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Muscle Strength and Mobility as Predictors of Survival in 75–84-Year-old People

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Summary

The purpose of the study was to examine the associations of physical capacity, as determined on the basis of self-report and physical measurements, with survival in three groups of elderly people aged 75, 80 and 75–84 years. The main aspects of physical capacity were mobility, walking speed, hand grip strength and knee extension strength. Altogether 1142 persons participated in the mobility interview, of whom 466 also took part in the walking speed test, and 463 in the strength tests. The follow-up periods ranged from 48 to 58 months.

Risk of death was significantly related to difficulties in indoor mobility among the 75–84-year-olds (odds ratio = 1.99, 95% confidence interval = 1.27–3.13) and 75- and 80-year-olds (OR = 1.60, CI = 1.07–2.38) and outdoor mobility among the 75–84-year-olds (OR = 2.44, CI = 1.63–3.67) and 75- and 80-year-olds (OR = 2.75, CI = 1.72–4.40). The odds ratios for hand grip strength (OR = 1.86, CI = 1.13–3.07), knee extension strength (OR = 2.52, CI = 1.50–4.42) and walking time over 10 metres (OR = 1.98, CI = 1.18–3.34) for the 75- and 80-year-olds were also significant. Since these variables can be easily measured and provide valuable information about functional capacity and risk of death they merit inclusion in medical examinations of elderly clients.

Introduction

One of the concerns of mortality research is to identify critical risk factors where early intervention and effective treatment and rehabilitation can help to improve the quality of life of elderly people and in the best case give them more active years. Ultimately, the objective is to develop methods of diagnosis that can be easily applied at the level of primary health care. Earlier studies with elderly people have found that the risk of mortality is linked with physical and mental health and functional capacity by a wide range of factors; these comprise illnesses [1–3], cognitive capacity [4, 5], self-rated health [5, 6], difficulties in carrying out the activities of everyday living [1, 5, 7–9], physical capacity [10] and living habits [11].

One way to study functional capacity in elderly people is to measure their level of ability in carrying out the activities of everyday living. In recent years, however, there have been increasing calls for the measurement of individual functions using simple physical tests [12–14], such as measurements of walking speed and muscle strength. To be able to manage many of the activities of daily living satisfactorily requires at least a basic level of physical mobility, but in earlier population-based studies this has generally only been measured on a self-report basis in interviews or questionnaires. Some studies [15, 16] provide evidence that self-report and performance measures complement one another in providing information about functional capacity and that they are also independent predictors of mortality.

The purpose of this study was to examine the associations of physical capacity (mainly walking capacity and muscle strength), as defined in interviews and in physical tests, with survival rates in people aged 75–84.

Materials and Methods

The study forms part of the EVERGREEN project, a research and development programme aimed at describing, maintaining and improving the physical, mental and social capacity and health status of the elderly population of Jyväskylä, central Finland. When the first interviews were carried out in 1988, the city had a population of approximately 65 000, of whom 7600 (11.6%) were aged 65 or over. The majority (67.3%) of the elderly population in the city were women, and 38.9% were in the age group 75 or over.

Interview: There were three groups of interviewees. In 1988, two random samples each of 1000 respondents from cohorts born in 1904–13 and 1914–23, respectively, were drawn from the population register of Jyväskylä. However, for reasons of budget restrictions the number had to be randomly reduced to two groups of 800. The interviews took place at the subjects' homes and covered a wide range of issues concerning health, functional capacity and living conditions. This report considers the results based on the interviews with the older cohort. The interviews with these people were carried out during 1988, when they were aged between 75 and 85 years. The interview team consisted of 28 women students from the university, who received special training for the job. People living in institutions were not interviewed.

