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The impact of cardiac rehabilitation on the tolerance of physical exercise in patients after myocardial infarction

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Abstract

The aim of this study was evaluation of the impact of complex cardiac rehabilitation on the improvement of exercise tolerance of patients after myocardial infarction.
Material and methods: Sixty patients after myocardial infarction underwent cardiac rehabilitation (physical activities, cardio-respiratory exercise, education). Their heart rate, blood pressure, energy expenditure and duration of exercise tolerance test were evaluated.
Results: Resting heart rate was slightly reduced and exercise heart rate increased as a result of cardiac rehabilitation. Blood pressure did not change significantly after rehabilitation. Energy expenditure was changed from 5.74 MET before rehabilitation to 7.56 MET after it. Duration of exercise tolerance test was changed from 5.07 min. To 7.34 min.
Conclusion: Myocardial infarction causes significant reduction of exercise tolerance of the patient. After cardiac rehabilitation resting heart rate does not change and exercise heart rate increases as well as energy expenditure and duration of exercise tolerance test. As a result of cardiac rehabilitation exercise tolerance of patients after myocardial infarction increase

Introduction

Nowadays, the risk of a heart attack is very high. The changes in civilization and the pace of life are conducive to increasing the incidence of cardiovascular diseases. The advances in knowledge and the development of treatment methods, but also the growing awareness of patients, cause lower incidence and mortality due to cardiac diseases. Not so long ago, myocardial infarction caused the patient to be excluded from any life activities for several months. Currently, quickly implemented treatment, immediate and effective cardiac rehabilitation have a significant impact on a patient's rapid return to physical and mental health [1].

Currently, cardiac rehabilitation plays a very important role in the treatment of patients after myocardial infarction. It has been developed in detail and divided into individual models, which are implemented depending on the patient's clinical condition and the course of the disease [2].

Based on many years of observations, it was found that regular rehabilitation, both during hospitalization and in the outpatient setting, causes many beneficial changes in the cardiovascular system of the patient. It allows for a quick recovery by increasing the physical efficiency and exercise tolerance of the patient [3].

Aim

The aim of the study was to assess the impact of comprehensive cardiac rehabilitation on the tolerance of physical exercise in patients after myocardial infarction.

Material and methods

The study included 60 patients (15 women and 45 men) after myocardial infarction aged 40-65 years. For each patient included in the study, it was the first episode of acute coronary syndrome in life. All patients underwent diagnostic coronarography and none of the patients were qualified for conservative treatment (each patient had angioplasty of at least one coronary artery). Patients were enrolled after 14 days after uncomplicated myocardial infarction. All patients were optimally treated pharmacologically according to ECS guidelines from the time of the heart attack. Patients with ejection fraction below 50% were excluded from the study - echocardiography was performed on the first day after the infarction and patients with contraindication for exercise testing. Patients before and after the rehabilitation were subjected to an exercise test, conducted on the treadmill according to the Bruce protocol. The rehabilitation cycle lasted 21 days and consisted of:

- 45-minute interval training on the cycloergometer five times a week,
- thirty-minute cardiopulmonary gymnastics twice a week run by the same physiotherapist,
- care of a dietitian, psychologist, doctor.

The next element of the rehabilitation cycle were cardio-respiratory exercises in which there was gradation of effort:

- in the first week the exercises were performed without a load, only with the use of a gym stick,
- in the second week, exercises with 0.5 kg weight were added to the exercises already known,
- in the third week another 0.5 kg weight was added.

In the analysis of the test results, the following parameters were taken into account for the assessment of physical exercise tolerance:

- the value of the resting heart rate,
- the value of the final pulse,
- the value of resting pressure,
- load applied during exercise tests (MET),
- body mass index,
- duration of the stress test.

