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FUNCTIONAL STUDIES IN 79-YEAR-OLDS

III. *Walking Performance and Climbing Capacity*

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ABSTRACT. Walking speed and the ability to climbing steps were studied in a subsample of 112 women and 93 men of the longitudinal population study "70-year-old people in Göteborg", in order to evaluate the functional capacity of the lower extremities. No women or men of this age achieved, when walking comfortably, a speed of maximum 1.4 m/s which is recommended in Sweden as a norm for pedestrians at signalized intersections. At their maximum walking speed only 32% of the women and 72% of the men reached 1.4 m/s. In comfortable walking women on an average used 78% and men 70% of their maximal walking speed. All subjects could climb up and down a 20 cm step when using a handrail. Less than half of the women but almost all the men were able to climb up and down a 50 cm high step using a handrail. Subjects having handicap transport service choose significantly lower walking speed than the rest of the subjects. Correlations were found between step test results and walking speed. It is concluded that both traffic vehicles and the rythm at signalized intersections are not in accordance with the functional capacity of older persons.

Key Words: Gerontology, capability, gait-pattern, stair-climbing, population study, handicap, rehabilitation

Among the elderly various disorders of the musculoskeletal system affecting lower extremity function are common (8). An age-dependent reduction in physical activities accentuates such functional disorders (2, 28). In a population study in Göteborg (30) only 13% of the women and 19% of the men aged 70 had had a regular walking activity of more than four hours per week over the last ten years. It is of interest to develop simple tests to evaluate the functional performance.

In previous studies the distance covered by walking for a certain time such as 12 min (1) or the speed used in walking a relatively long distance as 128 meters (7) or a short distance e.g. 30 (2) or 50 (29) meters have been used.

Walking tests of longer duration emphasizes endurance and give an evaluation of the aerobic power whereas the results of shorter walking tests can be assumed to be more dependent on factors such as ability, muscle function and balance. On the other hand the capacity to walk a short distance with relatively high speed is taxed in various practical situations, such as at traffic intersections. The ability to climb stairs of various heights is also of interest to evaluate with respect to certain home-situations and for the use of public transport vehicles. Consequently, a reduced walking performance in old age may be of hindrance for various daily activities. In the present study the interest has been specially focused towards the ability to use pedestrians street intersections and therefore a short distance walking test has been used. Furthermore, climbing ability with references to the demand by public transport has been studied.

Elderly people seem to be at special risk in the traffic. In Sweden 1981, 26% of the pedestrians killed in road traffic accidents were 65 years of age or more (32). In Göteborg the corresponding figure was 29% (17). This means an over-representation as in the Swedish population the proportion of people aged 65 and above was at the end of 1980 16.4% and in Göteborg 17.0%. Traffic accidents in which pedestrians are killed or severely injured are also heavily overrepresented in urban districts and occur specially at street crossings (16). Furthermore, in a study by Aniansson et al. (3) in 70-year-old women and men, the average comfortable walking speed was 1.1 and 1.2 m/s respectively, which is below the Swedish norm for signalized intersections, this discrepancy increases even more in elderly persons which will be demonstrated in the present study. These facts indicate that the walking speed in the elderly is not in harmony with the present traffic rhythm in more closely populated urban areas.

The elderly also encumber difficulties when utilizing the public transportation services (11). By

Table I. *Causes of non-response in tests of walking and climbing capacity in the total subsample of 79-year-old women and men*

	Women (n=126)	Men (n=100)
Refusal	3	2
Severe illness		
Living at home	6	2
Institutional care	5	3

adapting the physical surroundings to the needs of the elderly it might be possible to maintain a good functional capacity even at higher age.

MATERIAL

Altogether 601 women and men were invited to participate in the population study which was performed in 1980–81 and was a second re-examination of participants in a previous study carried out in 1971–72 "70-year-old people in Göteborg". The participants were originally drawn at the age of 70 from the Revenue Office Register as a systematic sample comprising 30% of the 70-year-olds living in Göteborg between 1 July 1971 and 30 June 1972. The method of sampling as well as the design and performance of the general study, have been described in detail by Rinder et al. (30) and Svanborg (34). The subjects had been numbered consecutively from 1 to 5.

