ARTYKUŁ ORYGINALNY / *ORIGINAL ARTICLE*

# Effect of various forms of physical training on the autonomic nervous system activity in patients with acute myocardial infarction

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**Abstract**

**Background:** A shift in the dynamic autonomic nervous system (ANS) balance towards sympathetic activity in patients with acute myocardial infarction (AMI) predisposes them to life-threatening ventricular arrhythmias. Improvement of unfavourable changes in ANS can be expected in such patients as a result of physical training. A beneficial shift in ANS balance towards parasympathetic activity could be confirmed by demonstrating increased baroreceptor reflex sensitivity (BRS) as well as favourable changes in heart rate variability (HRV) parameters.

**Aim:** To analyse the effect of different forms of physical training on ANS activity in patients with AMI after hospital discharge.

**Methods:** The study included 38 patients with AMI (aged 59 ± 8 years) subjected to 2-month exercise training. Group 1 (n = 19) underwent 3-week supervised in-hospital cardiac rehabilitation followed by 5-week home-based training, and Group 2 (n = 19) underwent 8-week home-based training. BRS and HRV were determined based on a 10-min recording of systolic arterial pressure and the cardiac cycle. Measurements were performed one day before discharge (R1) and after 2 months of training (R2).

**Results:** A significant increase in the mean values of TP (total power), HF (high frequency power), rMSSD (square root of the mean of the squared differences between successive R-R intervals), and pNN50 (proportion of differences between successive R-R intervals that are greater than 50 ms) was observed in the overall study group, along with trends for higher SDNN (standard deviation of the mean of sinus rhythm R-R intervals) and HFnu (normalised HF power), and for lower LFnu (normalised LF power). Additionally, a significant increase in BRS (from 2.2 ± 0.6 to 5.1 ± 2.2 ms/mm Hg, p = 0.01) was found in patients with baseline BRS ≤ 3 ms/mm Hg. A significant increase in rMSSD, pNN50, HF and HFnu, as well as a decrease in LFnu and LF/HF (LF to HF ratio) was observed in Group 1. In contrast, a significant increase in BRS was noted in Group 2.

**Conclusions:** Various forms of 2-month physical training led to a favourable shift in autonomic balance towards parasympathetic activity. Our findings suggest a clinically important effect of physical activity in patients after AMI.

**Key words:** autonomic nervous system, physical training, myocardial infarction

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## INTRODUCTION

Numerous literature data indicate that a shift in the dynamic autonomic nervous system (ANS) balance towards sympathetic activity that occurs in patients with acute myocardial infarction (AMI) predisposes them to life-threatening ventricular arrhythmias and sudden cardiac death (SCD). This was confirmed by evaluation of both heart rate variability (HRV) and baroreceptor reflex sensitivity (BRS) [1–3]. Improvement of these unfavourable changes in ANS activity in such patients may be expected following exercise training including cardiac rehabilitation. It is known that in patients after AMI, exercise may contribute to reduction in ischaemic area and the risk of recurrent coronary event, improves exercise tolerance, reduces mortality, and in some cases it may improve social functioning including return to work [4–7]. For these reasons, regular physical exercise is an important component of the secondary prevention of cardiovascular events in patients after AMI [8–10]. Increase in BRS and favourable changes in HRV parameters may indicate

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a beneficial shift in ANS balance towards parasympathetic activity in such patients [11, 12] which likely reduces the risk of malignant ventricular arrhythmia and SCD.

Data regarding the role of physical training in restoring appropriate ANS balance in patients after MI, including exercise performed during cardiac rehabilitation, are not entirely clear and come from studies that were performed many years ago [13–17]. In addition, only few studies compared unsupervised home-based exercise with supervised hospital cardiac rehabilitation programs [18, 19]. Demonstration of beneficial effects of various forms of exercise training, and particularly of home-based exercise programs, would be an important argument for wide promotion and implementation of such programs in patients after AMI.

