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PHYSIOLOGICAL REACTION TO WORKLOAD IN WOMEN PERFORMING MANUAL OR MENTAL WORK

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Abstract: The aim of our study was to evaluate the reaction of the circulatory system on work with various levels of physical and mental load. The examinations were carried out at a department store in two groups of women: 20 cashiers (mental work) and 53 saleswomen (physical work). There were no statistically significant differences in age, duration of employment or physical fitness between those groups. Work at this department store was performed on a two-shift system with irregular rotations. The psychic load was evaluated as a relation between subjective estimation of work demands and the ability to cope with them. Physical effort was measured as an energy expenditure during work. Cardiovascular reaction was expressed by heart rate during work, leisure time and sleep estimated according to the 24-hour Holter monitoring method. No statistically significant differences in heart rate were found to exist between cashiers and saleswomen. This, taking into account the much higher energy expenditure in saleswomen, suggests that mental effort is likely to affect heart rate. In fact, mean values of subjective assessment of work demands in cashiers were much higher (5.1) than in saleswomen (4.4), unlike the evaluation of the ability to cope with them, which points to the occurrence of a significant psychic load in the work of cashiers. A lower difference between maximum and minimum frequencies of heart rate in cashiers in comparison with saleswomen confirmed this observation, although it might have resulted from different levels of physical activity during work. After the work, heart rate in a group of cashiers remained for a long time on the level similar to that, observed during work, which is a typical consequence of psychic effort. In the group of saleswomen heart rate after work decreased progressively. These results show the usefulness of the analysis of heart rate variation after work for determining the type of workload factor.

INTRODUCTION

According to the concept of stress and strain, the physiological reaction to work depends on the intensity and type of the loading factors and on the individual characteristics of the person performing the work (3, 7). Rational steps toward

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reducing the physiological reactions (strain) to work can be taken only if the type of the essential loading factor is known. By analyzing the results of evaluation of the individual physiological parameters, such as heart rate during work only, it is not possible to clearly indicate the load source, i.e. to determine whether the loading is attributable to physical stress or to work-related nervous or emotional stress.

The analysis of long-term recordings of the physiological parameters may offer some help in an attempt to solve this problem. Physical stress is a factor which essentially increases the level of the basic physiological functions and extends their daily amplitudes, while work involving only small physical load may act to disturb the diurnal rhythm of the physiological functions. The psychic stress, on the other hand, acts to reduce the amplitude of the periodic fluctuations of the physiological functions (8). In our present study we have attempted, therefore, to evaluate the feasibility of using the analysis of circadian heart rate variations for diagnosing the sources of the workload.

MATERIALS AND METHODS

The examinations were carried out in a group of 20 female cashiers and 53 saleswomen employed in a department store. Data on age and duration of employment are presented in Table 1. Their heart rate was registered during 24 hours by the Holter method using an Oxford Medilog 3000 Recording System. The

Table 1. Mean values (± standard deviation) of age, working age, maximum oxygen consumption and energy expenditure during work in the groups of cashiers and saleswomen working during morning, afternoon and both shifts

Shift during ECG registration		Number of subjects	Age (years)	Duration of employment (years)	$V0_2$ max (ml/kg/min)	Energy expenditure (kcal/day)
Morning shift	cashiers	5	38.5 ± 9.8	16.3 ± 2.9	26.1 ± 0.8	300 ± 0
	saleswomen	16	34.2 ± 10.2	14.9 ± 9.8	28.6 ± 4.1	846 ± 42
Afternoon shift	cashiers	6	30.8 ± 6.0	12.3 ± 4.8	34.9 ± 8.8	300 ± 0
	saleswomen	27	30.2 ± 7.6	11.8 ± 7.5	32.7 ± 8.3	872 ± 37
Afternoon + morning shift	cashiers	9	35.8 ± 6.3	15.2 ± 5.2	29.5 ± 5.6	520 ± 0
	saleswomen	10	34.5 ± 12.0	14.4 ± 8.5	28.7 ± 4.6	922 ± 99

