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Impact of exercise on the activity of the autonomic nervous system among patients with acute myocardial infarction: A case-control study

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Abstract

Considering the diversity of proposed programs, various studies yielded different findings in this regard. The aim of the present study was to evaluate different types of exercise as a method of rehabilitation after acute myocardial infarction on the activity of the autonomic nervous system.

Methods

In this case-control and prospective study, a total of 60 patients with the first acute myocardial infarction were randomly selected. Controlled treadmill exercise was performed for 15-20 minutes three days a week for three consecutive weeks and then 5 weeks of home-based exercise, including 30-min walking 3 times a week based on heart rate in the two groups (n= 20 people per group). The control group performed home-based exercise for 8 weeks.

Results

In A, B, and control groups, the mean changes in SDNN (28.30, 29.28, and 15.40, respectively), LF (57.10, 198.8 and -47.70, respectively), HF (-11.70, 120.60, and -58.10, respectively) TP (192.80, 1251.20, and-0.225, respectively), pNN50 (0.80, 4.60, and -0.40, respectively), SDNN index (90.20, 13.4, and -0.20, respectively), and SDANN (80.80, 22.24, and 16.20, respectively) were significantly higher in the intervention groups, but there was no statistically significant difference between the two intervention groups (A and B).

Conclusion

The present study showed that in-hospital exercise-based rehabilitation can have a more favorable effect on the activity of the autonomic nervous system after acute myocardial infarction. It seems necessary to establish rehabilitation centers in hospitals, because uncontrolled home-based rehabilitation is probably less effective for various reasons, such as lack of strict adherence to the instructions.

Keywords

Rehabilitation, Exercise, Acute myocardial infarction, Activity of autonomic nervous system, Heart rate variability

Imprint

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Introduction

Cardiovascular diseases are the leading cause of death among people over 30 years of age in the world, and acute myocardial infarction (AMI) accounts for almost 10% of these deaths1. Daily lifestyle and exercise have been shown to be a risk factor for cardiovascular diseases, therefore, exercise are recommended both at workplace and during leisure time 2,3. Changes in cardiac biomarker values, along with at least one of the following: ischemic symptoms, abnormal electrocardiogram changes, or abnormalities in the structure or wall motion abnormalities detected by imaging techniques, are considered as criteria used to diagnose AMI in a clinical context 4. According to the results of some studies, patients with AMI demonstrate increased sympathetic activity in the autonomic nervous system (ANS), which predisposes them to fatal ventricular arrhythmias and sudden death 5. HRV is a relatively simple, non-invasive, reproducible, and low-cost method for determining cardiac autonomic regulation. HRV measures variations between normal heart rate intervals or R-wave peaks (RR or NN intervals) 6. Changes in heart rate and R-R interval are measured to assess sympathetic and parasympathetic changes in the sinus group and diagnose patients at risk for fatal cardiovascular events. Cardiac rehabilitation can lead to improvement of these unpleasant changes in patients 5, 7, 8. Time domain indices include standard deviation of all NN intervals (SDNN), mean standard deviation of NN intervals calculated for each 5-minute segment (SDNN), and percentage of successive RR intervals that differ by more than 50 ms (pNN50). Frequency domain indices include low frequency peak (LF) and high frequency peak (HF), which are expressed as millisecond squares or normalized units (nu) 5, 9. It has been shown that time domain variables are generally interrelated and are affected to varying degrees by parasympathetic block. Accordingly, these are indices of parasympathetic cardiac regulation. However, the HF peak is the most important HRV index of vagal efferent activity (vagal regulation of heart rate). Although there is no complete agreement on the interpretation of the LF component, this parameter is generally considered as an index of both sympathetic and parasympathetic regulation 10, 11, 12. One of the most important results of exercise after myocardial infarction (MI) is a decrease in the activity of the sympathetic nervous system, which changes the sympathetic-parasympathetic balance and increases the activity of the parasympathetic system by reducing the sympathetic dominance. Diastolic dysfunction is an important factor as a result of complications from MI and unlike systolic function, no treatment or intervention has led to a significant improvement in the diastolic function. Data from animal studies and patients with diastolic heart failure show that exercise can have a positive effect on diastolic function parameters 13. Other factors (other than HRV), which predict the occurrence of post-MI arrhythmia and increased subsequent mortality include heart rate turbulence, change in QT size, T-wave alternation, and baroreceptor sensitivity (BRS) index, which do not have many clinical aspects 14,15,16. So far, there have been few articles on the effect of various types of exercise on the activity of ANS among patients with AMI. The aim of the present study was to evaluate the effect of different types of exercise on the activity of ANS among patients with AMI by measuring HRV indices.