The aim of this study was to evaluate the effect of various forms of exercise training on ANS activity in patients discharged home after AMI.

## METHODS

### Study group

We studied consecutive AMI patients hospitalised in the Department of Cardiology at the Medical University of Gdansk who completed the initial step of early (in-hospital) cardiac rehabilitation and were able to walk unaided. Additional inclusion criteria included the presence of sinus rhythm on the electrocardiogram (ECG), uncomplicated and stable clinical condition of the patients, and patient consent for participation in the study. Exclusion criteria included age above 75 years, permanent II or III degree atrioventricular block, more than 5% of supraventricular and/or ventricular premature beats in resting ECG, implanted cardiac pacemaker, peripheral neuropathy (as documented in in-hospital or outpatient medical records), unstable angina pectoris, heart failure with New York Heart Association (NYHA) class III/IV symptoms, inability to exercise, angina during cardiac rehabilitation or exercise performed after hospital discharge, and poor general condition of the patients.

On inclusion into the study, all patients completed supervised early in-hospital rehabilitation according to the model A1 or A2 [20, 21].

On completion of the first step of early in-hospital rehabilitation, all patients were offered continued in-hospital cardiac rehabilitation. Patients who consented were included into Group 1, and those patients who did not give their consent for in-hospital rehabilitation but declared readiness for regular home-based exercise training were included into Group 2. To allow meaningful statistical analyses, the number of patients in Groups 2 and 1 were planned to be similar.

**Group 1.** Based on the result of an exercise test performed on admission to the cardiac rehabilitation unit, patients were selected for one of 4 models (A, B, C, D) of the second step of early cardiac rehabilitation [16] performed for 3 weeks, followed by 5 weeks of unsupervised home-based training. In Group 1, exercise training was commenced at 7–14 days after discharge. Training models (A, B, C, D) included endurance training, resistance training and general fitness exercises with the intensity adjusted to individual exercise tolerance and cardiovascular risk, performed 3 times a week. Exercise intensity was set at 60–80% of the heart rate reserve in model A, and at up to 50–60% of the heart reserve in model B; in model C, exercise program was similar to models A and B but without resistance training and with exercise intensity set at 40–50% of the heart rate reserve; finally, model D included individually adjusted training with exercise intensity below 20% of the heart rate reserve.

In-hospital rehabilitation lasted for 3 weeks, followed by unsupervised home-based training for 5 weeks, consisting of walking for 30 min three times a week. Overall duration of exercise training was 2 months.

**Group 2.** Patients in this group began to exercise the next day after hospital dicharge, and training consisted of walking for 30 min three times a week at an individually adjusted pace.

During home-based training, patients in both groups completed a diary that included precise information on the date and time of walking. These diaries were then verified by physicians participating in the present study.

### Study protocol

In all patients, parameters of ANS activity (BRS and HRV) were evaluated one day before hospital discharge (R1) and after 2 months of training (R2). Measurements were performed in conditions typical for evaluation of ANS activity, with recordings in the morning hours in a quiet room in a relaxed patient lying supine with slightly elevated head (at 30°). Subjects refrained from eating for at least 4 h, and for smoking and drinking coffee for 12 h. After an initial 15-min waiting period to allow stabilisation of systolic arterial pressure (SAP) and interbeat interval (heart period — HP), actual 10-min recording of SAP and HP signals was performed during controlled breathing at 0.23 Hz.

