

Associations between functional capacity and work ability among elderly municipal employees

by Clas-Håkan Nygård, PhD,^{1,2} Leena Eskelinen, PhD,¹ Sakari Suvanto, MSc,¹ Kaija Tuomi, LSocSc,¹ Juhani Ilmarinen, PhD¹

NYGÅRD C-H, ESKELINEN L, SUVANTO S, TUOMI K, ILMARINEN J. Associations between functional capacity and work ability among elderly municipal employees. *Scand J Work Environ Health* 1991;17(suppl 1):122-7. The relationship between objectively measured physical and mental functional capacity and work ability was studied among 137 workers with a mean age of 55 years. Of the physical capacity tests muscular strength correlated the best with the constructed work ability index. Cardiorespiratory capacity and work ability did not correlate statistically significantly. About 50 % of the subjects was classified uniformly, and less than 10 % not uniformly, with respect to muscular strength. The correlation between cardiorespiratory capacity and work ability was significant for those without, but not for those with, a musculoskeletal disease. The mental capacity tests had systematically lower correlations with work ability than the tests for physical capacity. The highest statistically significant correlation was found between visuospatial speed and work ability. Objective measurements of muscular strength seem useful for defining work ability, but other tests need to be improved to be more work-related. Furthermore, musculoskeletal diseases should be checked for when cardiorespiratory capacity is assessed.

Key terms: cardiorespiratory capacity, mental capacity, musculoskeletal capacity, performance test, physical capacity.

The measurement of functional capacity is important when the needs for early rehabilitation or early retirement are being assessed. In general, functional capacity means the capability of the organism to reach set goals (1). Functional capacity can be divided into physical, mental, and social levels (2). Physical capacity is also often separated into cardiorespiratory and musculoskeletal capacity. The different functions also have different levels of demand. At the lowest levels are the basic physiological functions and other very simple functions, whereas functions requiring special skills (eg, top athletics) or creativity have high demands, as do functions aiming at self-realization (2). The classification of handicap due to diseases that has been devised by the World Health Organization is based on the same type of concept (3).

It is therefore appropriate to assess functional capacity in relation to the demands of daily living or occupational work. Work ability means that one relates functional capacity individually to the incumbents of work demands. According to the stress-strain concept (4) functional capacity can be considered the base for work ability. In other words a high functional capacity is necessary for good work ability. According to the stress-strain concept, such individual characteristics as functional capacity have a significant impact on the strain on the worker during work. Therefore functional

capacity is very important in the regulation of work strain and in the prevention of work disability.

In practice it is necessary to have objective data of individual work ability. Work ability should primarily be assessed in the job of the worker in question. However such an assessment is, in practice, often impossible because of lacking methods. Work ability has usually been assessed by an expert group of, for example, a physician, a psychologist, a nurse, a physiotherapist, and a social worker (5). Functional capacity on the other hand can be measured with laboratory tests. Physical work ability has traditionally been assessed by a bicycle ergometer test. Work ability has also been assessed by an index based on responses to a questionnaire (6). Eskelinen et al (7) found that this work ability index correlated well with clinically assessed work ability.

The aim of the present study was to investigate the relationship between objectively measured functional capacity, both physical and mental, and the subjectively estimated work ability obtained with a questionnaire.

Subjects

The subjects comprised 72 men and 65 women in different municipal occupations. Their mean age was approximately 55 years, and it ranged from 48 to 62 years (table 1). The sample is the same as that used for the assessment made of musculoskeletal capacity (8).

¹ Institute of Occupational Health, Helsinki, Finland.

² Present address: Department of Public Health, University of Tampere, Tampere, Finland.

Reprint requests to: Dr J Ilmarinen, Institute of Occupational Health, Laajaniityntie 1, SF-01620 Vantaa, Finland.

Methods

Physical capacity

Cardiorespiratory capacity was assessed by a submaximal bicycle ergometer test. Oxygen consumption and heart rate were measured during the test, and the maximal oxygen consumption and maximal work load were calculated (9).

Musculoskeletal capacity was measured with several methods. The maximal isometric muscular strength of the trunk flexors and extensors was measured with a calibrated dynamometer with the subjects in a standing position (10) and thereafter related to body weight. Maximal isometric gripping strength for the right hand was measured with a dynamometer (11). A sit-up test (12) was used to assess the dynamic muscular endurance of the trunk flexors. The forward mobility of the back was measured with a tape with the subjects in a standing position (ie, the increase in the length of the spine, for C_7-S_1 when the back was bent forward) (13). The sideward bending of the back (13) was measured with an inclinometer (Myrin). The mean value for the bendings to the right and left combined was used. The flexibility of the legs was assessed with a straight-leg raising test (14) and measured with an inclinometer (Myrin). The mean value of both legs combined was used for the analysis.

