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Walking speed as a good predictor for the onset of functional dependence in a Japanese rural community population

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Abstract

Objective: to investigate and compare the predictive values of four physical performance measures for the onset of functional dependence in older Japanese people living at home.
Design: a population-based prospective cohort study.
Setting: Nangai village, Akita Prefecture, Japan.
Methods: out of the population aged 65 years and older living in Nangai ($n = 940$) in 1992, we measured hand grip-strength, one-leg standing, and usual and maximum walking speeds in 736 subjects who were independent in the five basic activities of daily living. Their functional status was assessed each year for the subsequent 6 years. The outcome event was the onset of functional dependence, defined as a new disability in one or more of the five basic activities of daily living, or death of a subject who had shown no disability at the previous follow-up.
Results: even after controlling for age, sex and a number of chronic conditions, lower scores on each baseline performance measure showed increased risk for the onset of functional dependence. Maximum walking speed was most sensitive in predicting future dependence for those aged 65–74 years, while usual walking speed was most sensitive for people aged ≥75 years.
Conclusion: walking speed was the best physical performance measure for predicting the onset of functional dependence in a Japanese rural older population.

Keywords: *cohort study, functional dependence, older adults, physical performance measure, walking speed*

Introduction

Performance-based measures of physical function can predict future incidence of disability, dependence in activities of daily living (ADLs), institutionalization and death in initially non-disabled older people [1–9]. Objective measures of lower-extremity function, such as walking speed, standing balance and repeated rising from a chair, are highly predictive of subsequent disability in various ethnic older populations [2, 3]. In addition, hand grip-strength is an important predictor for disability and mortality in older people [5–7].

However, previous studies have not examined whether the predictive value of such performance measures in an older population is affected by age. The Tokyo Metropolitan Institute of Gerontology launched a prospective cohort study on ageing in 1990. As part of the baseline survey of this study, several physical performance tests were conducted on a rural Japanese older population [10]. The functional status of these subjects was followed-up annually until 1998. We have used these data to investigate and compare the predictive values of different baseline physical performance measures for the onset of functional dependence in people aged either 65–74 years or 75 years and older.

Methods

Study area and subjects

We obtained the data in this study from the Tokyo Metropolitan Institute of Gerontology Longitudinal Interdisciplinary Study on Ageing. Details of this project have been described elsewhere [10]. The

study area was Nangai village, Akita Prefecture, Japan. In 1992, 940 people aged 65 years and older were registered as residents in the village. Of these, 88 were living in institutions, bed-ridden at home or long-term absent. The remaining 852 were invited to participate in the baseline survey held at community halls. After signing informed consent forms, which had been approved by the ethics committee of the Institute, 748 took part in the survey (88% response).

Baseline survey

We asked the subjects about their dependence in five basic ADLs: bathing, dressing, walking, eating and continence [1, 11, 12]. Dependence in an ADL was defined as the subject needing help from someone else or being unable to perform the activity. We ascertained the presence of chronic conditions (defined as a history of heart disease, stroke or diabetes mellitus) from the subjects' reports. In addition, we defined arthritis as persistent pain in any joint in arms or legs (knee, hip, etc.) and included it among the group of chronic conditions.

The participants then underwent tests of hand grip-strength, length of time standing on one leg, and usual and maximum walking speed. We evaluated hand grip-strength by a mechanical dynamometer in the dominant hand and used the higher of two trials in the analysis. For the one-leg standing test, we asked subjects to look straight ahead at a dot 1 m in front of them. We then asked them to stand on the preferred leg with their eyes open and hands down alongside the trunk. The time until balance was lost (or maximum 60 s) was recorded. We used the better of two trials in the analysis. To test walking speed, we asked subjects to walk on a straight walkway 11 m in length on a flat floor once at their usual speed and then, twice, at their maximum speed. Walking speed was measured over a 5 m distance between marks 3 and 8 m from the start of the walkway. For maximum walking speed, we used the faster result in the analysis. The good reproducibility of these walking tests has been reported previously [13].

Follow-up survey

Of the 748 participants in the baseline survey, the 736 who had no disability in their basic ADLs were followed up annually for the next 6 years. Each July their levels of basic ADLs were assessed as in the

Table 1. Quartiles of the physical performance measures at baseline by sex and by age group

