

Stress and strain of elderly employees in municipal occupations

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SUURNÄKKI T, NYGÅRD C-H, ILMARINEN J. Stress and strain of elderly employees in municipal occupations. *Scand J Work Environ Health* 1991;17(suppl 1):30-9. Cardiorespiratory and musculoskeletal stress and strain during work were investigated for 129 men and women aged 45 to 58 years. In physical work the women had more physical demands (34 % of the workshift) than the men (21 %) although the men had more peak loads (heavy and very heavy) than the women. Cardiorespiratory strain varied between 63 and 131 beats $\cdot$ min⁻¹, which equaled a metabolic rate of 68 to 223 W $\cdot$ min⁻². The relative cardiorespiratory strain of the older subjects was the same as that of the younger subjects. Among the physical workers with good cardiorespiratory capacity the absolute and relative strain was 10 and 18 % lower, respectively, than among those with poor or moderate capacity. Poor work postures were the most common in physical work (17 % of the workshift) and more common among the women (22 %) than among the men (15 %). It seems that work is often physically heavy for elderly women because of their decreased physical work capacity.

Key terms: age, gender, heart rate, job analysis, physical activity, physical capacity, work postures, work tasks.

The stress-strain concept hypothesizes that a given work load (stress) does not result in the same strain for all persons (1, 2). The strain depends to a very high degree on the individual characteristics of the worker. For example, in heavy dynamic work, the higher the cardiorespiratory capacity, the lower the strain on a worker at a given work load.

As a part of a comprehensive research project on the work, health, and retirement age of municipal employees, the main objectives of the present study were to measure the work load and strain on elderly municipal workers and to analyze the effects of individual characteristics (age, gender, functional capacity) on the strain (heart rate during work). The stress factors were taken from a job analysis (work content groups), work sampling data (physical activity, work tasks, work postures), and direct measurements of oxygen consumption during work. The maximal cardiorespiratory capacity of the subjects was measured in the laboratory. The main variables of the present study, grouped according to the stress-strain concept, are given in figure 1.

Subjects and methods

One hundred and twenty-nine subjects, 60 women and 69 men, from 88 different occupations were divided into three main groups according to the nature of the

work (physical, mental, or mixed physical and mental) and into 13 profile groups according to a job analysis with the AET (Arbeitswissenschaftliche Erhebungsverfahren zur Tätigkeitsanalyse) method. [See the report of Ilmarinen et al (3).] The subjects were the same as those whose functional capacity was studied in the laboratory (4-6). The mean age was 51.8 (SD 3.1) years for the men and 52.3 (SD 3.7) years for the women (table 1). There were no marked differences in the anthropometric measurements and maximal oxygen consumption between the three work groups among either the men or the women.

Physiological measurements

The heart rate (HR, beats $\cdot$ min⁻¹) during a workshift was registered minute by minute with a portable heart-rate meter with a microprocessor (7) or with a Howel Corder tape recorder (8). The mean heart rate at work was related individually to the heart rate range (% HRR), the estimated maximal heart rate [$210 - (0.8 \times \text{age})$] and the lowest measured heart rate during the workshift being used for the calculations (9).

Oxygen consumption ($\dot{V}O_2$, l $\cdot$ min⁻¹) was measured for 12 subjects with a portable Oxylog device (10, 11). The mean duration of the direct measurements was 45 (range 17-72) min. The individual relative aerobic strain during work was determined according to the measured absolute oxygen consumption (l $\cdot$ min⁻¹) during work and also according to the assessed maximal oxygen consumption ($\dot{V}O_{2\text{max}}$, l $\cdot$ min⁻¹) under laboratory conditions (3) and expressed as the percentage of the maximal oxygen consumption (% $\dot{V}O_{2\text{max}}$). The $\dot{V}O_{2\text{max}}$ in relation to body weight (ml $\cdot$ kg $\cdot$ min⁻¹), gender, and age was

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used to classify the physical capacity of the subjects as poor, moderate, or good (12).

Observation studies

The activities during work were recorded according to the Edholm scale with the use of minute-by-minute registrations during a period of observation (13–15). The activities were classified into eight categories based on energy consumption and metabolic rate (table 2).

A minute-by-minute registration of the work tasks was also carried out through the use of an observation technique (15), and the main work tasks of the

municipal occupations were classified into 75 different work categories. The activity data and work task data were combined in the analysis with the simultaneously measured heart rate data.

