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INSTRUMENTAL ACTIVITIES OF DAILY LIVING RELATED TO IMPAIRMENTS AND FUNCTIONAL LIMITATIONS IN 70-YEAR-OLDS AND CHANGES BETWEEN 70 AND 76 YEARS OF AGE

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ABSTRACT. The aim of this study was to analyse in particular dependence in instrumental daily life activities (I-ADLs) and its association with physical impairments and functional limitations in the elderly. The study was based on cross-sectional data on 70-year-olds (n = 602) and longitudinal data on subjects followed up to the age of 76 (n = 371). Persons dependent in ADL had lower values in maximum walking speed, grip strength, knee extensor strength, stair climbing capacity and in forward reach, compared with those who were independent in ADL. Walking speed in both women and men and sight impairment in men had the greatest influence on dependence in ADL. Possible critical levels for disability in ADL are discussed, as persons who developed dependence between 70 and 76 already had a lower capacity in walking speed and knee extensor strength at age 70 than persons who retained their independence in ADL.

Key words: activities of daily living, longitudinal population study, elderly, muscle strength, walking speed.

Many factors influence functional ability among the elderly, and development of a disability is often described in conceptual terms according to the ICIDH (WHO) or the Nagi model (20, 26, 27). The ICIDH concept comprises disease, impairment, disability and handicap (27), while the Nagi framework consists of pathology, impairment, functional limitation and disability (20) where functional limitations and disability cover essentially the same area as ICIDH disability (26). Muscle weakness and a restricted range of motion are examples of impairments. Functional limitations, i.e. restrictions in accomplishing basic physical and/or mental actions such as walking, lifting, and talking, represent the most direct way in which impairments lead to disability (20, 22, 26). An impairment or functional limitation may lead to practical difficulties in performing activities of daily living (ADL). These include personal daily life activities (P-ADL), such as bathing, dressing and feeding, as well as activities necessary for maintaining a dwelling in the community, and instrumental activities (I-ADL), such as cleaning, shopping and transportation. In prevention as well as in rehabilitation praxis, it is of interest to study the association between impairments and functional limitations and dependence in daily life activities. However, such a relationship may not be linear, as there may be certain threshold levels in an impairment or functional limitation that will result in disability in a specific activity in a given situation (4). Disability occurs when there is a gap between a person's capability and the environmental demand (20, 22, 26, 27).

The aim of the present report was to establish to what degree disability, assessed as dependence in ADL, is associated with physical impairments and functional limitations in 70-year-old women and men and to study changes between 70 and 76 years of age.

MATERIALS AND METHODS

Population

In 1981–82, 806 70-year-olds were invited to participate in the InterVention study of Elderly (IVEG), in Göteborg, Sweden. The sample was divided into an intervention group (IG) (n = 400) and a medical control group (MC) (n = 406) (5). The response rate at age 70 was 77% (n = 619) (IG 78%, MC 76%). The study involved three examinations, at 70, 73 and 76 years of age (5). Of those still alive at age 76, 79% participated in the examination (n = 405) (IG 80%, MC 79%). Between 70 and 73 years of age, the IG was subjected to medical and social intervention both in the group and individually, i.e. information about ageing, various health factors, and benefits of physical activity, adaptations of the environment, support in the form of assistive devices, individual training programs, etc. (5, 9, 24, 25).

This report is based firstly on 97% of all subjects participating at the age of 70, 309 women and 293 men, secondly, on 92% of all subjects who participated in the follow-up at age 76, 200 women and 171 men. Subjects living in hospitals,

nursing homes or in old people's homes were excluded from the study.

This study was approved by the Ethics Committee of the Faculty of Medicine, Göteborg University, Sweden.

Methods

Data concerning ADL were collected at home visits in interviews conducted by occupational therapists, but the subjects were also examined at the out-patient department (5). Most of the measurements used in this study were conducted by physiotherapists.

The level of dependence on, or independence of, another person in activities of daily living was assessed according to a cumulative scale of four defined instrumental activities, I-ADL (cleaning, shopping, transportation and cooking), and five defined personal daily activities, P-ADL (bathing/taking a shower, dressing, going to the toilet, transfer and feeding) (16, 23). The observations can be arranged in conditional ADL steps, where 0 = independent in all activities and 9 = dependent in all activities. The reliability and validity of the instrument have been presented earlier (12, 23).

Maximum walking speed was measured for 30 m indoors. The test was preceded by a test of the same distance at a spontaneously chosen speed.

