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STRESS AND STRAIN DURING WORK AMONG WOMEN PERFORMING DIFFERENT WORK TASKS

TERESA MAKOWIEC-DĄBROWSKA

Department of Work Physiology
The Nofer Institute of Occupational Medicine
Lodz, Poland

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Abstract. This study measured the association between the severity of work in occupations performed most frequently by women, workload (as relative aerobic strain and heart rate during work) and the reaction to work measured on the basis of changes after work in the subjective fatigue rating and working ability. The results indicate that there is no rational selection to individual work posts from the point of view severity of work and the level of physical working capacity. Nevertheless, it has been found that the heart rate during work was dependent on the severity of work and not the level of physical working capacity. A decrease of working ability after work was more frequent than an increased level of fatigue, but the work performed, the level of physical working capacity and the relative aerobic strain did not produce any significant differences in these parameters. Thus, the data presented above does not confirm the suggestion that people with a higher level of physical working capacity can engage a higher percentage of VO_2max during working time. On the other hand, changes in the reaction to work, especially working ability changes, were significantly statistically dependent on the heart rate during work. Working ability was unquestionably worse when the heart rate during work exceeded 100 beats/min, 50% maximal heart rate or 30% heart rate reserve.

INTRODUCTION

Recently, the occupational working of women is quite commonplace, even in developed countries. It is also quite usual to employ women in occupations requiring physical effort. The differences in effort tolerance between females and males have been taken into account in the classification of work severity. The maximal permissible level of energy expenditure for females coincides with the moderate work range for males; the corresponding ranges of light, moderate and heavy work are also

Address reprint requests to T. Makowiec-Dąbrowska M.D., Department of Work Physiology, The Nofer Institute of Occupational Medicine, P.O. Box 199, 90-950 Lodz, Poland.

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shifted towards the lower values. For the relative aerobic strain ($\dot{V}O_2$ during work as the percentage of $\dot{V}O_2max$), it is however, longer considered reasonable to use different values for females and males. It still remains disputable how great relative aerobic strain (RAS) can be on daily occupational work. The quoted values range from 50% $\dot{V}O_2max$ (1) through 35% (15), 30% $\dot{V}O_2max$ (4) up to 25% $\dot{V}O_2max$ (18, 19). The guidelines generally accepted at present in Western Europe assume that the 30% $\dot{V}O_2max$ limit concerns prolonged physical work without breaks, while the 50% $\dot{V}O_2max$ limit concerns work during which such great strains is compensated for by the rest pauses (2, 20). The guidelines on the permissible limit of work load during working hours generally accepted in Poland state that people with higher physical capacity can perform, in steady-state conditions, physical effort which is higher not only in absolute, but also in relative terms. It is suggested, therefore, that the 30% $\dot{V}O_2max$ value should apply to people with a low physical capacity, while the 50% $\dot{V}O_2max$ value would be admissible for people with a high physical capacity (10). The implementation of the principles adopted in our country is rather diffucult, as no comprehensive investigations of $\dot{V}O_2max$ levels in the occupationally active population have been performed up to the present. The results of the study performed on some limited groups were not sufficient to prepare a classification of the level of the physical capacity of the Polish population (11). Therefore, in evaluating physical capacity, the classification prepared by. Astrand, which refers to the population of Sweden, is usually employed (1).

In addition to the percentage of maximal oxygen uptake, heart rate (HR), which is considered to be an indicator of circulatory strain, is often used as an index of work load. Opinions on this indicator in literature are not consistent, with regard to both the methods of worktime HR (HR_{work}) presentation and also to the classification of strain level. The ability to maintain a steady-state for HR_{work} is a recognized indicator of good effort tolerance. According to the literarure data, a steady state can be maintained when the mean HR_{work} is from 102/min (25) to 110/min (16). As HR in different individuals vary, it has been attempted to obtain comparable data by considering the resting level and determining the admissible value of the work pulse ($HR_{work} - HR_{rest}$) from 25/min (17) through 33–40/min (16) to 40/min (23). As HR varies with age, some authors represent it as a percentage of maximal HR (% HR_{max}) or as a percentage of HR range (% HRR) (7, 8, 14). The maximal levels for these values have not been determined, although 50% HR_{max} or 30% HRR are considered to be reasonable (7, 8). The use of HR_{work} as a measure of strain is rational insofar as it is the circulatory system which responds to any loads during work in the most sensitive way, and HR determinations have been made very easy since the implementation of Holter monitoring. It is worth noting, however, that HR during exercises engaging the same percentage of $\dot{V}O_2max$ is by 10 beats per minute higher in females than in males (3). It is also stressed that HR_{work} is more dependent on the type of work than on work severity (7).

It should also be noted, however, that the majority of studies conducted in experimental conditions and intended to determine the limits of the permissible loads have been performed in males. Only few similar studies in occupational work conditions have been performed in women. It is not clear, therefore, whether the classification of the loads, which was prepared for males, is suitable also for females.

The determination of the permissible exercise level limits during occupational work on the basis of strain is generally accepted but insufficient, as the significance

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of the values obtained is not known. For women performing their housework, it is essential to know the level of functional reserves required to preform non-occupational tasks. An analysis of the level of after-work fatigue, which supposedly indicates functional reserve level, may be used for more a comprehensive evaluation of occupational work load in women and to verify the exisiting work load classifications. Therefore, the aim of our study is:

1. To determine the intensity of exercise (work severity in relative and absolute terms) during occupational work in occupations performed most frequently by women.

2. To determine the reaction to that exercise during work and the level of fatigue after work, evaluated subjectively and objectively (change in physical efficiency).

3. To determine factors which affect the level of reaction to work and the level of fatigue.

MATERIALS AND METHODS

The subjects were 222 females (from 18 to 55 years old) employed as office workers, cashiers, saleswomen, quality control inspectors, printing machine operators, oprators of machines producing small metal items, and electric device assemblers. The maximal oxygen uptake value ($\dot{V}O_2max$) was predicted from heart rate during standardized submaximal exercise loads on a bicycle ergometer (12). The level of physical working capacity was determined by using the classification for women proposed by J. Astrand (1). The values of these parameters in female individual subgroups are presented in Table 1. Oxygen uptake during work was determined and used to calculate energy expenditure. The strain value was expressed as a percentage of $\dot{V}O_2max$ (RAS). Table 2 shows the classification of work severity and strain adopted in Poland. The response to work was determined from the subjective evaluation of physical fatigue and from the evaluation of differences in working ability before and after work.

Heart rate during working hours was determined from 8-hour Holter recordings (the recordings were performed on 111 females; for technical reasons, the recordings were not taken by the quality control inspectors). HR_{work} was expressed in absolute values and as a percentage of HR reserve. The maximal HR was calculated from the formula: $HR_{max} = 220 - \text{age (years)}$, and the HR reserve percentage from the formula: $\%HRR = [(HR_{work} - HR_{rest})/(HR_{max} - HR_{rest})] \times 100$. Since it was difficult to determine the point of rest during the day, the mean HR from the Holter recording taken during sleeping hours was assumed to be the HR_{rest} (5, 13).

The level of physical fatigue during working hours and after working hours was determined from a 5-grade subjective assessment of the following symptoms: feeling fatigue, weariness in the arms, weariness in the legs, thirst, yawning, drowsiness, a feeling of discomfort, the need to pause, a desire to lie down, a feeling of heaviness, a feeling of weariness. The symptoms were selcted, using factorial analysis, as those representing physical fatigue, from a list of 40 symptoms of fatigue based on a list from the Japanese Fatigue Committee (9, 24) and from a list of eye strain symptoms (6).