recordings were started and finished after the morning shift or before the afternoon shift at about 2 p.m. (the morning shift was from 7 a.m. to 2 p.m., the afternoon shift from 1 to 8 p.m). The shift rotation system was irregular, and it often happened that women working during the afternoon shift worked during the morning shift on the next day. The tested persons had been therefore, divided into three gropups: group M – women who, on the day of taking the electrocardiographic record, were working during the morning shift only, group A – who were working during the afternoon shift only, and group AM – who were working during the afternoon shift and the morning shift on the following day.

The duration of work, house chores and sleeps were estimated on the basis of the subjects activity diaries which enabled us, using the Cardio-Soft software by Temed-Zabrze, to determine heart rate during work (HR work), after work (HR home) and during sleep (HR sleep). Energy expenditure during occupational work was estimated and from heart rate during submaximal effort, the predicted maximum oxygen consumption values ($V0_2max$) were determined (5). Energy expenditure during leisure time was not estimated, but from the subjects, activity dairies we concluded that the work load during home activities was on a comparable level in cashiers and saleswomen.

The subjects were also asked to estimate the psychic load according to the method developed at the Department of Work Psychology, the Nofer Institute of Occupational Medicine, Lodz (2). The method involves, using a 9 point scale, a subjective estimation of work demands and the ability to cope with them. It includes six measures of psychic workload: mental difficulties, monotony, risk, responsibility, interpersonal conflicts and time pressure.

RESULTS AND DISCUSSION

In every group there were no statistically significant differences between cashiers and saleswomen in age, duration of employment or physical fitness in terms of VO_2max values. There were, however, remarkable differences in their energy expenditure values (Table 1). No statistically significant differences in heart rates were found to exist between the cashiers and saleswomen (Table 2). Considering the difference in energy expenditure between these two groups, a much greater difference in heart rate levels between them could have been expected. Therefore, it may be assumed that some other factor in the work of the cashiers is responsible for the increased heart rate. This could be, for example, the psychic load associated with the kind of work.

Table 2. Heart rate (mean ± standard deviation) in the groups of cashiers and saleswomen working during morning, afternoon and both shifts

Shift during ECG registration	Heart rate [beats/min]					
	work		leisure time		sleep	
	cashiers	saleswomen	cashiers	saleswomen	cashiers	saleswomen
Morning shift	91.4 ± 7.9	94.5 ± 11.9	92.3 ± 9.2	86.9 ± 8.6	70.2 ± 4.3	66.5 ± 6.6
Afternoon shift	89.6 ± 10.9	95.0 ± 8.7	91.8 ± 13.4	92.7 ± 7.7	67.8 ± 11.8	72.5 ± 7.2
Afternoon + morning shift	90.9 ± 9.8	100.6 ± 12.1	90.3 ± 9.9	95.6 ± 8.5	72.4 ± 10.4	73.4 ± 5.1

Table 3. Mean values (± standard deviation) of subjective assessment of work demands and ability to cope with them in the group of cashiers and saleswomen

Measures of psychic workload [Values in points 1-9]	Cashiers		Saleswomen	
	Work demands	Ability to cope with demands	Work demands	Ability to cope with demands
Mental difficulty	3.84 ± 2.09	2.98 ± 1.12	3.24 ± 2.27	3.29 ± 1.22
Monotony	6.30 ± 2.13	6.50 ± 1.97	5.78 ± 1.96	6.63 ± 2.28
Risk	4.42 ± 2.25	4.66 ± 2.24	3.37 ± 2.01	4.31 ± 1.87
Responsibility	5.64 ± 2.18	5.63 ± 2.38	4.98 ± 1.93	5.40 ± 2.74
Interpersonal conflicts	4.01 ± 2.42	5.06 ± 2.22	3.55 ± 2.13	4.19 ± 2.45
Time pressure	6.21 ± 1.46	5.02 ± 1.32	5.41 ± 1.85	5.41 ± 1.84
Mean values	5.08 ± 0.99	4.98 ± 1.03	4.39 ± 0.95	4.88 ± 1.26

