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CIRCADIAN BLOOD PRESSURE VARIABILITY AND EXERCISE THERAPY

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A b s t r a c t

The objective of this study was to find if there was a relationship between the time when cardiovascular rehabilitation was running in the patients after myocardial infarction and an average daily value of systolic and diastolic blood pressure at 7-day ambulatory blood pressure monitoring.

Systolic and diastolic pressures significantly increased in patients who underwent cardiovascular rehabilitation in the morning from 9.00 a.m. to 10.15 a.m., and significantly decreased in those who did their physical exercise in the afternoon from 1.30 p.m. to 2.45 p.m., compared to their blood pressure values on days without rehabilitation.

K e y w o r d s

Blood pressure, Ambulatory blood pressure monitoring, Circadian variability, Chronobiology, Cardiovascular rehabilitation

INTRODUCTION

High blood pressure is number one in risk factors of cardiovascular diseases and civilization diseases in general that have been known as yet.

It seems that repeated single measurements of blood pressure in medical practice are no longer sufficient for the determination of optimal treatment of patients with heart diseases. Ambulatory monitoring of blood pressure opens up new possibilities in the prevention, screening, diagnostics, and therapy of chronically ill patients. Blood pressure is a biological parameter showing, in spite of numerous regulation mechanisms, a considerable beat-to-beat variability within 24 hours and also at longer time intervals (weekly, monthly) (*9,8,2*). In recent years, 24-hour monitoring has contributed significantly to the progress in diagnostics and therapy of cardiovascular diseases. In combination with the knowledge of pharmacokinetics and pharmacodynamics of antihypertensive medicines it offers other possibilities of

medical treatment (*10, 11*). A longer lasting (7 days at least) monitoring increases the validity of obtained information with observing biological rhythms of blood pressure. The knowledge of chronobiology of circadian cycles of physiological functions initiates a modern trend in medicine, i.e. intervention before the manifestation of clinical symptoms of the disease (*1, 8, 12*).

Monitoring of blood pressure response to physical load is well-founded not only in the exercise diagnostics of hypertonic patients and of patients with cardiovascular and other internal diseases, but also in setting up and checking an optimal training program that should be beneficial to improvement or stabilization of their health state. Cardiovascular rehabilitation is perceived as a process helping patients with heart diseases in retaining their optimal physical, mental, working, and emotional states. Its principles are based on the assumption that the adaptation of the cardiovascular system to physical load is conditioned by regular, particularly dynamic endurance activities of adequate kind and intensity (*7*).

PURPOSE

The objective of this study was to find if there was a relationship between the day time when cardiovascular rehabilitation was running in patients after myocardial infarction and an average daily value of systolic and diastolic blood pressure at 7-day ambulatory monitoring.

METHODS

The set monitored consisted of ten patients after myocardial infarction of age (63 ± 6.3) and an ejection fraction of (43 ± 12.3) %.

The patients underwent phase II of cardiovascular rehabilitation (controlled ambulatory rehabilitation program) lasting two to three months with a frequency of two to three times a week at the Department of Functional Diagnostics and Rehabilitation of St. Anne's Faculty Hospital.

In the course of rehabilitation the patients went through 7-day ambulatory monitoring of blood pressure. During BP recording they did not interrupt their pharmacotherapy.

The seven-day blood pressure monitoring was carried out using the instrument TM – 2421 of the Japanese firm AD on the principle of oscillometric analysis. During the time of monitoring the patients carried the recording instrument in a case on the body and the cuff with the measuring probe above a. brachialis. The instrument measured blood pressure for 7 days repeatedly every 30 minutes from 5 to 22 h and once in an hour from 22 to 5 h. If a value which was not very probable from the point of view of the setting-up of the instrument was recorded, a control measurement was performed (*10*).

The BP values measured for every patient from the monitored set were statistically processed in the form of arithmetic means. BP profiles on days without cardiovascular rehabilitation (hereafter days without exercises) and on days with cardiovascular rehabilitation (hereafter days with exercises) at individual time intervals were obtained as arithmetic means of the values in every hour of individual days with suppression of the individuality of persons in the monitored set.

The average SBP and DBP and their standard deviations (SD) on the given days were determined by calculating the arithmetic mean of these values. These average values were compared by means of two-factor analysis of variance without repetition (ANOVA). Concrete differences between the averages from the days without exercises and the averages of the values at the time intervals when cardiovascular rehabilitation was running in individual groups of patients were tested by the paired t-test.

RESULTS

Table 1 gives the average of BP profiles on the days without exercises and with exercises that were obtained from the arithmetic means of SBP and DBP for every hour of individual days regardless of individual differences between the patients in the monitored set.

The calculated value F (ANOVA) for SBP highly exceeds the critical value for the significance level $\alpha = 0.01$. It was proved that there are statistically conclusive differences between the daily averages of SBP in the monitored groups. The differences of averages in individual groups of the days with exercises in comparison with the group of days without exercises were tested by the paired t-test.

The average value of SBP in 24 h in the group of patients doing exercises from 9 a.m. to 10.15 a.m. is statistically highly conclusively higher ($\alpha = 0.01$) in comparison with the group of days without exercises (133 or 120 mm Hg). The average value of SBP in 24 h in the group of patients doing exercises from 1.30 p.m. to 2.45 p.m., however, is statistically conclusively lower ($\alpha = 0.05$) (115 or 120 mm Hg). The averages of the remaining two groups and of the group without exercises are identical. It is interesting that in all groups with exercises lower minimal values of SBP were found than in the group without exercises.