In order to determine physical ability we used a standard exercise test performed on a bicycle ergometer. The test comprised of 2 stages: stage I – 2 minutes

Table 1. Age, duration of employment and maximal oxygen consumption in subjects by work post (mean values ± standard deviations, and distributions in percentage)

Work post./ kind of work	Number of persons	Age (years)			Duration of employment (years)			VO_2max (ml/kg/min)		
		< 30	30-40	> 40	< 10	10-20	> 20	very low	low	moderate and high
Office workers	18		35.9 ± 7.4			14.6 ± 9.4			29.8 ± 8.0	
		27.8	44.4	27.8	50.0	22.2	27.8	38.9	22.2	38.9
Cashiers	25		32.8 ± 7.7			15.7 ± 5.3			30.8 ± 7.8	
		44.0	44.0	12.0	24.0	72.0	4.0	40.0	24.0	36.0
Electric device assemblers	22		40.2 ± 9.8			16.5 ± 8.3			32.2 ± 7.9	
		19.0	38.1	42.9	13.6	45.5	40.9	23.8	23.8	52.4
Operators of machines producing small metal items	20		37.1 ± 8.5			15.9 ± 9.0			30.8 ± 9.5	
		20.0	35.0	45.0	30.0	45.0	25.0	40.0	5.0	55.0
Quality control inspectors	39		38.5 ± 10.9			14.8 ± 10.9			33.9 ± 6.3	
		33.3	15.4	51.3	43.6	15.4	41.0	7.7	30.8	61.5
Saleswomen	67		32.1 ± 9.4			16.2 ± 8.6			30.7 ± 6.8	
		44.8	32.8	22.4	41.8	34.2	24.0	28.3	46.3	25.4
Printing machine operators	31		39.0 ± 7.7			13.7 ± 7.1			31.5 ± 5.5	
		19.4	35.5	45.1	25.8	51.6	22.6	12.9	51.6	35.5
	F		4.336			1.219			1.373	
	P		0.000			0.298			0.373	

Table 2. The classification of work severity and strain for women adopted in Poland

Severity of work/ level of strain	Energy expenditure (kcal/workshift)	Relative aerobic strain (% VO_2max)	Heart rate during work: Absolute values (beats/min)	Percentage of maximal heart rate	Percentage of heart rate reserve
Light/low	⩽ 700	⩽ 10	⩽ 75	⩽ 40	⩽ 5
Moderate/medium	700 – 1000	10 – 30	75 – 100	40 – 50	5 – 25
Heavy/high	1000 – 1200	30 – 50	100 – 120	50 – 65	25 – 45
Very heavy/ very high	> 1200	> 50	> 120	> 65	> 45

at 0.5 W/kg followed by 5 minutes recovery, stage II – 2-minute periods of increasing workloads (0.5 W/kg, 1 W/kg, 1/3 W/kg and so on) to a submaximal level followed by 5 minutes recovery. A method proposed by Szirinsky and Bruskin (22)

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was used to calculate the working ability index, in which the HR and blood pressure values recorded during the test, the exercise duration and intensity were converted into index values according to the formulas:

$$B_i = 0{,}5 - \frac{P_{50} - x_i}{2\,(P_{50} - P_{0{,}025})} \qquad (1)$$

$$B_i = 0{,}5 + \frac{P_{50} - x_i}{2\,(P_{50} - P_{0.025})} \qquad (2)$$

$$B_i = 0{,}5 + \frac{x_i - P_{50}}{2\,(P_{99{,}975} - P_{50})} \qquad (3)$$

$$B_i = 0{,}5 - \frac{x_i - P_{50}}{2\,(P_{99{,}975} - P_{50})} \qquad (4)$$

where:

B_i = index value
x_i = value of the parameter for which the calculation is made
P_{50} = median
$P_{0.025}$ and $P_{99.975}$ = percentiles

Formulas (1) and (2) are used when the value of the parameter is smaller than the median, and the formulas (3) and (4) are used when the value of the parameter is greater than the median; formulas (1) and (3) are used where a higher value of a specified parameter (e.g. the duration of the exercise test) point to a better working ability, while formulas (2) and (4) are used when a lower value of a specified parameter (e.g. HR during the recovery period) points to a better working ability. All parameters measured during the strain tests are converted into the corresponding index values, and the harmonic mean is calculated.

The results of strain tests performed before work and the results of earlier tests performed on a group of 150 females employed at different workplaces in Polish industry were used to calculate the median and the extreme percentiles serving as the basis for standardization.

One-way ANOVA was used in the statistical calculations to determine differences in work severity and differences in the reaction to work vs. the type of work performed. Two-way ANCOVA was used to analyse the differences in the response to work vs. RAS and physical working capacity level. The age of the subjects was used as the covariant. The same type of analysis was used to evaluate the variation in fatigue after work vs. RAS and HR_{work}. The calculations were performed using a SYSTAT software package.

RESULTS

The results of the energy expenditure measurements indicate that jobs involving the operation of some machines and associated with lifting and carrying heavy loads is heavy physical work for women (work at a printing house). The job of saleswomen

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is classified as moderate or heavy work, and jobs involving the operation of machines producing small metal items are classified as light or moderate work. Work performed in the sitting position, such as assembling electrical units, is classified as light physical work. The work of women employed as officers or cashiers also does not require physical effort (Table 3). The estimated level of $\dot{V}O_2$max, when age had been taken into account, indicated that a remarkable number of the women had low or very low physical working capacity. The level of the $\dot{V}O_2$ max was not dependent on work severity, it was, however, dependent on the age of the women (Table 4).

Table 3. Severity of work by work post/kind of work (mean values of energy expenditure ± standard deviation, and distributions in percentage)

Work posts/ kinds of work	Number of persons	Severity of work						
		Energy expenditure			%VO_2max			
		light	moderate	heavy	≤ 10%	10–30%	30–50%	> 50%
Office workers	18		300 ± 0			20.7 ± 5.1		
		100	0	0	0	94.4	5.6	0
Cashiers	25		414 ± 110			22.6 ± 5.6		
		100	0	0	0	92.0	12.0	0
Electric device assemblers	22			599 ± 24			23.8 ± 5.2	
		100	0	0	0	85.7	14.3	0
Operators of machines producing small metal items	20		696 ± 78			30.6 ± 11.2		
		50.0	50.0	0	0	60.0	35.0	5.0
Quality control inspectors	39		718 ± 60			25.8 ± 4.9		
		43.6	56.4	0	0	79.5	20.5	0
Saleswomen	67		883 ± 66			33.8 ± 7.6		
		0	85.0	15.0	0	31.3	68.7	0
Printing machine operators	31		1133 ± 82			38.1 ± 7.8		
		0	19.4	80.6	0	16.1	74.2	9.7
	F		426.0			24.16		
	p		0.000			0.000		

Table 4. Results of two-way ANOVA (severity of work x age) for maximal oxygen uptake (ml/kg/min)

Sources of variance								Interaction
Severity of work			Analysis of variance	Age (years)			Analysis of variance	Analysis of variance
light	moderate	heavy		– 30	30–40	40 –		
32.0 ± 8.3	30.8 ± 6.9	31.3 ± 5.4	F = 0.602 p = 0.549	33.7 ± 8.3	30.4 ± 5.9	29.9 ± 6.9	F = 4.658 p = 0.010	F = 1.156 p = 0.331

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From the graphical representation of the simple effects of work severity and age on $\dot{V}O_2$max values we can see that its was lower in older women at each work severity level. The rate of decrease was slightly faster in the women performing light physical jobs, and the difference in comparison with higher work severity degrees was not significant (Fig. 1A). The duration of employment at a given work post did not affect the level of $\dot{V}O_2$max after the effect of age had been taken into account (Table 5, Fig. 1B). The relatively low level of $\dot{V}O_2$max in the women studied meant that even light

Table 5. Results of two-way ANCOVA (severity of work x duration of employment, covariat-age) for maximal oxygen consumption (ml/kg/min)