Statistical methods

Statistical analysis of the collected data was carried out in the Statistica 10.0 program. The Wilcoxon pairs order test was used for analysis - a test from the group of non-parametric tests. His choice was conditioned by the failure of the basic assumption of parametric tests, ie the compatibility of distributions of variables with the normal distribution, verified by the Shapiro-Wilk test The Wilcoxon pairs test is an alternative to the t test for dependent samples and allows to check the intergroup variability that occurs in the study - based on measuring the same objects twice before and after the given factor - in this case: before and after rehabilitation or before and after the endurance test. In this study, $p < 0.05$ was assumed as the level of statistical significance.

Results

The values of the resting heart rate and exercise heart rate were compared in the measurement made before starting the rehabilitation. The mean value of the resting heart rate in the pre-rehabilitation measurement was 66.85 beats per minute ± 9.14 beats per minute in the study group. After the stress test, the final heart rate was 111.15 beats per minute ± 13.54 beats per minute, an increase of 44.7 beats per minute on average.

The difference between resting heart rate and exercise heart rate in the measurement made before the rehabilitation was statistically significant ($p < 0.001$).

Table 1. Comparison of resting and exercise heart rate in the measurement of I.

Pulse [beats/min.]	Descriptive statistics							
	n	x̄	Me	Min.	Max.	Q1	Q3	SD
Resting I	60	66,85	65,50	49,00	88,00	60,00	72,50	9,14
Exercise I	60	111,55	112,00	81,00	153,00	103,00	118,00	13,54
Level of probability (p)	Z=6,73 p<0,001 d=44,7							

n - number of observations; x̄ - average arithmetic; Me - median; Min. - minimum; Max - maximum; Q1 - lower quartile; Q3 - upper quartile; SD - standard deviation; d - difference, Z - result test of Wilcoxon pairs order; p - level of probability.

The average value of the resting heart rate in the measurement after rehabilitation was 64.88 beats per minute ± 9.17 beats per minute in the study group. After the stress test, the final heart rate was on average 121.43 beats per minute ± 15.29 beats per minute, that is, it increased on average by 56.55 beats per minute.

The difference between resting heart rate and exercise heart rate in the measurement performed after the end of rehabilitation was statistically significant (p <0.001).

Table 2. Comparison of resting and exercise heart rate in the measurement of II.

Pulse [beats/min.]	Descriptive statistics							
	n	x̄	Me	Min.	Max.	Q1	Q3	SD
Resting II	60	64,88	64,50	50,00	88,00	57,50	70,00	9,17
Exercise II	60	121,43	122,50	82,00	153,00	111,50	129,50	15,29
Level of probability (p)	Z=6,73 p<0,001 d=56,55							

n - number of observations; x̄ - average arithmetic; Me - median; Min. - minimum; Max - maximum; Q1 - lower quartile; Q3 - upper quartile; SD - standard deviation; d - difference, Z - result test of Wilcoxon pairs order; p - level of probability.

The value of the resting heart rate after completing the rehabilitation in relation to the measurement of the resting heart rate before the beginning of the rehabilitation was compared. The mean value of the resting heart rate in the pre-rehabilitation measurement was 66.85 beats per minute ± 9.14 beats per minute in the study group. After rehabilitation, the resting heart rate was on average 64.88 beats per minute ± 9.17 beats per minute, that is, it decreased by 1.97 beats per minute on average.

The difference between the resting heart rate in the measurement made before the rehabilitation and in the measurement made after the rehabilitation was completed was statistically insignificant (p = 0.080).

Table 3. Comparison of resting heart rate in measurement I and II.

Pulse of resting [beats/min.]	Descriptive statistics							
	n	x̄	Me	Min.	Max.	Q1	Q3	SD
Mensuration I	60	66,85	65,50	49,00	88,00	60,00	72,50	9,14
Mensuration II	60	64,88	64,50	50,00	88,00	57,50	70,00	9,17
Level of probability (p)	Z=1,74 p=0,080 d=1,97							

n - number of observations; x̄ - average arithmetic; Me - median; Min. - minimum; Max - maximum; Q1 - lower quartile; Q3 - upper quartile; SD - standard deviation; d - difference, Z - result test of Wilcoxon pairs order; p - level of probability.