Poor work postures were registered continuously during the workshift with an observation method (15). The work postures were defined as poor if they differed from the normal physiological position and included a risk thought to load the musculoskeletal system harmfully. The duration of a poor work posture had to be at least 30 s continuously or repeatedly during 1 min before it was noted. The original classification

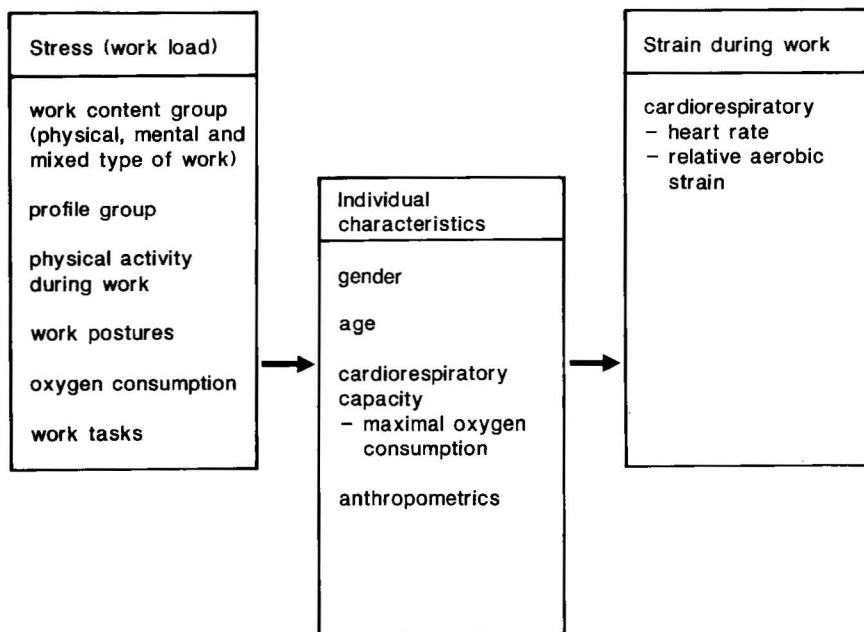


Figure 1. The stress-strain concept and the variables in the present study. (mixed = mixed physical and mental work)

Table 1. Age, anthropometrics, and maximal oxygen consumption of the subjects by gender and work group.

Work group	N	Age (years)		Weight (kg)		Height (cm)		Body fat (%)		Maximal oxygen consumption			
										l · min ⁻¹		ml · kg ⁻¹ · min ⁻¹	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<i>Men</i>													
Physical	29	52.0	3.2	77.9	11.1	175	7	23	7	2.68	0.54	34.2	6.5 ^a
Mixed physical and mental	23	51.2	3.2	77.5	10.9	174	6	23	7	2.74	0.40	36.0	5.7 ^b
Mental	17	51.8	3.1	81.0	7.9	175	5	24	5	2.67	0.55	33.2	6.0 ^c
All	69	51.8	3.1	78.5	10.1	175	6	23	6	2.70	0.49	34.6	6.1 ^d
<i>Women</i>													
Physical	17	53.0	3.1	69.9	17.7	161	8	35	10	1.82	0.48	27.1	6.3 ^e
Mixed physical and mental	17	50.6	3.2	66.8	6.4	163	5	31	6	1.82	0.40	27.4	5.5 ^f
Mental	26	52.3	4.1	67.6	10.6	161	5	36	10	1.90	0.36	28.2	5.5 ^g
All	60	52.3	3.7	68.3	12.7	161	6	34	9	1.85	0.40	27.6	5.6 ^h

^a N = 24; ^b N = 22; ^c N = 15; ^d N = 61; ^e N = 13; ^f N = 15; ^g N = 23; ^h N = 51.

Table 2. Activity levels of the work according to the Edholm scale and the reference values of energy consumption and metabolic rate for each category (15).

Category	Classification of activities	Energy consumption		Metabolic rate (MET ^a)	
		W · m ⁻² ^b	W	%	kJ · min ⁻¹
1	Lying asleep	110	5	50	85
2	Lying, sitting, break	120	6	55	95
3	Sitting without special movement, standing with no movement	150	7	65	120
4	Standing with light activity	300	14	130	235
5	Walking, moving	400	19	175	315
6	Activity with moderate intensity	500	24	220	396
7	Activity with high intensity	800	38	350	635
8	Activity with extremely high intensity	1000	48	440	790
0	Official breaks (lunch, coffee)				

^a Multiples of basal metabolic rate.

^b Total metabolic rate related to body surface area (1.8 m²).

of 10 different poor work postures was pooled into four classes as follows: (i) poor postures of the neck and shoulders: neck bent forwards, neck rotated, and neck bent backwards; (ii) poor postures of the upper arm: upper arm free from the trunk and elevated 30–90 degrees and upper arm free from the trunk above 90 degrees; (iii) poor postures of the back: back rotated, back bent (less than 10 degrees), and back extremely bent (above 90 degrees); and (iv) poor postures of the legs: squatting and kneeling.

The differences between the work content groups or between the profile groups were tested with the two-tailed t-test.

Results

Cardiorespiratory stress and strain during work

During one-third of the workshift, sitting was the most pronounced activity. In the mental work groups it was used more than 50 % of the shift.