Sources of variance								Interaction	Covariant (age)
Severity of work			Analysis of variance	Duration of employment			Analysis of variance	Analysis of variance	Analysis of variance
light	moderate	heavy		– 10	10–20	20 –			
31.8 ± 8.3	30.9 ± 6.9	31.0 ± 5.4	F = 0.366 p = 0.694	32.1 ± 7.8	31.3 ± 6.7	30.3 ± 6.8	F = 0.328 p = 0.721	F = 1.226 p = 0.301	F = 2.429 p = 0.121

Table 6. Subjects' heart rate during work (absolute values, percentage of maximal heart rate and percentage of heart rate reserve) by work post/kind of work (mean values ± standard deviation and distribution in percentage)

Work post/ kind of work	Number of persons	Heart rate during work											
		Absolute values (beats/min)				Percentage of maximal heart rate				Percentage of heart rate reserve			
		⩽ 75	75	100	< 120	⩽ 40	40	50	> 65	⩽ 15	15–30	30–45	> 45
Office workers	6		87. ± 3.8				47.4 ± 2.1				19.4 ± 2.9		
		0	100.0	0	0	0	83.3	16.7	0	0	100.0	0	0
Cashiers	18		89.5 ± 8.9				48.3 ± 4.5				16.5 ± 4.7		
		0	83.3	16.7	0	0	77.8	22.2	0	50.0	50.0	0	0
Electric device assemblers	7		92.8 ± 5.4				51.5 ± 3.5				22.2 ± 2.4		
		0	85.7	14.3	0	0	42.9	57.1	0	0	100.0	0	0
Operators of machines producing small metal items	8		98.0 ± 18.8				55.1 ± 11.0				24.5 ± 14.2		
		12.5	62.5	0	25.0	0	37.5	37.5	25.0	12.5	62.5	0	25.0
Saleswomen	45		95.4 ± 10.6				50.5 ± 5.3				21.1 ± 8.1		
		4.4	69.0	22.2	4.4	0	55.6	44.4	0	22.2	66.4	13.3	0
Printing machine oprators	27		95.7 ± 8.9				53.0 ± 4.7				24.1 ± 7.7		
		3.7	66.7	29.6	0	0	29.6	70.7	0	14.8	59.2	25.9	0
	F		1.666				2.921				2.508		
	p		0.149				0.016				0.035		

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physical work constituted a great load for some of them, exceeding 30% $\dot{V}O_2$max, or even 50% $\dot{V}O_2$max in isolated cases.

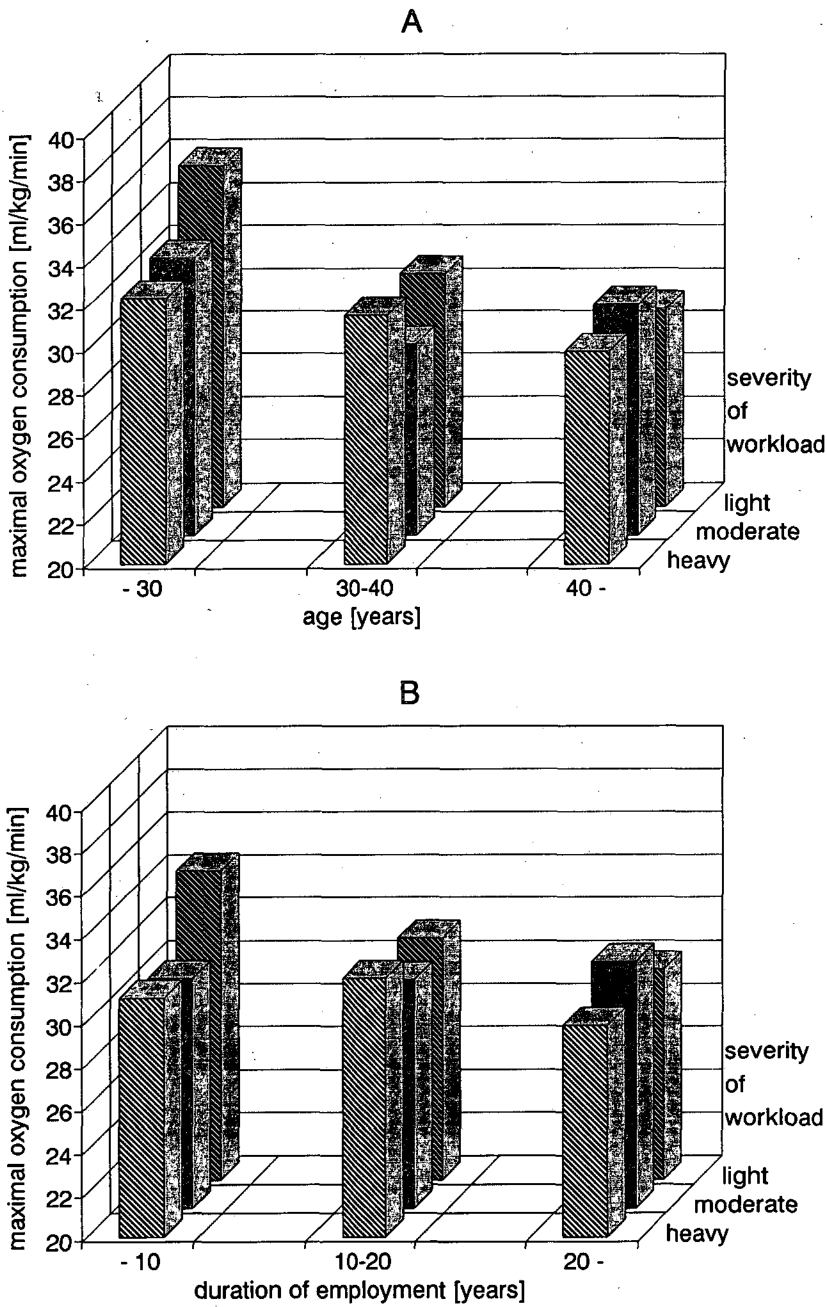

Fig. 1. Graphical representation of the simple effects of work severity and age (A) or duration of employment (B) on the level of maximal oxygen consumption.