The mean value of the exercise pulse in the pre-rehabilitation measurement was 111,55 beats per minute in the study group ± 13,54 beats per minute. After completion of rehabilitation, the exercise heart rate was on average 121.43 beats per minute ± 15.29 beats per minute, that is, it increased on average by 9.88 beats per minute.

The difference between exercise pressure in the measurement made before the rehabilitation and in the measurement performed after the end of rehabilitation was statistically significant ($p < 0.001$).

Table 4. Comparison of exercise heart rate in measurement I and II.

Pulse of exercise [beats/min.]	Descriptive statistics							
	n	x̄	Me	Min.	Max.	Q1	Q3	SD
Mensuration I	60	111,55	112,00	81,00	153,00	103,00	118,00	13,54
Mensuration II	60	121,43	122,50	82,00	153,00	111,50	129,50	15,29
Level of probability (p)	Z=5,12 p<0,001 d=9,88							

n - number of observations; x̄ - average arithmetic; Me - median; Min. - minimum; Max - maximum; Q1 - lower quartile; Q3 - upper quartile; SD - standard deviation; d - difference, Z - result test of Wilcoxon pairs order; p - level of probability.

The average value of systolic blood pressure in the measurement before rehabilitation in the studied group of patients was 127.08 mmHg ± 17.79 mmHg. After completion of the rehabilitation, the systolic arterial pressure was on average 126.05 mmHg ± 14.69 mmHg, that is, it decreased on average by 1.03 mmHg.

The difference between the value of systolic blood pressure in the measurement made before the rehabilitation and in the measurement made after the end of rehabilitation was statistically insignificant ($p = 0.452$).

Table 5. Comparison of resting systolic blood pressure in measurement I and II.

SBP [mmHg]	Descriptive statistics							
	n	x̄	Me	Min.	Max.	Q1	Q3	SD
Mensuration I	60	127,08	124,00	90,00	161,00	114,50	141,50	17,79
Mensuration II	60	126,05	127,50	102,00	153,00	112,00	138,00	14,69
Level of probability (p)	Z=0,75 p=0,452 d=1,03							

n - number of observations; x̄ - average arithmetic; Me - median; Min. - minimum; Max - maximum; Q1 - lower quartile; Q3 - upper quartile; SD - standard deviation; d - difference, Z - result test of Wilcoxon pairs order; p - level of probability.

The diastolic blood pressure was also compared after completion of rehabilitation in relation to the measurement of diastolic blood pressure made before the beginning of rehabilitation. Mean value of diastolic blood pressure in the measurement before rehabilitation was 74.45 mmHg ± 9.44 mmHg in the studied group of patients. After completion of rehabilitation, the diastolic blood pressure was on average 73.43 mmHg ± 9.04 mmHg, which decreased on average by 1.02 mmHg.

The difference between the value of the diastolic blood pressure measured before the rehabilitation and in the measurement performed after the end of rehabilitation was statistically insignificant (p = 0.426).

Table 6. Comparison of resting diastolic blood pressure in measurement I and II.

DBP [mmHg]	Descriptive statistics							
	n	x̄	Me	Min.	Max.	Q1	Q3	SD
Mensuration I	60	74,45	74,50	57,00	97,00	68,00	81,00	9,44
Mensuration II	60	73,43	74,00	52,00	101,00	67,00	80,00	9,04
Level of probability (p)	Z=0,79 p=0,426 d=1,02							

n - number of observations; x̄ - average arithmetic; Me - median; Min. - minimum; Max - maximum; Q1 - lower quartile; Q3 - upper quartile; SD - standard deviation; d - difference, Z - result test of Wilcoxon pairs order; p - level of probability.

The value of energy expenditure after the end of rehabilitation compared to the energy expenditure before the beginning of rehabilitation was compared. The average value of energy expenditure in the measurement before rehabilitation in the studied patient group was 5.74 MET ± 2.07 MET. After completion of rehabilitation, the value of energy expenditure was on average 7.56 MET ± 2.92 MET, ie it increased on average by 1.82 MET.

