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ORIGINAL ARTICLE

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Muscle strength and aerobic capacity in a representative sample of employees with and without repetitive monotonous work

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Abstract *Objectives* The purpose of the study was to determine a possible association between the type of work individuals perform and his or her physical capacity. There was focus on whether workers performing repetitive monotonous work differ from workers with varied work tasks with respect to the physical capacity. *Methods*: Maximal backward extension and forward flexion torques of the trunk, maximal shoulder elevation and abduction torques, handgrip strength and aerobic capacity were measured on 423 (213 male and 210 female) Danish employees with a mean age of 40 years. Half of the group had varied work and the other half had repetitive monotonous work. *Results*: The main finding was that there is no difference in the measured physical capacities between employees with repetitive monotonous work and those compared with workers with varied work tasks. *Conclusions*: No difference in the physical capacities measured in the two groups of employees was found. Reasons for this are discussed.

Keywords Physical capacity · Maximal voluntary contraction · Fitness · Repetitive monotonous work · Varied work

Introduction and background

Earlier studies point towards an association between different types of jobs and differences in physical capacities, such as muscle strength and aerobic capacity. Some studies found a tendency to lower maximal muscle strength in the hand, back and abdomen among workers having physically heavy work (Era et al. 1992; Karlqvist et al. 2003; Ruzic et al. 2003; Nygård et al. 1987, 1998a, 1998b; Søgaard et al. 1996). These studies indicated that physically heavy work is no guarantee for high physical capacities. Other studies point towards a training effect of some jobs and a wearing effect of other jobs on certain body parts, the latter due to an inappropriate and unbalanced loading of the musculoskeletal system (Schibye and Christensen 1997; Schibye et al. 2001). The type of job may therefore be of importance for the work having either training or wearing effect on the implicated muscle groups.

In 1994 the Danish Minister of Labor declared that repetitive monotonous work should be reduced by 50% before the end of 2000. The definition of repetitive monotonous work was work with work cycle times less than 30 s or work where the same movements were performed for more than 50% of the work cycle time. The high-risk repetitive monotonous work was defined as repetitive monotonous work performed more than 4 h per day. According to this definition, repetitive monotonous work covers a wide range of exposure levels from highly repetitive and forceful work like meat cutting to less repetitive and less forceful work like secretary work and some assembly line work. In this study we focus on repetitive monotonous work performed 75% or more of the working day.

Against this background the present paper describes and compares the muscle strength and aerobic capacity of workers, who perform varied work with those of workers performing repetitive work, and discusses differences if any. The paper also presents an up-to-date reference material on the physical capacity of the Danish work force.

Methods

The population

The study population is based on a representative sample of Danish employees living in nine counties in Denmark. The study population is a subsample from the Danish National Working Environment Cohort (Borg

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and Burr 1997; Burr et al. 2003) In 1990 a random sample of 10,703 members of the Danish population between 18 and 64 years of age were interviewed (response rate: 90%). Data concerning work conditions and health were collected from the respondents who were employed on the day of the interview or had been employed within the last 2 months ($n = 5940$). In 1995 the respondents from 1990 were contacted again along with a new random sample of members of the Danish population between 18 and 22 years of age ($n = 1383$). Here, the response rate was 80% and interviews were completed with 5575 employees. Of these 4194 (75%) agreed to be physically examined for further measurements. For this purpose a random sample of 839 was made. The sample was equally divided into males and females, employees having varied or monotonous repetitive work, and divided into three age groups. In this way we wanted to ensure that the "average Danish employee" in regard to gender and age could be estimated. For each group, random sampling was made stratifying according to the factors, associated with the willingness to participate in the measurements. Fig. 1 shows the flow from the random sample of 839 employees to the measured employees, and Table 1 shows the height, weight and body mass index of the 213 male and 210 female participants. It should be noted, that the equal distribution between employees with and without repetitive monotonous work does not reflect any distribution of the Danish workforce, as only 15% had repetitive monotonous work in 1995 (Borg and Burr 1997).

The work of each participant was categorized as being repetitive or varied based on the answers to the following questions:

1. "Does your work require that you repeat the same work tasks many times per hour?"

The question could be answered: "Almost all working hours"; "Approx. 3/4 of working hours"; "Approx. 1/2 of working hours"; "Approx. 1/4 of working hours"; "Seldom/very little"; "Never".