A systematically selected subsample (with subject numbers 3 and 5) representing 40% of the total sample, and including 126 women and 100 men were at the same time as the main investigation invited to participate in a special investigation of walking capacity and climbing steps. The participation rate in this subsample was 87 per cent. Reasons for non-response are shown in Table I.

Table II. *The use of walking aids, personal assistance home care and transport by the handicap transport service in 79-year-old women (n=112) and men (n=93)*

	Women		Men	
	n	%	n	%
Walking aids				
Sticks	30	27	23	25
Other walking aids	4	4	2	2
Wheel chair	3	3	2	2
Other persons help	2	2	2	2
Home care				
With shopping, cleaning, laundry and cooking	48	38	28	28
Transport by the hadicap transport service	43	38	18	20

Another eight subjects (five women and three men) could for technical reasons not fulfill the test.

All subjects in the subsample were investigated in accordance with a broad social, psychological and medical program in a standardized manner (30). Seventy-six women (62%) and 63 men (68%) had no signs or symptoms from the lower extremities. Subjects who had cardiovascular disease (22), neurological (central or peripheral paresis, transitory ischaemic brain attack, rigidity, coarse tremor, treated Mb Parkinson) or locomotor (joint and lower back pains, amputees) disorders or combinations of these are presented in Fig. 1. Those not included in this figure are classified as "healthy". Reduced anamnestic vision was reported by 17% of the subjects. Walking aids were used in 27% of the women and 25% of the men. The number of women and men with personal assistance, home care and transportation by the Handicap Transport Service are presented in Table II.

METHODS

Walking test

The subjects were first requested to walk a distance of 30 m in a corridor at their most comfortable walking speed. They were then asked to walk the same distance as fast as possible. This is a normal distance for a pedestrian crossing one of the larger urban streets. The flooring was of "nonslip" material and none of the women were wearing real high-heeled shoes. The observer walked behind the subject without interfering. The walking time was registered with a chronometer without the knowledge of the participants and their heart rate was registered by ECG telemetry during the test (Medinik, Örbyhus, Sweden).

Step test

The step test was performed according to Aniansson et al. (3). The test equipment consisted of three boxes which could be combined to form steps of 10, 20, 30, 40 and 50 cm in height. The subjects were requested to climb up and down steps starting with alternating right and left leg. Handrails that were mounted on the wall could be used when necessary. The maximum step height which the subject was able to climb both up and down with either leg was registered, as well as the use of handrail. The heart rate was determined by ECG recordings during the test.

Immediately after the test subjects rated their perceived exertion on a scale from 6 to 20 according to Borg (9) (7 indicating "very very easy", 9 "very easy", 11 "rather easy", 13 "somewhat strenuous", 15 "strenuous", 17 "very strenuous" and 19 "very very strenuous"). The subjects were interviewed about their ability to enter and leave vehicles such as trams, buses and trains. If they had difficulties, they were asked whether the problem depended on step height, doorwidth or lack of handrails. The subjects were also asked whether they experienced dizziness and, if so, how often.

Statistical methods

Standard statistical methods were used to calculate means (M), standard deviations (SD) and correlation coefficients

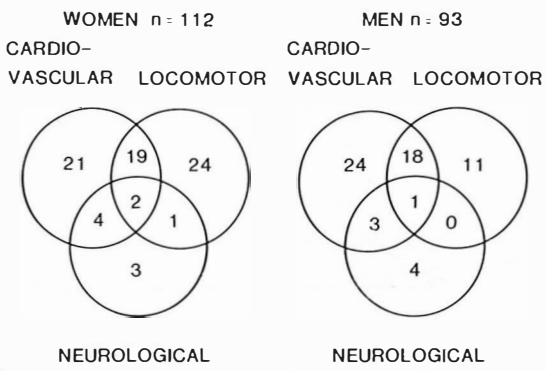


Fig. 1. Numbers of 79-year-old women and men in the sub-sample participating in the walking and climbing study with cardiovascular, locomotor and/or neurological signs and symptoms.