Ability to climb onto boxes of varying heights (10, 20, 30, 40, 50 cm) without using a handrail was tested. The results from the better leg were used here. The results were classified as those able/not able to step onto a box that was at least 40 cm high without using a handrail.

Ability to reach one's right ear behind one's head with the fingertips of the left hand and vice versa was tested and classified as able without extensive difficulty—or not able.

Ability, when sitting, to reach one's right big toe with the fingertips of the left hand and vice versa was tested and classified as able without extensive difficulty—or not able.

Grip strength in the right and left hand was measured at an elbow-angle of 90° and with the shoulder joint in a neutral position; medium-sized ball for women and big ball for men (Martin Vigorimeter, MA Produkter, Sweden). In the present study, the results from the stronger hand were used.

Voluntary isometric muscle strength was measured in the right and left knee extensors with a tensiometer (Cable Tensiometer Pacific Scientific, Anaheim, Calif., USA), and with the subject sitting in a special chair, with a hip angle of 90° and a knee angle of 90°. A cable was looped around the ankle and fixed to the wall. The moment arm from the knee joint was measured to calculate maximal torque values. The test was repeated three times and the best value was recorded. In this study, only the results from the stronger leg were used. The tensiometer was calibrated, and the calibrating factor was constant throughout the test period.

Forced expiratory volume in one second ($FEV_{1.0}$) was measured with a Vitalograph (Single Breath Spirometer, Maids Moreton House, Buckingham, England).

Visual acuity was tested at a distance of 5 m with the subject's own spectacles. Visual impairment was defined as vision < 0.4 in the better eye with the subject's own glasses.

Ability to hear an ordinary conversation at a distance of 5 meters (without using a hearing aid) was tested. The results were classified as those able/not able to hear.

The number of participants differs in some of the variables (from 553 to 590) as some subjects received only a home visit and some only participated in a limited number of examinations. A few drop-outs were due to technical failure.

In the analyses, body weight and height have been used as background variables.

Statistics

Standard methods for numerical data were used to calculate means and standard deviations. Non-parametric methods were used to test differences between groups. Fisher's two-sided permutation test was used to test differences in level in ADL between responders and non-responders, between sexes, between IG and MC, etc.

Confidence intervals (95%) for proportion were calculated using exact formulas for the binomial distribution. Spearman's rank order correlation was used to test intercorrelation between performance tests, i.e. for climbing capacity recorded by original data, and for maximum walking speed, grip strength, knee extensor strength and ventilatory capacity recorded by ratio scales.

Stepwise logistic regression analysis was used to identify the predictive factors (x) in relation to disability in a multivariate context (using the SAS computer program package). The risk of ADL dependence (p) was determined by logit $p = a + bx$, where logit $p = \log p/(1-p)$ and a is the constant of the logistic regression model and b is the regression coefficient (1).

Values of $p < 0.05$ were considered statistically significant.

RESULTS

Results at 70 years of age

No significant difference was found between IG and MC concerning overall dependence in ADL. Of the functional tests, only the one for grip strength showed a difference in females, as MC women had slightly higher values (mean 69.0, SD 16.0 kp/cm^2) than IG women (mean 65.0, SD 18.2 kp/cm^2). In males, some group difference in stair-climbing capacity was found; the proportion who did not manage to climb 40 cm was greater in IG (18%) than in MC (10%). Thus, the two groups were treated together in the further analysis, 309 women and 293 men.

Table I. *Percentage distribution of 70-year-old women and men dependent on personal help in different activities*

Activities	Women ($n = 309$)	Men ($n = 293$)
I-ADL		
Cleaning	13.6	12.6
Shopping	10.7	8.2
Transportation	8.1	5.1
Cooking	3.2	5.5
P-ADL	3.7	1.7
Proportion of overall disability	16.2	14.0

Table II. *Results from different performance tests at baseline in 70-year-old women and men*

	Women		Men		
	n		*n*		
		mean ± SD		mean ± SD	
Max. walking speed, m/s	291	1.5 ± 0.3	269	1.8 ± 0.4	***
Grip strength, kp/cm^2	301	67.0 ± 17.3	289	83.0 ± 18.3	***
Knee extensor strength, Nm	293	72.8 ± 21.0	264	125.0 ± 28.2	***
$FEV_{1.0}$, l	289	1.5 ± 0.5	266	2.2 ± 0.6	***
		%		%	
Stair-climbing capacity ≥ 40 cm	295	56.9	277	86.3	***
Ability to reach opposite ear	299	98.3	277	97.8	ns
Ability to reach opposite toe	299	83.3	277	95.3	**
Sight (visus ≥ 0.4)	286	88.1	267	90.3	ns
Hearing (conversation at 5 m)	297	98.3	270	93.3	**

Significance levels are given for differences between women and men.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, ns, non-significant.