The moderate and heavy physical activities were the most common in the physical occupations (ie, 21 % of the workshift for the men and 34 % for the women) (table 3). Walking demanded an average of 17 % of the shift for the men and 16 % of the shift for the women and was most common in the physical work group (22 %). Among both the men and the women the highest absolute heart rate (HR) and relative heart rate (% HRR) were measured during physical work. The mean absolute and relative heart rates during the workshift were the lowest for the men in mixed work and for the women in mental work. Among the men the differences in the mean heart rate between the physical and mixed work groups was significant ($P < 0.001$), as well as among the women between the physical and mental work groups ($P < 0.001$). Both the absolute and relative heart rates were higher for the men than for the women, especially during the heavy physical activities in mixed work ($P < 0.001$). The

difference in the mean heart rate during heavy activities in physical and mixed work among the women was significant ($P < 0.001$). During moderate physical activity the absolute and relative heart rates were an average of 5 beats · min⁻¹ and 6 %-units higher, respectively, for the men than the women. During heavy and very heavy physical activity the differences were 12 beats · min⁻¹ and 11 %-units, respectively.

Among the profile groups the highest mean cardiorespiratory strain was found for installation work among the men (99 beats · min⁻¹) and for auxiliary (98 beats · min⁻¹) and home care (94 beats · min⁻¹) work among the women (figure 2). The lowest mean heart rate during the workshift was determined for administrative work among both the men and the women (77 beats · min⁻¹), in office work among the women (80 beats · min⁻¹), and in teaching work among the men (82 beats · min⁻¹). The ranking of the profile groups according to the relative heart rate was almost the same as when the groups were ranked according to absolute heart rate.

A summary of the cardiorespiratory stress and strain is given in table 4. The range of the individual mean metabolic rates was large in most of the profile groups. The highest metabolic rates were twice as high as the lowest ones (eg, technical supervision, transport work). The mean metabolic rate of the auxiliary and home care work was twice as high as in office or administrative work. The results were similar for cardiorespiratory strain, but the variations between both the individuals and the profile groups were smaller because of the smaller possible range in heart rate than in metabolic rate.

Age and cardiorespiratory strain

In spite of the lower mean heart rate of the older subjects (52–58 years of age) their relative cardiorespiratory strain during the workshift was nearly as high as that of the younger subjects (45–51 years of age) (fig-

Table 3. Mean duration (% the workshift) of the physical activities in different categories and the subjects' absolute heart rate (HR, beats · min⁻¹) and relative heart rate (% HRR)^a by gender and work group.

Work group	N	Sitting			Standing			Walking			Moderate physical activities			Heavy and very heavy physical activities			All activities	
		Duration (%)	HR	% HRR	Duration (%)	HR	% HRR	Duration (%)	HR	% HRR	Duration (%)	HR	% HRR	Duration (%)	HR	% HRR	HR	% HRR
Men																		
Physical	29	21	84	19	36	93	28	22	101	36	15	109	43	6	122	56	95	30
Mixed physical and mental	23	65	77	16	20	82	21	12	89	26	2	105	42	1	118	52	80	19
Mental	17	52	79	15	28	84	19	14	90	25	4	101	37	1	113	46	82	16
All	69	43	81	17	29	87	23	17	94	30	8	107	42	3	121	55	87	24
Women																		
Physical	17	9	86	19	35	94	28	22	99	33	31	106	40	3	118	52	96	30
Mixed physical and mental	17	25	79	14	46	87	22	20	90	25	8	96	30	1	99	33	86	21
Mental	26	70	76	12	20	82	18	9	87	23	1	107	39	0	—	0	79	15
All	60	40	80	15	32	87	22	16	91	26	11	102	36	1	109	44	86	21
All men and women	129	42	81	16	30	87	23	17	93	28	9	105	39	2	115	50	87	23

^a Heart rate range calculated from the estimated maximal heart rate [$210 - (0.8 \text{ age})$] and the lowest measured heart rate during the workshift.

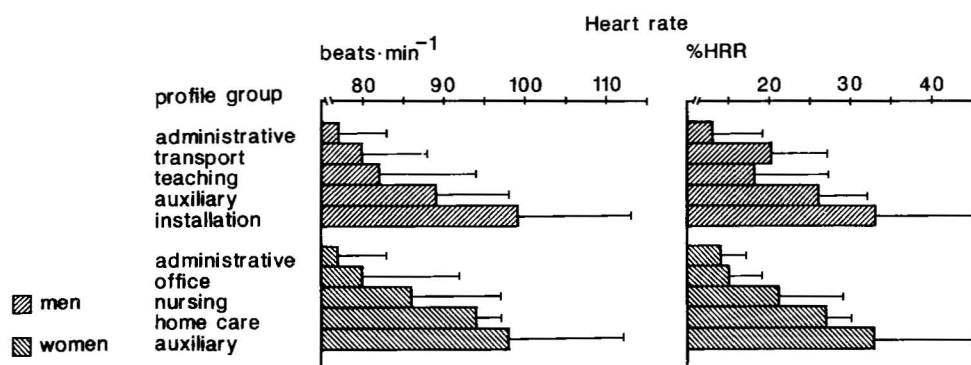


Figure 2. Means and standard deviations of the subjects' absolute (beats · min⁻¹) and mean relative (% HRR) heart rate during the workshift by gender and job profile group (N ≥ 5).

Table 4. Summary of the cardiorespiratory stress (mean metabolic rate and range) and strain (mean heart rate and range) during one workshift by profile group.