The second group of interviewees consisted of all the 75-year-old residents of Jyväskylä (n = 388) and the third group comprised all the 80-year-old residents (n = 291). In both

Table I. Participation rates in different studies

	Age group (years)		
	75–84 n (%)	75 n (%)	80 n (%)
No. of subjects	800	388	291
Eligible subjects	769 (96.1)	382 (98.5)	283 (97.3)
In institutions	26 (3.4)	14 (3.7)	15 (5.3)
Home visit	589 (76.6)	355 (92.9)	262 (92.6)
Refused	144 (18.7)	25 (6.5)	21 (7.4)
No contact	10 (1.3)	2 (0.5)	0 (0.0)
10-m walking test	—	293 (76.7)	173 (61.1)
Hand grip strength	—	290 (75.9)	173 (61.1)
Knee extension strength	—	290 (75.9)	171 (60.4)

these groups the institutionalized population was included. The interviews included the same items as the schedules for those born in 1904–13, and they were conducted in 1989 and 1990 by ten university researchers and women students, who also received training for the job. The response rate for the age group 75–84 years was 76.6%, for those aged 75 years 92.9% and for those aged 80 years 92.6%.

Non-respondents were contacted by phone to collect some basic background information (age, sex, marital status, education, occupation, self-related health and reason for non-participation). In the age group 75–84 years the most common reason for refusal was illness. Amongst those who refused to be interviewed at home, people with poor self-rated health were over-represented. In the age groups 75 and 80 years, there were no significant differences in health status or in managing the activities of everyday living between those taking part in the interviews and the non-participants. The participation rates in the different studies are shown in Table I.

One of the items included in the questionnaire schemes for all these groups concerned indoor as well as outdoor mobility. The responses were graded on a scale from able to move without difficulty to unable to move even with help. The test–retest correlation coefficients of these items studied by interviewing 39 persons twice at a 2-week interval were 0.90 for indoor and 0.82 for outdoor mobility.

Laboratory assessments: Two weeks after the interviews, the 75- and 80-year-old subjects were invited to comprehensive laboratory investigations of their health and functional capacity. The tests included measurements of height–weight, sensory perception, physical performance, and cognitive capacity. The methods employed in these investigations have been described elsewhere [17]. Amongst the measurements made were those of muscle strength and walking speed. Maximal isometric muscle strength was measured for five different muscle groups using a method developed earlier at the University of Jyväskylä [18]. In this study hand grip strength and knee extension strength, assessed on the dominant side were taken as the measures of muscle strength. Walking speed was measured in the laboratory corridor over a distance of 10 m by the researcher using a regular stopwatch. The reproducibility of the maximal isometric strength measurements expressed as correlation coefficients between two successive trials has been observed to be quite high for both hand grip ($r = 0.88$–0.92 [19]) and knee extension ($r = 0.98$ [20]).

Those who only took part in the interview were compared with the subjects who also took part in the laboratory assessments with respect to sex, marital status, education, income, number of depressive symptoms, number of chronic illnesses and self-reported health. In both age groups those who took part both in the interviews and in the laboratory examinations had more chronic conditions than those who only took part in the interviews.

Analysis of mortality: Time of death and cause of death (in accordance with the 1977 International Classification of Diseases) [21] for all the participants who died were obtained from the official register of the province of Central Finland and from hospital records. Mortality was followed up from the baseline studies until the end of 1993: the follow-up time varied in the different groups from 48 to 58 months.

Statistical methods: Statistical analyses were initially based on cross-tabulations. In significance testing the χ^2 test was used for classified variables and the *t* test for continuous variables. In the logit-regression analysis, the purpose was to study the possible relationship of a dependent variable with independent variables. Survival functions were presented to describe survival in the different groups. Comparisons of different survival distributions were carried out by using statistic D as introduced by Lee and Desu [22]. D is asymptotically χ^2 distributed with g-1 degrees of freedom, where g is the number of examined groups. The links of confounding factors with mortality were studied using logit-regression models [23]. The computations were done with SPSSx [24].

Results

The follow-up period in the age groups 75 and 80 years was about 48 months and in the age group 75–84 years about 58 months. During the follow-up period a total of 271 persons died: the mortality figures for the three age groups 75, 80 and 75–84 years were 21 men and 44 women, 20 men and 40 women, and 52 men and 94 women, respectively. The mortality figures for the 75- and 80-year-olds who took part in the laboratory examinations were 15 and 27 and 7 in men and 25 for the men and women, respectively. The most common cause of death was cardiovascular disease, followed by

Table II. Cause of death in different studies

	Age group (years)		
Cause of death	75–84 n (%)	75 n (%)	80 n (%)
Cardiovascular disease	77 (52.7)	28 (43.1)	32 (53.3)
Cancer	28 (19.2)	19 (29.2)	10 (16.7)
Dementia	5 (3.4)	4 (6.2)	1 (1.7)
Accident	2 (1.4)	3 (4.6)	2 (3.3)
Other	34 (23.3)	11 (16.9)	15 (25.0)
Total	146 (100.0)	65 (100.0)	60 (100.0)

cancer. The total number of accidental deaths was seven. The full breakdown of causes of death is shown in Table II.