Materials and methods

This case-control and prospective study was performed on 60 patients with acute ST elevation in 2019. Patients underwent initial examination after initial recovery and when they were able to walk 10 days following MI. Inclusion criteria included a normal sinus rhythm, consent to participate in the study, left ventricular ejection fraction (LVEF 30-40%), exercise tolerance in the initial test. Exclusion criteria included patients aged over 75 years, systolic blood pressure above 200 mm Hg or diastolic blood pressure above 100 mm Hg, ventricular block / acute systemic disease, unstable angina / peripheral neuropathy (according to medical records and evidence), chest pain during exercises, valvular heart disease requiring surgery, severe renal failure (serum creatinine>2.5 mg / dL), diabetes, and thyroid disease. Pre-study assessments (first visit) included heart murmurs, 12-lead ECG, eco-doppler, CBC, and measurements of serum Na, K, BUN, and CR levels. Information such as age, sex, location of MI, medications, and medical history in patients were also recorded. Patients underwent a 24-hour holter and HRV indices were recorded. Then, patients were divided into two groups of 20 and 40 of people based on their desire to be in the hospital and do exercises or the desire to do these exercises at home. The 40-person group was randomly divided into A and B groups (n= 20 people per group). In the intervention group, the exercises included 5-10-min body warm-up and treadmill-based cooling and endurance exercises for the same period, which included complete control of the ECG and heart rate for 15 to 20 minutes, three days a week, for 3 consecutive weeks based on Karvonen formula. Later on, home-based exercises (30-min walking) were performed 3 times a week for 5 weeks. These patients were divided into two groups, i.e. group A (40-50% of maximum heart rate) and group B (60-80% of maximum heart rate). All patients referred for re-examination one week after exercise, underwent a 24-hour holter, and HRV indices were recorded again. Finally, the obtained data were compared between 3 groups in a pairwise comparison manner. This study has been approved by the Ethics Committee of Urmia University of Medical Sciences with the Ethics Code of IR.UMSA.REC.1393.5. Written consent was obtained from all participants prior to the study. Participants were assured that their information would be kept confidential. STROBE checklist was used to report the study 19. Data analysis was carried out using descriptive (mean, percentage, frequency) and analytical (chi-square) tests in SPSS ver. P-value< 0.05 was considered as the significance level.

Results

A total of 60 patients with AMI were studied in 3 groups of 20 people. Mean age of participants was 54.41 (29-73). Most of participants in all groups were male (n=50, 90%), the most prevalent comorbidity was

Table 1
Demographic characteristics of participants and baseline variables in three groups

Group / Variables	Group A (N=20) N (%)	Group B (N=20) N (%)	Control group (N=20) N (%)
Gender Male Female	 16(80) 4(20)	 16(80) 4(20)	 18(90) 2(10)
Age Mean±SD (Range)	 54.60±13.39 (29-73)	 53.70±4.52 (46-59)	 54.3±6 (48-63)
Comorbidity HTN Hyperlipidemia Smoking	 3(30) 0(0) 8(40)	 2(10) 4(20) 6(30)	 0(0) 0(0) 10(50)
Anatomical location of occurred MI			
Anteroseptal	10(50)	8(40)	6(30)
Lateral	2(10)	-	-
Inferior	4(20)	6(30)	4(20)
وسیع	2(10)	-	2(10)
Anteroseptal and Inferior	-	-	4(20)
Posteroinferior right ventricular and Inferior	2(10) - -	- 2(10) 2(10)	- 4(20) -
Lateral posterior inferior	-	2(10)	-
Type of intervention			
Streptokinase PCI	10(50%) 10(50%)	2(10%) 18(90%)	12(60%) 8(40%)
Type of drugs			
ACET, Beta blocker, Astatin, and Aspirin	8(40%)	4(20%)	4(20%)
ACE inhibitor, Beta blocker, Astatin, and Aspirin, Spironolactone	12(60%)	16(80%)	16(80%)