Profile group	N	Metabolic rate ^a (W · m ⁻²)		Heart rate ^b (beats · min ⁻¹)	
		Mean	Range	Mean	Range
Auxiliary work	22	168	103—223	93	73—117
Home care work	6	166	146—182	94	89—97
Installation work	18	151	107—193	99	76—131
Nursing work	16	137	114—164	85	67—103
Technical supervision	4	125	84—187	83	73—96
Physician's work	2	118	106—127	94	91—97
Kitchen supervision	2	116	109—119	89	84—94
Teaching work	10	114	88—136	81	63—108
Dump work	3	114	68—153	85	82—86
Transport work	17	96	70—141	80	66—95
Dental work	2	91	83—95	77	68—86
Office work	10	85	72—101	80	63—100
Administrative work	17	84	70—104	77	65—88
Total	129	124	68—223	86	63—131

^a Calculated according to the Edholm scale.

^b Continuous minute-by-minute recording of heart rate over the workshift.

ure 3). The difference between the older and younger subjects was significant only in the mixed work group [HR (beats · min⁻¹), $P < 0.05$].

Cardiorespiratory capacity and cardiorespiratory strain

The highest mean absolute heart rate during the workshift was found for physical work among those with average (101 beats · min⁻¹) and lower than average (100 beats · min⁻¹) cardiorespiratory capacity (figure 4). The relative cardiorespiratory strain was also highest among the subjects with average or low capacity (34 % HRR). In physical work the absolute heart rate was 10 % ($P < 0.05$) and the relative heart rate 6 %-units (not significant) lower among the subjects with higher than average or average cardiorespiratory capacity than among those with lower than average capacity.

In addition, in the mixed work group, the level of cardiorespiratory strain was higher among the subjects with a low capacity than among those with an average ($P < 0.01$) or good ($P < 0.01$) capacity. The lowest mean levels of absolute heart rate during the workshift were 79 beats · min⁻¹ for mixed work and 77 beats · min⁻¹ for mental work among the subjects with good cardiorespiratory capacity.

Oxygen consumption in physical work

The oxygen consumption was, on the average, 0.7 (SD 0.3) l · min⁻¹ in physical work. This value corresponded to a relative aerobic strain of 34 % $\dot{V}O_{2\max}$. The oxygen consumption ranged from 0.3 to 1.7 l · min⁻¹, values corresponding to 9 and 91 % of the $\dot{V}O_{2\max}$, respectively.

According to the regression between the relative aerobic strain and absolute heart rate at work (figure 5), the absolute heart rate which corresponded to 50 % of the $\dot{V}O_{2\max}$ was calculated. The 50 % $\dot{V}O_{2\max}$ has been suggested to be the upper limit for prolonged physical work (16). The absolute heart rate corresponding to the 50 % $\dot{V}O_{2\max}$ was 111 beats · min⁻¹ in this sample.

Cumulative distribution of heart rate

The cumulative distribution curve of the time spent at different levels indicated that those in physical work worked 50 % of the workshift with a heart rate above 95 beats · min⁻¹, while those in mixed and mental jobs worked the same amount of time with a heart rate of around 80 beats · min⁻¹ (figure 6). The heart rate exceeded the acceptable 50 % $\dot{V}O_{2\max}$ level (110 beats · min⁻¹) the most often in physical occupa-

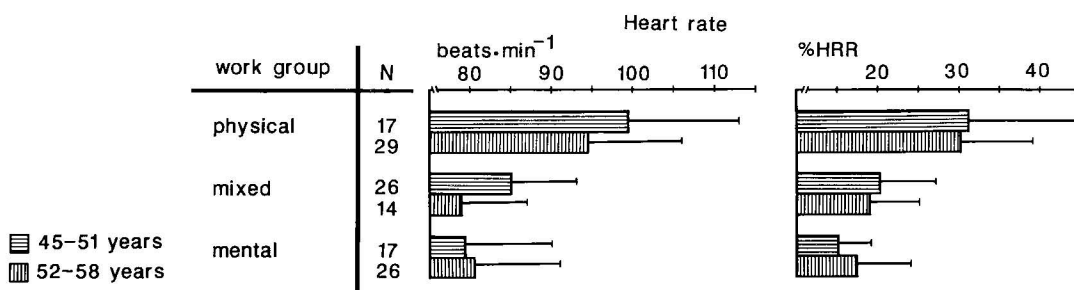


Figure 3. Means and standard deviations of the subjects' absolute (beats · min⁻¹) and mean relative (% HRR) heart rate during the workshift by work group and age. (mixed = mixed physical and mental work)