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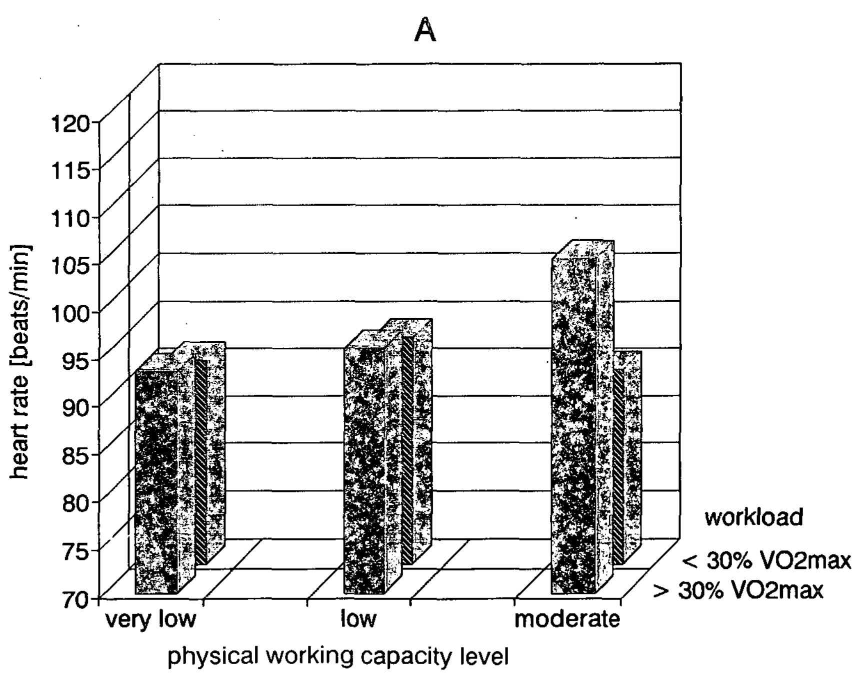
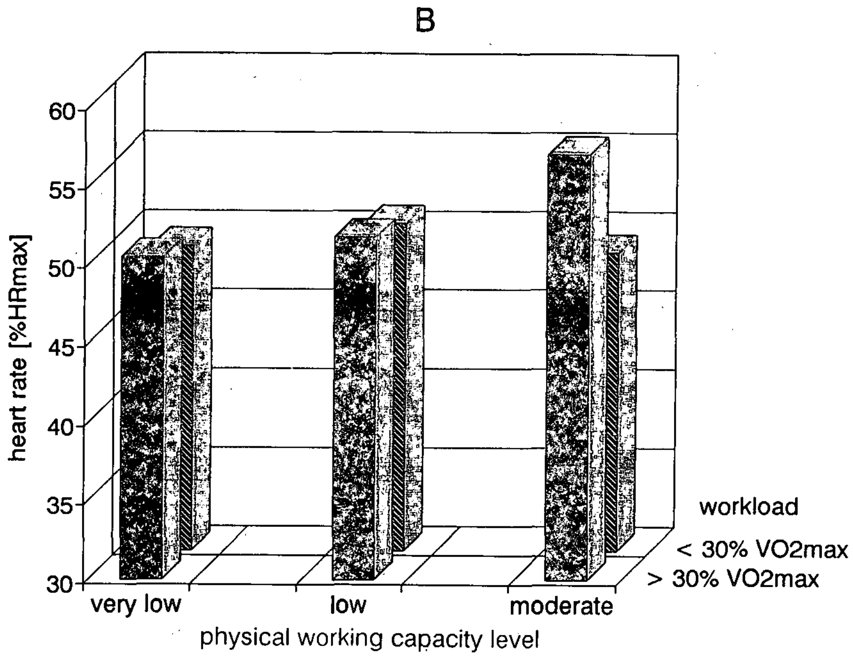
Table 7. Results of two-way ANCOVA (severity of work x level of physical working capacity, covariant age) for heart rate during work

Heart rate during work	Sources of variance							Interaction	Covariant (age)
	Relative aerobic strain			Level of physical working capacity					
	< 30% VO_2max	> 30% VO_2max	Analysis of variance	very low	low	moderate and high	Analysis of variance	Analysis of variance	Analysis of variance
Mean value of heart rate during work	91.8 ± 9.8	98.0 ± 11.1	F = 8.307 p = 0.005	92.3 ± 11.7	94.8 ± 10.9	97.8 ± 9.9	F = 1.980 p = 0.143	F = 3.711 p = 0.028	F = 10.014 p = 0.002
Percentage of maximal heart rate	49.6 ± 5.3	53.1 ± 6.0	F = 8.405 p = 0.005	49.9 ± 6.2	51.2 ± 5.6	53.0 ± 6.0	F = 2.109 p = 0.127	F = 3.696 p = 0.028	F = 2.851 p = 0.094
Percentage of heart rate reserve	19.9 ± 7.5	23.1 ± 8.1	F = 3.616 p = 0.060	20.1 ± 8.0	22.2 ± 8.4	22.3 ± 7.2	F = 0.711 p = 0.493	F = 1.543 p = 0.219	F = 0.001 p = 0.975

The load rating on the circulatory sytem during working time was dependent on the way in which HR_{work} was presented. Mean heart rate during 8-hours working time made it possible to guess that the stress on the circulatory system was moderate and did not significantly differ between people employed at different workposts (Table 6). However, when age had been taken into account and the heart rate had been expressed in terms of $\%HR_{max}$, the strain rating was higher, especially in the older groups, and the single-way ANOVA confirmed the differences between the groups. Accounting for the resting value and expressing the heart rate in terms of %HRR meant that the mean strain values shifted back to the moderate level, while the differences between the individual groups remained statistically significant.

RAS during working time and the level of physical working capacity were the next sources of HR_{work} variance to be analyzed. It was found that RAS was the more important factor responsible, and that the physical working capacity level did not produce any differences in HR_{work} (Table 7). From the graphical representation of the simple effects of both those factors it can be seen that higher RAS was usually accompanied by a higher HR_{work}, but the effect of the physical working capacity level was different from what was expected. According to this, women with a higher physical working capacity had higher HR_{work} at the load > 30% $\dot{V}O_2$max. At the load < 30% $\dot{V}O_2$max, women with a low capacity had the highest HR_{work} (Fig. 2). When the energy expenditure value and the RAS during work were presented in a similar way as in Figure 2, it was found that the increase in the physical working capacity level was associated with higher work severity (energy expenditure) and lower %$\dot{V}O_2$max (Fig. 3). Both these indicators of physical loads were of course higher in the subgroups in which the RAS exceeded 30% $\dot{V}O_2$max. After these two figures had been put together, it could be concluded that, in women in whom oxygen





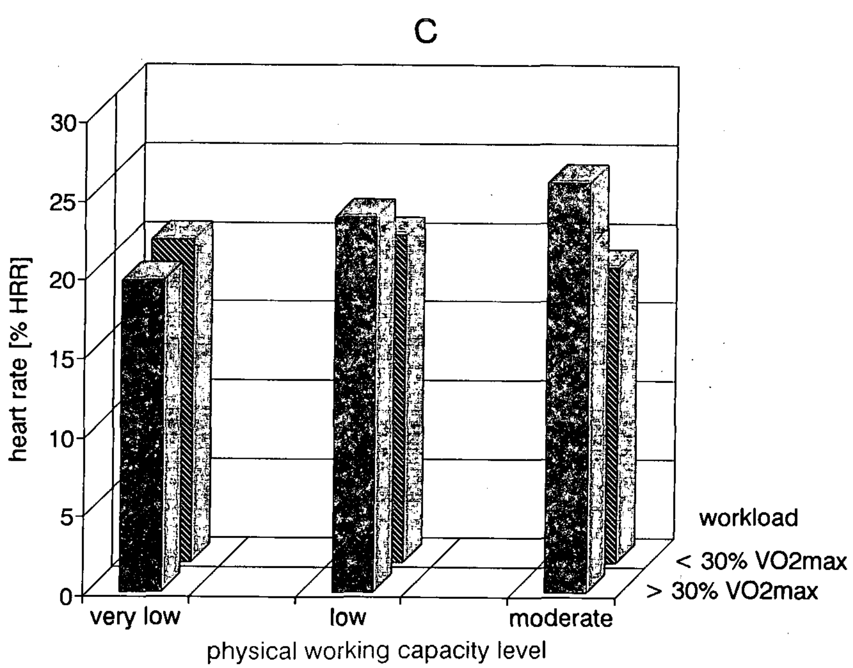


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Fig. 2. Graphical representation of the simple effects of workload and the physical working capacity level on the heart rate during work (absolute values — A, percentage of maximal heart rate — B, and percentage of heart rate reserve — C).