### Evaluation of ANS activity parameters

Non-invasive SAP measurement was performed using the Finapress device (Ohmeda) with the cuff placed on the middle phalanx of the third finger of the right hand, and HP was recorded using the Mingograf 720C device. Self-adjustment feature of the Finapress device was switched off immediately before the actual recording, and then switched on again to recalibrate the device after the recording. Analog SAP and HP signals were transformed and synchronised using an analog-to-digital converter at 250 Hz, and then transmitted to a computer equipped with the POLYAN software [22] that allows calculations of individual BRS and HRV parameters. An algorithm of linear interpolation was used to obtain 1 ms resolution for the heart rate signal. During BRS evaluation, premature beats and trends were first removed from the recording. Then, a fragment of stable SAP and HP recording lasting not less than 240 s was selected for analysis. BRS was evaluated automatically to reduce subjective assessment. BRS was measured based on spectral analysis of spontaneous SAP and HP variability, using the Blackman-Tukey algorithm and 0.03 Hz wide Parzen windows, as the mean value of transfer function (TF) module in the range of 0.04–0.15 Hz, calculated from all points of the SAP and HP curves regardless of coherence value and variability [23]. BRS was expressed in milliseconds per mm Hg (ms/mm Hg). Patients with more than 5% of ventricular and/or supraventricular premature beats during actual 10-min SAP and HP recording for measurements of BRS and HRV parameters were excluded from further analyses.

During evaluation of short-term HRV (based on the analysis of 240-s ECG tracing used for the evaluation of BRS), the following parameters were taken into account [24]: total power of the spectrum (TP, $ms^2$); standard deviation of the mean of all sinus rhythm R-R intervals (SDNN, ms); square root of the mean of the squared differences between successive R-R intervals (root-mean-square successive difference, rMSSD, ms); percentage of differences between successive R-R intervals that are greater than 50 ms (pNN50, %); low frequency (0.04–0.15 Hz) spectral power (LF, $ms^2$); high frequency (0.15–0.4 Hz) spectral power (HF, $ms^2$); relative spectral power at low frequencies expressed in normalised units (LFnu, NU); relative spectral power at high frequencies expressed in normalised units (HFnu, NU); and LF/HF ratio (LF/HF). In the light of literature debates on the evaluation of time domain parameters of HRV based on short-term recordings, we analysed these parameters in the present study but our conclusions were based on global analysis of both time domain and frequency domain parameters of HRV, the latter being more accepted when based on short-term recordings [24].

The above evaluations were performed in the context of a wider research project to evaluate the effect of various forms of exercise on ANS activity. This project was approved by the Independent Bioethics Committee for Research at the Medical University of Gdansk (approval No. NKEBN/448/2004).

### *Statistical analysis*

Statistical analyses were performed using the STATISTICA 6.0 package. Comparison of the evaluated parameters before (R1) and after cardiac rehabilitation (R2) was performed using a nonparametric test for paired samples (Wilcoxon signed rank test). Clinical variables, BRS, and HRV parameters in both groups were compared using the Mann-Whitney test or, depending on the sample size, $\chi^2$ test, $\chi^2$ test with the Yates' correction or exact Fisher test. All data are shown as mean values ± standard deviation. $P \leq 0.05$ was considered statistically significant.

## RESULTS

Each group consisted of 19 patients. In Group 1, model A1 was used for the first step of in-hospital cardiac rehabilitation in 15 patients, and model A2 in 4 patients. Following discharge, further in-hospital cardiac rehabilitation was performed according to model A in 6 patients, model B in 5 patients, model C in 5 patients, and model D in 3 patients. Mean time from admission to R1 recordings was 6 ± 2 days.

In Group 2, model A1 was used for the first step of in-hospital cardiac rehabilitation in 13 patients, and model A2 in 6 patients. Mean time from admission to R1 recordings was 7 ± 3 days.

The two groups did not differ significantly in regard to age, left ventricular ejection fraction, numerous clinical parameters, and drug therapy used. In Group 2, only a trend for a higher prevalence of type 2 diabetes was noted ($p < 0.07$). Detailed characteristics of patients included into the study are shown in Table 1.