(r). Statistical comparisons between two groups and correlation analysis were performed by means of Pitman's non-parametric permutation test (12). Only two-tailed tests were used. Values of $p \leq 0.05$ were considered as statistically significant.

RESULTS

Men generally walked faster than women, their mean of comfortable walking speed being 1.03 m/s while that of women was 0.92 m/s ($p<0.001$). None of the subjects reached 1.4 m/s in comfortable walking. The mean maximal walking speed were 1.43 m/s in men and 1.18 m/s in women ($p<0.001$). Thirty-two per cent of the "healthy" women and 72% of the men walked faster than 1.4 m/s. Very few women with disorders were able to walk as fast as 1.4 m/s, but 50% of the men with disorders achieved this velocity (Fig. 2). When comparing the "healthy" participants with those having disorders, no significant differences were observed except for maximal walking speed in men (Table III). Comfortable and maximal walking speed showed a high correlation ($r=0.94$ for women and 0.79 for men) and had a similar correlation to other variables. Therefore correlations are normally presented for comfortable walking.

All subjects were able to climb up and down the 10–20 cm steps when using the handrail. Twenty per cent of the women and 6% of the men were not able to climb up 40 cm step-height even when using the handrail (Fig. 3). All "healthy" men managed 40 cm height. There were no differences if the subjects started with the right or the left foot.

Of those women who were able to climb the 40 cm step, 24% reported difficulties when using public transportation while this proportion was 61% among those women unable to climb the 40 cm step ($p<0.001$). In "healthy" women, the proportions were 18% and 50% and, in women with disorders, 28% and 67% respectively.

As shown in Table IV a high correlation was found between comfortable walking speed and the ability of climbing steps in women in the total series studied ($r=0.66$) and a lower but significant correlation in men ($r=0.34$). Similar correlations were obtained for both sexes when those with and without disorders were studied separately. As also seen in Table IV significant negative correlations were found between walking speed and perceived exertion for women as well as for men in the total group.

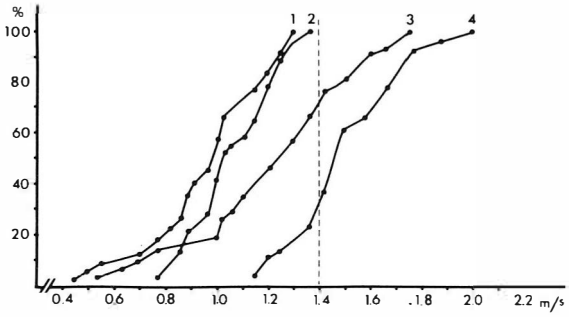
Women (33%) and men (38%) with dizziness achieved lower height in climbing steps and slower speed in walking. The subjects reporting difficulties with public transportation had a significantly lower walking speed than others.

In addition, a significant correlation was found, but only in women, between climbing steps and difficulties in using public transportation. The correlations were similar when women and men with and without disorders were studied separately and are therefore not included in the table.

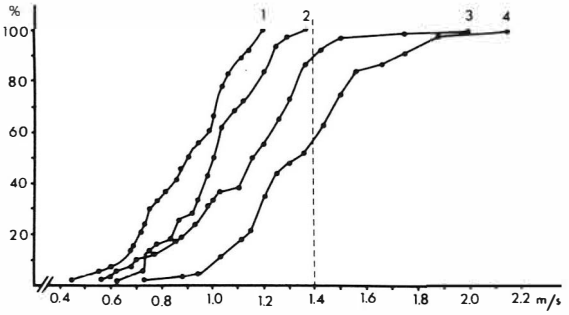
The comfortable and maximal walking speed were significantly lower ($p<0.001$) in the subjects using handicap transport service than in the rest of the subjects. Furthermore, the walking speed was lower in subjects using walking aids ($p<0.001$). These subjects had also a lower climbing ability than the rest of the subjects ($p<0.05$–0.001). The climbing ability was reduced in the women using handicap transport service ($p<0.001$). Difficulties when using public transporttation was correlated with the use of handicap transport service in all subjects ($p<0.001$). No significant correlations were found between walking speed and climbing steps on one hand and body weight and body height on the other.