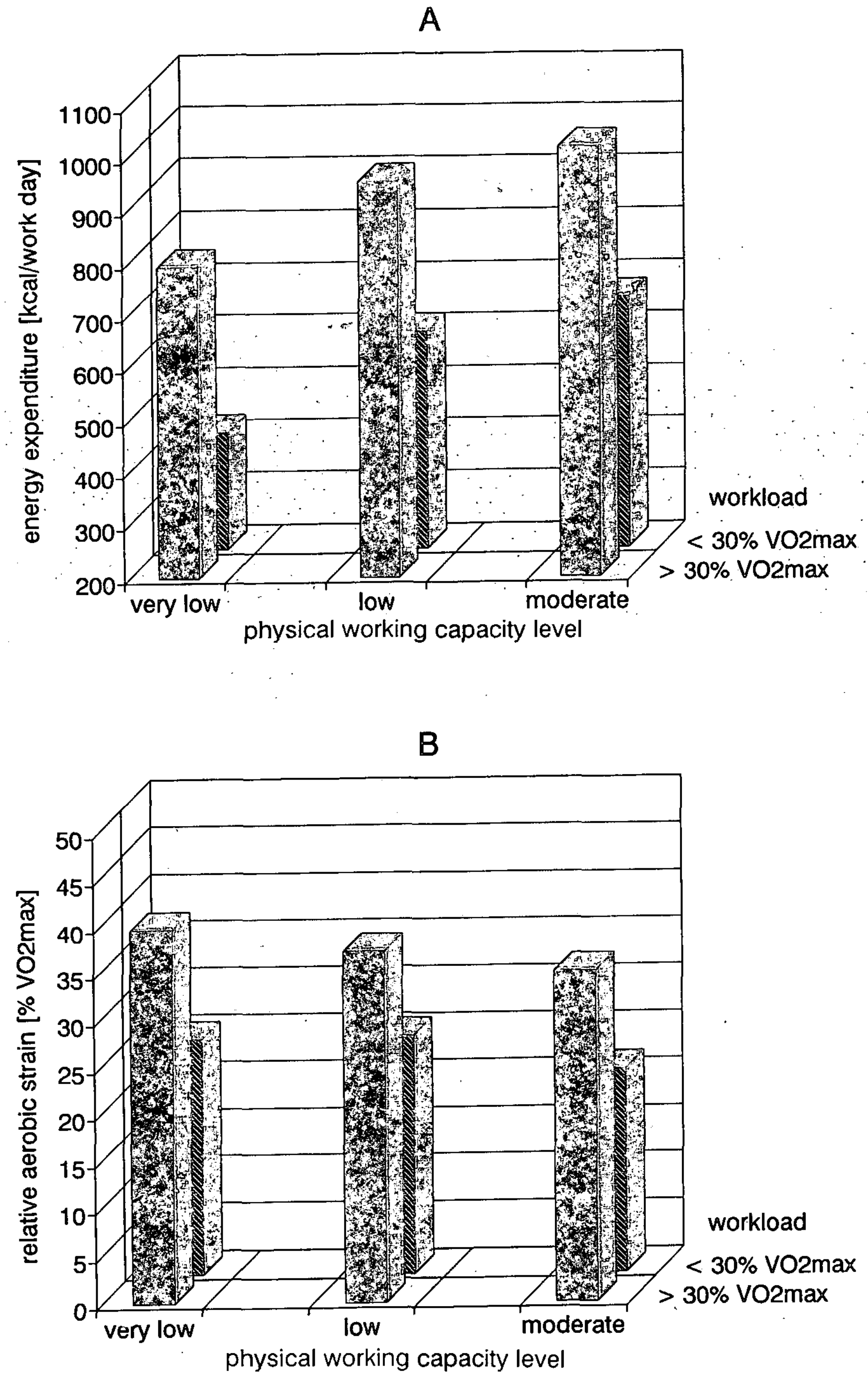

Fig. 3. Graphical representation of the simple effects of workload and the physical working capacity level on energy expenditure during work (A) and relative aerobic strain (B).

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uptake during work was higher than 30% $\dot{V}O_2max$. HR_{work} was dependent on the absolute value of work severity. In women in whom oxygen uptake was lower than $< 30\% \dot{V}O_2max$, HR_{work} was affected rather by the value of RAS.

The significance of the work load was estimated by analysing the changes in subjective and objective fatigue (changes in working ability). It has come out that not all the women experienced increased subjective fatigue or reduced strain capacity. Generally, it can be stated that a deterioration in working ability was more frequent than an increased level of fatigue, but the type of work performed did not produce significant differences in these parameters (Table 8). Therefore, RAS and the level of physical working capacity were considered to be the sources of the variance.

Table 8. Reactivity to workload: changes in subjective fatigue level and working ability after work by work post/kind of work (mean values ± standard deviation and distribution in percentage)

Work post/ kind of work	Number of persons	Changes in fatigue after work		Changes in working ability after work	
		Decrease	Increase	Increase	Decrease
		0.545 ± 0.562		−0.021 ± 0.063	
Office workers	18	16.7	83.3	33.3	66.7
		−0.055 ± 0.578		−0.005 ± 0.029	
Cashiers	25	60.0	40.0	48.0	52.0
		0.236 ± 0.411		−0.006 ± 0.033	
Electric devices assemblers	22	48.1	51.9	42.9	57.1
Operators of machines		0.341 ± 0.701		−0.028 ± 0.056	
producing small metal items	20	30.0	70.0	15.0	85.0
		0.102 ± 0.588		−0.032 ± 0.043	
Quality control inspectors	39	53.8	46.2	23.1	76.9
		0.185 ± 0.878		−0.014 ± 0.033	
Saleswomen	67	45.3	54.7	29.9	70.1
Printing machine		0.229 ± 0.656		−0.015 ± 0.051	
Operators	31	45.2	54.8	32.3	67.7
	F	1.553		1.601	
	p	0.162		0.148	

Referring to the level of physical fatigue, the two-way ANOVA demonstrated that its change after work did not depend either on RAS or on physical working capacity level (Table 9). The greatest increase in physical fatigue after work was observed in the subgroup of women with a moderate or very low physical working capacity who engaged more than 30% $\dot{V}O_2max$, but only slightly lower values were observed in women with a low capacity who engaged less than 30% $\dot{V}O_2max$ (Fig. 4A). Similarly, the two-way ANOVA for changes in working ability demonstrated that its value after work did not depend either on RAS or on the physical working

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Table 9. Results of two-way ANCOVA (relative aerobic strain x assessment of physical working capacity, covariant-age) for changes in subjective fatigue and changes in working ability after work

	Sources of variance							Interaction	Covariant (age)
	$\%VO_2max$		Analysis of variance	Assessment of physical working capacity			Analysis of variance	Analysis of variance	Analysis of variance
	< 30% VO_2max	> 30% VO_2max		very low	low	moderate and high			
Changes in subjective assessment of fatigue	0.159 ± 0.657	0.334 ± 0.768	F = 2.360 p = 0.123	0.243 ± 0.752	0.177 ± 0.747	0.319 ± 0.646	F = 0.538 p = 0.585	F = 2.763 p = 0.065	F = 0.190 p = 0.663
Changes in working ability	−0.017 ± 0.042	−0.018 ± 0.047	F = 0.013 p = 0.908	−0.011 ± 0.042	−0.023 ± 0.045	−0.018 ± 0.044	F = 0.961 p = 0.384	F = 1.116 p = 0.329	F = 0.307 p = 0.580

Table 10. Results of two-way ANCOVA (heart rate during work x relative aerobic strain, covariant-age) for changes in subjective rating of fatigue and changes in working ability after work