Mental capacity

Fine motor speed was measured with a finger tapping test (15, 16). The test result was the number of taps during 10 s. Auditory short-term memory was measured with the digit span subtest of the Wechsler Adult Intelligence Scale (17, 18). The picture completion subtest of the same scale (17, 18) was used as an indicator of perceptual and conceptual abilities. Visuomotor speed was measured with the digit symbol subtest of the Wechsler scale (17, 18). Visuoconstructive ability was measured with the block design subtest of the Wechsler scale (17, 18). Visual search was measured with a Bourdon-type letter cancellation test (16). The task was to search and cancel, in 5 min, the given five letters in the rows of letters on a standard sized (A-4) sheet of paper. The result was the number of letters read in 5 min. Verbal concept formation was measured with the similarities subtest of the Wechsler scale (17, 18).

Work ability

Work ability was assessed from a sum variable made from seven items inquired about on a questionnaire (6). The index comprised the following aspects: (i) current work ability in comparison with the best during the worker's lifetime, (ii) current work ability in relation to the physical and mental demands of the job, (iii) number of diagnosed diseases, (iv) the effect of the diseases on daily work, (v) the number of days away from the job due to sickness during the past year,

(vi) self-estimated work ability after two years, and (vii) mental resources (to enjoy daily activities, etc).

Diagnosed diseases

The subjects were also classified into groups with or without a diagnosed cardiovascular or musculoskeletal disease reported on the questionnaire. The cardiovascular diseases included coronary heart disease, hypertension, and heart insufficiency, and the musculoskeletal diseases comprised degenerative arthritis of the upper and lower back and the lower extremities (6).

The correlation between functional capacity and work ability was assessed with the use of Pearson's correlations procedure. Functional capacity and work ability were also categorized into three groups so that the middle class included 50 % of the subjects and the other two classes comprised 25 % each. In the Results section the variables with the highest correlation with work ability have been given (trunk muscular endurance and visuomotor speed).

Results

Physical and mental capacity

The men had significantly higher mean values in the cardiorespiratory and the musculoskeletal capacity tests than the women (table 2), but the women had greater leg flexibility than the men. No significant differences between the genders were found for back mobility. In the mental capacity tests, there were no statistically significant differences between the men and the women (table 3).

Physical capacity and work ability

All the factors describing muscular strength and endurance correlated significantly with the work ability index (table 4), whereas the correlations of back and leg mobility and cardiorespiratory capacity with the work ability index were not significant. Among the women hand-grip strength and trunk muscular endurance, and among the men trunk flexion strength, correlated significantly with work ability.

Fifty-five subjects (49 %) were classified into the same class by the test for trunk muscular endurance and the work ability index (table 5). Seven subjects (6 %) were classified into extremely opposite classes.

Table 1. Age, height, weight, and body mass index of the men and women.

	Age (years)		Height (cm)		Weight (kg)		Body mass index (kg · m ⁻²)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Men (N = 72)	55.3	3.3	174.6	6.5	79.9	12.8	26.1	3.6
Women (N = 65)	54.8	3.5	159.7	5.6	67.9	9.5	26.5	3.6

Table 2. Results of the physical capacity tests by gender. ($\dot{V}O_2\text{max}$ = maximal cardiorespiratory capacity)

	Cardiorespiratory tests				Musculoskeletal tests													
	$\dot{V}O_2\text{max}$ ($\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$)		Maximal work load (W)		Hand-grip strength (kPa)		Trunk flexion strength ($\text{N} \cdot \text{kg}^{-1}$)		Trunk extension strength ($\text{N} \cdot \text{kg}^{-1}$)		Trunk muscular endurance (times $\cdot 30 \text{ s}^{-1}$)		Forward back bending (mm)		Sideward back bending (degrees)		Leg mobility (degrees)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Men	35.3	5.5	196.0	40.0	88.0	11.0	6.9	1.2	7.9	1.9	11.2	4.1	77.0	14.0	42.0	6.0	79.0	8.0
Women	27.2	6.2	123.0	34.0	63.0	10.0	4.7	1.2	5.3	1.6	6.5	4.1	75.0	16.0	43.0	7.0	88.0	10.0
All	30.7	7.1	156.0	52.0	74.0	16.0	5.6	1.7	6.4	2.2	8.6	4.7	76.0	15.0	42.0	6.0	84.0	10.0

Table 3. Results of the mental capacity tests by gender.