The calculated value F (ANOVA) for DBP also highly exceeds the critical value for the significance level $\alpha = 0.01$. It was proved that there are statistically conclusive differences between the averages of individual monitored groups. The results of the paired t-test demonstrate statistically highly conclusively higher values in the groups of days when the exercises were running from 7.30 a.m. to 8.45 a.m. and from 9 a.m. to 10.15 a.m. ($\alpha = 0.01$), and statistically highly conclusively lower values in the group of days when the patients were doing exercises in the afternoon from 1.30 p.m. to 2.45 p.m. ($\alpha = 0.01$) in comparison with the average of values in 51 days without cardiovascular rehabilitation (71, 75, 63 or 69 mm Hg).

DISCUSSION

The diagnosis based on one clinical measurement of BP is wrong in about 40 % of the cases compared to 24-hour ambulatory monitoring. The 48-hour record furthermore reduces uncertainty in the assessment of blood pressure parameters by 35 % in comparison with 24-hour monitoring. *Halberg et al.* (2006) and *Watanabe et al.* (2006) tend to a long-term monitoring of blood pressure for the sake of increasing validity of the obtained data and optimization of the therapy. They recommend a 7-day recording of blood pressure to cover the biological week.

The nature of reaction of the cardiovascular system to exercises depends on intensity, type and duration of physical load, and also on individual characteristics of the organism and on external influences. Even a moderate load affects the tonus of the vegetative nervous system by reducing the activity of n. vagus and stimulation of sympathicus occurs. Autonomous nervous regulations with predomination of

Table 1
A 24-hour profile of systolic and diastolic blood pressure [mm Hg] obtained as arithmetic mean of values of the patients

	without exercises		with exercises at time [h]							
			7:30–8:45		9:00–10:15		10:30–11:45		13:30–14:45	
N	51		10		3		6		3	
[mmHg]	SBP	DBP	SBP	DBP	SBP	DBP	SBP	DBP	SBP	DBP
x	**120**	**69**	**120**	**71****	**133****	**75****	**120**	**67**	**115***	**63****
SD	5.9	4.0	11.9	5.6	12.0	10.2	12.9	6.3	12.8	6.3
x_{max}	128	75	152	83	158	91	142	81	136	74
x_{min}	110	62	99	62	108	57	97	56	94	48
$t_{calculated}$.			0.221	3.448	5.317	4.029	0	1.657	2.795	6.183
$F_{calculated}$	16.371	23.662								

n – number of days monitored
x – arithmetic mean SD – standard deviation
x_{max} , x_{min} – maximal and minimal average circadian values of blood pressure
* statistically conclusive difference at the significance level $\alpha = 0.05$
** statistically conclusive difference at the significance level $\alpha = 0.01$
t criterion of paired t-test $t_{(0.05)} = 2.068$ $t_{(0.01)} = 2.807$
F criterion of analysis of variance $F_{(0.05)} = 2.471$ $F_{(0.01)} = 3.530$

the sympathicus at a high intensity of the load bring about increased heart rate, peripheral resistance of vessels, secretion of catecholamines, and blood pressure. After the termination of the load sympathetic activity decreases and parasympathetic activity increases with latency.

Systolic blood pressure at a dynamic load of low and moderate intensity quickly achieves a steady state (130 – 170 mm Hg), diastolic pressure does not show substantial changes or slightly decreases. Loads of submaximal and maximal intensity lead to gradual increasing of systolic pressure. Diastolic blood pressure mostly decreases, but in some cases it also increases. Both blood pressure parameters react to static (isometric) load by increasing (*7*).

This study confirms the blood pressure reaction to the load, both in the interval of proceeding exercises and in the whole circadian cycle. Systolic blood pressure was increasing at the time of rehabilitation; sometimes, however, also within two hours after the termination of exercises. The reaction of diastolic pressure to the load is less specific in physiological conditions. Regularity in diastolic pressure curves in individual persons tested is also difficult to find.

Both foreign literature and the studies carried out in St. Anne's Faculty Hospital prove a positive influence of cardiovascular training on the prognosis of heart diseases. *Mífková et al. (5)* assesses successfulness of the rehabilitation program depending on how early rehabilitation is started (already during hospitalization), on the length of duration of individual phases of the training, and on the frequency

of arranging individual exercise units. The content of individual phases of the rehabilitation program was also a subject of the discussion (*3, 6*).

For example, according to *Jančík (4)*, it is not the time devoted to exercises or the particular type of exercises, but intensity of the load that is decisive for a direct influence on the prognosis of cardiovascular diseases, regardless of the type of exercises done by the patient.

This study provides additional information to the above-mentioned facts concerning cardiovascular rehabilitation by claiming that, apparently, the effect of the complex therapy of heart diseases also depends on the time of day when the patients perform the rehabilitation program.

The persons tested in this study were divided into four groups differing in time intervals of rehabilitation. It was proved that the time of exercises influences the average value of blood pressure during the circadian cycle. Cardiovascular training taking place in the morning increased statistically conclusively the average 24-hour values of blood pressure in comparison with the days without exercises. Exercises arranged in the afternoon decreased statistically conclusively the average 24-hour values of blood pressure.

The influence of exercises on circadian variability of blood pressure was also investigated by *Homolka (2);* he states that exercises of an aerobic nature done in the evening by patients with hypertension caused abnormal fluctuation of circadian values of blood pressure contributing to CHAT (Circadian Hyper-Amplitude-Tension). He did not find any abnormalities on days without exercises and with exercises done in the morning and in the afternoon. An effective complex therapy of high blood pressure and cardiovascular rehabilitation as its integral part are a basic condition for the decrease of morbidity and mortality caused by cardiovascular diseases and their complications. Our studies show that the time of day when the load is applied influences the average 24-hour values of blood pressure.

CONCLUSION

It was proved that there is a statistically highly conclusive dependence of SBP and DBP values on the day time when the patients went through cardiovascular rehabilitation.

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