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Smoking as a factor influencing the rehabilitation process after cardiac surgery

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Abstract

Introduction: Comprehensive cardiac rehabilitation is a standard therapeutic procedure in patients after cardiac surgery. Its course depends on many factors. One of them is smoking. Exposure of the body to tobacco compounds reduces the supply of oxygen to the organs, which in turn has a damaging effect on the heart tissue.

Objective: The aim of this study is to determine the effect of smoking on the effectiveness of rehabilitation in patients after cardiac surgery.

Materials and methods: The research was carried out at the Department of Cardiac Surgery, SPSK 2, Pomeranian Medical University in Szczecin. The research was conducted among 35 patients, divided into 3 groups. The first group of 9 people (26%) were non-smokers. The second group was assigned to 11 people (31%) who were heavy smokers. The third group consisted of 15 people (43%) who had been addicted to cigarettes in the past. The research tool used in the study was the 6-minute walk test.

Results: Non-smokers achieved a greater improvement in the 6-minute test score compared to the group of smokers and ex-smokers, whose mean score was lower by 39.17 m (± 100.80) and 85.74 m (± 80.56), respectively.

Conclusion: Smoking may have an impact on the exercise capacity and exercise tolerance in patients after cardiac surgery.

Key words: rehabilitation; cardiology; walk test

Introduction

Comprehensive cardiac rehabilitation is the basic procedure of therapeutic management in patients after cardiac surgery [1]. It mainly includes an organized exercise program, as well as educational interventions aimed at behavior modification, which is conducive to the improvement of eating habits and lifestyle [2,3]. Cardiac rehabilitation activities focus mainly on reducing the risk of secondary coronary events, improving the efficiency, functional capacity and quality of life of patients [4,5]. The effectiveness of cardiac rehabilitation is illustrated by a 31% decrease in cardiac rehospitalisation within a year, as well as a 26% decrease in the mortality rate over a 3-year period [2,6]. Its course depends on many factors. One of them is smoking. It is estimated that in the 20th century around the world 100 million people died of tobacco-related diseases. Currently, both the US and Europe are experiencing a decline in smoking rates among the general population. Another correlation is observed among cardiac patients, whose percentage has been consistently at the level of 20% for 20 years [2,7]. Exposure to tobacco compounds leads to a potentially reduced supply of oxygen to organs, which in turn has damaging effects on heart tissue, causing a complex cascade of inflammation, endothelial damage, dysfunction and cell

death. Smoking cigarettes, by affecting the microcirculation, may also cause functional systolic disorders of the heart [8]. Smoking after a cardiac incident is a strong factor predisposing to future morbidity, as well as adverse cardiac events and a higher mortality rate [2]. Despite the benefits of comprehensive cardiac rehabilitation, more than 60% of smokers hospitalized due to a cardiac event relapse [9].

The aim of this study is to determine the effect of smoking on the effectiveness of rehabilitation in patients after cardiac surgery.

Material and methods

The research was carried out at the Department of Cardiac Surgery, SPSK 2, Pomeranian Medical University in Szczecin. The study included patients who underwent cardiac surgery and then qualified for the second stage of inpatient cardiac rehabilitation from March to May 2019. The research was carried out among 35 patients - 6 women (17%) and 29 men (83%), divided into 3 groups. The first group of 9 people (26%) were non-smokers. 11 people (31%) who were heavy smokers were assigned to the second group. The third group consisted of 15 people (43%) who had been addicted to cigarettes in the past. The vast majority of patients were over 60 years of age (68.57%). People over 40 accounted for 28.57% of the group. A proprietary questionnaire containing questions was used for the study, allowing for obtaining such information on lifestyle, especially smoking. Patient data, such as diagnosis or comorbidities was obtained on the basis of medical records. The research tool used in the study was a 6-minute walk test, used to assess the physical capacity of patients.

6-minutes walk test

In order to prepare for the 6-minute walk test, the patient takes a sitting position in which he spends a period of 10 minutes. After the rest, on the signal of the physiotherapist, the patient starts walking along the corridor of the ward, where the starting point and the place of return have been marked earlier. The test lasts 6 minutes, during which the patient moves at his own, free pace. The therapist counts the distance traveled by the patient in meters. Additionally, the patient's blood pressure and heart rate are measured immediately before and after the test. The occurrence of chest pain, dyspnoea, pale face or balance disorders during the test is tantamount to its discontinuation and repeated when the clinical state is stabilized. The above-described test is performed in each patient twice: on the first day on admission to the rehabilitation department and on the last day on discharge. The test results are then compared and the difference obtained is a measure of the improvement over time.