Sixteen per cent of the women and 14% of the men were dependent in ADL (NS). In females, 3.7% and in men 1.7% were dependent in at least one P-ADL (NS). There was no significant difference between the sexes in different I-ADLs (Table I). All subjects who were dependent in P-ADLs were also dependent in I-ADLs. Comparisons between individual P-ADLs and results of performance tests are hard to make, due to the small number of subjects dependent in different P-ADLs, and to the fact that some of these subjects had not performed the tests. Thus, the further analysis will focus on instrumental daily life activities (I-ADL).

In most of the performance tests, males had significantly higher values than women (Table II). More men had hearing impairment, 7% *vis-à-vis* 2% for women ($p < 0.01$). No significant difference was found between the sexes concerning sight impairment (women 12%, men 10%). A minority, ranging from 2% to 17%, had limitations in the simple tests of reaching ability (Table II).

Those subjects, varying in number from 12 to 49, who did not participate in different performance tests were shown to be more dependent in daily life activities ($p > 0.01$) than those who participated.

In women, the strongest correlations between the results of the different tests were found between maximum walking speed and stair-climbing capacity ($r_s = 0.65$), between stair-climbing capacity and knee extensor strength ($r_s = 0.58$) as well as between knee extensor strength and maximum walking speed ($r_s = 0.44$). In men, the strongest correlations were found between maximum walking speed and stair-climbing capacity ($r_s = 0.51$), between knee extensor strength and maximum walking speed ($r_s = 0.43$) and between stair-climbing capacity and knee extensor strength ($r_s = 0.41$). All the correlations above were significant ($p < 0.001$).

The tests of association between ADL steps (0–9) and the result from the performance tests (measured in ordinal and ratio scales) showed the strongest negative correlation between ADL and stair-climbing capacity and between ADL and maximum walking speed, for both women and men (Table III).

The bivariate analyses showed significant differences between the ADL-independent group and the ADL-dependent group in most of the tests except ventilatory capacity ($FEV_{1.0}$) and grip strength among males, and in reaching ability among females and males (Table IV a and b). In females, no significant difference was found regarding visual impair-

Table III. *Rank correlations between independence/dependence in activities of daily living (ADL-steps 0–9) and various performance tests for women and men at 70 years of age*

The numbers of individuals in the different tests are given in Table II

	Women r_s	Men r_s
Max. walking speed	−0.38***	−0.30***
Stair-climbing capacity	−0.41***	−0.45***
Grip strength	−0.17*	−0.12
Knee extensor strength	−0.27***	−0.22**
Ventilatory capacity ($FEV_{1.0}$)	−0.08	−0.05

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, ns, non-significant.

Table IV. *a. Subjects independent (ID) and dependent in ADL (D) related to maximum walking speed, grip strength, knee extensor strength, and ventilatory capacity ($FEV_{1.0}$), among 70-year-old women and men*

CI: confidence intervals

		Max walking speed (m/s)			Grip strength (kp/cm^2)			Knee extensor strength (Nm)			$FEV_{1.0}$ (l)		
			$\bar{x}$	95% CI		$\bar{x}$	95% CI		$\bar{x}$	95% CI		$\bar{x}$	95% CI
Women													
ADL	ID	$n = 252$	1.5	(1.5–1.6) ***	$n = 256$	69.2	(67.3–71.1) **	$n = 249$	75.8	(73.4–78.3) ***	$n = 245$	1.6	(1.5–1.6) *
	D	$n = 39$	1.1	(1.0–1.2)	$n = 45$	54.3	(47.9–60.8)	$n = 44$	55.4	(49.4–61.3)	$n = 44$	1.3	(1.1–1.5)
Men													
ADL	ID	$n = 241$	1.8	(1.8–1.9) ***	$n = 249$	84.7	(82.5–86.9) ns	$n = 233$	127.8	(124.3–131.4) ***	$n = 237$	2.2	(2.1–2.3) ns
	D	$n = 28$	1.4	(1.2–1.6)	$n = 40$	72.6	(66.4–78.8)	$n = 31$	103.6	(95.0–112.1)	$n = 29$	2.0	(1.8–2.2)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, ns, non-significant.