	Method of presentation of heart rate	Sources of variance								Interaction	Covariant (age)
		Heart rate			Analysis of variance	Relative aerobic strain			Analysis of variance	Analysis of variance	Analysis of variance
		low	moderate	high		< 30% VO_2max	30–40% VO_2max	> 40% VO_2max			
Changes in subjective assessment of fatigue	Mean value	0.434 ± 0.826	0.065 ± 0.760	0.175 ± 0.737	F = 1.754 p = 0.178	0.125 ± 0.674	0.359 ± 0.848	0.175 ± 0.877	F = 0.892 p = 0.413	F = 0.632 p = 0.641	F = 0.061 p = 0.806
	Percentage of HR_{max}	0.325 ± 0.898	0.411 ± 0.811	0.047 ± 0.715	F = 2.092 p = 0.129	0.125 ± 0.674	0.414 ± 0.848	0.245 ± 0.877	F = 1.081 p = 0.343	F = 0.285 p = 0.887	F = 1.264 p = 0.264
	Percentage of HRR	0.304 ± 0.865	0.152 ± 0.735	0.096 ± 0.630	F = 0.552 p = 0.577	0.177 ± 0.674	0.313 ± 0.848	0.062 ± 0.877	F = 0.642 p = 0.528	F = 1.928 p = 0.112	F = 1.004 p = 0.319
Changes in working ability	Mean value	0.010 ± 0.051	−0.019 ± 0.037	−0.025 ± 0.033	F = 6.105 p = 0.003	−0.024 ± 0.039	−0.015 ± 0.038	0.005 ± 0.052	F = 3.367 p = 0.010	F = 3.504 p = 0.010	F = 1.910 p = 0.170
	Percentage of HR_{max}	0.002 ± 0.042	−0.007 ± 0.045	−0.020 ± 0.052	F = 1.578 p = 0.201	−0.019 ± 0.039	−0.013 ± 0.038	0.007 ± 0.052	F = 2.020 p = 0.138	F = 0.884 p = 0.476	F = 0.294 p = 0.589
	Percentage of HRR	0.000 ± 0.037	−0.018 ± 0.047	−0.030 ± 0.034	F = 3.573 p = 0.032	−0.025 ± 0.039	−0.014 ± 0.038	−0.009 ± 0.052	F = 1.024 p = 0.269	F = 1.317 p = 0.269	F = 0.015 p = 0.903

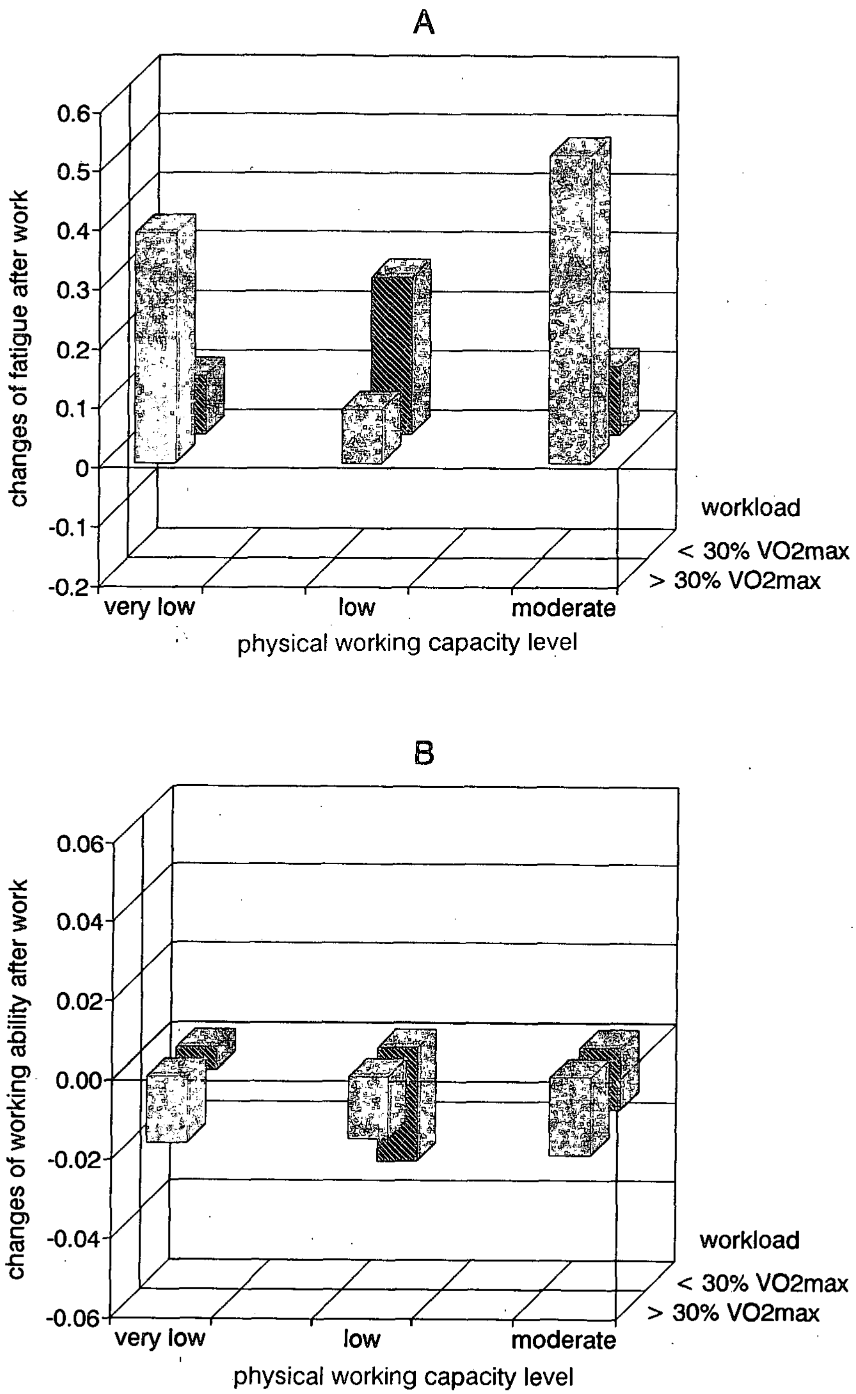

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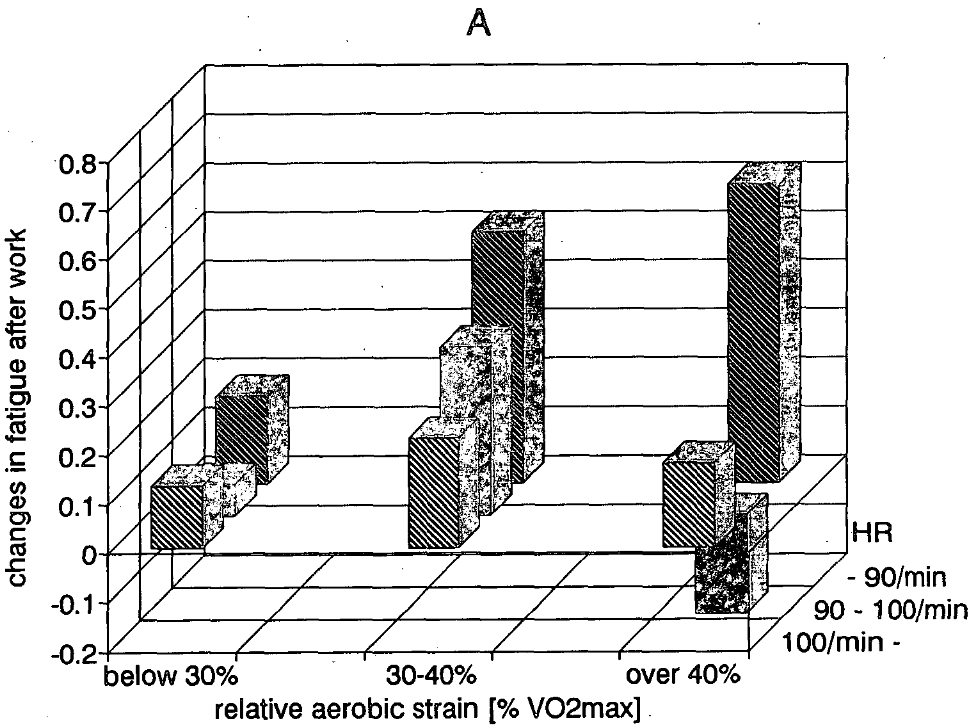
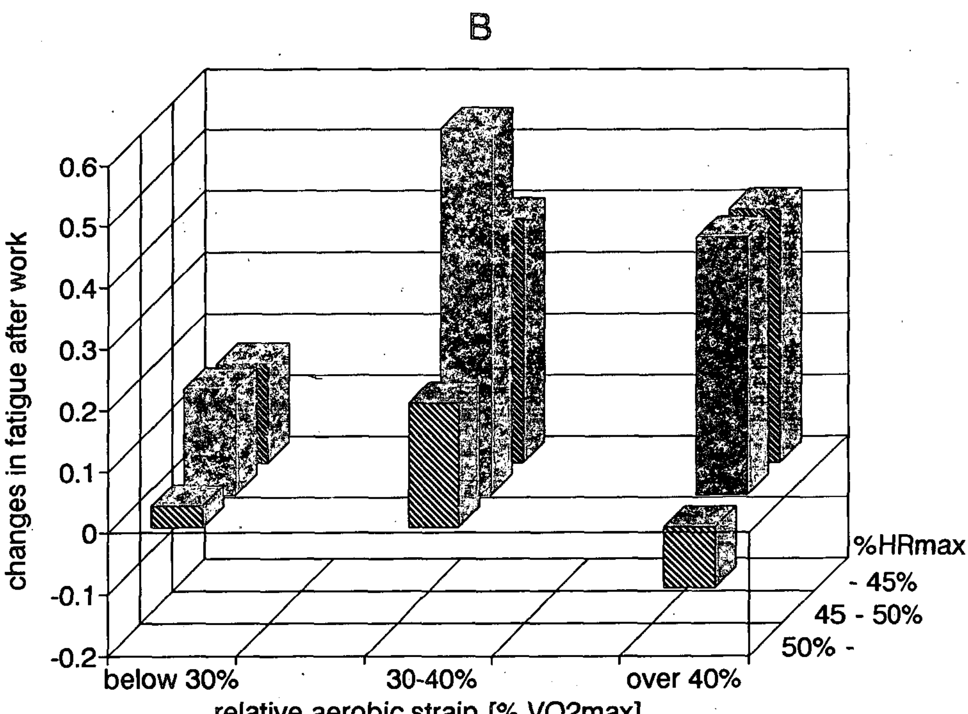
Fig. 4. Graphical representation of the simple effects of workload and the physical working capacity level on changes in the subjective assessment of fatigue (A) and changes in working ability after work (B).