Fig. 1 Flow diagram illustrating the investigated population

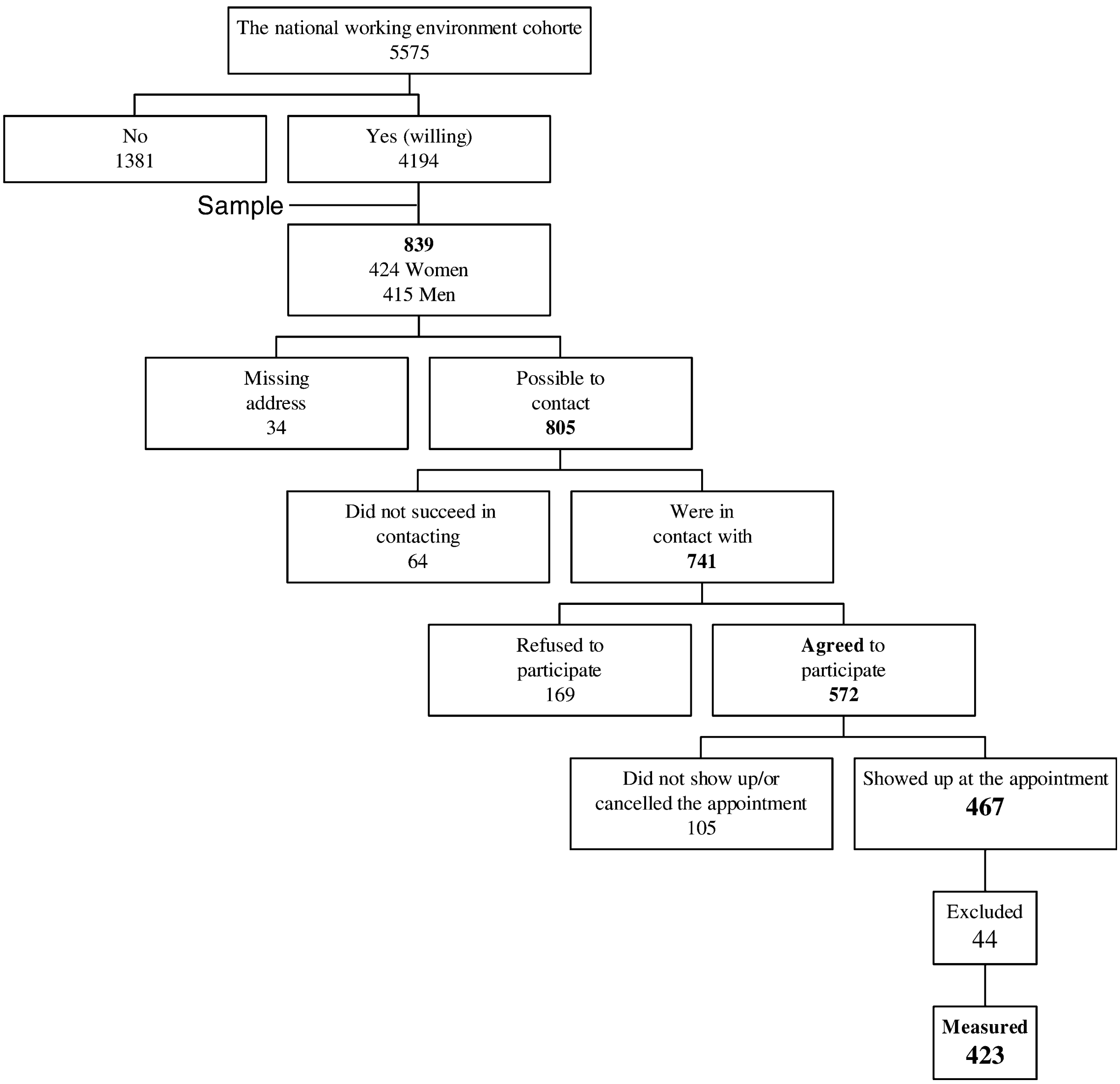

Table 1 Height, weight and body mass index of all males and females with varied work and all males and females with repetitive monotonous work

	Males				Females			
	n	V-Males	*n*	R-Males	*n*	V-Females	*n*	R-Females
Height (cm)	120	178 (161–196)	93	177 (158–195)	100	166 (153–179)	110	166 (153–184)
Weight (kg)	120	82* (53–125)	93	79 (55–107)	100	67 (51–112)	110	65 (47–108)
Body mass index (kg m^{-2})	120	25.8 (17.4–36.5)	93	25.3 (18.3–34.2)	100	24.4 (17.2–40.5)	110	23.9 (18.1–36.1)

Mean value and (range)
*Significant difference between repetitive monotonous work and varied work

2. "Is your work varied?"
This question could be answered: "Very much"; "To some extent"; "Not much"; "No, or only very little".