Cardiac rehabilitation

Comprehensive cardiac rehabilitation is an interdisciplinary form of patient assistance. It is carried out in a stationary form, to which patients after cardiac surgery are qualified. The period of stay of patients in the ward is from 3 to 4 weeks, during which the patients undergo various procedures aimed at restoring their fitness. Manual patting is one of the many activities that are carried out during rehabilitation. On the ward, patients perform regular, hourly breathing exercises using the Triflo device and anticoagulant exercises. Moreover, patients participate in daily group gymnastics lasting half an hour, during which they perform general fitness exercises. Resistance active exercises are recommended to patients every other day. The load is adjusted individually to the patient's condition. An inherent element of cardiac rehabilitation is also training on a cycloergometer. An appropriate training program is selected for each patient, based on the parameters obtained during the stress test carried out on the first day of stay at the ward. In addition, patients are advised to walk and exercise their lower limbs on the rotor in their free time.

Statistical analysis

The statistical analysis was performed using the Statistica 13 licensed program (StatSoft, Inc. Tulsa, OK, USA). The normality of quantitative data distribution was assessed using the Shapiro-Wilk test. Quantitative data were presented as mean, SD and median and evaluated using the Mann-Whitney U test. The p-value of ≤ 0.05 was regarded as statistically significant.

Ethical part

The study was performed in accordance with the Declaration of Helsinki. It received a waiver from the Bioethical Committee of the Pomeranian Medical University (decision no. KB-0012/16/01/2019).

Results

Data analysis showed that non-smokers achieved a greater improvement in the 6-minute test score compared to the other groups. While the difference in the test results before and after the rehabilitation cycle in non-smoking patients was 186.67 m (± 96.25), the group of smokers and smokers in the past showed the same relationship at the level of 147.5 m, respectively (± 100.80) and 100.933 m (± 80.56). Detailed intergroup results along with the

analysis of systolic and diastolic pressure, as well as the heart rate measured before and after comprehensive cardiac rehabilitation are presented in Table 1.

Table 1. Results of the 6-minute walk test in non-smokers, smokers and smokers in the past with blood pressure and heart rate measurements

		No-smoking (n=9)	**Smoking (n=11)**	**Smoking in the past (n=15)**	p
		mean±SD; Me	mean±SD; Me	mean±SD; Me	
First 6-MWT distance [m]		**241.67±135.18; 255.00**	**339.18±89.84; 330.00**	**301.20±117.05; 341.00**	**0.259**
Systolic pressure	before	121.11±17.77; 119.00	123.18±13.83; 128.00	130.00±13.07; 137.50	0.234
	after	134.89±17.47; 136.00	132.64±15.77; 135.00	142.08±20.43; 140.00	0.630
Difference of systolic pressure		13.78±7.12; 16.00	9.45±10.32; 14.00	12.08±16.23; 6.50	0.522
Diastolic pressure	before	71.89±13.54; 66.00	73.45±8.26; 73.00	75.33±8.79; 75.00	0.596
	after	74.22±15.59; 81.00	77.82±12.21; 74.00	80.92±9.42; 80.00	0.714
Difference of diastolic pressure		2.33±10.72; 2.00	4.36±6.50; 3.00	5.92±10.13; 3.50	0.649
Heart rate	before	76.56±11.49; 75.00	76.64±10.00; 80.00	79.25±13.36; 83.00	0.691
	after	81.00±14.71; 80.00	85.36±13.64; 87.00	89.07±12.57; 91.00	0.373
Difference of heart rate		4.44±7.75; 5.00	8.73±7.85; 4.00	11.17±17.10; 6.00	0.766
Last 6-MWT distance [m]		**381.50±172.26; 434.50**	**487.60±133,97; 526.00**	**402.13±149.41; 438.00**	**0.264**
Systolic pressure	before	113.13±16.43; 112.50	113.60±9.12; 112.50	131.27±10.73; 134.00	0.002
	after	129.63±25.86; 138.50	144.90±22.04; 154.00	153.80±14.70; 150.00	0.091
Difference of systolic pressure		16.50±20.65; 18.50	31.30±21.67; 35.50	22.53±11.27; 25.00	0.165
Diastolic pressure	before	66.63±8.48; 67.50	70.10±8.48; 70.50	72.60±11.28; 72.00	0.401
	after	68.71±12.18; 70.00	80.70±13.94; 78.00	78.33±14.30; 82.00	0.201
Difference of diastolic		2.29±8.75; 1.00	10.60±11.33; 8.00	5.73±6.03; 5.00	0.311

pressure					
Heart rate	before	74.38±7.84; 76.50	72.30±11.71; 66.50	72.93±8.65; 71.00	0.623
	after	83.25±12.04; 82.50	81.40±12.73; 85.00	85.60±16.44; 82.00	0.979
Difference of heart rate		8.88±10.80; 9.50	9.10±9.84; 6.50	12.67±9.82; 10.00	0.647
Difference of 6-MWT distance [m]		**186.67±96.25; 156.50**	**147.50±100.80; 116.50**	**100.93±80.56; 88.00**	**0.146**

Legend: n-number of patients, p-statistical significance, SD-standard deviation, Me-median, 6-MWT-6 Minute Walk Test, CKD - chronic kidney disease

Moreover, in those who smoked in the past during the 6-minute test, higher values of systolic blood pressure were observed before rehabilitation ($p = 0.002$) and after rehabilitation ($p = 0.091$). Data analysis also showed four times higher differences in diastolic blood pressure after rehabilitation in smokers compared to non-smokers.