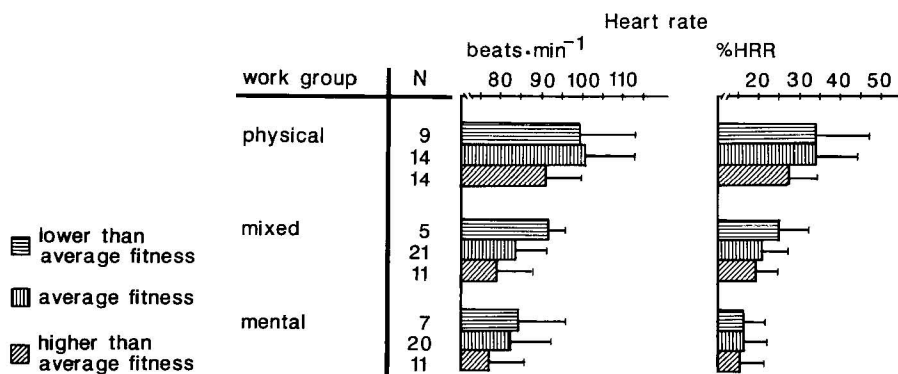


Figure 4. Means and standard deviations of the subjects' absolute (beats · min⁻¹) and mean relative (% HRR) heart rate during the workshift by work group and level of physical fitness. (mixed = mixed physical and mental work)

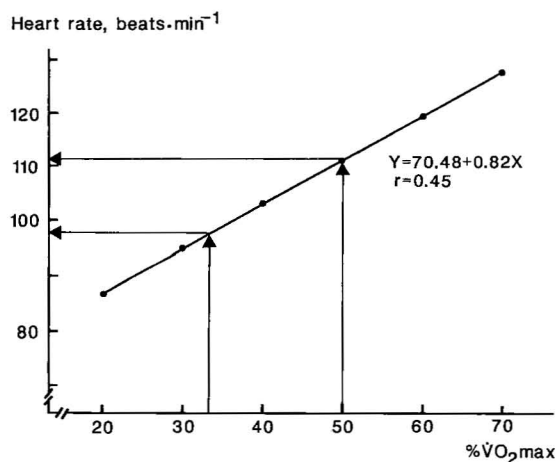


Figure 5. Heart rate as a function of relative oxygen consumption (% VO_2max) in physical work ($N = 12$).

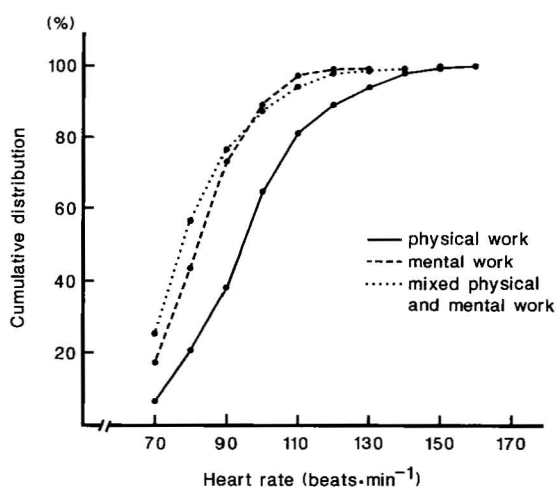


Figure 6. Cumulative distribution of time (% of workshift) spent on different heart rate levels by work group.

tions, where the heart rate of the workers was over 110 beats $\cdot \text{min}^{-1}$ during 19 % of the workshift and over 130 beats $\cdot \text{min}^{-1}$ during 6 % of the workshift. In mental occupations the strain exceeded 110 beats $\cdot \text{min}^{-1}$ during about 5 % of the shift, and the corresponding figure for mixed mental and physical work was about 3 %. For four subjects in physical work the mean heart rate during the workshift exceeded the acceptable level for prolonged physical strain.

Cardiorespiratory strain in different work tasks

The heart rate was, on the average, 71–138 beats $\cdot \text{min}^{-1}$, depending on the work tasks. Generally, the heart rate was below 100 beats $\cdot \text{min}^{-1}$ during two-thirds of the work tasks. The mean duration of the work tasks in which the corresponding mean heart rate was above 110 beats $\cdot \text{min}^{-1}$ varied from 1 min (concrete laying, carpentry, bicycling, handling of fire fighting equipment) to 64 min (carpentry) (table 5). The individual mean heart rate varied remarkably. For example, the same task of shoveling for 30 min was carried out with a strain of 100 beats $\cdot \text{min}^{-1}$ and also with a strain of 132 beats $\cdot \text{min}^{-1}$. In service and maintenance work the strain varied between 99 and 147 beats $\cdot \text{min}^{-1}$. Pushing and pulling a loaded cart or striking with a hammer or crowbar included even higher heart rates.

The heaviest work tasks according to the highest measured heart rate were the tasks with high muscular effort and use of strength like striking, hitting with a sledgehammer, pushing or pulling a heavily loaded cart, lifting or carrying, and also service, maintenance, assembly, and repair work (figure 7). The duration of these tasks was usually short.

Table 5. Mean duration of the work tasks and the range of the mean heart rate for tasks in which the mean heart rate was above 110 beats $\cdot \text{min}^{-1}$ (>50 % of maximal oxygen consumption).