The work of each participant was categorized as being repetitive if the answer was "Almost all working hours" or "Approx. 3/4 of working hours" to the first question and "Not much" or "No, or only very little" to the second (Feveile et al. 2002).

The employees with varied work were compared with the employees with repetitive monotonous work to investigate if the work category associated with muscle strength and aerobic capacity. Multivariate regression models were used for these analyses including work category, age and seniority in the initial model.

The self-reported level of physical activity during leisure time was rated as one of four possible categories: "(1) Almost physically passive or less than 2 h of physical activity per week"(passive); "(2) Light physical activity for 2–4 h per week" (slightly active); "(3) Light physical activity for more than 4 h per week or vigorous activity for 2–4 h per week" (moderately active); "Vigorous activity for more than 4 h per week, or regular vigorous training or competitions several times per week"(extremely active).

Representativity of the study population

This design allowed for an analysis of representativity of the 423 subjects who participated in this study in relation to the Danish National Working Environment Cohort ($n = 5940$). The associations between the willingness to participate in the physical examination and some specified factors showed the following tendencies:

- The young employees were the least likely to participate in the physical examination, whereas employees in the 30s and early 40s were more likely to participate.
- Males were more likely to participate than females.
- Employees with musculoskeletal troubles of wrist or neck were more likely to participate in the physical examination than employees without these complaints.
- Employees, who ended school with a final examination, were more likely to participate than employees without one.
- The farther away from Copenhagen the employee lived, the less was the likelihood to participate. We also compared the subsample of 467 participants with the whole survey population of 10,703 persons and found some differences:
- Among males with repetitive monotonous work the sample tended to be older, and more individuals having ended primary school with an examination than the rest of the survey. Academics and managers were over-represented, while clerks were under-represented in the sample.
- Among men with varied work, managers and salesmen were over-represented, whereas service jobs were underrepresented.
- There were no differences among females with repetitive monotonous work between the sample and the rest of the survey.
- Females with varied work weighed more than females in the rest of the survey. Furthermore teachers, managers and manual jobs were over-represented in the survey.

In general, the authors concluded that the type of the differences between the subgroup ($n = 467$) and the survey population ($n = 10{,}703$) would not affect the physical capacities in any particular way. Thus, the measured capacities can be considered as representative of the Danish employee.

Procedure

All subjects gave their written informed content and the local Ethics Committee approved the study. Before testing the subjects they were interviewed about their health status, and the blood pressure was measured.

Exclusion criteria

Subjects were excluded in case of self-reported or measured excessive blood pressure, angina pectoris, previous disc prolapse or use of heart or lung medicine (Appleyard 1989). Furthermore, the subjects were asked about musculoskeletal pain or disorders within the last 7 days and in case of a positive answer, they were asked if they felt considerable pain in this specific body region on the test day. If so they were excluded from the muscle strength measurements affecting this body region. Forty-four persons were excluded for medical reasons.

Measurements

The mobile measuring station of the Danish National Institute of Occupational Health constituted the setting in which the measurements were performed from September 1996 to September 1997. Citizens of nine counties participated.

Aerobic capacity

The aerobic capacity was estimated indirectly by use of a submaximal test on a mechanically braked bicycle ergometer (Monark 864, Sweden). The maximal oxygen consumption rate ($\dot{V}O_{2max}$) was estimated from work intensity and the heart rate (Sport tester, Polar Electro, Finland) measured in the sixth minute according to the nomogram of Åstrand and Rhyming (1954) and corrected for age according to Åstrand (1960). The workload was set between 50 and 75% of the relative workload (validated from the heart rate increase above resting level), where the validity of the test is found to be highest (Åstrand 1960). The subjects were told to stop if they felt uncomfortable. In addition to the absolute $\dot{V}O_{2max}$, the weight related $\dot{V}O_{2max}$ was calculated as the absolute $\dot{V}O_{2max}$ divided by the weight of each subject.

Muscle strength

The maximal isometric muscle strength (MVC) was measured for backward extension and forward flexion of the trunk, shoulder elevation, shoulder abduction and handgrip. Detailed descriptions of the test procedures are given by Essendrop et al. (2001). For each muscle group, the measurement was performed at least three times with 30 s restitution. If the third registration was more than 5% higher than the higher of the previous two registrations, a fourth test was performed. Maximum five tests were performed. The subject was instructed to build up the force over 5 s, then to maintain the force for about 2 s and finally to reduce the force to zero. The highest value obtained during a 1s period was used. Verbal encouragement was given.