Discussion

The study investigated the influence of smoking on the effectiveness of the rehabilitation process in patients after cardiac surgery.

The research tool used in the study was a 6-minute walk test with heart rate and pressure measurements. It allowed for a safe and simple way to assess the physical capacity of patients. Thanks to the repeatability of the test, it was also possible to measure the progress in subsequent stages of rehabilitation [10].

According to our study, it was found that non-smokers achieved a better result in the test after the completion of rehabilitation, reaching the difference in the results of the test performed before and after the rehabilitation cycle at the level of 186.67 m (± 96.25), while the group of smokers and smokers in the past, lower by 39.17 m (± 100.80) and 85.737 m (± 80.56), respectively.

Najem and co-researchers conducted a study to determine the correlation between the number of steps taken during the day and smoking in patients during outpatient cardiac rehabilitation. 192 patients were included in the study. The following parameters were assessed: maximum working capacity and heart rate, body mass index (BMI), New York Heart Association (NYHA) class, ejection fraction (EF), state of coronary artery disease, beta-blockers, age, gender, smoking, and laboratory parameters. Each patient also performed an exercise test using a bicycle ergometer. Based on the data collected, the correlation with the

daily step count was calculated. Comprehensive cardiac rehabilitation lasted 3 weeks, during which patients were subjected to exercises aimed at strengthening endurance, strength and coordination. Additionally, sports games and outdoor activities such as hiking and Nordic walking tours were organized. The results showed that the number of steps taken per day was significantly reduced in smokers and ex-smokers. Non-smokers achieved an average score of 986 steps more than smokers and 1125.36 steps more than former smokers [1]. The presented results, as in this study, prove that the physical fitness of cardiac patients is higher in non-smokers compared to smokers.

Gardner and co-researchers conducted a study to compare the changes in pain associated with claudication after a rehabilitation program in smokers and non-smokers in patients with peripheral arterial disease limited by intermittent claudication. 39 smokers and 46 non-smokers were included in the study. The rehabilitation program lasted six months and included intermittent treadmill walking 3 days a week, during which the walking intensity was increased along with the duration of the training. Each of the participants of the study was also subjected to measurements that were taken before and after the rehabilitation cycle. Statistical analysis showed that both smokers and non-smokers achieved a similar improvement in exercise parameters. Moreover, rehabilitation also contributed to the improvement of daily physical activity, peripheral circulation and the quality of life of patients. According to the results, it was found that despite the relatively low initial physical fitness of smokers, their ability to regain the lost functionality is not limited to obtaining similar results to that of non-smokers [11]. The presented results differ from our own research, which may result from different disease entities.

In their study, North and co-researchers assessed the effects of smoking on physical and cognitive performance. The study used an observational and genetic approach, and the entire project involved 26,692 people of European descent with an average age of 50-79 years. According to the analysis, it was found that current and past smoking was associated with poorer physical and cognitive abilities. Smokers showed a slower walking speed compared to those who never smoked, which confirmed the hypothesis that smoking is harmful to physical and cognitive abilities [12]. The collected data in this study refer to similar conclusions shown in the own study.

In their study, Hendriks and co-researchers assessed the effects of smoking on the structure and function of the heart muscle. The study involved 102 smokers who were matched for gender, body surface area and age, with an average of 56 years. Numerous imaging studies were performed to collect the data, and a final analysis of the data showed

that smoking was associated with an increased end-systolic volume and a decreased heart stroke fraction. Consistent with the results, the observed changes were higher in daily smokers compared to occasional smokers [8]. The presented results confirm the adverse effect of smoking on the work of the heart, and thus physical performance.

Sato and co-researchers in their study, which aimed to determine the effect of exercise training on endothelial function in smokers and non-smokers with type 2 diabetes, studied 44 patients. 27 participants who had never smoked in their lives. The rest of the respondents formed a group of smokers. Each patient underwent exercises that he performed at home. The research tool used to assess endothelial function was the bone-brachial pressure index (ABI). Measurements were taken at the start of the study and after a 3-month period. According to the statistical analysis, the non-smoking group had a more significant improvement in ABI after 3 months of home training ($P < 0.01$). Research shows that smoking has a negative impact on the function of the endothelium, which plays an important role in the prevention of cardiovascular diseases [13].

