

# The influence of cardiac rehabilitation according to the C model on exercise tolerance and hemodynamic indices in patients after cardiac incident

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

## Abstract

**Purpose:** Cardiovascular diseases are currently classified as civilization diseases. The number of cases since the 20th century has dramatically increased. Currently, as many as 46% of all deaths in Poland are caused by diseases of the circulatory system. The aim of the study is to assess the impact of cardiac rehabilitation according to the C model on exercise tolerance and hemodynamic indices in patients after a cardiac incident.

**Material:** The research was carried out in the Department of Cardiac Rehabilitation in Szymbark. The study group consisted of 32 patients who, after physical examination at admission, were qualified for the preliminary assessment of physical fitness on the basis of 6MWT. The test was carried out the day after the admission, according to current standards. Subsequently, the examined persons underwent a 28-day cycle of early cardiac rehabilitation according to the C model.

**Results:** As a result of a 4-week cardiac rehabilitation, a statistically significant improvement in physical performance was obtained, with a distance increase of 68.34 m on average. A statistically significant change in the level of fatigue according to Skala Borga after the completion of the rehabilitation cycle was demonstrated. Patients with normal body weight, overweight and obesity received a similar increase in 6MWT results due to the rehabilitation cycle.

**Conclusions:** The results of this study indicate the urgent need to educate patients in the prevention and prevention of cardiovascular disease and to increase the availability of rehabilitation for all people after a cardiological incident.

**Keywords:** cardiac rehabilitation, 6-minute walk test, diseases of civilization, hemodynamic, cardiovascular.

## Introduction

Cardiovascular diseases are currently classified as civilization diseases. The number of cases since the 20th century has dramatically increased. Currently, as many as 46% of all deaths in Poland are caused by diseases of the circulatory system [1]. In addition, it is the most common reason for hospitalization. The highest percentage of all certificates issued by the Social Insurance Institution for incapacity for work is caused by diseases of the cardiovascular system (23.4%). In Poland, about 1.1-1.5 million people suffer from coronary heart disease [2]. In the case of cardiovascular diseases factors related to lifestyle in up to 54% determine deaths of people [3]. The goals of secondary prevention relate to the prevention of relapse and reemission [4]. Systematic physical effort is aimed at reducing the risk of acute cardiac events and shortening the treatment time of incidents already occurring [5, 6].

In order to assess the tolerance of effort, as well as the effectiveness of the rehabilitation process, many tools are used, among others electrographic stress test and spiroergometric test. In the clinical setting, a six-minute walk test is commonly used - 6MWT (6 Minute Walk Test) [7]. The test is most often used to determine exercise tolerance in patients with respiratory diseases, and to determine the level of exercise in people with cardiovascular disease [8]. 6 MWT is one

of the methods of objective evaluation of the functional efficiency of the patient. It allows for a comprehensive assessment of the work of all organs and systems of the human body involved in performing physical activity (respiratory, cardiovascular, blood, peripheral circulation, neuromuscular units and muscle metabolism) [7]. In patients with chronic heart failure, this test has prognostic value regarding the severity of the disease and mortality, especially at distances below 300 m [9–11]. 6MWT in 1993 was recognized by the European Society of Cardiology Working Group as a test useful in a cardiological clinic [12]. Langenfeld et al. [13] used the march test to assess the performance of patients with pacemaker, compared its results with studies on the cycloergometer and treadmill, obtaining a good correlation of results.

*Aim of study.* The aim of the study is to assess the impact of cardiac rehabilitation according to the C model on exercise tolerance and hemodynamic indices in patients after a cardiac incident.

## Material and Methods

*Participants:* The research was carried out in the Department of Cardiac Rehabilitation in Szymbark. The study group consisted of 32 patients who, after physical examination at admission, were qualified for the preliminary assessment of physical fitness on the basis of 6MWT.

Characteristics of the studied group:

- 32 women aged:  $M = 77$  years,  $\delta \pm 6.8$
- Inclusion criteria: cardiac surgery (CABG, AVR), percutaneous coronary intervention (PCI)
- left ventricular ejection fraction ranging from 30% to 65% ( $M = 51\%$ ,  $\delta \pm 9.7$ )
- the BMI index was: 19 to 41 ( $M = 29$ ,  $\delta \pm 5.5$ )

*Research Design:* The test was carried out the day after the admission, according to current standards. Subsequently, the examined persons underwent a 28-day cycle of early cardiac rehabilitation according to the C model [14] (people with a metabolic rate below 5 MET). The day before the discharge, 6MWT was repeated.