Maximal backward extension and forward flexion torques of the trunk

The subject stood in an upright position with a strap around the shoulders at the level of insertion of the deltoid muscle. The strap was horizontally connected to a strain gauge dynamometer. For MVC of the back extensor muscles, the subject faced the dynamometer with the pelvis against a plate placed with the upper edge aligned with the iliac crest of the subject. In this position a maximal isometric backward extension was performed (Asmussen et al. 1959). Correspondingly, for MVC of the abdominal muscles, the subject was placed with the back towards the dynamometer and the pelvis against the plate. In this position a maximal isometric forward flexion of the trunk was performed. The vertical distance between the L4/L5 level and the middle of the strap was measured for torque calculation.

Maximal shoulder elevation and abduction torques

The subject was placed in a specially designed chair adjustable in height so that the subject's feet had no contact with the floor. For MVC of the shoulder elevation muscles, the subject's arms hung vertically without support. Two Bofors dynamometers (33,400, Bofors Elektronik, Karlskoga, Sweden) were placed bilaterally 1 cm medial to the lateral edge of the acromions (Jensen et al. 1993; Søgaard et al. 1996). In this position, the subject performed a bilateral maximal shoulder elevation and the highest value registered for each side was used. The distances from the dynamometers to the sternoclavicular joints were measured for calculating torque.

For MVC of the shoulder abduction muscles, the elbows were flexed 90° with the upper arms in vertical position. Two Bofors dynamometers were placed bilaterally 1 cm proximal from the elbow joints. In this position, the subject performed bilateral maximal shoulder abduction and the highest value registered for each side was used (Bäckman et al. 1995) The distances from the two dynamometers to the acromions were measured and a subtraction of 5 cm was used to estimate the lever arm for shoulder abduction torque calculation (Plagenhoef 1971).

Handgrip strength

The maximal handgrip strength of the dominant side was measured in a sitting position with the elbow flexed 90° and the upper arm in the vertical position. A Jamar dynamometer (5030 J1, J. A. Preston Corp., Jackson, MI 49204, USA) was used preset for the suitable hand size (Bäckman et al. 1995).

Statistics

In the statistical analyses the sample was divided into males and females, employees having varied or monotonous repetitive work, and divided into three age groups (18–29, 30–44, 45 years or more). When to comparing participants with repetitive monotonous work with participants with varied work, the difference between the distributions of a categorized variable is assessed by comparing multinomial distributions (chi square colloquially). Since the body weight and BMI could not be assumed to follow a normal distribution (according to Kolmogorov–Smirnov's test), these measurements were compared by means of Wilcoxon's test of rang sum (Mann–Whitney test). The height and the capacity measurements were compared by means of the *t*-test and the correlation between the capacity measurements was assessed by means of Pearson's correlation coefficient. Linear regression analyses, were made to examine any connections between the measured capacities and other available information partly from this study and partly from the survey "Work Environment and Health among Danish Employees 1990–1995" (Borg and Burr 1997). The other available information concerned anthropometrical measurements, physical activity in the leisure time, health, demography and working environment. The models that formed the basis for the linear regression analysis were controlled by means of residual plots. A significance level of 0.05 were chosen so that a hypothesis is rejected if the *p*-value is ≤ 0.05.

Results

The employees classified as having monotonous repetitive work included service jobs and manual jobs: butchers, clerks, assembly line workers, skilled and unskilled workers in the electronic and metal industries, workers in the fishing industry, and workers in the leather and textile industries. Employees with varied work included academics, employees in the human and health care sector, managers, manual jobs, and teachers.

Comparison of the results between employees of the same age and gender showed no significant differences between employees with varied work and employees with repetitive monotonous work (Tables 2,3, 4). Figures 2, 3, and 4 show maximal oxygen uptake, maximal handgrip strength, and maximal muscle strength of back flexors, back extensors and shoulder elevation of the dominating side, of all males and females with varied work and all males and females with repetitive monot-

Table 2 Calculated maximal oxygen uptake and aerobic power of males and females with varied work and males and females with repetitive monotonous work

Males					Females			
	n	V-Males	*n*	R-Males	*n*	V-Females	*n*	R-Females
Oxygen uptake (l O_2 min^{-1})								
Y	21	3.2 (2.4–5.3)	19	3.2 (2.6–4.3)	12	2.5 (1.8–3.4)	26	2.6 (1.6–4.5)
M	28	3.0 (1.9–4.2)	44	2.7 (1.6–4.1)	34	2.3 (1.2–3.6)	37	2.2 (1.3–3.9)
E	35	2.8 (1.9–5.0)	15	2.7 (1.5–5.0)	20	2.0 (1.5–3.0)	25	1.2 (1.4–2.9)
Aerobic power (ml O_2 min^{-1} kg^{-1})								
Y	21	41 (29–62)	19	44 (29–58)	12	43 (27–65)	26	41 (24–70)
M	28	36 (22–54)	44	34 (22–55)	34	36 (22–55)	37	33 (22–55)
E	35	34 (21–64)	15	34 (22–51)	20	30 (21–48)	25	31 (17–38)