Table IV *b. Percentage distribution of subjects independent (ID) and dependent (D) in ADL, respectively, for stair-climbing capacity, ability in reaching ear and opposite big toe, among 70-year-old women and men*

CI: confidence intervals

		Stair-climbing capacity ≥ 40 cm			Reaching behind one's head			Reaching opposite big toe		
			%	(95% CI)		%	(95% CI)		%	(95% CI)
Women										
ADL	ID	$n = 251$	62.6	(56–68) ***	$n = 252$	99.2	(97–100) ns	$n = 252$	92.1	(88–95) ***
	D	$n = 44$	25.0	(13–40)	$n = 47$	93.6	(82–98)	$n = 47$	68.1	(53–81)
Men										
ADL	ID	$n = 243$	90.9	(87–94) ***	$n = 243$	97.9	(95–99) ns	$n = 243$	97.1	(94–99) *
	D	$n = 34$	52.9	(35–70)	$n = 34$	97.1	(85–100)	$n = 34$	85.3	(65–93)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, ns, non-significant.

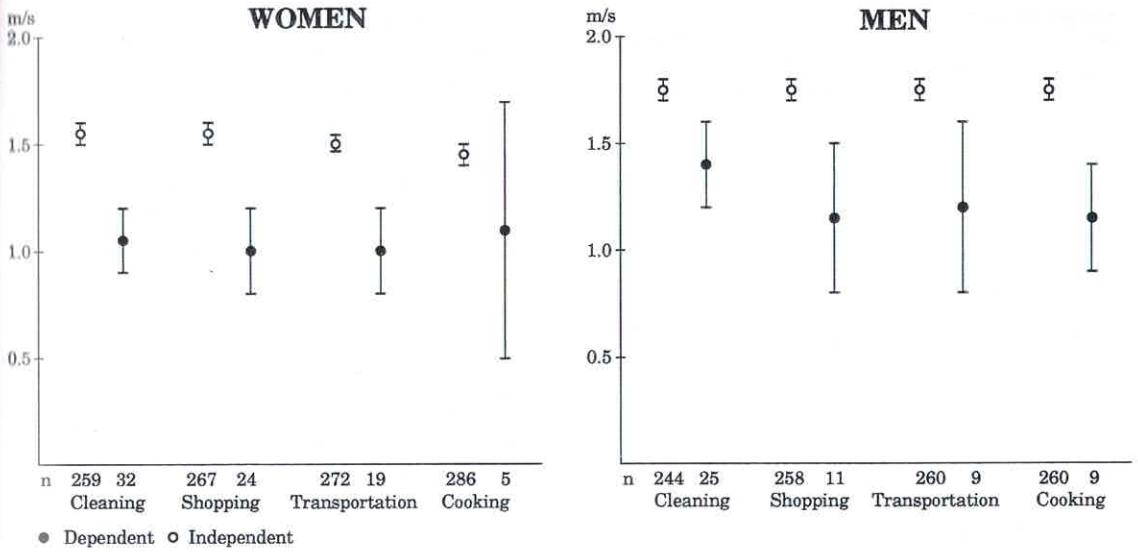

Fig. 1. Mean values with 95% confidence intervals in maximum walking speed among women and men, independent and dependent in different daily life activities.

ment between the ADL-independent group and the ADL-dependent group (12.2–9.8%); in males, there was a significant difference, 7.7% vs. 24.2% ($p < 0.01$). With reference to hearing impairment, no significant differences were found between the groups among females (2–0%) or among males (5.9–12.5%).

Subjects who were independent in the different activities, cleaning, shopping, transportation and cooking, had similar mean values for maximum walking speed (Fig. 1), but had significantly different values from those with dependence in the separate activities. Cooking was an exception among the women, very few being dependent in this regard. The same pattern was shown in grip strength and knee extensor strength for women (Fig. 2). For males, differences between the independent and dependent persons were significant in the activities cleaning and