The difference between the value of energy expenditure in the measurement made before the rehabilitation and in the measurement made after the rehabilitation was completed was statistically significant (p <0.001).

Table 7. Comparison of energy expenditure [MET] in measurement I and II.

Energy expenditure [MET]	Descriptive statistics							
	n	$\bar{x}$	Me	Min.	Max.	Q1	Q3	SD
Mensuration I	60	5,74	6,00	2,70	10,00	3,75	7,00	2,07
Mensuration II	60	7,56	7,00	2,50	13,50	4,75	10,00	2,92
Level of probability (p)	Z=6,33 p<0,001 d=1,82							

n - number of observations; $\bar{x}$ - average arithmetic; Me - median; Min. - minimum; Max - maximum; Q1 - lower quartile; Q3 - upper quartile; SD - standard deviation; d - difference, Z - result test of Wilcoxon pairs order; p - level of probability.

The average duration of the stress test in the measurement before rehabilitation was determined in the study group of patients at the level of 5.07 min. ± 1.52 min. After completing the rehabilitation, the average duration of the stress test was determined at an average level of 7.34 min. ± 2.03 minutes Therefore, the duration of the exercise test increased by an average of 2.27 minutes.

The difference between the duration of the exercise test in the measurement made before the rehabilitation and in the measurement made after the end of rehabilitation was statistically significant (p <0.001).

Table 8. The duration of the test in measurement I and II.

Duration of the trial [min.]	Descriptive statistics							
	n	$\bar{x}$	Me	Min.	Max.	Q1	Q3	SD
Mensuration I	60	5,07	5,00	1,30	9,00	4,00	6,00	1,52
Mensuration II	60	7,34	7,00	2,30	12,00	6,00	9,00	2,03
Level of probability (p)	Z=6,55 p<0,001 d=2,27							

n - number of observations; $\bar{x}$ - average arithmetic; Me - median; Min. - minimum; Max - maximum; Q1 - lower quartile; Q3 - upper quartile; SD - standard deviation; d - difference, Z - result test of Wilcoxon pairs order; p - level of probability.

Both in the measurement before the beginning of rehabilitation and in the measurement after the end of cardiac rehabilitation, most patients stopped the stress test due to fatigue. In the measurement of I 46 people (76.7%) and in measure II 47 people (78.3%).

The difference was statistically insignificant (p = 0.831).

Table 9. The reason for stopping the test in measurement I and II.

Reasons for stopping the trial	Mensuration I		Mensuration II	
	n	%	n	%
Heart rate limit	14	23,3%	13	21,7%
Amount	60	100,0%	60	100,0%
Level of probability (p)	Z=0,21 p=0,831			

n - number of observations; % - percent, Z - result test of Wilcoxon pairs order; p - level of probability.

Discussion

The prolongation of life, the growing importance of risk factors such as: hypertension, obesity, diabetes result in an increase in recognition in the general population and the incidence of cardiovascular disease, including myocardial infarction. The importance of the problem is additionally increased by the significant social and economic costs of this disease [4].

A significant reduction in physical performance after a heart attack is, unfortunately, one of the characteristic effects of this disease. In the own research, the maximum oxygen uptake (VO2max) measured in MET units was used to measure physical capacity. Under normal conditions, the correct value of VO2max of a healthy person is 13 MET [5]. Meanwhile, the average value of VO2max in the examined group of patients before rehabilitation was only 5.74 MET.

Jureczko and Włoka stated in their research that the energy output of a fifty-year-old man should be at least 10 MET, while women at a similar age - at least 7 MET [6]. In our own research it was shown that as a result of cardiac rehabilitation, the value of the resting heart rate did not change significantly (slightly decreased, but this change was not statistically significant). In turn, the value of the exercise heart rate increased as a result of rehabilitation and this change was statistically significant.