Mean value and (range)
Y young, 18–29 years, *M* Middle aged, 30–44 years, *E* Elderly, 45 years or more
*Significant difference between repetitive monotonous work and varied work. *R* males/females: males/females with repetitive monotonous work, *V* males/females: males/females with varied work

Table 3 Maximal muscle strength (*MVC*) of back extensors, back flexors (abdomen) and handgrip of males and females with varied work and males and females with repetitive monotonous work

Males					Females			
	n	V-Males	*n*	R-Males	*n*	V-Females	*n*	R-Females
Back extensors (N m)								
Y	28	196 (84–330)	20	196 (88–301)	17	95 (26–143)	26	114 (54–168)
M	31	222 (82–485)	38	209 (128–308)	39	119 (47–159)	40	114 (50–183)
E	42	202 (87–368)	19	186 (140–264)	22	104 (54–132)	32	106 (54–169)
Back flexors (N m)								
Y	28	190 (125–322)	21	182 (124–282)	18	95 (30–176)	26	102 (57–159)
M	30	192 (75–326)	38	195 (128–344)	38	99 (48–166)	41	96 (41–195)
E	43	185 (109–307)	20	171 (106–223)	23	92 (46–151)	33	97 (47–133)
Handgrip strength (N)								
Y	29	574 (452–775)	23	559 (412–726)	20	338 (265–442)	28	357 (265–412)
M	35	553 (373–825)	46	561 (412–795)	44	361 (245–530)	42	354 (245–461)
E	56	517 (383–677)	24	505 (353–628)	33	330 (236–452)	34	337 (226–412)

Mean value and (range)
Y young, 18–29 years, *M* middle aged, 30–44 years, *E* elderly, 45 years or more
*Significant difference between repetitive monotonous work and varied work. *R* males/females: males/females with repetitive monotonous work, *V* males/females: males/females with varied work

Table 4 Maximal shoulder abduction strength (*MVC*) and maximal shoulder elevation strength (*MVC*) in the dominant and non-dominant side of males and females with varied work and males and females with repetitive monotonous work

Males					Females			
	n	V-Males	*n*	R-Males	*n*	V-Females	*n*	R-Females
Dom. shoulder abduction (N m)								
Y	24	79 (37–130)	20	71 (44–148)	18	33 (19–71)	25	32 (20–55)
M	29	67 (31–119)	37	73 (38–156)	38	33 (18–55)	39	31 (19–53)
E	40	67 (37–138)	21	69 (38–177)	25	30 (18–56)	30	31 (9–58)
Non-dom. shoulder abduction (N m)								
Y	24	73 (43–120)	20	71 (40–134)	18	30 (19–52)	25	30 (18–49)
M	29	71 (32–135)	37	73 (32–151)	38	31 (18–65)	39	31 (14–58)
E	40	68 (34–142)	21	72 (45–146)	25	28 (16–47)	30	31 (8–47)
Dom. shoulder elevation (N m)								
Y	25	135 (49–198)	19	114 (71–160)	18	56 (21–143)	24	59 (35–80)
M	27	130 (70–193)	35	122 (70–210)	38	57 (21–115)	39	52 (23–96)
E	37	113 (44–187)	19	104 (40–182)	24	52 (10–85)	29	56 (22–105)
Non-dom. shoulder elevation (N m)								
Y	25	132 (68–228)	19	122 (59–122)	18	53 (19–107)	24	60 (29–83)
M	28	126 (64–239)	35	119 (53–212)	38	58 (20–117)	39	56 (18–113)
E	37	110 (33–202)	19	105 (40–218)	24	52 (12–85)	29	55 (25–125)

Mean value and (range) *Y* young, 18–29 years, *M* middle aged, 30–44 years, *E* elderly, 45 years or more
*Significant difference between repetitive monotonous work and varied work. *R* males/females: males/females with repetitive monotonous work, *V* males/females: males/females with varied work