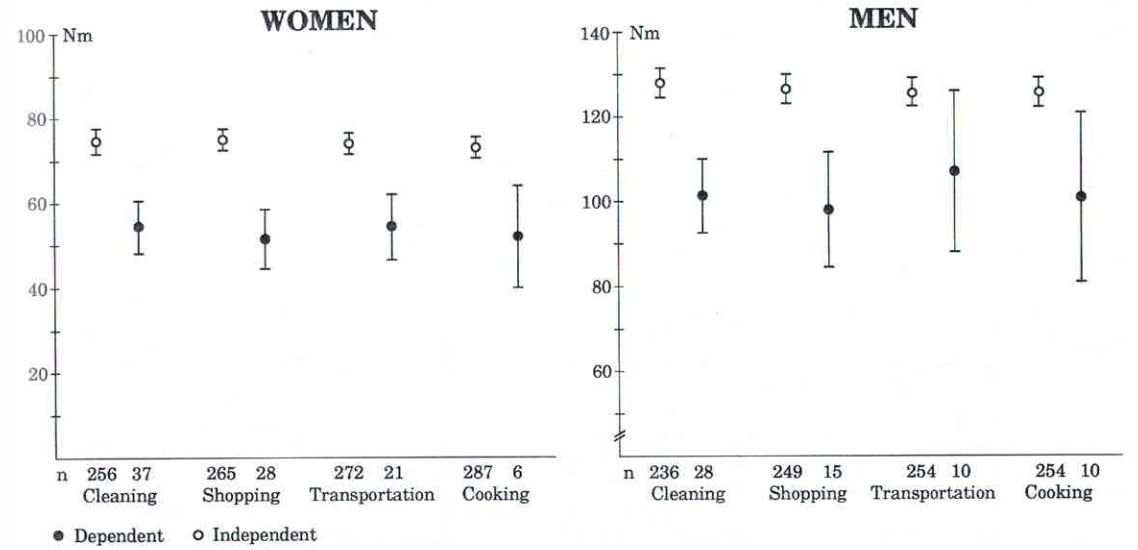

Fig. 2. Mean values with 95% confidence intervals in knee extensor muscle strength among women and men, independent and dependent in different daily life activities.

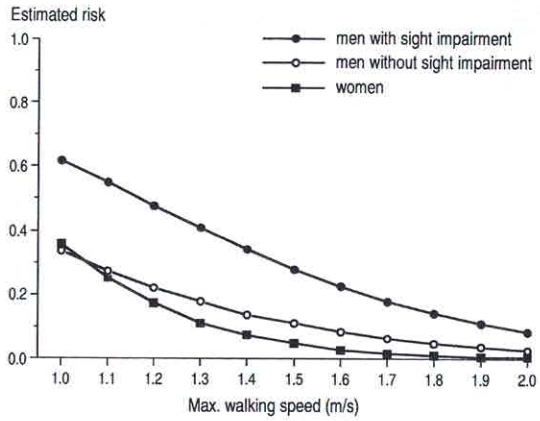

Fig. 3. Risk of ADL dependence related to maximum walking speed, estimated from multivariate logistic regression model. For men, the relationship both with and without visual impairment is shown, but not for women, as visual impairment did not account for the risk.

shopping (Fig. 2). Ventilatory capacity was lower for women who were dependent regarding shopping and transportation, than for those who were independent. For males, no differences were found in this respect.

A logistic regression analysis was carried out in order to ascertain which performance tests would have the greatest influence on dependence in ADL in a multivariate context. Overall disability in ADL was used as a dependent variable and the results of the performance tests, visual and hearing impairment included, as explanatory variables. The multivariate analysis showed that maximum walking speed in both women and men, and sight impairment in men, had the greatest influence on dependence in ADL, $p < 0.001$ and $p < 0.05$, respectively.

The estimated risk of ADL-dependence for women was determined by $\exp A/(1+\exp A)$ where $A = \text{logit}\ p = 4.336–4.933$ WS, where WS denotes maximum walking speed (m/s). The corresponding estimated risk for men without sight impairment was determined by $A = 2.179–2.863$ WS and for those with sight impairment by $A = 3.345–2.863$ WS. According to the models, the risk of being ADL-dependent was about 3 times as high for men with sight impairment as for men without (Fig. 3). The estimated risk of being ADL-dependent was 7% for women with a maximum walking speed of 1.4 m/s. The corresponding risk for men without sight impairment was 14% and with sight impairment 34% (Fig. 3).