Table 2
Baseline and final values of HRV parameters in three groups0

Group / Variables	Group A Range Mean±SD	Group B Range Mean±SD	Control group Range Mean±SD
SDNN(ms)			
Before	(49-125) 94.30±21.40	(38-140) 80.10±28.34	(43-112) 82.10±23.93
After	(80-194) 122.60±33.50	(48-161) 109.50±33.93	(50-144) 97.50±30.15
LF(ms^2)			
Before	(59-1059) 388.10±308.24	(68-664) 252.90±188.56	(31-865) 337.10±258.50
After	(60-969) 445.20±75.19	(23-1826) 451.70±527.54	(50-648) 289.40±239.28
HF(ms^2)			
Before	(10-528) 126.60±151.88	(17-185) 85.90±64.26	(26-512) 144±142.43
After	(12-204) 144.90±73.58	(23-1130) 206.50±326.93	(24-185) 85.90±57.43
TP			
Before	(400-3714) 2036.60±1169.99	(289-2557) 1356.10±813.56	(203-4492) 1791.40±1168.97
After	(323-5272) 2229.40±1316.24	(126-10029) 2607.30±2789.50	(200-3171) 1566.40±1169.07
PNN50 (%)			
Before	(0-12) 4.50±4.48	(0-7) 3.40±2.60	(0-6) 2.30±2
After	(0-19) 5.30±6.04	(0-37) 8±11.38	(0-7) 1.90±2.31
SDNN index (ms)			
Before	(18-63) 42.80±14.40	(19-49) 35.20±11.12	(15-67) 40.50±13.81
After	(20-74) 47±15.18	(26-104) 49.10±21.67	(25-59) 40.30±10.63
SDANN (ms)			
Before	(44-130) 83.80±22.62	(27-137) 68.70±28.94	(30-99) 68.90±21.45
After	(64-175) 108.60±34.70	(39-138) 91.50±35.91	(35-125) 85.10±29.06
LF/HF (%)			
Before	(2.01-7.80) 4.44±2.05	(0.47-9.72) 3.99±2.47	(0.06-7.52) 4.29±2.71
After	(2.18-7.84) 4.41±1.73	(0.50-7.61) 3.20±2.10	(0.27-8.64) 4.51±3.11

Table 3
Changes in baseline and final values of HRV parameters in three groups

Variables	Group A (N=20)	Group B (N=20)	Control group (N=20)	Value P
SDNN(ms)	28.02±28.30	5.53±29.40	34.13±15.40	0.03
LF(ms2)	165.45±57.10	5.53±198.80	235.63±-47.70	0.03
HF	129.56±-11.70	5.53±120.60	111.94±-58.10	0.02
TP	1319.78±192.80	234.16±1251.20	1253.3±225	0.03
PNN50	3.61±0.80	10.86±4.60	2.56±-0.40	0.05
SDNN index	14.02±4.20	17.94±13.90	14.32±-0.20	0.02
SDANN	23.33±24.80	33.37±22.80	33.26±16.20	0.04
LF/HF	1.65±-0.03	2.08±-0.79	2.98±0.21	0.36

HTN. The most common location of MI in all patients was Anteroseptal. Patient characteristics and baseline variables of the three groups are summarized in Table 1. The mean HRV parameters of baseline and final values in three groups are summarized in Table 2 (Table 2).

Results of one-way ANOVA test showed a statistically significant difference between the three groups in all cases except for LF / HF. Tukey post hoc test was used to compare the two groups in a pairwise manner and the results showed a statistically significant difference between both A and control (P = 0.03) groups and B and control (P = 0.04) groups in terms of mean changes in SDNN. There was a statistically significant difference only between the B and control groups in terms of mean changes in LF (P =0.02). There was no statistically significant difference between A and control groups in this regard (P = 0.46). There was a statistically significant difference only between the B and control groups in terms of mean changes in HF (P = 0.02). There was no statistically significant difference between the A and control groups in this regard (P = 0.75). There was a statistically significant difference only between the B and control groups in terms of mean changes in TP (P = 0.02). There was no statistically significant difference between A and control groups in this regard (P = 0.72). There was a statistically significant difference only between the B and control groups in terms of mean changes in pNN50 values (p <0.001). There was no statistically significant difference between A and control groups in this regard (p = 0.84). There was a statistically significant difference only between the B and control groups in terms of mean changes in SDNN (p = 0.02). There was no statistically significant difference between A and control groups in this regard (p = 0.65). There was a statistically significant difference between both A and control groups (p = 0.02) and B and control groups (p = 0.02) in terms of mean changes in SDNN. There was no statistically significant difference between the A and B groups terms of mean changes in of the above-mentioned indices (p=0.99, p= 0.25, p= 0.10, p= 0.13, p= 0.19, p=0.13, and p=0.98, respectively). The mean changes of HRV parameters in the three groups are summarized and compared in Table 3 (Table 3).