### *ANS activity parameters*

In the overall study population, we noted a significant increase in the mean values of TP, HF, RMSSD, and pNN50, a trend for an increase in SDNN and HFnu, and a trend for a decrease in LFnu (Table 2). When we analysed ANS activity parameters in 9 patients in whom baseline BRS was ≤ 3 ms/mm Hg, indicating a particularly high SCD risk, a significant increase in this parameter was noted. Detailed data for these patients are shown in Table 3. We did not perform a comparison of ANS activity parameters in relation to the training mode in this small subset due to low patient number (3 of these patients underwent training in Group 1, and 6 patients in Group 2).

Baseline ANS activity parameters (R1 recordings) in Groups 1 and 2 did not differ significantly despite noticeable differences in the mean values of the measured parameters. When we analysed ANS activity parameters in Group 1 and compared R2 recordings to R1 recordings, we found a significant increase in rMSSD, pNN50, HF, and HFnu, and a decrease in LFnu and LF/HF which may suggest a shift in the ANS balance towards parasympathetic activity (Table 4).

Home-based training (Group 2) resulted in a shift in the ANS balance towards vagal activity, as evidenced by a significant increase in BRS (Table 5). Changes in HRV parameters were noticeable but did not reach statistical significance in this group.

## DISCUSSION

The most important observation in our study is the fact that regular physical exercise of moderate intensity, performed for 2 months by patients after AMI, led to favourable changes in ANS balance towards parasympathetic activity, particularly among patients with baseline BRS ≤ 3 ms/mm Hg.

Beneficial changes in ANS balance towards parasympathetic activity in response to physical exercise, including cardiac rehabilitation in patients after AMI, were already suggested by other authors in previous reports [13–17]. For example, Fujimoto et al. [15] noted a significant increase in SDNN and HF, and a decrease in LF/HF after just 2 weeks in intensive exercise in patients after AMI. After 8 weeks

Table 1. Demographic and clinical characteristics of the overall study group (data shown as mean values ± standard deviation or numbers and percentages)

| | Overall (n = 38) | Group 1 (n = 19; in-hospital rehabilitation) | Group 2 (n = 19; home-based rehabilitation) | Patients with baseline BRS ≤ 3 s/mm Hg (n = 9) |
|---|---|---|---|---|
| Age [years] | 59 ± 8 | 57 ± 7 | 60 ± 8 | 62 ± 8 |
| Men | 30 (79%) | 15 (79%) | 15 (79%) | 6 (67%) |
| Infarct location: | | | | |
| Anterior wall | 11 (29%) | 4 (21) | 7 (37) | 3 (33) |
| Inferior wall | 12 (32%) | 6 (32) | 6 (32) | 2 (22) |
| Other | 15 (39%) | 8 (42%) | 7 (37%) | 4 (44%) |
| STEMI | 26 (68%) | 14 (74%) | 12 (63%) | 6 (67%) |
| NSTEMI | 12 (32%) | 5 (26%) | 7 (37%) | 3 (33%) |
| LVEF [%] | 50 ± 11 | 53 ± 10 | 48 ± 13 | 44 ± 16 |
| LVEF ≤ 35% | 4 (11%) | 0 (0%) | 4 (21%) | 3 (33%) |
| NYHA class: | | | | |
| NYHA I | 16 (42%) | 9 (47%) | 7(37%) | 3 (33%) |
| NYHA II | 22 (58%) | 19 (53%) | 12 (64%) | 6 (67%) |
| Previous myocardial infarction | 7 (18%) | 2 (11%) | 5 (26%) | 3 (33%) |
| Concomitant disease: | | | | |
| Hypertension | 30 (79%) | 14 (74%) | 16 (84%) | 8 (89%) |
| Type 2 diabetes | 11 (29%) | 3 (16%) | 8 (42%) | 4 (44%) |
| Risk factors: | | | | |
| Hyperlipidaemia | 22 (58%) | 12 (64%) | 10 (53%) | 5 (56%) |
| Smoking | 19 (50%) | 11 (58%) | 8 (42%) | 4 (44%) |
| Medications: | | | | |
| Beta-blocker | 37 (97%) | 18 (95%) | 19 (100%) | 9 (100%) |
| ACEI/ARB | 35 (92%) | 16 (84%) | 19 (100%) | 9 (100%) |
| Acetylsalicylic acid | 38 (100%) | 19 (100%) | 19 (100%) | 9 (100%) |
| Statin | 38 (100%) | 19 (100%) | 19 (100%) | 9 (100%) |