Task ^a	Number of subjects	Mean duration (min)	Range of mean heart rate (beats $\cdot \text{min}^{-1}$)
1 Sweeping, raking	9	42	87–136
Assembly, repair	8	35	89–133
Machine operation	6	17	102–122
Bicycling	1	46	111
Carpentry	4	64	109–129
Shoveling	10	30	100–132
Service, maintenance	18	33	99–147
2 Carrying, lifting (10–25 kg)	29	8	90–148
Carpentry, hands above shoulder level	1	36	126
Pushing, pulling a loaded cart	7	17	108–156
Striking (hammer, crowbar)	5	11	100–158
3 Concrete laying	1	4	130
Handling of fire-fighting equipment	1	4	134
Physical exercise (fire brigade)	2	84	136
Carrying, lifting (> 25 kg)	5	7	123–148

^a 1 = mean heart rate 110–119 beats $\cdot \text{min}^{-1}$, 2 = mean heart rate 120–129 beats $\cdot \text{min}^{-1}$, and 3 = mean heart rate 130–139 beats $\cdot \text{min}^{-1}$.

Musculoskeletal load

Eighty-eight percent of the subjects had poor work postures during work. All the subjects in physical work had poor work postures for at least 1 min during the workshift. Poor work postures were used the most in physical work, on the average about 17 % of the workshift (figure 8), and the least in mental work (an average of 4 % of the workshift).

Both the men and the women used poor work postures the most in physical work and the least in

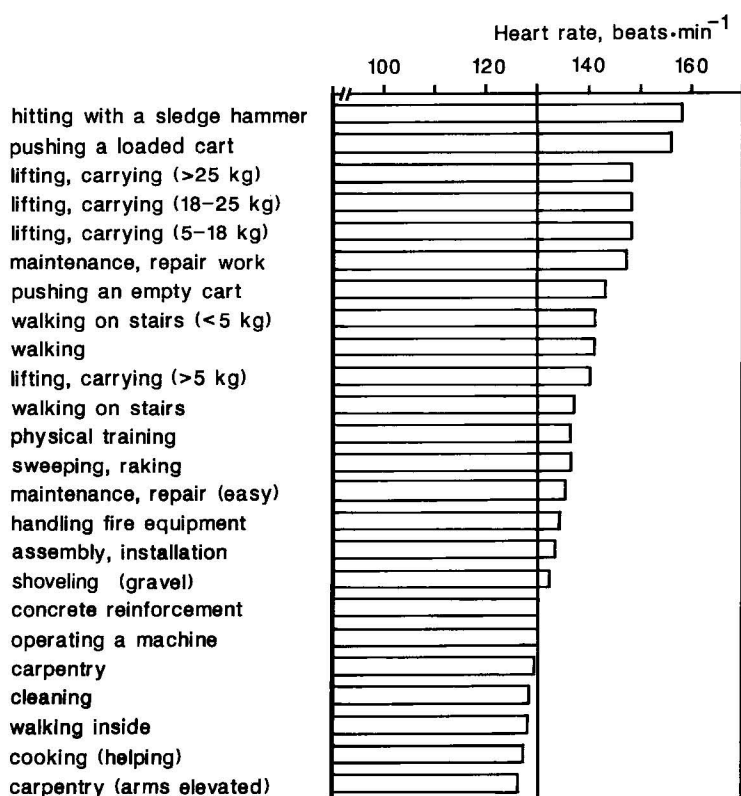


Figure 7. Work tasks with the highest mean peak heart rates.

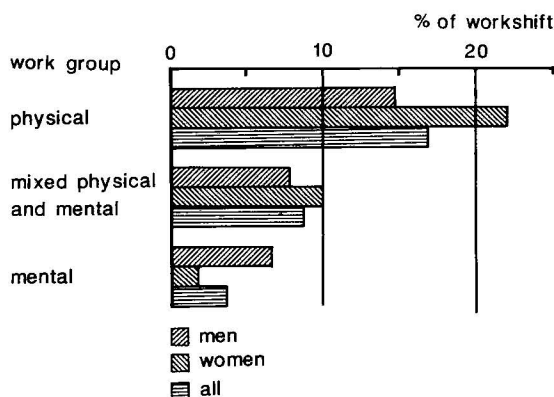


Figure 8. Mean occurrence of poor work postures (% of workshift) among the subjects by gender and work group.

mental work. In physical and mixed physical and mental work the women used more poor work postures than the men. In mental work the situation was the opposite.

Poor work postures generally involved the back (82 % of the subjects) and the arms (55 % of the subjects) (figure 9). For the legs and the neck 33 and 31 % of the subjects, respectively, used poor work postures. For all parts of the body except the neck the persons doing physical work used poor work postures the most.

The men in mixed work used poor neck postures the most. In physical work the women used more poor postures of the back, the arms, and the neck than the men. However the women had fewer poor leg postures than the men. Poor work postures were also often found simultaneously for many body parts.

The women in auxiliary and home care work had poor work postures about 25 and 20 % of the workshift, respectively (figure 10). These profile groups had more poor work postures than any of the men's profile groups. Among the men, the installation and auxiliary workers used poor work postures the most (16 and 12 % of the workshift, respectively).