A similar logistic regression analyses was done with dependence in each separate activity (cleaning, shopping, transportation and cooking) as a response variable. To ascertain the influence on the model of sex difference in the independent variables, sex was included in the model as the first independent variable regardless of its significance. In this way, sex plays the role of a background factor in the analysis. Maximum walking speed ($p = 0.0001$) and knee extensor strength ($p = 0.0279$) were explanatory variables for dependence in cleaning. Maximum walking speed was the only explanatory variable for dependence in shopping ($p = 0.0001$), in transportation ($p = 0.0001$), and in cooking ($p = 0.0002$), respectively.

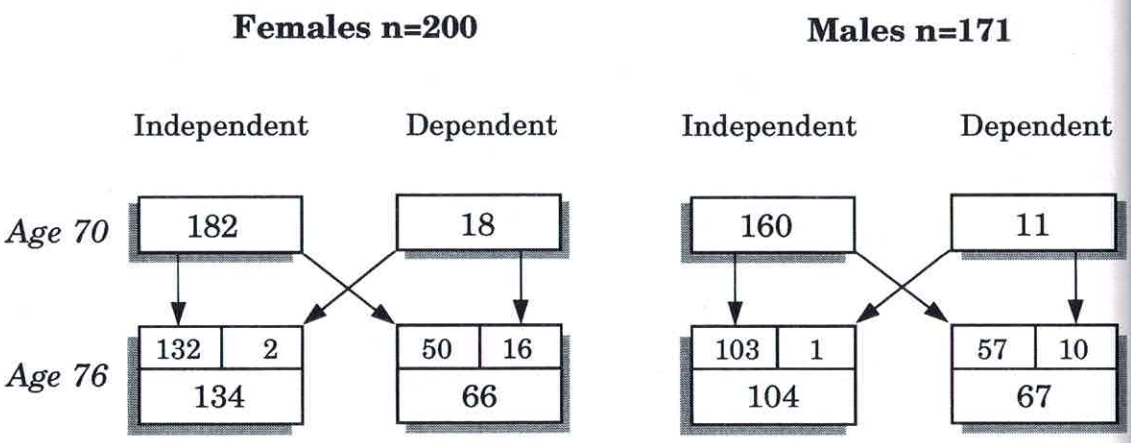

Fig. 4. Distributions of women and men who are independent/dependent in ADL as followed longitudinally between 70 and 76 years of age.

Table V. *Results from performance tests at 70 and 76 years of age (women n = 200, men n = 171) and relation to ADL in three groups*

A = independent at 70 and 76, B = independent at 70 and dependent at 76, C = dependent both at 70 and 76. Mean values and pair-wise test of change with 95% Confidence Intervals (CI) for the change are given

		Women					Men				
	Group	*n*	at 70	at 76	95% CI for change	*p*	*n*	at 70	at 76	95% CI for change	*p*
Max. walking speed (m/s)	A	132	1.6	1.5	(−0.1to −0.02)	**	108	1.9	1.8	(−0.2 to −0.1)	***
	B	35	1.5	1.2	(−0.4 to −0.2)	***	33	1.7	1.3	(−0.5 to −0.2)	***
	C	9	1.2	1.2	(−0.3 to 0.2)	ns	5	1.4	1.3	(−0.4 to 0.1)	ns
Knee extensor strength (Nm)	A	131	77.0	74.0	(−6.1 to 0.2)	ns	104	129.6	117.2	(−17.7 to −7.0)	***
	B	34	68.7	63.5	(−10.8 to 0.3)	ns	31	118.0	92.6	(−34.7 to −16.1)	***
	C	9	50.0	60.4	(−8.9 to 29.8)	ns	5	105.8	84.0	(−36.6 to −6.9)	*
Grip strength (Kp/cm^2)	A	132	69.4	68.3	(−3.6 to 1.1)	ns	107	84.0	76.3	(−10.5 to −4.9)	***
	B	35	66.4	56.1	(−14.9 to −5.7)	***	34	78.2	67.6	(−15.1 to −6.1)	***
	C	8	65.6	59.1	(−16.8 to 3.8)	ns	5	62.0	60.0	(−8.9 to 4.9)	ns
$FEV_{1.0}$(l)	A	136	1.6	1.6	(−0.6 to 0.5)	ns	107	2.3	2.2	(−1.9 to −0.1)	*
	B	36	1.5	1.4	(−2.1 to 0.1)	ns	36	2.0	1.9	(−3.2 to 0.4)	ns
	C	12	1.5	1.3	(−4.7 to 0.7)	ns	4	1.8	1.8	(−2.6 to 4.1)	ns

Significance levels are given for pair-wise test of change within the different groups. $*p < 0.05$, $**p < 0.01$, $***p < 0.001$, ns = non-significant.