	Mental capacity																Verbal concept formation (similar- ities)	
	Fine motor speed (finger tapping)				Auditory short-term memory (digit span)				Perceptual and conceptual ability (picture completion)	Visuomotor speed (digit symbol)	Visuocon- structive ability (block design)	Visual search (letter cancel- lation)						
	Dominant hand		Nondomin- ant hand		Digits forward		Digits backward											
	Mean	SD	Mean	SD	Mean	SD	Mean	SD						Mean	SD	Mean		SD
Men	48.4	8.8	45.1	8.0	5.7	0.8	4.2	1.0	14.5	3.2	40.0	13.2	33.6	9.8	457.0	173.0	19.3	1.6
Women	44.9	7.9	40.9	8.1	5.6	0.8	4.3	0.9	12.2	3.7	42.9	13.6	31.0	9.1	529.0	166.0	19.1	5.6
All	46.5	8.4	42.8	8.3	5.7	0.8	4.2	0.9	13.3	3.6	41.5	13.4	32.2	9.5	496.0	172.0	19.2	5.8

Table 4. Correlation (r) between physical capacity and work ability by gender.

Physical capacity	Work ability		
	Men ($N = 44$) (r)	Women ($N = 56$) (r)	All ($N = 100$) (r)
Cardiorespiratory			
Maximal oxygen consumption ($\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$)	0.25	-0.05	0.17
Maximal work load (W)	0.23	-0.11	0.18
Musculoskeletal			
Hand grip strength (kPa)	0.08	0.31*	0.27**
Trunk flexion strength ($\text{N} \cdot \text{kg}^{-1}$)	0.34*	0.21	0.32**
Trunk extension strength ($\text{N} \cdot \text{kg}^{-1}$)	0.21	0.26	0.30**
Trunk muscular endurance (times $\cdot 30 \text{ s}^{-1}$)	0.25	0.39**	0.37***
Forward back bending (mm)	0.06	0.20	0.14
Sideward back bending (degrees)	0.14	0.24	0.17
Leg mobility (degrees)	0.16	-0.25	-0.16

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.**Table 5.** Correspondence between trunk muscular endurance and work ability.

Trunk muscular endurance	Work ability							
	Poor		Moderate		Good		All	
	N	%	N	%	N	%	N	%
Poor	14	12.4	8	7.1	2	1.8	24	21.2
Moderate	11	9.8	29	25.7	14	12.4	54	47.8
Good	5	4.4	18	15.9	12	10.6	35	31.0
All	30	26.5	55	48.7	28	24.8	113	100.0

Physical capacity, work ability and health

Physical capacity correlated better with work ability among those without a cardiovascular or musculoskeletal disease than among those with a disease (table 6). Among those without any cardiovascular disease

strength correlated significantly with work ability, whereas among those with a cardiovascular disease only the sideward bending of the back correlated with work ability. Among those without any musculoskeletal disease the maximal oxygen consumption and maximal work load, hand-grip strength, and trunk muscular endurance correlated significantly with work ability, whereas among those with a diagnosed musculoskeletal disease only trunk muscular endurance correlated with work ability.

Mental capacity and work ability

In the whole sample only visuomotor speed (digit symbol) correlated significantly with the work ability index (table 7). It explained 7 % of the variation of the work ability index. Among the women visual search

Table 6. Correlation (*r*) between physical capacity and work ability according to occurrence of cardiovascular and musculoskeletal disease.

Physical capacity	Work ability			
	Cardiovascular disease		Musculoskeletal disease	
	Yes (N = 23) (<i>r</i>)	No (N = 77) (<i>r</i>)	Yes (N = 44) (<i>r</i>)	No (N = 56) (<i>r</i>)
Cardiorespiratory				
Maximal oxygen consumption (ml · kg ⁻¹ · min ⁻¹)	0.03	0.05	0.05	0.32*
Maximal work load (W)	-0.14	0.14	-0.10	0.38**
Musculoskeletal				
Hand-grip strength (kPa)	0.16	0.26*	0.11	0.34*
Trunk flexion strength (N · kg ⁻¹)	0.20	0.32**	0.27	0.23
Trunk extension strength (N · kg ⁻¹)	0.14	0.30**	0.21	0.21
Trunk muscular endurance (times · 30 s ⁻¹)	0.07	0.36**	0.38**	0.27*
Forward back bending (mm)	0.05	0.13	0.19	0.20
Sideward back bending (degrees)	0.51*	0.03	0.03	0.18
Leg mobility (degrees)	-0.11	-0.20	-0.13	-0.18

* *P* < 0.05, ** *P* < 0.01.

Table 7. Correlation (*r*) between mental functions and work ability by gender.