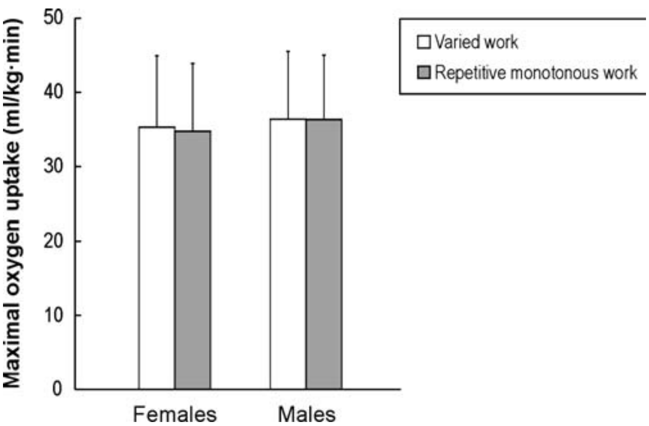

Fig. 2 Maximal oxygen uptake per kg bodyweight. The *columns* indicate the mean values of all males and females with varied work and all males and females with repetitive monotonous work. The *whiskers* indicate the standard deviation

Fig. 3 Maximal handgrip strength (*MVC*). The *columns* indicate the mean values of all males and females with varied work and all males and females with repetitive monotonous work. The *whiskers* indicate the standard deviation

onous work. There was a tendency towards higher shoulder elevation strength in both shoulders as well as higher back muscle strength among males with varied work compared with males with repetitive monotonous work. This tendency was not present in the female group. The correlation coefficient between the measured strength parameters ranged from 0.17 to 0.87, the higher coefficients were found between associated muscles. The correlation coefficient between aerobic capacity and the different strength parameters ranged from −0.01 to −0.31 and was nonsignificant.

The ratio between back extensor and flexor muscle strength in this study ranged from 1.06 (among males between 18 and 29 years) to 1.21 (among females between 30 and 44 years).

Self-reported levels of physical activity during leisure time were similar for the two groups of employees. Thus, 92% of the females with varied work and 86% of the females with repetitive monotonous work were slightly or moderately active, whereas 80% of the males with varied work and 82% of the males with repetitive monotonous working were slightly or moderately active. Cycling and walks were the most common activities.

Discussion

In this study, we have analysed for willingness to participate and for representativity. When comparing the

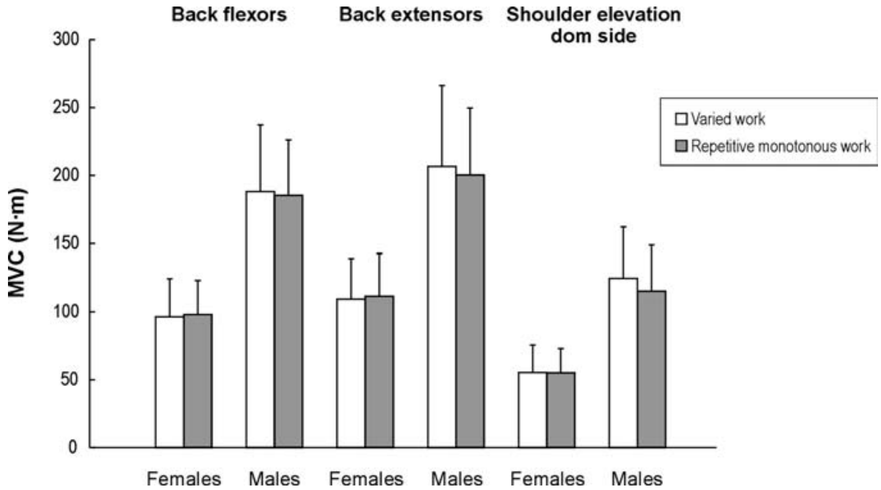

Fig. 4 Maximal muscle strength (*MVC*) of back flexors, back extensors, and shoulder elevation of the dominating side. Mean values of all males and females with varied work and all males and females with repetitive monotonous work. The *whiskers* indicate the standard deviation

subsample of 467 participants with the whole survey population of 10,703 according to education, branch, sector, musculoskeletal disorders, self-rated health, body-weight, height or Body Mass Index, the authors found no differences that would affect the physical capacities in any particular way. Thus, the measured capacities can be considered as representative of the Danish employee.

In general, the aerobic capacity was not associated with the work category, as there were no significant differences between the group with varied work compared with the group with repetitive monotonous work. The calculated maximal oxygen uptake (2.7 l–3.2 l/min for males, 1.2–2.6 l/min for females) and the weight-related aerobic capacity corresponds to earlier findings (Åstrand 1960). According to the Åstrand classification, the participants are classified as "fair to average" to "average". Thus, the results on aerobic capacity show no differences either between work categories or when compared with earlier results. The latter indicates no evidence of a deterioration of the aerobic capacity during the last four decades.