Changes between 70 and 76 years of age

A larger proportion of those who turned out to be non-responders (incl. subjects in sheltered accommodation) in the age interval 70–76 ($n = 231$) were dependent in ADL at 70, compared with those who participated in the longitudinal follow-up at 76 ($n = 371$, 200 women and 171 men) ($p < 0.001$). The drop-outs had a lower maximum walking speed, lower grip and knee extensor strength and a lower ventilatory capacity than the participants, and a greater proportion of the drop-outs were unable to climb 40 cm. In the pooled group of women and men, all the differences mentioned above were significant ($p < 0.001$). No differences were found concerning the proportion with sight or hearing impairment, nor in reaching ability.

In females, no differences were found between IG and MC in this study as regards change, except in the knee extensor strength, where the decline between 70 and 76 years of age was less in IG (76.7 Nm SD 17.0; 74.8 Nm SD 20.9) than in MC (79.3 Nm SD 20.3; 73.0 Nm SD 18.2) ($p < 0.001$).

In males, differences were found only in ADL, where the decline was greater within IG (7 to 41%) than in MC (6 to 25%) ($p < 0.05$). As the correlation coefficients (r_s) between ADL (step 0–9) and the performance tests did not differ significantly between IG and MC, the two groups were treated together in the further analysis.

Of all subjects participating in the longitudinal follow-up (Fig. 4), 235 subjects were independent both at 70 and 76 years of age (Group A), 107 subjects were independent at 70 but dependent at age 76 (Group B), and 26 subjects were dependent both at 70 and 76 years of age (Group C). Subjects dependent in ADL at 70 but independent at 76 were excluded in the further analysis, due to the small number concerned ($n = 3$).

In females, Groups A and B demonstrated significant changes in maximum walking speed. For grip strength, changes were found only among those who became dependent during the interval (Group B) (Table V). Stair-climbing capacity showed a significant deterioration during the interval. The 95% confidence intervals for the change in the proportion unable to climb 40 cm were 0.15 to 0.30 in Group A, $p < 0.001$, and 0.10 to 0.41, $p < 0.01$, in Group B. A possible change in subjects dependent at both ages (Group C) in the different tests was not demonstrated due to the small sample.

At age 70, subjects in Group A had a higher maximum walking speed and a better knee extensor strength than subjects in Group B ($p < 0.05$) and

Group C ($p < 0.001$). In grip strength and ventilatory capacity, no significant differences were found between groups at age 70.

In males, significant changes over time were found in Groups A and B regarding maximum walking speed, knee extensor strength and grip strength. In Group C, there was a significant decline only in knee extensor strength (Table V). With regard to stair-climbing capacity, significant ($p < 0.01$) changes in the proportion unable to climb 40 cm were only found in Group B (95% confidence intervals for the change 0.09 to 0.46).

At age 70, subjects in Group A had a higher maximum walking speed than subjects in Group B ($p < 0.05$) and Group C ($p < 0.01$), and the same pattern was found concerning knee extensor strength between Groups A and B ($p < 0.05$), and Groups A and C ($p < 0.05$), and in grip strength between Groups A and C ($p < 0.01$). No significant differences between the three ADL groups were found in levels of ventilatory capacity.

During the period, there were changes in the proportions of visual impairment (women 12% to 13%, men 9% to 12%), hearing impairment (women 2% to 5%, $p < 0.05$, men 6% to 8%), limitations in reaching opposite ear (women 1% to 4%, $p < 0.05$, men 2% to 5%) and reaching opposite toe (women 10% to 13%, men 5% to 7%), but no significant changes between the three ADL groups, either for women or for men.

DISCUSSION

Earlier studies have often focused on impairments/functional limitations in relation to mobility and P-ADLs (2, 13, 21). As the incidence of ADL dependence in general populations occurs mostly in I-ADLs in the age group concerned here, the relations to these activities are of vital interest. The results from the present study should be considered representative of fairly well functioning 70-year-old persons, as those who did not participate in the performance tests (varying from 2% to 8%) were more disabled than the participants. This is also true of the subjects followed longitudinally ($n = 371$), as they were less impaired and disabled than the drop-outs. Furthermore, it should be borne in mind that persons in sheltered accommodation were excluded from the present study. It seems likely then that the relationship between ADL and impairment and functional limitations would have been more obvious if no subjects had dropped out of the tests.