The limitation of this study was the small size of the study groups. In the course of further research, the number of patients should be expanded, thanks to the cooperation with other centers where cardiosurgical operations are performed.

Conclusion

Comprehensive cardiac rehabilitation has a positive effect on the improvement of physical performance parameters in both smoking and non-smoking patients. However, the progress of rehabilitation was noted to a greater extent in non-smoking patients, which proves that tobacco dependence has an impact on physical performance and exercise tolerance in patients after cardiac surgery.

Bibliografia

1. Najem SA, Groll A, Schmermund A, Nowak B, Voigtländer T, Kaltenbach U, et. al. Walking activity during ambulant cardiac rehabilitation is related to maximum working capacity, age, and smoking behavior. *Vasc Health Risk Manag.* 2018; 9;14: 361-369. doi: 10.2147/VHRM.S179798

2. Gaalema DE, Cutler AY, Higgins ST, Ades PA. Smoking and cardiac rehabilitation participation: Associations with referral, attendance and adherence. *Prev Med.* 2015; 80: 67-74. doi: 10.1016/j.ypmed.2015.04.009

3. Sjölin I, Bäck M, Nilsson L, Schiopu A, Leosdottir M. Association between attending exercise-based cardiac rehabilitation and cardiovascular risk factors at one-year post myocardial infarction. *PLoS One.* 2020; 11;15(5):e0232772. doi: 10.1371/journal.pone.0232772

4. Kachur S, Chongthammakun V, Lavie CJ, De Schutter A, Arena R, Milani RV, et. al. Impact of cardiac rehabilitation and exercise training programs in coronary heart disease. *Prog Cardiovasc Dis.* 2017; 60(1): 103-114. doi: 10.1016/j.pcad.2017.07.002

5. Kubilius R, Jasiukevičienė L, Grižas V, Kubilienė L, Jakubsevičienė E, Vasiliauskas D. The impact of complex cardiac rehabilitation on manifestation of risk factors in patients with coronary heart disease. *Medicina (Kaunas).* 2012; 48(3): 166-73. doi: 10.3390/medicina48030024

6. Riley H, Headley S, Lindenauer PK, Goff S, Szalai H, Gaalema DE, et. al. Patient Perception of How Smoking Status Influences Cardiac Rehabilitation Attendance After an Acute Cardiac Hospitalization. *J Cardiopulm Rehabil Prev.* 2019; 39(3): 181-186. doi: 10.1097/HCR.0000000000000366

7. White WB. Smoking-related morbidity and mortality in the cardiovascular setting. *Prev Cardiol.* 2007; 10(2 Suppl 1):1-4. doi: 10.1111/j.1520-037x.2007.06050.x

8. Hendriks T, van Dijk R, Alsabaan NA, van der Harst P. Active Tobacco Smoking Impairs Cardiac Systolic Function. *Sci Rep.* 2020; 20;10(1):6608. doi: 10.1038/s41598-020-63509-3

9. Riley H, Headley S, Winter C, Mazur S, Gaalema DE, Goff S, et. al. Effect of Smoking Status on Exercise Perception and Intentions for Cardiac Rehabilitation Enrollment Among Patients Hospitalized With an Acute Cardiac Condition. *J Cardiopulm Rehabil Prev.* 2018; 38(5): 286-290. doi: 10.1097/HCR.0000000000000288

10. Uszko-Lencer NHMK, Mesquita R, Janssen E, et. al. Reliability, construct validity and determinants of 6-minute walk test performance in patients with chronic heart failure. Int J Cardiol. 2017; 240: 285-290. doi: 10.1016/j.ijcard.2017.02.109

11. Gardner AW, Killewich LA, Montgomery PS, Katzel LI. Response to exercise rehabilitation in smoking and nonsmoking patients with intermittent claudication. *J Vasc Surg.* 2004; 39(3): 531-8. doi: 10.1016/j.jvs.2003.08.037

12. North TL, Palmer TM, Lewis SJ, Cooper R, Power C, Pattie A, et. al. Effect of smoking on physical and cognitive capability in later life: a multicohort study using observational and genetic approaches. *BMJ Open*. 2015; 15;5(12):e008393. doi: 10.1136/bmjopen-2015-008393

13. Sato S, Nakayama N, Otsuki S, Tanaka S, Nakamura H, Koshiyama H, et. al. Smoking counteracts the favorable effect of exercise training on endothelial function in patients with type 2 diabetes. *Jpn Clin Med*. 2013; 9;4:15-9. doi: 10.4137/JCM.S11152