Around 80% of each group of employees reported to be physically active for at least 2 h per week. Weight-related aerobic capacity correlated with self-reported activity level through the categories, "slightly active"—"passive"—"moderately active"—"extremely active", for both females and males. This is contrary to the view, that the work category may influence the choice of leisure-time activities.

In general, the muscle strength did not depend on the work category, as there were no significant differences between the strength parameters in the group with varied work compared with the group with repetitive monotonous work.

Asmussen and Heebøl-Nielsen (1961) measured the maximal muscle strength of 25 different muscle groups, including three of the muscle strength parameters measured in this study: backward extension strength and forward flexion strength of the trunk, and handgrip strength, on 250 females and 360 males aged 15–60 years. These results have served as an excellent reference material since then. The methods were identical to the methods used in this study and it is therefore possible to compare the results of the two studies. In general, the muscle strength seemed to be higher in 1961 with some exceptions. The females were stronger in backward extension and forward flexion of the trunk and handgrip in 1961 (approx. 25, 10 and 10%, respectively), whereas the males were stronger in backward extension only in 1961 (approx. 25%). The tendency to lower muscle strength in 1997, especially of the back extensors, may be caused by decreased physical demands in occupational and daily life. A comprehensive mechanization of all industries has taken place during the past 40 years, which means that handling of heavy burdens has reduced. In continuation of this a change of the relationship between back extensor and flexor muscle strength during the past 40 years is found in this study. Asmussen and Heebøl-Nielsen (1961) and Biering-Sørensen (1984) found a ratio between back extensor and flexor strength of 1.33 among males, and 1.4 and 1.3 among females, respectively. The ratio between back extensor and flexor muscle strength in this study is between 1.06 and 1.13 among males and between 1.16 and 1.21 among females. It may be hypothesized, that the ratio is a predictor of back trouble. However, the results of this study are consistent with the results of Nicolaisen and Jørgensen (1985), which found a back extensor muscle/flexor muscle strength ratio of 1.15 in males with no previous back problems.

The low to moderate correlation between the strength measured on different muscle groups showed that the subjects could not always be characterized as either weak or strong in a general manner. Thus, the strength of different muscle groups were relatively independent, which indicates that factors with a possible influence on muscle strength, such as age or work category, may affect some muscles more than others. As expected, the correlation between aerobic capacity and muscle strength is low, −0.01 to −0.31, and shows that muscle strength and aerobic capacity are independent variables.

In contrast to the results of this study, earlier studies point towards an association between different jobs and differences in physical capacities, such as muscle strength and aerobic capacity. Some studies find a tendency to lower maximal muscle strength in the hand, backward extension and forward flexion of the trunk among workers with physically heavy work (Era et al. 1992; Nygård 1987, 1988a, 1988b; Ruzic et al. 2003), which may be explained by a wearing effect of the job. These studies indicate that physically heavy work is no guarantee for high physical capacities.

Other studies point towards a training effect of some jobs and a wearing effect of other jobs on specific body parts, due to an inappropriate and unbalanced loading of the musculoskeletal system. A study by Schibye and Christensen (1997) compared handgrip strength in a group of young and elderly waste collectors (varied work), a group of young and elderly meat cutters (heavy monotonous work) and a control group. The results showed that the handgrip strength was higher among the waste collectors. The handgrip strength of the young meat cutters with low seniority did not differ from the handgrip strength of the young control group, whereas the elderly meat cutters with high seniority showed markedly lower handgrip strength compared with the elderly control group. The results indicated that the repetitive, monotonous, forceful work of meat cutters seemed to enhance the natural age related strength decline of the forearm muscles. Thus, it could be hypothesized that monotonous, repetitive work induces a decrease in muscle strength of the forearm. In contrast to this a possible training effect can be expected in other physically demanding jobs in the same way as during physical training. A study of 25 young waste collectors with low seniority and 29 elderly waste collectors with high seniority documented that waste collectors generally have a higher physical capacity than control groups (Schibye et al. 2001). For the young waste collectors the higher physical capacity may be an indication of a selection into the job. For the elderly waste collectors the job was concluded to have a maintaining effect, Since particularly on the shoulder muscle strength. The study indicated that the work itself had a maintaining effect, as especially the high shoulder muscle strength was maintained among the elderly waste collectors.

The latter studies indicate that detailed measurements, with focus on the exposed muscle groups in the job in question, are necessary if any effect of the job on the relevant physical capacities is to be described. Thus, the definitions of the two work categories in this study may be too general. The group with varied work includes both employees with physically heavy and light work, and the group with monotonous repetitive work includes both employees with heavy and light repetitive work. Thus the exposures of the two work categories may be too mixed to reflect any differences in exposures as well as in capacities.