This seems to be confirmed by the data, in Table 3, on the subjective assessment of work demands which determines the magnitude of the psychic load. Each of the factors contributing to the psychic load was rated higher by the cashiers than by the saleswomen. Besides, work demands related with mental difficulty and time pressure was rated by the cashiers higher than the ability to cope with them. In the saleswomen, the reverse held true – work demands were rated lower than the ability to cope. Considering the heart rate in the female cashiers during work and the fact that the energy expenditure during work was rather small, their psychic load can be rated at 3, accordnig to the 4-level scale proposesd by Navakatikian (6).

Saleswomen and female cashiers work affected the course of their heart rate variations also during their off-duty hours. Although during the off-duty period, just like during work, there were no significant differences in the average heart rate values between the cashiers and the saleswomen, the distribution of the variations in both groups was, however, different. During leisure time in group M of cashiers, the heart rate level continued to be relatively high and remained at this level till 9.00 p.m., only after that time was there a relatively rapid heart rate slow-down. Prolonged continuation of heart rate on a level similar to that observed during work is typical of psychic load. The gradual decrease of the heart rate after work, observed in the saleswomen of group M is a typical consequence of physical effort. The course of heart rate variations before work in the cashiers and seleswomen belonging to group A, on the other hand, was very similar, which indicates that repose during night hours acted to cancel out the work-related differences.

The course of heart rate variations during 24 hours differed singificantly from the typical 24-hours curves obtained for resting persons (1, 4). Non-occupational activities were, in addition to occupational work, another factor significantly affecting circadian heart rate. Heart rate maximum occurred at different times, both during work and off duty. In group M, in the majority of the cashiers, heart rate maximum occurred during off-duty hours, while the same held true only in 4 out of 14 sales women. In the majority of the women employed during the afternoon shift (group A), heart rate maximum was observed before work. In 4 cashiers and in 3 saleswomen of group AM, the maximum heart rate frequency was observed before starting their morning shift, in the remaining women the maximum occurred during work. It has to be noted that many of the heart rate peak values observed during the day in particular groups correspond to the moments of occupational work starting and finishing. This suggests enormous loads accompanying commuting, caused by haste and increased motor activity: walking, climbing stairs, etc. (Fig.1).

Table 4. Diurnal variations of heart rate: maximal values, minimal values and amplitude (mean ± standard deviation) in the groups of cashiers and saleswomen working during morning, afternoon and both shifts

Shift during ECG registration	Groups	Heart rate maximal values		minimal values		amplitude	
		beats/min	% mean day value	beats/min	% mean day value	beats/min	% mean day value
Morning shift	cashiers	106.8 ± 8.9	127.0 ± 3.8	65.2 ± 2.5	77.9 ± 4.6	41.6 ± 8.1	49.1 ± 7.0
	saleswomen	105.4 ± 12.6	128.0 ± 8.9	61.9 ± 6.9	75.3 ± 6.5	43.5 ± 12.5	52.7 ± 13.7
Afternoon shift	cashiers	108.4 ± 9.1	127.3 ± 9,4	62.7 ± 8.9	76.5 ± 3.3	45.7 ± 6.6	50.8 ± 11.2
	saleswomen	108.8 ± 7.5	126.4 ± 6.4	67.1 ± 7.1	76.6 ± 6.1	41.7 ± 7.5	49.8 ± 9.7
Afternoon + morning shift	cashiers	102.3 ± 10.0	119.7 ± 3.9	66.2 ± 7.6	77.4 ± 4.3	36.0 ± 6.7	42.3 ± 7.1
	saleswomen	113.2 ± 14.2	123.3 ± 8.6	66.5 ± 4.1	73.1 ± 6.7	46.6 ± 14.9	50.2 ± 13.0