6MWT was made on the corridor with a length of 30 m; the distance of the march was marked with posts, and on the route, every 3 meters there were distance markers. During the test, a stopwatch and a blood pressure gauge were used. Before starting the test, the subject rested in a sitting position for 10 minutes. Patients were advised not to make intense efforts 2 hours before the start of the test. At the same time, the respondents were instructed to walk their own pace during the test with the option of being released or stopped. The test consists in walking along the longest possible distance in the course of 6 minutes. The degree of patient fatigue, experienced just after the end of

the test, was also assessed. For this purpose, a subjective, modified Borga scale was used, in which 0 points means the feeling of “total lack of effort”, and 10 points means the feeling of “maximum effort”.

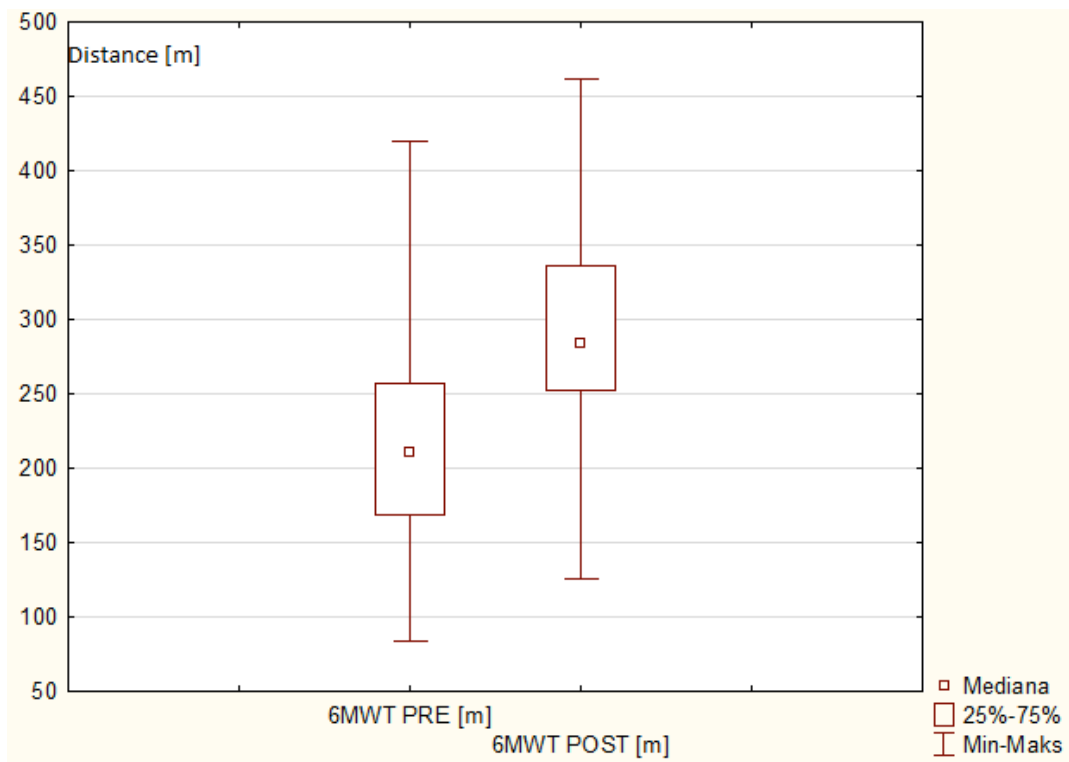
*Statistical Analysis:* Statistical analysis of the results was performed by means of: Wilcoxon matched pairs test and Kruksal-Wallis test. The level of statistical significance was assumed at  $p < 0.05$ .

### Results

The basic criterion for the 6MWT assessment is the length of the distance travelled within 6 minutes. In the study before the beginning of the rehabilitation cycle, the distance was from 84 to 420 meters - an average of 219,5 meters ( $\delta \pm 65.47$ ). However, in the study after completion of the rehabilitation cycle, the result was from 126 to 462 meters, on average 288 meters ( $\delta \pm 77.52$ ) (Table 1). The resulting difference in the distance covered was from 42 meters to 126 meters, on average 68.34 meters ( $\delta \pm 21.34$ ) and this value is statistically significant at  $p < 0.05$  (Table 2). The above results indicate the value of the conducted rehabilitation - despite a relatively short duration (4 weeks), a significant increase in efficiency and shaping the mechanisms responsible for adapting the body to the effort is evident. The characteristics of the results obtained

**Table 1.** 6MWT results before and after the rehabilitation cycle

Study:	Statistical indicators		Min.	Max.
	M	$\delta \pm$		
Distance 6MWT PRE	219,5	65,47	84	420
Distance 6MWT POST	288	77,52	126	462
Borg scale PRE	3,55	1,12	2	7
Borg scale POST	2,87	0,68	2	5