The impairments and functional limitations examined in this study are connected mainly with the musculoskeletal system. Several other factors, not explored in the present study, could also have an effect on disability, e.g. cognitive dysfunction, balance problems, pain, lack of motivation, as well as the person's physical and social environment. We assume that cognitive impairment was not a common cause of ADL dependence, as persons with dementia often live in sheltered accommodation (excluded in this study), and as there was only a slight decline in intellectual functioning between 70 and 76 years of age in a sample ($n = 275$) from the same cohort of 70-year-olds examined in this respect (11).

Persons not dependent on personal help in daily life activities were less impaired and less functionally limited than those needing such assistance. Maximum walking speed was the most reliable predictor on dependence in ADL. Walking is one of the most common physical activities for these age-groups, and daily walks of at least 30 min have been shown to be positively associated with leg muscle strength and self-rated physical fitness (8). We know that, even among the very old, it is possible to improve e.g. muscle strength and mobility (6, 7, 22, 28), and that the elderly can be successfully engaged in different physical activity programs (17, 25).

As there were strong correlations between muscle strength, maximum walking speed and ability to climb (confirming previous studies (10)), these tests could be suitable risk markers as they constitute a direct way to disability (18, 19, 22). Jette et al. (15) have shown that progression of musculoskeletal impairments, measured as a range of motion in 10 gross body movements, was an important cause of disability; diminished hand function influenced dependence in P-ADLs, while decrement in the lower extremity influenced dependency in I-ADLs. In the present study, the simple performance tests such as reaching the opposite ear and toe did not discriminate well, implying that these tests are more appropriate for use in clinical settings or in studies of still older populations (18).

Other studies have shown that knee extensor strength is related to ability in daily life activities (13, 21, 22, 28), and that persons with poor knee extension felt more tired and were more dependent on personal help in ADL (2). In the present study,

muscle strength was not associated with dependence in ADL, when adjusting for other variables in the regression model. However, in the longitudinal analysis, persons who were independent at age 70 but who had become dependent by the age of 76 already had poorer knee extensor strength at the age of 70, compared with those who remained independent in ADL. Men demonstrated a decrease in muscle strength between 70 and 76 years of age (Group A and B), but the decrease in Group A did not affect ADL, implying that men have a high reserve capacity. Those persons who were dependent both at 70 and at 76 years of age did not change over time, probably due to underlying diseases and disorders. However, for persons with severe disability, a very small strength gain may result in improvements in 'key' daily life activities such as transfer or rising from a chair (6, 7, 28).

According to Buchner and de Lateur (4), muscle strength may be curvilinearly associated with functional ability, and the threshold at which the strength in relevant muscles is sufficient to perform a specific activity will be more or less evident, depending on the activity and on the scale used to measure it. Muscle strength and walking speed are continuous variables, and as activities of daily living were dichotomized in the present study, the possibility of studying relations between, e.g., strength and different levels of ADL is limited. Persons dependent in ADL in the present study had a lower maximum walking speed and knee extensor strength. The similarity in mean values for the different activities could depend on mobility being included in all activities, as in shopping, transportation. A possible rough critical level might exist in the range between the mean values for those who were independent and for those who were dependent in ADL. In the longitudinal analyses, a greater precision in critical levels can be identified, especially in maximum walking speed and in knee extensor strength, as there were significant differences between the mean values in Groups A and B and A and C. Accordingly, to predict disability, a critical level in knee extensor strength might exist around, or somewhat below, 70 Nm and 120 Nm for 70-year-old women and men, respectively. The corresponding values for maximum walking speed might be around or somewhat below 1.5 m/s for women and 1.7 m/s for men.

As has been shown by others using cross-sectional data, visual impairments are related to disability in ADL (14). This was confirmed in the present study, but only among men. One explanation could be that men had a higher degree of visual impairment than women, or that women could compensate for difficulties in the activities, and therefore did not need assistance from another person. No difference in the prevalence of impaired vision was found between women and men in this study or in a sample of ambulatory 82-year-olds (3). In the present study, progression of visual impairment was not associated with change in functional ability.

The present study has demonstrated the impact of certain impairments and functional limitations on dependence in daily life activities. Possible critical levels in knee extensor strength and maximum walking speed for disabilities in I-ADLs are discussed. At the age of 70, these levels predict disability 6 years later, as maximum walking speed and sight impairment in the case of the men in the multivariate model also increased the likelihood of disability.

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