Similar results were obtained in the Jureczko and Włoki studies. The average value of resting heart rhythm did not change significantly, and as a result of improved exercise tolerance, higher and higher values of maximum heart rate were obtained, and the trials ended more often for physiological than pathological reasons. The level of fitness is evidenced, among other things, by a slight reduction in the resting heart rate (similarly to own studies). Admittedly, these changes were not significant among the studied group of patients, however, in some individual cases, such a reaction was noted, which indicates that subjects after the completion of the rehabilitation program continued to go for a walk - the simplest form of physical activity [7].

In our own research it was shown that the average value of energy expenditure of patients measured after cardiac rehabilitation increased compared to the value of energy expenditure measured before the beginning of rehabilitation. The resulting difference in the value of energy expenditure was statistically significant.

Many research results available in the literature confirm the results of own research. Kielnar and partners [8] examined 83 patients after myocardial infarction underwent a three-month rehabilitation. The results obtained by the authors indicate a greater tolerance of effort and increased physical efficiency of patients. Similar results were also obtained in the studies of Korzeniowska-Kubacka and Piotrowicz [9] and Cannistry and partners [10]. These authors also showed that the amount of improvement in physical performance does not depend on the sex of the subjects. The beneficial effect of the rehabilitation program on the level of energy expenditure among patients after myocardial infarction was also demonstrated by the studies of Trzos and partners [11].

It seems that an important aspect of the conducted research should be the fact that cardiological rehabilitation, which is based on physical exercises, leads to an increase in the efficiency of patients, and thus should be an important element of therapy for myocardial infarction.

Conclusions

1) After application in patients after cardiological rehabilitation, the value of their resting heart rate does not change, while the value of the exercise heart rate increases.
2) The energy expenditure of patients after myocardial infarction increases after cardiac rehabilitation.
3) As a result of comprehensive cardiac rehabilitation, the physical exercise tolerance increases in patients after myocardial infarction.

Reference

1. Rudnicki S: Rehabilitacja w chorobach układu krążenia i po operacjach. Rehabilitacja medyczna. Red: Kwolek A. Urban&Partner, Wrocław, 2003.
2. Jaxa-Chamiec T: Rehabilitacja kardiologiczna - definicja, historia cele, znaczenie i korzyści. Post Nauk Med, 2008, 21(10): 634-642.
3. Makowiecki K, Mamcar A: Ambulatoryjna rehabilitacja kardiologiczna - czy można poprawić jej skuteczność? Kardiol Pol, 2009, 67(6): 639-641.
4. Fedyk- Łukasik M, Grodzicki T: Wydolność fizyczna u chorych z niewydolnością serca. Chor Serca Naczyń, 2007, 4(4): 162-167.
5. Dylewicz P, Przywarska J, Borowicz-Bieńkowska S: Wybrane problemy rehabilitacji pozawałowej. Ostre zespoły wieńcowe. Urban & Partner, Wrocław, 2002.
6. Górski J (red.): Fizjologia wysiłku i treningu fizycznego. PZWL, Warszawa, 2011.
7. Jureczko M, Włoka J: Analiza tolerancji wysiłku fizycznego u pacjentów po przebytym zawale serca. Folia Cardiol, 2013, 8(2):37-43.
8. Kielnar R, Janas M, Domka-Jopek E: Wpływ usprawniania ambulatoryjnego na wydolność fizyczną pacjentów po zawale mięśnia sercowego. PMUR, 2008, 3:220-225.
9. Korzeniowska-Kubacka I, Piotrowicz R: Czy sposób terapii zawału serca

w ostrej fazie wpływa na efekty rehabilitacji? Folia Cardiol, 2005, 12:377-381.
10. Cannistra LB, Ballady GJ, O'Malley CJ: Comparison of the clinical profile and outcome of women and men in cardiac rehabilitation. Am J Cardiol, 1992, 69:1274-1279.
11. Trzos E, Kurpesa M, Rechciński T, Wierzbowska-Drabik K, Krzemińska-Pakuła M: Wpływ rehabilitacji fizycznej na podatność tętnic u chorych po zawale serca. Folia Cardiol, 2007, 2:492-497.