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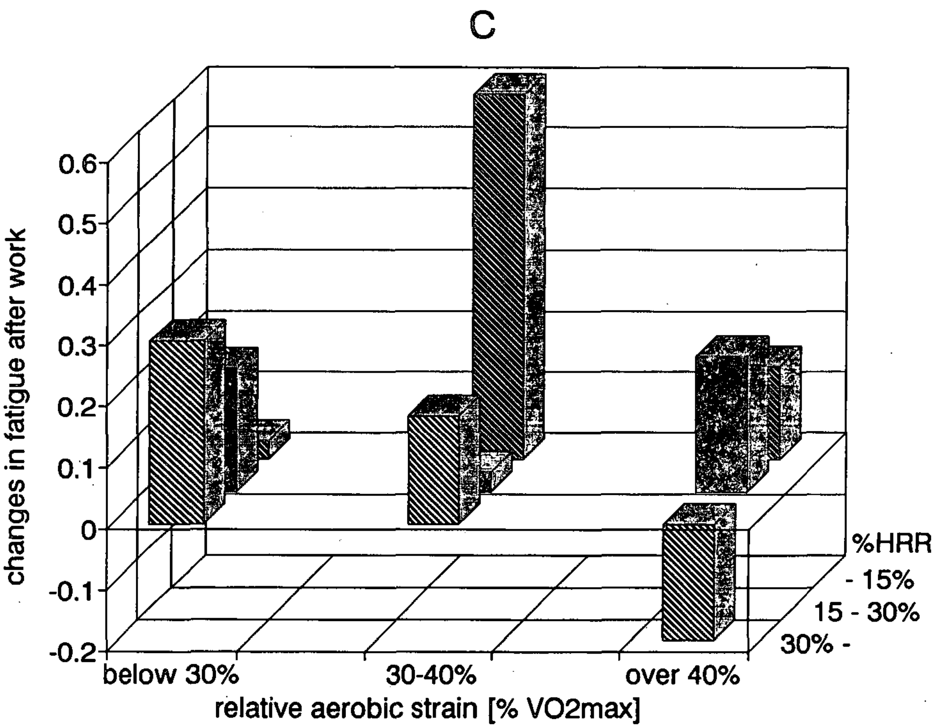
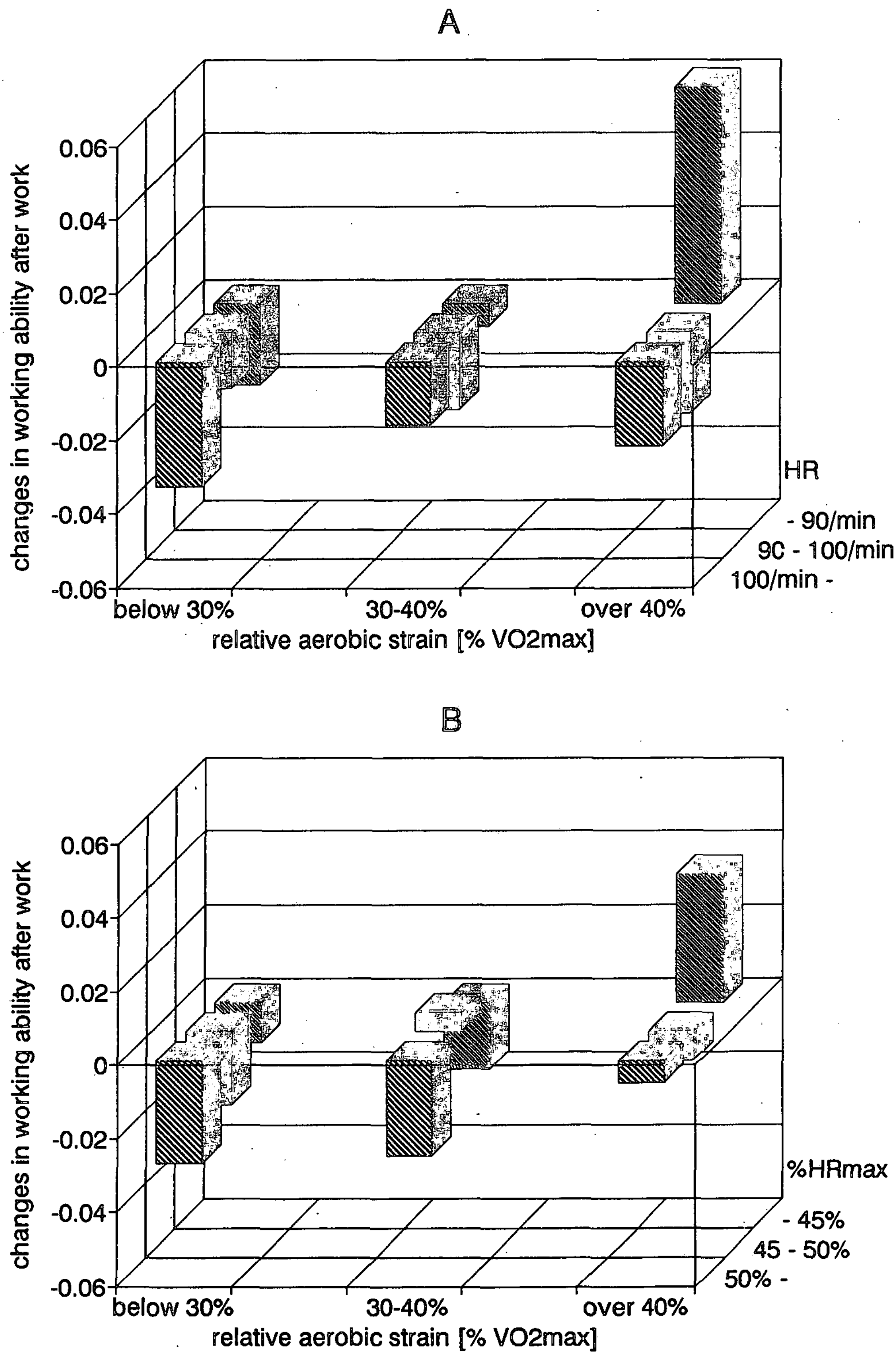


Fig. 5. Graphical representation of the simple effects of relative aerobic strain and the absolute heart rate values during work (A), percentage of maximal heart rate (B), and percentage of heart rate reserve (C) on changes in the subjective assessment of fatigue after work.

capacity level. From a graphical representation of the simple effects of these two factors on the changes in working ability, it can be seen that, in women with a very low or a moderate physical working capacity, engaging higher $\%\dot{V}O_2max$ results with more pronounced decrease in working ability (Fig. 4B). The situation is reversed in people with low physical capacity.