BRS — baroreceptor reflex sensitivity; STEMI — ST segment elevation myocardial infarction; NSTEMI — non-ST segment elevation myocardial infarction; LVEF — left ventricular ejection fraction; NYHA — New York Heart Association; ACEI — angiotensin-converting enzyme inhibitor; ARB — angiotensin receptor blocker

of cardiac rehabilitation, Malfatto et al. [13] observed beneficial changes in HRV parameters including an increase in pNN50 from 6.5 ± 1.5 to 16.2 ± 3.1% and a decrease in LF/HF from 8.3 ± 5.2 to 5.1 ± 2.9 ($p < 0.05$). Similar changes were noted by the same authors in another study that also showed a decrease in LF/HF after 12 weeks of cardiac rehabilitation [14]. La Rovere et al. [16] found a significant increase in BRS (from 7.9 ± 5.4 to 9.9 ± 6.4 ms/mm Hg, $p = 0.04$) after 4 weeks of exercise in patients after AMI. Martinez et al. [25] observed increase in BRS and beneficial changes in other ANS activity parameters after half a year of training in a similar patient population. Similar findings regarding BRS were also reported by other authors [17]. In the present study, trends consistent with previous reports in the literature were observed after 2 months of exercise training.

Another very important observation in our study is a significant increase in BRS in few patients with low BRS at baseline (≤ 3 ms/mm Hg), indicating a high risk of SCD. Most similar findings in this regard were reported by La Rovere et al. [16] who in addition found lower cardiac mortality in such patients. It is difficult to offer a clear explanation why the observed changes in this parameter were particularly prominent in patients with baseline BRS ≤ 3 ms/mm Hg. One possible reason may be higher arterial baroreflex reserve in these patients. A prognostic value of BRS < 3 ms/mm Hg was documented in a multicentre prospective ATRAMI study [2] so our findings suggest that cardiac rehabilitation might also decrease SCD risk.

Of note, when analysing ANS activity parameters in specific patient groups, changes indicating a beneficial shift in the

Table 2. Baroreceptor reflex sensitivity (BRS) and various heart rate variability indices in the overall study group, determined prior to (R1) and after 2 months of rehabilitation (R2)

| | R1 | R2 | P |
|---|---|---|---|
| Mean HP | 1109 ± 144 | 1117 ± 120 | 0.7 |
| BRS | 7.3 ± 5.5 | 8.4 ± 5.1 | 0.2 |
| TP | **871 ± 1154** | **1059 ± 859** | **0.05** |
| LF | 240 ± 350 | 338 ± 401 | 0.2 |
| HF | **351 ± 788** | **459 ± 547** | **0.004** |
| SDNN | **30 ± 14** | **34 ± 13** | **0.08** |
| rMSSD | **28 ± 22** | **32 ± 21** | **0.05** |
| pNN50 | **8 ± 12** | **12 ± 16** | **0.05** |
| LFnu | **48 ± 20** | **44 ± 25** | **0.07** |
| HFnu | **52 ± 20** | **56 ± 25** | **0.07** |
| LF/HF | 1.4 ± 1.6 | 1.7 ± 2.6 | 0.1 |

HP — heart period; TP — total power; LF — low frequency power (spectral power in low-frequency range: 0.04–0.15 Hz); HF — high frequency power (spectral power in high-frequency range: 0.15–0.4 Hz); SDNN — standard deviation of the mean of sinus rhythm R-R intervals; rMSSD — square root of the mean of the squared differences between successive R-R intervals; pNN50 — proportion of differences between successive R-R intervals that are greater than 50 ms; LFnu — normalised LF power (relative spectral power in low-frequency range expressed in normalized units); HFnu — normalised HF power (relative spectral power in high-frequency range expressed in normalised units); LF/HF — LF to HF ratio