DISCUSSION

In Sweden a maximum walking speed of 1.4 m/s is considered as the norm for pedestrians at signalized intersections. A slower walking speed is, however, recommended when the pedestrian traffic is very intense (36). In the present study, no subjects could



1. HEALTHY WOMEN, NORMAL WALKING SPEED
2. HEALTHY MEN, NORMAL WALKING SPEED
3. HEALTHY WOMEN, MAXIMAL WALKING SPEED
4. HEALTHY MEN, MAXIMAL WALKING SPEED



1. WOMEN WITH DISORDERS, NORMAL WALKING SPEED
2. MEN WITH DISORDERS, NORMAL WALKING SPEED
3. WOMEN WITH DISORDERS, MAXIMAL WALKING SPEED
4. MEN WITH DISORDERS, MAXIMAL WALKING SPEED

Fig. 2. Cumulative distribution curves with respect to comfortable and maximal walking speed in "healthy" 79-year-old women and men and in 79-year-old women and men with disorders.

manage the stipulated walking speed in comfortable walking. Elderly may walk even slower outdoors and especially in wintertime when the streets are slippery. The comfortable walking speed in this age group was on an average in women 78% and in men 70% of the maximal walking speed. However, values for comfortable and maximal walking speed showed a high correlation, why as an estimate of the walking capacity for a short distance only one of these tests may be needed.

A changed gait pattern has often been reported in elderly people (5, 6, 8, 14, 19, 27) as well as reduced walking speed. Aniansson et al. (3) showed that 70-year-old women and men managed a mean speed of 1.1 m/s and 1.2 m/s respectively in comfortable walking. From Finland Lautso (24) reported for elderly people an average walking speed of 1.07 m/s. In a population study in Copenhagen of women and men aged 78–81 years (21) the average walking speed was in agreement with that found in our study. In the study of 70-year-old pedestrians by Dahlstedt (13) the subjects defined a mean speed of 0.9 m/s as a "normal walking speed" and 1.3 m/s as "when catching a bus". It was, however, concluded in that study that the confidence of elderly pedestrians crossing at traffic signals seemed rather high, although most signals were set for higher speeds than many elderly can manage.

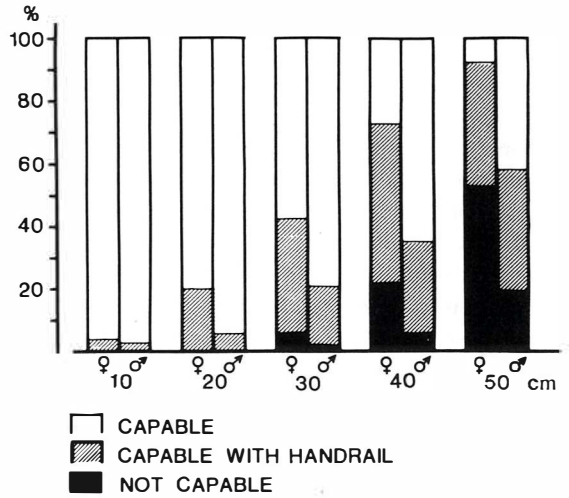


Fig. 3. The results of the step test in 79-year-old women ($n=107$) and men ($n=90$) in the subsample. Distribution with respect to their ability to climb up and down the different step-heights with and without using the handrail.

An additional course of problems for elderly in the traffic may be reduced vision. However, less than 20% of the subjects reported reduced vision in this study and the participants did not have any noted problems to fulfill the tests.

In the present study a history of dizziness was associated with a considerably reduced walking speed. The ability in climbing will be reduced with dizziness. To note is that this activity requires good balance in the one leg stance. Stout (33), however, has reported that the importance of dizziness symptoms probably have been overstressed in elderly, as this type of symptom is very difficult to interpret. Older persons may expect to experience dizziness as they are asked so frequently about such symptoms.