When analysing the significance of the two work strain indicators (HR and RAS) on the fatigue changes after work, it was found that the increase in subjective feelings of fatigue were not significantly dependent on either of these factors (Table 10). From the graphical representation of the simple effects of these factors it can be seen that the changes in subjective fatigue for every RAS and HR_{work} combination differed widely, which points that the fact that fatigue was also affected by some other factors which failed to be accounted for by the adopted method of evaluating the reaction to work (Figs. 5 A, B and C). On the other hand, the changes in working ability were significantly statistically dependent on HR_{work} and, to some extent, also on RAS. Generally, working ability changes after work were higher, the higher the HR_{work}, and the higher the HR_{work} the lower RAS was during working time. Graphical representation of the simple effect of these factors shows that even with an oxygen uptake exceeding 40% $\dot{V}O_2max$, when HR_{work} was low, there was an improvement in working ability after work (Figs. 6 A, B and C). Working ability was unquestionably worse when HR_{work} exceeded 100 beats per minute, 50% HR_{max} and 30% HRR.



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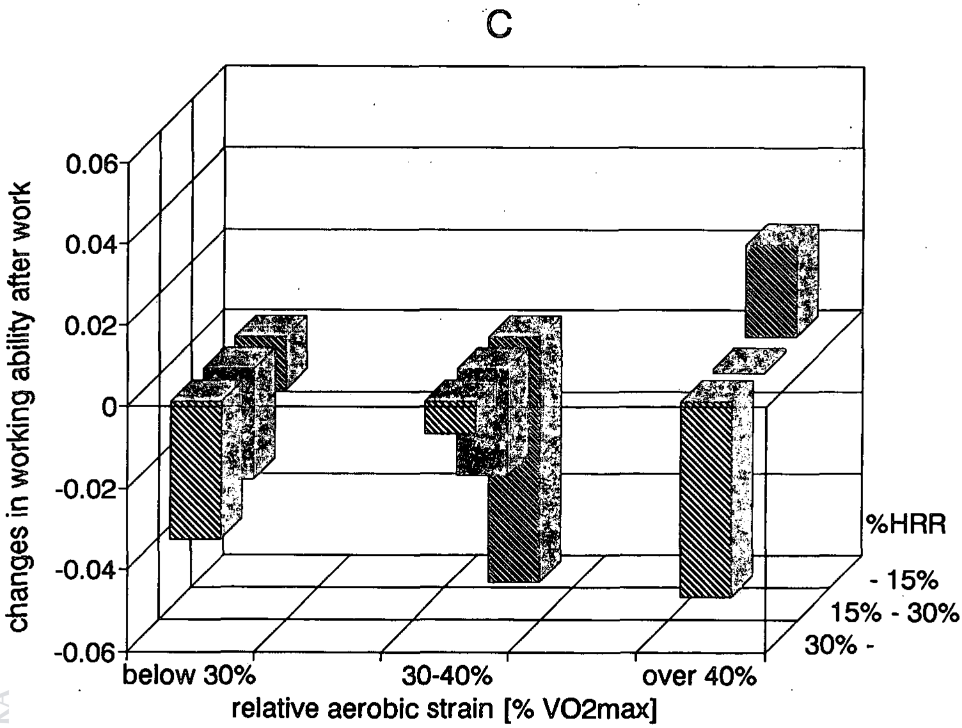

Fig. 6. Graphical representation of the simple effects of relative aerobic strain and absolute values of heart rate during work (A), percentage of maximal heart rate (B), and percentage of heart rate reserve (C) on changes in working ability after work.

DISCUSSION

From the data presented it can be seen that the distribution of $\dot{V}O_2$max in the whole group of females investigated is shifted in the direction of low values, which means that the physical working capacity of occupationally active Polish women is lower than that of the reference group of Swedish women. The lack of a relationship between maximal oxygen uptake and work severity shows that there is no rational selection to individual work posts. As a consequence, although only 16% of the women studied performed jobs classified as heavy according to the classification currently adopted in Poland, in as many as 42% of women the job performed constituted heavy strain, i.e. a RAS value in excess of 30% $\dot{V}O_2$max.

It should be stressed, however, that this heavy strain was fairly well tolerated. The latter conclusion is confirmed by the mean values showing an increase in fatigue and a decreased working ability after working time. Although the effort tolerance index differed widely between the individuals studied, the values which pointed to poorest effort tolerance did not refer to those women who were subjects to the greatest strain. This may suggest that the women subjected to exceptional strain (> 40% $\dot{V}O_2$max accompanied by high heart rate) were well adapted to it, and hence their reactions to work, especially in their subjective assessment, were not very negative. However, it should be noted that the women performing the heaviest jobs (saleswomen and printing shop workers) performed their jobs at a pace set by themselves. A relatively good tolerance to such work confirms the suggestion that higher RAS values are permissible when such a working mode is employed (2, 7, 8, 20).

However, the data presented above does not confirm the suggestion that people with a higher physical working capacity level can engage a higher percentage of $\dot{V}O_2$max during working time (10), as it was not confirmed that the capacity level affected the response to work heavier than 30% $\dot{V}VO_2$max. The jobs performed by the women varied widely. It is therefore reasonable to expect, the work severity or RAS during work not to reflect all the strenuous factors which might affect the reaction to work level. During the investigations, neither heart rate changes nor other steady-state indicators during working time were analyzed; the factor determined was the effect of work load on changes in working ability. The results indicate that the mean heart rate during the whole working shift was not dependent on the level of physical working capacity, it served, however, as a predictor of working ability changes. It should also be noted that a recent laboratory study demonstrated that the ability to work under a steady-state condition with the oxygen uptake constituting a great % $\dot{V}O_2$max by subjects with high $\dot{V}O_2$max, resulted from a greater muscle glycogen content in those people. If glycogen content in the muscles of the subjects with a lower $\dot{V}O_2$max was increased by prescribing a special diet, they were found to be able to utilize a similar $\dot{V}O_2$max percentage as the subjects with high $\dot{V}O_2$max (21). In our opinion, the suggestion that people displaying a higher $\dot{V}O_2$max can be loaded with a higher percentage of $\dot{V}O_2$max should be viewed with caution. It does not mean, of course, that the $\dot{V}O_2$max level is ineffective as an indicator of effort tolerance. During work at a specified degree of severity, a higher $\dot{V}O_2$max will result in a lower RAS. It should be remembered, however, that at the same RAS, people with a higher $\dot{V}O_2$max level perform heavier work, so their heart rate during working hours may be higher and their working ability after work may be lower.

From the data presented, certain conclusions can be drawn on the principles of scheduling occupational work for women. The most important factor is the possibility of allowing women themselves to set the pace of the work; it is also essential to avoid all factors which may increase the heart rate. The aceptable heart rate values during working time (100 beats per minute, 50% HR_{max} or 30% HRR) specified in the literature protect women from an excessive loss of working ability.

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