To evaluate the feasibility of using the analysis of the circadian heart rate variation level for diagnosing sources of workload, the values of the amplitudes of circadian heart rate variations were compared between the groups of cashiers and saleswomen (Table 4). It has been found that amplitudes of circadian heart rate variations in the cashiers and in the saleswomen were very similar – slightly lower values in the cashiers than in the saleswomen were found in group M and AM, in group A, on the other hand, the amplitude was slightly lower in the saleswomen. The differences were, however, statistically insignificant. Some flattening of the amplitude of circadian heart rate variations in the group M and AM of cashiers is visible also in Fig. 1, and particularly in Fig. 2, which represents the values of heart rate as the percentage of the mean day value.

Our results show, that the utilization of heart rate during work and amplitude of diurnal variation of heart rate as an indicator of psychic workload is useful only in the case, when the physical loads in tested groups are similar.

These results also indicate the usefulness of analysis of heart rate variation after work for determining the type of workload factor. This method makes it possible to identify the load factor even if no data on physical effort at work is available.

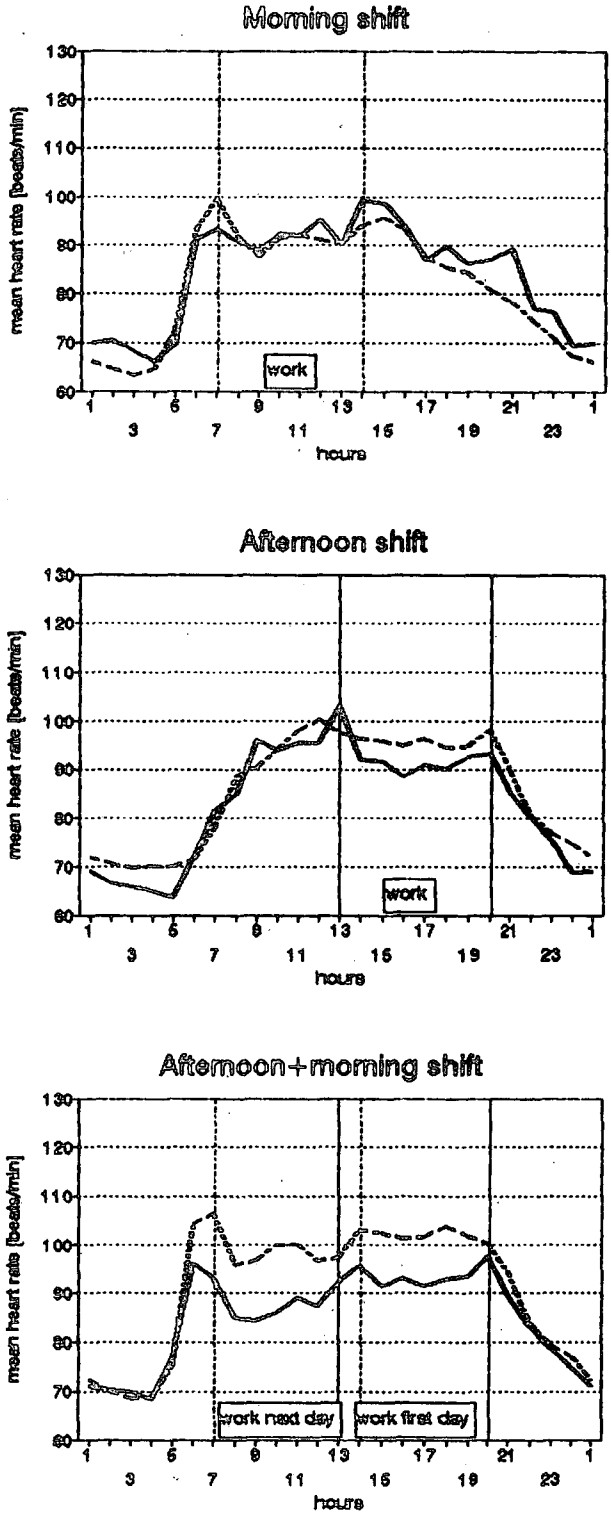

Fig. 1. Time course of heart rate variations in the groups of cashiers and saleswomen working during morning, afternoon and both shifts. Cashiers – solid line, saleswomen – dotted line.

