectories and mortality in community-dwelling older people [12,14]. However, there are many differences in the method used to assess PP trajectories, the duration of follow-up and the interval between the repeated measures.

The findings of this study have two implications for future practice. The data appear to support the assumption that repeated assessments with the SPPB test may be informative in clinical settings and may be a useful indicator in identifying nursing home residents at risk of death [13]. Moreover, our results highlight the importance of taking into account the clinical characteristics of residents for individual management to prevent the decline of PP.

Additional research studies should be conducted to confirm our results. In addition, future studies are recommended to determine whether PP trajectories are modifiable, particularly for residents with fast decline trajectories. Although a few physical activity intervention studies have been conducted in nursing homes [30], the information presented in this paper encourages the study and development of targeted interventions aimed at improving the PP of older individuals.

Some strengths of this research must be highlighted. This is the first study that examines the associations between PP trajectories and mortality in a nursing home population. The longitudinal design and the inclusion of confounding variables reported in the literature are advantages of this study. Moreover, we used multiple imputations to manage missing data and to overcome the attrition problem that occurs in cohort studies with older people. This method is often used in longitudinal studies with repeated measurements, although the results must be interpreted with caution [19].

On the other hand, the generalisability of these results is subject to certain limitations and should be performed with care. The major limitation of this study is the exclusion of the most vulnerable nursing home residents because of selection criteria used. This limitation led to a sample that does not exactly reflect the behaviour of the actual population of nursing homes. We must also be aware that the individual trajectories may not be the same for all members of the same trajectory group. Therefore, the average change should not be interpreted as individual-specific change. Our methodological choice of assigning a score of 0 to residents who had passed away may overestimate the number of rapid decline.

Conclusions

This prospective cohort study suggests that repeated assessments with the SPPB test add value to a single baseline clinical geriatric assessment for identifying individuals at risk of mortality. Regular monitoring of the SPPB score may help clinicians adjust healthcare plans for nursing home residents.

Declaration of Conflicts of Interest: None.

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