Logit-regression analysis was used to examine the associations between mortality and age, sex and the measurements of muscle strength (dichotomized by mean values) and walking speed (dichotomized by mean values). According to these analyses age and sex did not explain survival, and hence in the subsequent analyses, in order to increase the number of subjects, the results for those in age group 75 and those in age group 80 have been combined.

In indoor and outdoor mobility no significant sex or age differences were found. Difficulties in moving about indoors and outdoors showed a very significant association with risk of death both among those aged 75–84 years and in those aged 75 and 80. The risk of mortality increased almost in direct proportion to difficulties in movement. Among those who were unable to move about indoors and outdoors even with help, 48.6–83.3% died during the follow-up, whereas 78.9–88.5% of those who were able to move about without difficulty indoors and outdoors were still alive at the end of the follow-up. Figure 1 shows the survival

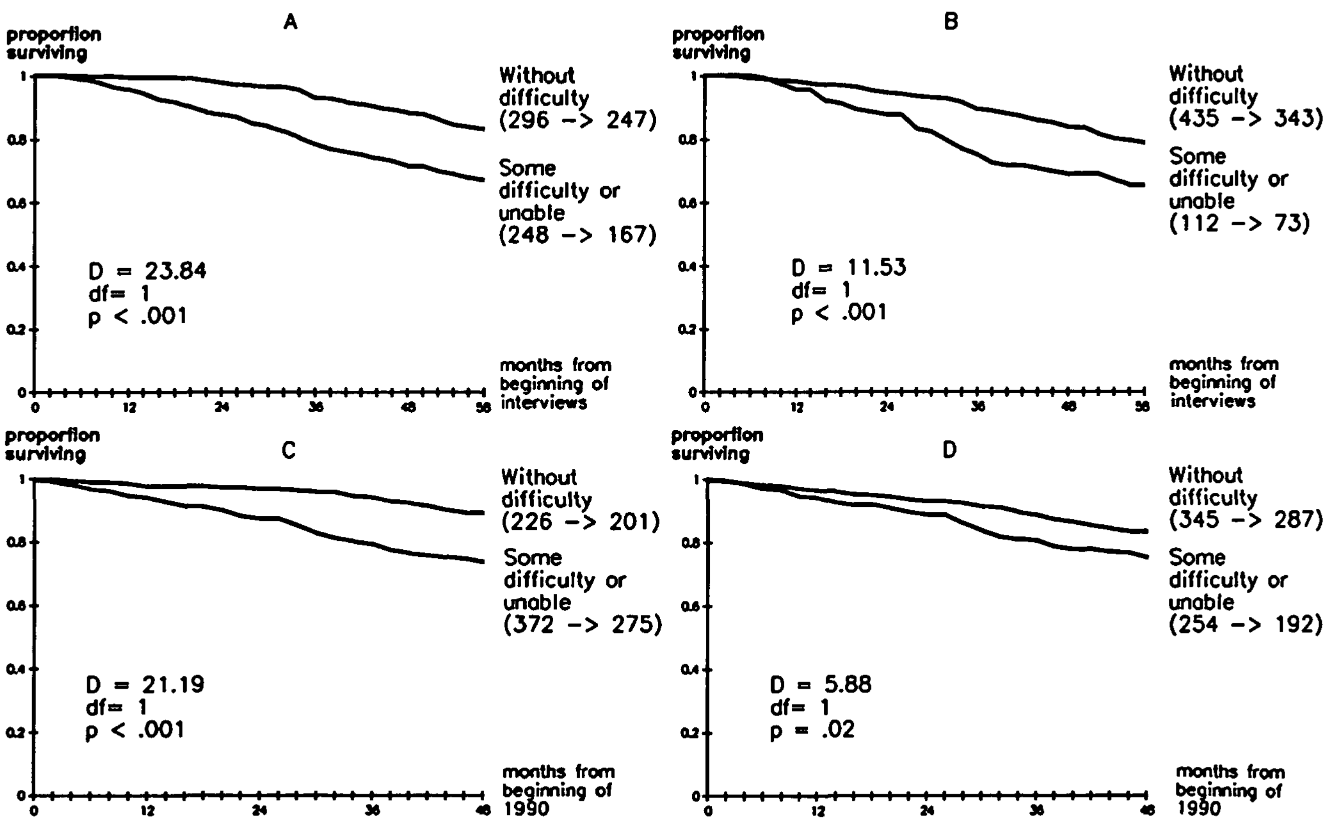

Figure 1. Survival function for 75–84-year-old persons (A and B) and those aged 75 and 80 years (C and D) in two different categories of outdoor (A and C) and indoor (B and D) mobility.

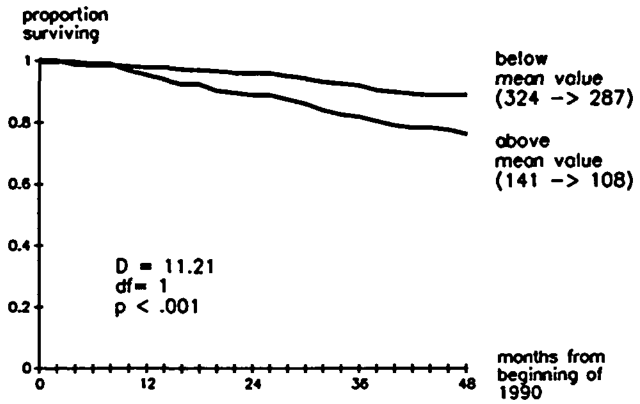

Figure 2. Survival function for 75 and 80 years old in relation to mean values for walking time adjusted by age group and sex.

function for those aged 75–84 years (A and B) and for those aged 75 and 80 years (C and D) in the two different categories of indoor and outdoor mobility.