Table 3. Baroreceptor reflex sensitivity (BRS) and various heart rate variability indices in patients with baseline BRS ≤ 3 ms/ /mm Hg, determined prior to (R1) and after 2 months of rehabilitation (R2)

| | R1 | R2 | P |
|---|---|---|---|
| Mean HP | 999 ± 83 | 1030 ± 74 | 0.2 |
| BRS | **2.2 ± 0.6** | **5.1 ± 2.2** | **0.03** |
| TP | 248 ± 206 | 373 ± 312 | 0.6 |
| LF | **41 ± 25** | **147 ± 161** | **0.06** |
| HF | **43 ± 71** | **79 ± 62** | **0.02** |
| SDNN | 18 ± 8 | 24 ± 8 | 0.1 |
| rMSSD | 18 ± 21 | 13 ± 5 | 0.2 |
| pNN50 | 1.5 ± 3.8 | 0.4 ± 0.9 | 0.6 |
| LFnu | 54 ± 17 | 51 ± 28 | 0.4 |
| HFnu | 46 ± 17 | 49 ± 28 | 0.4 |
| LF/HF | 1.5 ± 0.9 | 1.9 ± 2.1 | 0.6 |

Abbreviations as in Table 2

autonomic balance were noted in both these groups but in regard to different indices. This may have important practical implications, particularly in those patients who engaged in home-based training throughout the study. Literature data indicate that the value of home-based cardiac rehabilitation is at least equivalent to that of in-hospital rehabilitation but

Table 4. Baroreceptor reflex sensitivity (BRS) and various heart rate variability indices in patients assigned to Group 1 (rehabilitation in the hospital setting of a rehabilitation ward), determined prior to (R1) and after 2 months of rehabilitation (R2)

| | R1 | R2 | P |
|---|---|---|---|
| Mean HP | 1144 ± 125 | 1146 ± 120 | 0.9 |
| BRS | 8.0 ± 5.3 | 8.0 ± 4.8 | 0.9 |
| TP | 765 ± 348 | 1074 ± 672 | 0.2 |
| LF | 225 ± 175 | 297 ± 344 | 0.9 |
| HF | **264 ± 176** | **536 ± 498** | **0.01** |
| SDNN | 31 ± 8 | 35 ± 9 | 0.2 |
| rMSSD | **26 ± 10** | **32 ± 15** | **0.05** |
| pNN50 | **8 ± 8** | **16 ± 16** | **0.04** |
| LFnu | **47 ± 21** | **37 ± 25** | **0.02** |
| HFnu | **53 ± 21** | **63 ± 25** | **0.02** |
| LF/HF | **1.3 ± 1.2** | **1.2 ± 2.1** | **0.02** |

Abbreviations as in Table 2

Table 5. Baroreceptor reflex sensitivity (BRS) and various heart rate variability indices in patients assigned to Group 2 (exercise training at home), determined prior to (R1) and after 2 months of rehabilitation (R2)

| | R1 | R2 | P |
|---|---|---|---|
| Mean HP | 1079 ± 155 | 1083 ± 113 | 0.8 |
| BRS | **6.7 ± 5.8** | **8.9 ± 5.5** | **0.03** |
| TP | 961 ± 1548 | 1042 ± 1063 | 0.2 |
| LF | 253 ± 453 | 387 ± 466 | 0.1 |
| HF | 424 ± 1065 | 368 ± 605 | 0.1 |
| SDNN | 29 ± 18 | 33 ± 16 | 0.2 |
| rMSSD | 29 ± 29 | 32 ± 27 | 0.3 |
| pNN50 | 8 ± 15 | 7 ± 15 | 0.5 |
| LFnu | 49 ± 20 | 52 ± 25 | 0.7 |
| HFnu | 51 ± 20 | 50 ± 21 | 0.7 |
| LF/HF | 1.6 ± 1.7 | 2.3 ± 3.1 | 0.8 |