Conclusion

This study did not find any association between the individuals' physical capacity and the work category. In order to find positive or negative relationships between the work category and the physical capacity, it is necessary to examine individual job groups and the exposed parts of the body. Furthermore, the study gives a general view of some physical capacities in a representative sample of the Danish work force.

References

Åstrand I (1960) Aerobic work capacity in men and women with special reference to age. Acta Physiol Scand Suppl 49:1–92

Åstrand P-O, Ryhming I (1954) A nomogram for calculation of aerobic capacity (physical fitness) from pulse rate during submaximal work. J Appl Physiol 7:218–221

Appleyard M (eds) (1989) The copenhagen city heart study. Østerbroundersøgelsen. A book of tables with data from the first examination (1976–1978) and a five year follow-up (1981–1983). Scand J Soc Med 41:1–160

Asmussen E, Heebøll-Nielsen K (1961) Isometric muscle strength of adult men and women. Comm Nat Ass Infant Paral 11:3–44

Asmussen E, Heebøll-Nielsen K, Molbech S (1959) Methods for evaluation of muscle strength. Comm Nat Ass Infant Paral 3–13

Bäckman E, Johansson V, Häger B, Sjöblom P, Henriksson KG (1995) Isometric muscle strength and muscular endurance in normal persons aged between 17 and 70 years. Scand J Rehabil Med 27:109–117

Biering-Sørensen F (1984) Physical measurements as risk indicators for low-back trouble over a one-year period. Spine 9:106–119

Borg V, Burr H (1997) In: Borg V, Burr H (eds) Danske lønmodtageres arbejdsmiljø og helbred 1990–1995, 1st edn. Arbejdsmiljøinstituttet, København

Burr H, Bjorner JB, Kristensen TS, Tüchsen F, Bach E (2003) Trends in the Danish work environment in 1990–2000 and their associations with labor-force changes. Scand J Work Environ Health 29:270–279

Era P, Lyyra AL, Viitasalo JT, Heikkinen E (1992) Determinants of isometric muscle strength in men of different ages. Eur J Appl Physiol 64:84–91

Essendrop M, Schibye B, Hansen K (2001) Reliability of isometric muscle strength tests for the trunk, hands and shoulders. Int J Ind Eng 28:379–387

Feveile H, Jensen C, Burr H (2002) Risk factors for neck-shoulder and wrist-hand symptoms in a 5-year follow-up study of 3,990 employees in Denmark. Int Arch Occup Environ Health 75:243–251

Jensen BR, Schibye B, Søgaard K, Simonsen EB, Sjøgaard G (1993) Shoulder muscle load and muscle fatigue among industrial sewing-machine operators. Eur J Appl Physiol 67:467–475

Karlqvist L, Leijon O, Härenstam A (2003) Physical demands in working life and individual physical capacity. Eur J Appl Physiol 89:536–547

Nicolaisen T, Jørgensen K (1985) Trunk strength, back muscle endurance and low-back trouble. Scand J Rehabil Med 17:121–127

Nygård C-H, Loupajärvi T, Cedercreutz G, Ilmarinen J (1987) Musculoskeletal capacity of employees aged 44 to 58 years in physical, mental and mixed types of work. Eur J Appl Physiol 56:555–561

Nygård C-H, Luopajärvi T, Suurnäkki T, Ilmarinen J (1988a) Muscle strength and muscle endurance of middle-aged Women and men associated to type, duration and intensity of muscular load at work. Int Arch Occup Environ Health 60:291–297

Nygård CH, Luopajärvi T, Ilmarinen J (1988b) Musculoskeletal capacity of middle-aged women and men in physical, mental and mixed occupations. Eur J Appl Physiol 57:181–188

Plagenhoef S (1971) Patterns of human motion. Prentice-Hall Inc., New Jersey

Ruzic L, Heimer S, Misigoj-Durakovic M, Matkovic BR (2003) Increased occupational physical activity does not improve physical fitness. Occup Environ Med 60:983–985

Schibye B, Christensen H (1997) The work load during waste collection and meat cutting among workers in different age groups. Arbete och Hälsa 29:272–278

Schibye B, Hansen AF, Søgaard K, Christensen H (2001) Aerobic power and muscle strength among young and elderly workers with and without demanding work tasks. Appl Ergon 32:425–431

Søgaard K, Fallentin N, Nielsen J (1996) Work load during floor cleaning. The effect of cleaning methods and work technique. Eur J Appl Physiol 73:73–81