The mean value in the 10-metre walking test for those aged 75 years and 80 years was 7.7 seconds (SD 4.0). Between the sexes there were no significant differences but the mean for the 75-year-olds was significantly lower, 7.18 (SD 4.12) than that for the 80-year-olds, 8.49 (SD 3.62). In the fastest quartile, nine persons out of ten were still alive after 48 months, whereas in the slowest quartile one in four persons had died. Figure 2 shows the survival function in relation to walking time on the basis of mean values adjusted by age group and sex.

Hand grip strength (in the dominant hand) divided by Body Mass Index (weight/height^2: BMI) averaged 8.4 N (SD 2.5 N) in the 75-year-old women and 14.7 N (SD 3.8 N) in the men. The corresponding figures for the 80-year-old women were 7.5 N (SD 2.4 N) and for the men 13.4 N (SD 3.4 N). Knee extension strength divided by BMI averaged 8.8 N (SD 2.8 N) in the 75-year-old women and 14.2 N (SD 4.0 N) in the men; the figures for the 80-year-old women were 7.4 N (SD 2.5 N) and for the men 11.5 N (SD 3.7 N). The men had better strength in both muscle groups than the women and the younger age group had better strength in these measurements than the older group. Mortality during the follow-up was associated with reduced muscle strength. Figure 3 presents the survival function for hand grip strength and knee extension on the basis of mean values adjusted by age group and sex.

Risk of death was significantly related to difficulties in indoor mobility among the 75–84-year-olds (odds ratio = 1.99, 95% confidence interval = 1.27–3.13) and 75- and 80-year-olds (OR = 1.60, CI = 1.07–2.38) and in outdoor mobility among the 75–84-year-olds (OR = 2.44, CI = 1.63–3.67) and 75- and 80-year-olds (OR = 2.75, CI = 1.72–4.40). Where the result of the walking test was below the mean value in both men and women, the odds ratio with regard to death was 1.98 (95% confidence interval 1.18–3.34). The odds ratios for hand grip strength and knee extension strength were 1.86 (95% CI 1.13–3.07) and 2.52 (95% CI 1.50–4.24), respectively.