**Figure 1.** Distribution of results in 6MWT before and after a cycle of rehabilitation

**Table 2.** Differences in 6MWT and Borg scale before and after the rehabilitation cycle

Variable	M	$\delta \pm$	Significance (p) Wilcoxon test
Difference 6MWT [PRE-POST]	68,34	21,34	0,000001
Difference skali Borga [PRE-POST]	-0,75	0,68	0,00001

**Table 3.** 6MWT results before and after rehabilitation depending on the BMI value

Body mass index BMI [kg/m <sup>2</sup> ]	Medium difference 6MWT [m] (PRE-POST)		
	N	M	$\delta \pm$
BMI: 18.5 – 24.99 Normal range	10	68	21.61
BMI: 25.0–29.99 Overweight	9	70	48.85
BMI $\geq$ 30 Obesity	13	72	53.83
P value (Kruskal - Wallis test)	0 .85		

**Table 4.** Changes in haemodynamic indices 6MWT (before and after the rehabilitation cycle)

Study:	Statistical indicators		
	M	$\delta \pm$	Significance (Test t)
HR exercise PRE	82.22	12.99	0.91
HR exercise POST	82.41	11.23	
SBP exercise PRE	141.47	26.97	0.23
SBP exercise POST	147.06	22.18	
RPP exercise PRE	11645.63	2879.27	0.26
RPP exercise POST	12105.69	2443.50	

in 6MWT are presented in Fig. 1.

Each patient, both before the beginning of the rehabilitation cycle and after its completion, assessed the level of fatigue using the modified Borga scale. Before starting the rehabilitation, patients assessed their fatigue on average at 3.55 ( $\delta \pm 1.12$ ), and after rehabilitation, at 2.87 ( $\delta \pm 0.68$ ). The difference in the results is statistically significant at  $p < 0.05$  (Table 2).

The next aim of the analysis was to find the answer to the question: what is the level of efficiency in terms of the categories of patients with normal body weight, overweight and obesity. Analyzing the results obtained in 6MWT against the BMI body mass index no statistically significant differences were found (Table 3). Patients with normal body mass, overweight and obesity obtained similar results 6MWT ( $H = 0.85$ ).

One of the parameters describing the intensity of effort in 6MWT is the product of the maximum heart rate

(HR) and maximal systolic blood pressure (SBP), i.e. rate pressure product (RPP) [15]. This index correlates very well with the oxygen consumption of the heart muscle during dynamic exercise. Analyzing the data contained in Table 4, statistically insignificant differences between the results before and after the hemodynamic cycle were found ( $t = 0.23-0.91$ ), although higher blood pressure tolerance was observed at the end of the cycle, which may indicate directional adaptation mechanisms for effort. The study participants obtained statistically significant: increase in the distance in 6MWT with simultaneous lower heart rate and with less energy expenditure.

### Discussion

The distance covered in 6MWT predicts cardiovascular events in cardiac patients with similar accuracy as the MET value assessed during the exercise test. The addition of a simple to measure distance in 6MWT to traditional

risk factors improves the risk assessment in this group of patients [16]. The six-minute walk test is an easy test with simultaneous safety [17]. The obtained results indicate statistically significant increase in the distance obtained during 6MWT. Similar results were obtained by other authors [18, 19], which proves the effectiveness of the performed rehabilitation.

Convergent results with other authors were also demonstrated by analyzing the distance obtained in relation to the BMI index. Differences between individual BMI penalties are not statistically significant. It should also be noted that many scientific reports indicate postoperative complications in cardiac patients [20] and longer hospital stays [21]. Excessive body weight may also be a contraindication for performing cardiac surgery [22]. Hemodynamic indicators also did not change statistically significant with simultaneous increase in the distance length in 6MWT. The adaptive changes of the circulatory system to increased physical effort have also been described earlier in the literature [23, 24].

The 6-minute walk test is a test based on simple equipment and minimal costs. The test is easy to understand and be performed by older people. In addition, its advantage is safety, because the risk is not greater than during moderate physical activity.

Currently, there are no statistical standards for the Polish population. According to American authors,

overcoming a distance of less than 320 m means finding yourself in the so-called The “risk zone”, and sets a very low level of physical fitness [25]. The mean initial distance of the studied group was 219,5 m, while the final one was 288 m, which may mean an increase in efficiency under the influence of cardiac rehabilitation, which reduces the risk of another cardiovascular event.

### Conclusions

1. As a result of a 28-day cardiac rehabilitation, a statistically significant improvement in exercise tolerance was obtained, expressed in the distance increase in the 6MWT test and the reduction in the average number of points in the Borga scale.
2. The BMI index is not a factor significantly influencing the change of exercise tolerance as well as the subjective assessment of patient fatigue
3. The results of this study indicate the urgent need to educate patients in the prevention and prevention of cardiovascular disease and to increase the availability of rehabilitation for all people after a cardiological incident.

### Conflict of interests

The authors declare that there is no conflict of interests.

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