Discussion

The results indicated that among older employees both moderate and high stress and strain including peak loads were common in physical occupations. The duration of heavy physical tasks was longer for the women than for the men, especially in auxiliary work, but also in mixed physical and mental work like nursing. On the contrary, there were more peak loads among the men than among the women in physical work. The tasks in the physical occupations among the women differed from those of the men's. For example, in auxiliary work, the men usually used more technical devices in their jobs than the women. The work

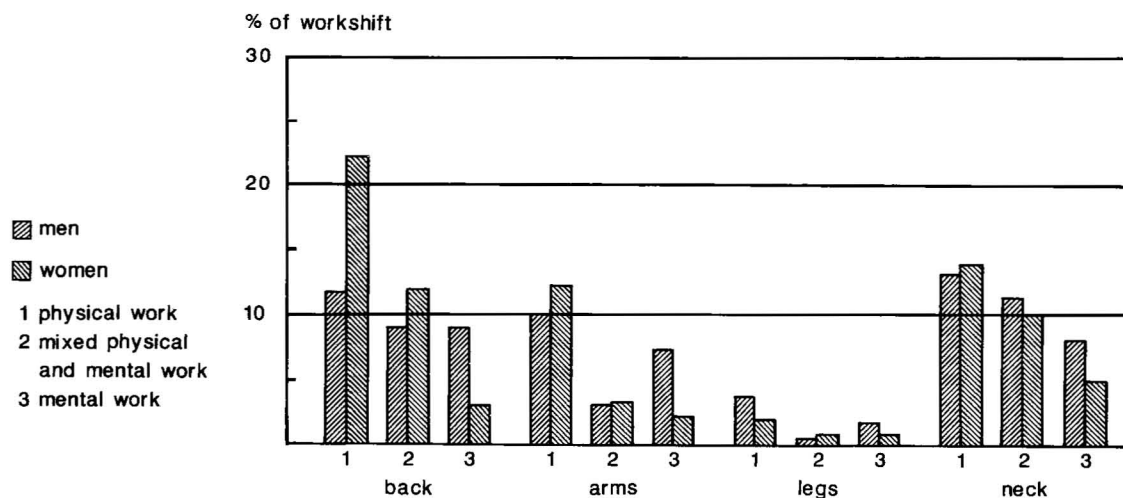


Figure 9. Mean occurrence of poor work postures (% of workshift) among the subjects by work group and body part.

in the women's occupations (eg, auxiliary and home care work) included mainly dynamic muscular work. The men's occupations (transport and installation work) included more static muscular work and also the use and support of various machines and heavy tools (17). Therefore the large variation in strain in different municipal occupational groups and also between individuals in the same group seems to be due to differences in the work equipment used, to differences in the amount of static and dynamic work between the men and the women, and also to the differences in the maximal work capacity of the workers.

According to the classification of the World Health Organization (16) the mean cardiorespiratory strain at work was low. However the classification based on mean heart rate at work may lead to incorrect conclusions because heart rate at work is closely related to physical work capacity and age. The continuous measurement of heart rates in our study included also the breaks during the workshift, and this procedure decreased the mean heart rate. Thus, when the age and capacity of our subjects is taken into account, auxiliary, installation, and home care work can be classified as moderate, or perhaps as heavy, physical work. Work periods and special tasks with high physical strain ($HR\ 125\text{--}150\text{ beats} \cdot \text{min}^{-1}$) and short periods with extremely high strain ($HR > 150\text{ beats} \cdot \text{min}^{-1}$), due primarily to a low capacity of the workers, appeared in most of the profile groups. These peak values of heart rate are on the same levels found, for example, in the building industry (18), in the iron and steel industry (19), in construction, foundry and shipyard work (11), and in physically loading industrial jobs (9).

In the aforementioned studies the subjects were usually men with a mean age of approximately 40 years. In the present study the subjects were older men and women with a mean age of 51 years. Especially

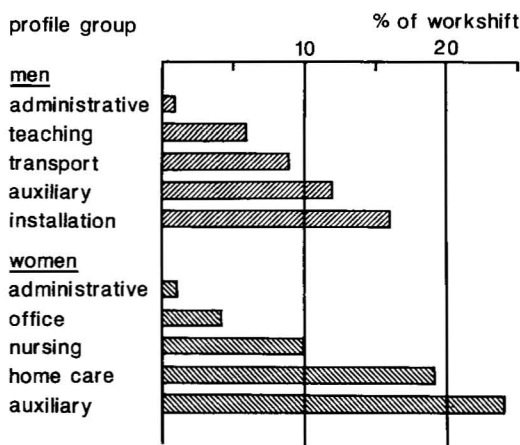


Figure 10. Mean occurrence of poor work postures (% of workshift) among the subjects by profile group and gender.

the relative aerobic strain in the physical work group (mean $34\% \dot{V}O_{2\max}$) was relatively high in comparison with that of many other occupations (20) with an extremely wide individual range of 9–91 % of the $\dot{V}O_{2\max}$. Therefore many municipal jobs still exist today which involve high strain. To prevent overloading, a good cardiorespiratory capacity is needed.