Discussion

The results of this study indicated that difficulties in moving about indoors and outdoors, reduced walking speed, and reduced muscle strength were all associated with an increased risk of death during the follow-up period. Of the 1206 people interviewed, 1150 took part in the study, of whom 466 also took part in the walking speed and 463 in the strength tests. Response and participation rates were fairly high in all the studies involved in the project, where the follow-up period was 48–58 months. It can be safely argued that the results of the study provide a reliable description of the associations between physical capacity (and primarily of physical mobility and muscle strength) and the risk of death in residents of Jyväskylä in this age group. The results are consistent with earlier findings on the association between mobility and risk of mortality [1,

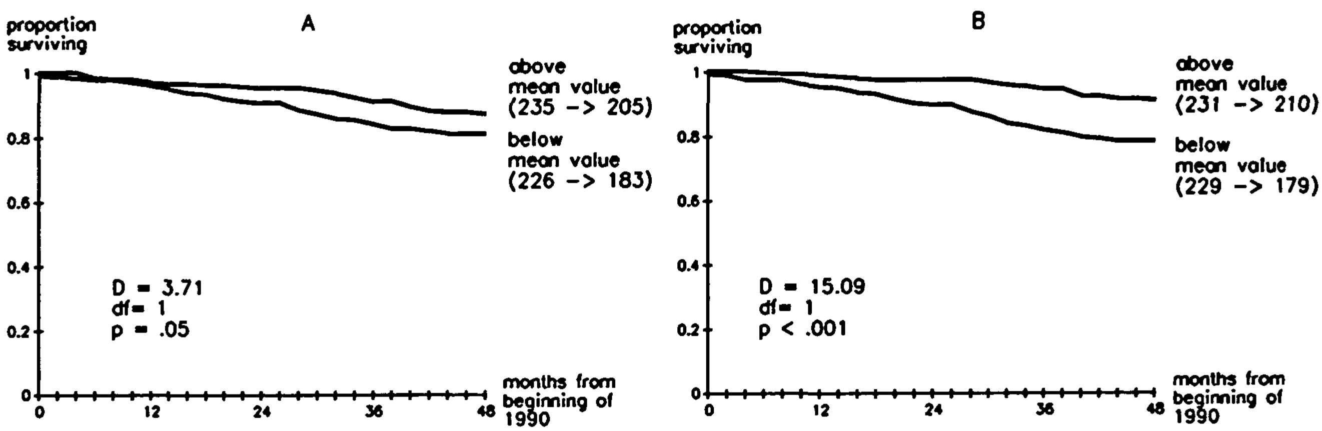

Figure 3. Survival function for 75 and 80 years old in relation to mean values for hand grip strength (A) and knee extension strength (B) adjusted by age group and sex.

15, 25]. As yet no comparable data are available on the aspects of muscle strength.

The choice of hand grip strength and knee extension as measures of physical performance was based on their high correlation with other measures of muscle strength and on the fact that they can be easily measured in a normal surgery setting. In addition, hand grip strength is required in many activities of daily living [26]. In an earlier study that used the same material, a significant correlation was discovered between muscle strength and mobility [27]. In our earlier studies [28] where we used a multivariate model, hand grip strength proved to have a significant role in explaining the carrying out of the activities of daily living. Hand grip strength and 10-metre walking time can easily be measured at any surgery and, combined with interview data on physical mobility, provide valuable information on functional capacity.

Given the crucial importance of good functional capacity in maintaining autonomy with increasing age, it is essential to continue efforts to develop new and better clinical methods for studying functional capacity. Physical performance tests can provide valuable information for purposes of diagnosis and prognosis as well as for the planning of prevention, rehabilitation, care and treatment. The findings of the EPESE studies have shown for example that functional level in physical performance tests predicts not only mortality but also nursing home admission [15]. The results of the present study also showed that reduced physical mobility and muscle strength are a significant mortality risk. However, it was not possible within the confines of the present study to look more closely at the role and significance of those factors that lie behind, for example, reduced muscle strength. Even though muscle strength can be increased quite rapidly even in elderly people [see 29], it seems unlikely that the risk of mortality could be significantly reduced simply by improving muscle strength. The 5-year follow-up studies currently being implemented will provide valuable information on the rate of change in muscle strength and walking speed and the significance of that speed with regard to prognosis.

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