Discussion

Heart rate variability (HRV) refers to the continuous changes in heart rate that depend on the continuous modulation of the sympathetic and parasympathetic branches of the autonomic nervous system. HRV is effective as a predictor of post-MI risk and an early warning sign of diabetic neuropathy and is currently a useful risk classification tool in cardiology after admission and discharge. Recent evidence suggests that HRV analysis may predict complications even among patients undergoing heart surgery 17, 18. The present study investigated the effect of different types of exercise on the activity of ANS among patients with AMI based on HRV indices. HF peak is the most important HRV index of vagal efferent activity (vagal regulation of heart rate). Although there is no complete agreement on the interpretation of the LF component, this parameter is generally considered as an index of both sympathetic and parasympathetic regulation. The present study demonstrated that both protocol A (in terms of SDNN and SDANN variables) and protocol B (in terms of all studied protocols except (LF / HF)) had more optimal rehabilitation outcomes compared to the control group (home-based exercises). So far, some studies have investigated the effect of exercise-based rehabilitation on impaired autonomic function in patients with coronary artery disease and MI. Kleiger et al., showed the prognosis of this group of patients in cases with SDNN values below 50 ms 5. In another study, however, La Rovere et al. reported a 70-second cut-off point as a predictor of 1- and 2-year mortality rate after MI (19). As noted earlier, previous studies showed that exercise activity can have positive effects on patients with MI. Kasargod Prabhakar and Stewart reported that cardiovascular disease mortality rates were lower among people who perform moderate-intensity exercises on a regular basis than those who exercised less frequently or did not exercise at all. However, more intense exercises may lead a relatively lower reduction in mortality rate and may even increase the risk of mortality. A meta-analysis of rehabilitation experiments in the Kasargod Prabhakar's and Stewart's study showed lower mortality among people who performed controlled exercises, which is consistent with the present study 20. Consistent with the present study, some studies have shown that exercises significantly improve HRV parameters in patients with MI. Consistent with the present study, Fujimoto et al. showed a significant increase in mean SDNN, SDANN and HF after exercise 14. Iellamo et al. 10, Stahle et al. 21, Tsai et al. 22, and Malfatto et al. 23 also reported an average increase in SDNN, SDANN and HF after exercise, which is consistent with the present study. Results of previous studies were inconsistent with the present study regarding some parameters, especially between B and control groups). Different reasons can be used to explain the differences in the results of studies, including low sample size, different inclusion and exclusion criteria for different groups in terms of cardiac status, different study times in terms of interval between inset of MI and exercise, lack of information about the size and location of MI, and lack of information about other potential interfering factors such as diet status and other physical activity. Besides, the use of different exercise protocols and different ways of recording HRV parameters may also be effective in this regard. The same different findings between A and B groups compared to the control group also confirm that the parameters involved in the regulation of exercise activities are one of the most important factors in obtaining different results in various studies.

In this study, patients were divided into two groups based on their exercise capacity. That is, the exercises were performed up to 40-50% of the maximum heart rate in one group and 60-80% of the heart rate in the other group. Although there was no statistically significant difference between the two groups, HRV indices showed better improvement in the second group. According to the results, it seems that establishment of in-hospital rehabilitation centers in patients after AMI is of high importance considering its positive effect on the autonomic system.

Limitations

It seems that future studies with a larger sample size can help to achieve more definite results in this field. In addition to the sample size, the present study has other limitations, such as not using a non-home-based exercise group. If a non-home-based exercise group w is used in future studies, a more comprehensive and complete conclusion can be achieved.

Conclusion

The present study showed that in-hospital exercise-based cardiac rehabilitation can have a more favorable effect on the activity of ANS after AMI as compared to home-based exercise. Therefore, it seems necessary to establish rehabilitation centers in hospitals, because uncontrolled home-based rehabilitation is probably less effective for various reasons, such as patients' lack of strict adherence.

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Statement on ethical issues
Research involving people and/or animals is in full compliance with current national and international ethical standards.

Conflict of interest
None declared.

Author contributions
The authors read the ICMJE criteria for authorship and approved the final manuscript.

Ethics approval
This study has been approved by the Ethics Committee of Urmia University of Medical Sciences with the Ethics Code of IR.UMSA.REC.1393.5. Written consent was obtained from all participants prior to the study. Participants were assured that their information would be kept confidential. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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