			Walking speed (m/s)							
			Maximum		Usual		Hand-grip strength		One-leg standing[b]	
Sex	Age (years)	Quartile[a]	Level	*n*	Level	*n*	Level (kg)	*n*	Time (s)	*n*
Men	65–74	1	≤1.81	50	≤1.08	52	≤27	49	≤18	51
		2	1.82–2.10	50	1.09–1.25	52	28–32	50	19–59	43
		3	2.11–2.36	50	1.26–1.38	52	33–36	53	≥60	114
		4	≥2.37	50	≥1.39	52	≥37	56	–	–
	≥75	1	≤1.34	17	≤0.82	18	≤20	18	≤5	19
		2	1.35–1.64	18	0.83–1.02	20	21–25	20	6–12	19
		3	1.65–1.99	18	1.03–1.20	19	26–29	18	13–49	19
		4	≥2.00	17	≥1.21	19	≥30	21	≥50	19
Women	65–74	1	≤1.45	72	≤0.9	76	≤16	73	≤7	73
		2	1.46–1.70	73	0.91–1.07	77	17–19	73	8–24	79
		3	1.71–1.98	73	1.08–1.25	76	20–21	88	25–59	52
		4	≥1.97	72	≥1.26	76	≥22	71	≥60	101
	≥75	1	≤1.08	29	≤0.69	29	≤12	30	≤1.9	17
		2	1.09–1.34	31	0.70–0.87	31	13–15	29	2–6	40
		3	1.35–1.62	29	0.88–1.04	29	16–19	32	7–15	33
		4	≤1.63	30	≥1.05	30	≥20	30	≥16	31

[a]Performance scores from 1 (lowest) to 4 (highest) were allocated according to quartile.
[b]Distribution of data on one-leg standing was skewed in subject groups aged 65–74 years because the maximum was set at 60 s.

baseline survey. Death was ascertained from death certificates. The outcome event in this study was the onset of functional dependence—defined as a new disability in one or more of the five basic ADLs—or death of person who had shown no disability at the follow-up in the previous year.

Statistical analysis

Within each age group we divided men and women into quartiles according to their baseline performance in each test, and allocated a performance score (1–4) according to the quartile: 1 indicating the lowest performance and 4 indicating the highest (Table 1). We created a summary performance score by adding the scores for the tests of hand grip-strength, one-leg standing and walking speed (maximum walking speed for subjects aged 65–74 years and usual walking speed for those aged ≥75 years), and grouped subjects into quartiles of summary performance score (3–5, 6–7, 8–9 and 10–12).

We analysed functional dependence over 6 years according to baseline scores on the individual tests and summary performance scores. We used the Cox proportional hazard model to assess the independent association of the individual test scores and summary performance score with the onset of functional dependence during follow-up period, controlling for age, sex, and number of chronic conditions.

Results

During the 6-year follow-up period, 251 outcome events (disability in 183, death in 68) occurred within the cohort of 736 subjects who had been initially independent in the five basic ADLs.

Tables 2 and 3 show the number of events according to the baseline score for each of the four performance measures for subjects in each of the age groups. As seen in their hazard ratios, lower performance levels for each measure had significantly increased risks of onset of functional dependence compared with the highest performance levels, even after controlling for age, sex and number of chronic conditions. Among the four performance measures, maximum walking speed was the most sensitive for predicting the onset of functional dependence among subjects aged 65–74 years, while usual walking speed was the most sensitive predictor among those aged 75

Table 2. Adjusted hazard ratios for baseline performance score against the onset of functional dependence during the 6-year follow-up period among subjects aged 65–74 years

		No. of subjects		
	Score[a]	At baseline	With functional dependence at 6 years[b]	Hazard ratio (95% CI)[c]
Maximum walking speed	1	122	61 (16)	5.15 (2.71–9.77)
	2	123	33 (13)	2.52 (1.29–4.90)
	3	123	21 (4)	1.65 (0.81–3.36)
	4	122	12 (4)	1.0
Usual walking speed	1	128	56 (14)	2.43 (1.42–4.17)
	2	129	40 (12)	1.76 (1.02–3.04)
	3	128	21 (8)	0.93 (0.50-1.72)
	4	128	20 (5)	1.0
One-leg standing	1	124	63 (13)	2.53 (1.40–4.55)
	2	122	30 (8)	1.12 (0.06–2.09)
	3	166	26 (14)	0.75 (0.39–1.46)
	4	101	18 (4)	1.0
Hand grip-strength	1	122	53 (12)	2.51 (1.50–4.20)
	2	123	34 (8)	1.50 (0.87–2.61)
	3	141	29 (12)	1.18 (0.67–2.08)
	4	127	21 (7)	1.0

[a]Higher number indicates better performance.
[b]Including deaths (numbers in parentheses).
[c]Adjusted for age, sex and number of chronic conditions (stroke, heart diseases, diabetes and arthritis).

Table 3. Adjusted hazard ratios for baseline performance score against the onset of functional dependence during the 6-year follow-up period among subjects aged ≥75 years

		No. of subjects		
	Score[a]	At baseline	With functional dependence at 6 years[b]	Hazard ratio (95% CI)[c]
Maximum walking speed	1	43	35 (11)	3.45 (1.81–6.56)
	2	45	24 (6)	1.64 (0.86–3.14)
	3	45	12 (2)	0.67 (0.32–1.43)
	4	43	16 (3)	1.0
Usual walking speed	1	47	41 (11)	6.18 (3.16–12.1)
	2	51	29 (9)	2.56 (1.32–4.98)
	3	48	19 (2)	1.71 (0.84–3.48)
	4	49	13 (3)	1.0
One-leg standing	1	36	28 (6)	3.69 (1.87–7.26)
	2	59	37 (8)	2.62 (1.39–4.93)
	3	52	25 (8)	1.73 (0.89–3.35)
	4	50	14 (3)	1.0
Hand grip-strength	1	48	35 (11)	2.21 (1.23–3.97)
	2	49	28 (5)	1.31 (0.73–2.37)
	3	50	20 (4)	0.89 (0.48–1.65)
	4	51	22 (6)	1.0