The absolute cardiorespiratory strain was lower among the older (52–58 years) workers, but their relative aerobic strain was at the same level as that of the younger workers (45–51 years). An increase in strain with age has also been documented earlier (21, 22). The increase in the relative cardiorespiratory strain of older subjects during work is caused by a decreasing maximal heart rate with age. As a consequence, the functional range of heart rate also decreases with age. The maximal heart rate was estimated in the present study,

and the comparisons indicated that the differences between estimated and measured maximal heart rates were minimal at the group level. [See the report by Ilmarinen et al (4).]

The cardiorespiratory strain during the workshift was 10 % lower among the subjects with good cardiorespiratory capacity than among those with a moderate or poor capacity. Several conclusions can be drawn from these results. The subjects with good capacity overcome the same absolute work load with lower cardiorespiratory strain than those with poor capacity because the relative load is lower. If the work pace is the same in the groups with poor and good capacity, the difference in strain should be at least as great as the difference in capacity. In addition those with a high capacity may work faster than those with a low capacity and therefore have higher heart rates for a shorter period. Furthermore, they are able to have longer rest periods between the tasks with better possibilities for recovery. Therefore, the relationship between high capacity and low strain or low capacity and high strain is influenced by several factors related to the actual work.

The level of physical load in the studied occupations seems not to have had any training effects on the cardiorespiratory capacity because there were no significant differences in physical work capacity between the groups doing physical or mental work when leisure-time activities were controlled for (4). Therefore, neither the level of physical load nor the number of peak loads are beneficial with respect to cardiorespiratory capacity. In fact the opposite is presumably true. A negative combination of intensity, duration, and frequency in static muscle work was more common than the respective positive combination in dynamic muscle work.

The objective of diminishing the level of individual cardiorespiratory strain during work can be achieved in several ways. The one-sided, static physical work load and peak loads should be decreased and work-rest schedules improved. Preventive actions should also include the maintenance and improvement of the cardiorespiratory capacity by aerobic training, carefully related to age and gender. Poor work postures were found mostly in physical work and more often among the women than among the men. The use of poor postures was the most common among the women in physical work [22 % of the workshift, which was more than that found among painters (19 %) but less than that of concrete reinforcement workers (35 %) (23)]. The greater use of poor work postures among the women may partly be due to the fact that the women had lower muscular strength than the men. The trunk strength of the women averaged about 58 % of the men's (5), and this lack of trunk strength may have influenced the ability of the women to keep a good physiological work posture. One-third of the women in physical work failed to do the squatting test, and this failure indicated that they had remarkably low

muscular strength in their legs. This lack of muscular strength may have increased the poor work postures of the back since a person can use the muscles of their back to compensate for a lack of sufficient leg strength in lifting tasks.

The subjects in physically heavy work had a musculoskeletal capacity that was similar to or lower than that of the subjects in mental jobs (24). This occurrence may have been due to the work content itself, which did not include an optimal pattern for musculoskeletal training effects. Thus the negative features of physical work (static muscle work, high use of force, etc) can speed up the effects of aging.

High musculoskeletal load (eg, poor work postures), together with low muscular strength, can also increase the cardiorespiratory strain of older employees (17, 25). In the present study the highest cardiorespiratory peak loads were found in tasks which included poor work postures.

The cardiorespiratory strain was high in sweeping and raking, assembly and repair work, and shoveling, all of which included a large number of poor work postures. The cardiorespiratory strain was high, but the duration was only a few minutes, in many physically heavy tasks (eg, lifting or carrying a heavy load, striking or hitting with a hammer, pushing or pulling a loaded cart). Certain tasks (eg, operating a machine, surgical and other operations, and drawing) included poor work postures very often, but, on the contrary, the cardiorespiratory system was not exceptionally strained.

The individual variation of the strain was large between the different work tasks but also within the same task. The strain was occasionally near maximum in the lifting and carrying of heavy loads, the pushing and pulling of a loaded cart, and the striking and hitting with a heavy hammer. It has also been proved earlier (26, 27) that the level of human strain is exceptionally high when work includes poor work postures and static muscular work. Large amounts of static muscular work and continuous static muscular work is, for older workers, a health risk.

Among the older municipal employees a high prevalence of cardiovascular diseases was associated with high energy demands, heavy dynamic and static work with a high application of force, and poor work postures (28). Heavy and static muscular work has also been shown to increase the risk of hypertension (29).

In summary, the physical demands of work, aging, and low functional capacity remarkably increased the strain of work. In physical occupations the strain was often higher among the women than among the men. Thus daily work still includes peak loads which can be a risk for older workers because of their health status and poor functional capacity.

The results also indicated some implications about too low a level of strain during a workshift. Although the problem is smaller than those of peak load and static work, it will become important in the future

when occupational activities are optimized. In our material low physical load at work was associated with the occupations with high demands for mental capacity (eg, administrative, office, and teaching work). More research is needed to study the interaction of low physical and high psychological stress on the health of aging workers.

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