Table III. *The results of walking comfortable and maximal speed in 79-year-old women and men*
Healthy defined as lack of neurological, locomotor and cardiovascular disease

	Women			Men			Diff. women/men Statistical significance
	n	*M*	SD	*n*	*M*	SD	
Comfortable walking speed							
"Healthy"	31	0.97	0.23	29	1.07	0.10	NS
Disorders	56	0.90	0.19	52	1.01	0.18	$p<0.01$
Statistical significance		NS			NS		
Maximal walking speed							
"Healthy"	31	1.25	0.32	29	1.52	0.21	$p<0.001$
Disorders	56	1.15	0.28	52	1.38	0.28	$p<0.001$
Statistical significance		NS			$p<0.05$		

There are no compulsory norms at present for step-heights on public transport vehicles in Sweden. The Swedish Public Transport Association's recommendations for both city and country traffic is a step-height from the ground to the first step of 35 cm at most. This is also the usual step-height of the buses in the city of Göteborg (10) but the maximum step-height from the street to the lowest step of a Göteborg tram is 37.5 cm (Pers. comm., Göteborg Tram Co). The Swedish railway trains have a maximum step-height of 30 cm. The distance between the platform and the lowest step is usually 12 cm but this distance can be considerably higher at the distal slope of the platform (Pers. Comm.).

Aniansson et al. (3) have shown that 70-year-olds in Göteborg were able to climb up and down a 40 cm step-height. However, the tested group was without major disorders in the lower extremities and had a fairly good muscle function in both lower and upper extremities. It was stated that subjects with low strength in the quadriceps muscles probably can compensate for this by using their arm-strength. In a study from Copenhagen (21) only 10% of the women and 52% of the men at the age of 78–81 were able to climb 50 cm step-heights. Women as a group had greater difficulties than men, which is in accordance with the findings in the present study.

The present study shows that at the age of 79 all were able to climb up and down a 10–20 cm height with or without using a hand-rail. The difficult height seems to start between 30 and 40 cm.

Table IV. *Correlations between different variables*

WS = walking speed, CS = climbing stairs (40 cm with handrail), HR1 = heart rate after climbing stairs, HR2 = heart rate after walking, RPE = relatively perceived exertion, Dizz = experienced dizziness, Diff = difficulties when using public transportation

	Total						
	WS	CS	HR1	HR2	RPE	Dizz	Diff
WS		0.34**	−0.05	0.07	−0.31**	−0.22	−0.34**
CS	0.66***		−0.17	−0.13	−0.15	−0.24*	−0.22
HR1	0.21	0.16		0.87***	−0.17	0.12	−0.08
HR2	0.05	−0.08	0.82***		−0.06	0.10	−0.08
RPE	−0.22*	0.03	−0.02	0.01		0.25*	0.26*
DIZZ	−0.30**	−0.32**	−0.23	−0.20	0.23*		0.28**
DIFF	−0.49***	−0.32**	−0.13	−0.01	0.06	0.20*	

Lower triangle women/upper triangle men

* $p<0.05$; **$p<0.01$; ***$p<0.001$.

Many elderly women may thus have difficulties when climbing up and down public transport vehicles. With a step height of 50 cm the difficulties increased even more. A handrail was of great importance for increasing the ability of climbing up steps specially above 30 cm step-height.

The correlation, in both women and men between maximum step-height and walking speed shows that the same persons often have difficulties in performing the two important practical functions of the lower extremities. These difficulties in climbing stairs and walking with old age might be explained by the physical changes observed to occur at old age. Changes in the central nervous system and in the neuromuscular control cause a gradual decline in balance (18) coordination (15, 28), proprioception (20) and muscle function (3, 4, 23, 28). The prevalence of locomotor disorders, such as arthritic conditions of the hip and knee (26), osteoporosis (25) and other bone abnormalities including amputations (31), increase with age.

Previous reports show that 11% of the 70-year-olds and 9% of the 75-year-olds were driving their car (35). In the present study one women and 17 men were driving their car. Thus elderly people have to use public transport more often than other people. Consequently it is of great importance that not only the vehicles but also the entire transport system is adapted to the needs of the elderly in order to help them to live an independent life as long as possible in their old age.

The present results indicate that the traffic must in different ways better adjust to the older part of the population. Especially the norms at signalized intersections are much too high for elderly pedestrians with respect to their actual normal walking speed. Observations on the functional capacity in representative samples of elderly are needed for an adequate planning of the environment.

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