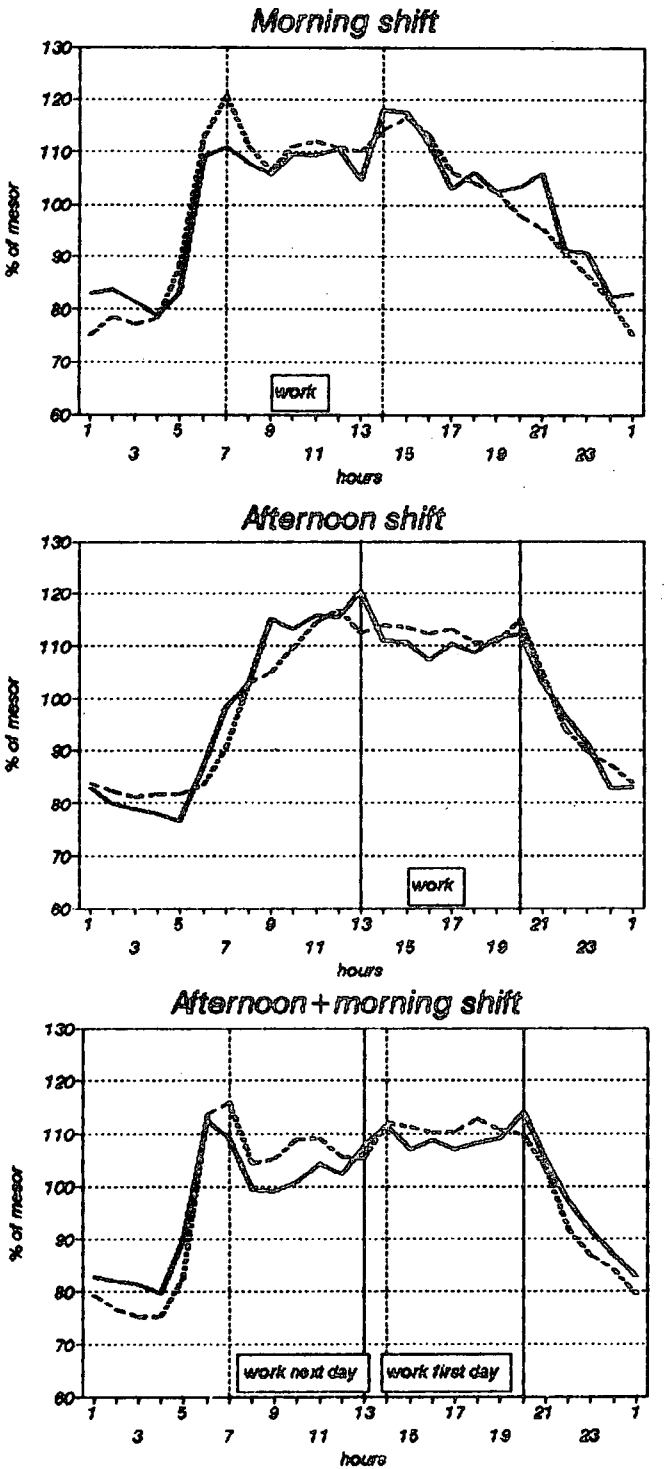

Fig. 2. Time course of heart rate variations as percent of mean day values (mesor) in the groups of cashiers and saleswomen working during morning, afternoon and both shifts. Cashiers — solid line, saleswomen — dotted line.

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