Mental capacity	Work ability		
	Men (N = 56) (<i>r</i>)	Women (N = 60) (<i>r</i>)	All (N = 116) (<i>r</i>)
Fine motor speed (finger tapping)			
Dominant hand	0.18	-0.11	0.08
Nondominant hand	0.23	0.00	0.15
Auditory short-term memory (digit span)			
Digits forward	0.10	0.04	0.08
Digits backward	0.14	-0.08	0.02
Perceptual and conceptual ability (picture completion)	0.20	0.08	0.18
Visuomotor speed (digit symbol)	0.28*	0.30*	0.26**
Visuoconstructive ability (block design)	0.18	0.10	0.16
Visual search (letter cancellation)	0.08	0.26*	0.11
Verbal concept formation (similarities)	0.15	0.03	0.09

* *P* < 0.05, ** *P* < 0.01.

(letter cancellation test) correlated significantly with work ability, and it explained 7 % of the variation of the work ability index.

In the cross-tabulation of visuomotor speed (digit symbol) and work ability 57 subjects (48 %) were placed in the same class (table 8), whereas 10 subjects (9 %) were placed in completely opposite classes.

Discussion

Of the physical capacity tests trunk and hand-grip strength correlated significantly with the work ability index. Of the mental functions visuomotor speed correlated significantly with the work ability index. In general, the mental capacity tests correlated less with the work ability index than the physical capacity tests did.

Our results are in agreement with those of Mäkiä (19), who found muscular strength (hand grip and

Table 8. Correspondence between visuomotor speed (digit symbol) and work ability.

Visuomotor speed	Work ability index							
	Poor		Moderate		Good		All	
	N	%	N	%	N	%	N	%
Poor	9	7.6	13	11.0	4	3.4	26	22.0
Moderate	16	13.6	33	28.0	10	8.5	59	50.0
Good	6	5.1	12	10.2	15	12.7	33	28.0
All	31	26.3	58	49.1	29	24.6	118	100.0

trunk muscular endurance) to be significantly associated with the ability to manage occupationally, especially among men. Surprisingly, the maximal oxygen consumption and maximal work load did not correlate with work ability in our study. This finding disagrees with that of an earlier study (5), in which the results of a bicycle ergometer test correlated well with the work ability assessed by a clinical work group. The

results of bicycle ergometer tests have traditionally been used as an objective measurement of physical work ability. One explanation for the significant correlation between muscular strength and work ability could be that maximal muscular strength is more concrete for the subjects than maximal oxygen consumption. Peak loads of the musculoskeletal system (eg, extreme work postures or lifting) are much more common in work than peak loads of the cardiovascular system (eg, high heart rates) (20). The results indicate that work ability can be assessed from measurements of muscular strength as reliably as from measurements of maximal oxygen consumption or maximal work load.

Interestingly, the results of the bicycle ergometer test correlated significantly with the work ability of those without any musculoskeletal disease but not with the work ability of those with a musculoskeletal disease. One explanation could be that healthy subjects can cycle without pain from the musculoskeletal system stopping the test. A bicycle ergometer test may therefore be a measurement of work ability only if the subject does not have a musculoskeletal disease that impedes his or her completion of the test. Therefore, before an exercise stress test on a bicycle ergometer, a subject should be examined for musculoskeletal diseases; otherwise pain tolerance of the musculoskeletal system, or something else, may be measured rather than the cardiovascular work capacity.

Generally speaking, mental capacity correlated less with work ability than physical capacity did. Visuomotor speed (digit symbol) correlated significantly with work ability, but the other correlations with mental functions were not significant. Tests measuring fine motor speed, short-term memory, perceptual and conceptual ability, visuoconstructive ability, and verbal concept formation did not significantly explain the variation in work ability. However, they are considered central aspects of mental performance. It is therefore obvious that the used work ability index measured primarily physical features of work ability. The significant explanatory power of a test of visuomotor speed may be due to the fact that visuomotor speed weakens more with age than the other mental functions measured in this study. At the same time it is a central part of the mental requirements of work. In the job analysis done in connection with this study, accurate sensory perception and visual information input were ranked high in office, administrative, nursing, transport, and installation work (21).

Although some of the measured functional capacity tests showed significant correlations with the work ability index, the correlation coefficients were not high. Functional capacity explained, at the most, only 16 % of the variation in work ability. This finding could partly be explained by the fact that the study was not primarily designed to answer the question of how functional capacity and work ability correlate. However, when we classified the functional capacity and work

ability results into categories of poor, moderate, and good, about every second subject belonged in exactly the same class for both, and less than 10 % was rated into completely opposite classes. These results are in agreement with the results reported by Eskelinen et al (7) of the correlation between clinically assessed work ability and the same work ability index. In other words, the objective measurements of functional capacity often gave a good base for work ability decisions, but the used laboratory tests should be developed more in the direction of actual work requirements.

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