[a]Higher number indicates better performance.
[b]Including deaths (numbers in parentheses).
[c]Adjusted for age, sex and number of chronic conditions (stroke, heart diseases, diabetes and arthritis).

years and older. Of interest is that the one-leg standing test showed the second highest predictive value after the maximum walking speed test for subjects aged 75 years and older.

Table 4 presents the adjusted hazard ratios for each category of summary performance score against the onset of functional dependence. This score identified the subgroups within the cohort at lowest or highest risk of the onset of functional dependence. The predictive value of this score for older subjects was superior to that for younger subjects.

Table 4. Adjusted hazard ratios for each summary performance score against the onset of functional dependence during the 6-year follow-up period among subjects aged 65–74 years and ≥75 years at baseline

	65–74 years at baseline			≥75 years at baseline		
	No. of subjects			No. of subjects		
Summary performance score[a]	Total	With functional dependence at 6 years[b]	Hazard ratio (95% CI)[c]	Total	With functional dependence at 6 years[b]	Hazard ratio (95% CI)[c]
3–5	110	59 (13)	4.07 (2.28–7.27)	46	39 (13)	6.05 (3.09–11.9)
6–7	118	34 (13)	2.07 (1.14–3.75)	49	29 (4)	2.85 (1.50–5.44)
8–9	133	17 (4)	0.90 (0.46–1.76)	45	19 (5)	1.60 (0.81–3.18)
10–12	129	17 (7)	1.0	55	15 (3)	1.0

[a]Calculated by adding scores for walking speed (maximum in younger group, usual in older group), one-leg standing and hand grip-strength; higher scores indicate better performance.
[b]Including deaths (numbers in parentheses).
[c]Adjusted for age, sex and number of chronic conditions (stroke, heart diseases, diabetes and arthritis).

Discussion

Muscle strength, standing balance and walking ability are key components of physical performance in older people [14–16]. Thus, in this study we adopted the hand grip-strength, one-leg standing and walking speed tests for assessments of the physical performance of subjects living at home. These tests do not require special equipment and are not time-consuming, and thus hold advantages for a large-scale population survey.

Among these physical performance measures, maximum walking speed was the most sensitive in predicting the onset of functional dependence for younger people, while usual walking speed was most sensitive for older people. To date, several reports have shown that walking speed is highly predictive of future disability and mortality in non-disabled older people [2, 3, 5, 8]. However, it has remained unclear whether maximum and usual walking speeds differ in terms of predictive value. The present study is the first to show that the two walking speed indices differ in predictive value depending on the age group being investigated.

The reason for this is unclear. Perhaps, as a person ages, leg function decreases to an extent which limits usual walking speed. In other words, the usual walking speed in older people may represent functional capacity of the leg. Usual walking speed can be measured without difficulty for almost all older people who are independent in ADLs. By contrast, it is difficult for some older people to perform a maximum walk test. For example, in this study, 4.5% of younger and 9.7% of older people who completed the usual walking test could not complete the maximum walk test, mainly because of pain. Taken together, we recommend the test of usual walking speed rather than the test of maximum walking speed for examinations of walking ability for subjects aged 75 years and older.

The one-leg standing and hand grip-strength tests were also shown to be useful for detecting older people at increased risk of future functional dependence. This result largely confirmed previous reports [5, 6]. Using the Tokyo Metropolitan Institute of Gerontology Index of Competence [17], we had demonstrated that lower performance in these two physical tests was independently associated with decline in the higher-order levels of functional capacity (instrumental self-maintenance, intellectual activity and social role) in a rural older population [18]. The mechanisms underlying the association, however, remain unclear and need further study.

Furthermore, separate analysis by age group showed that physical performance measures are as much or even more valuable for predicting future dependence in older people than in younger people, as seen in the summary performance score. This result may imply that at advanced ages, physical performance level becomes more critical for maintaining an independent life than at younger ages, and stresses the importance of functional evaluation even at advanced ages in a clinical setting.

In summary, the four physical performance measures can be used for predicting the onset of functional dependence in community-dwelling older people. The walking speed—maximum for younger subjects and usual for older subjects—is the best physical performance measure in terms of predictive value for the onset of functional dependence.

Key points

- Hand grip-strength, one-leg standing and walking speed are predictive of the onset of functional dependence in older people living at home.
- Maximum and usual walking speeds are the best predictors in younger (65–74-years) and older (≥75 years) people, respectively.
- Baseline summary performance score is more useful for older people than for younger people in predicting future dependence.

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