Abbreviations as in Table 2

the former is associated with clearly lower costs [26–29]. The observed beneficial effects on ANS activity are another important argument when promoting this form of cardiac rehabilitation. Some previous studies also compared hospital and home-based rehabilitation. For example, Leitch et al. [18] showed no differences between in-hospital based rehabilitation and low-intensity unsupervised home-based training. As reported by Korzeniowska-Kubacka et al. [19], hybrid cardiac rehabilitation that included in-hospital rehabilitation and home-based training monitored by telemetry resulted in a beneficial shift of the autonomic balance towards parasympathetic activity. Our study, although it did not evaluate typical home-based rehabilitation, indicates that even unsupervised but regular home-based exercise consistent with healthy lifestyle may lead to beneficial changes in ANS activity.

When evaluating the effect of various forms of physical training in patients after AMI, a possibility of spontaneous improvement of ANS parameters should also be considered [30]. However, this phenomenon is usually more evident in patients who do not undergo coronary revascularisation, and all patients in our study underwent percutaneous coronary intervention in the culprit vessel in accordance with the current management guidelines. On the other hand, to demonstrate such a phenomenon in AMI patients treated according to the current guidelines, a control group performing no physical exercise should be included in the study protocol which would be deemed non-ethical in the current era of widely recommended moderate physical exercise as a part of healthy lifestyle.

Of note, a trend for increased prevalence of type 2 diabetes was noted in Group 2. Literature data indicate an effect on this condition of ANS activity parameters [31]. However, despite measurable differences in various evaluated parameters noted in Group 2, which was characterised by a higher prevalence of type 2 diabetes, none of these differences reached statistical significance.

### *Clinical implications*

Our findings should be interpreted in the context of recent reports indicating that the effect of physical exercise on the cardiovascular system in AMI patients treated according to the current guidelines, including during cardiac rehabilitation, may differ from the effects reported in the past [32]. This is likely related to modern management of AMI including coronary revascularisation in the acute phase of infarction and the use of antiplatelet drugs, beta-blockers, and statins. In this context, even modest changes in ANS activity parameters indicating an increase in parasympathetic activity as a result of cardiac rehabilitation in patients after AMI may have important clinical implications related to a potential beneficial effect on the risk of malignant ventricular arrhythmia and SCD. In addition, demonstrating the value of home-based, unsupervised physical activity in the form of regular walking may have potential economic implications as this form of training dose not require any significant financial investments nor rearrangements of daily routine. Thus, it may be expected to be more acceptable for patients, encouraging them to introduce appropriate lifestyle modifications, and at the same time improving long-term outcomes after a coronary event.

### *Limitations of the study*

One limitation of the present study was a low number of evaluated subjects. In addition, the choice between various forms of training was based on patient preference and not randomised. Of note, this was a pilot study that may encourage further research on the effect of physical exercise on ANS activity in patients after MI. Another limitation of the study was the fact that it evaluated only ANS activity and not improvement in cardiorespiratory fitness after 2 months of training which might have also occurred, as indicated by the literature data [33].

## CONCLUSIONS

Various forms of 2-month physical training led to a favourable shift in autonomic balance towards parasympathetic activity. This may have important practical implications, as our findings suggest a beneficial effect of physical activity in patients after AMI.

***Conflict of interest:*** *none declared*

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# Wpływ różnych sposobów treningu fizycznego na czynność autonomicznego układu nerwowego u chorych po ostrym zawale serca

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## Streszczenie

**Wstęp:** Przesunięcie dynamicznej równowagi autonomicznego układu nerwowego (ANS) w stronę dominacji współczulnej u pacjentów po ostrym zawale serca (AMI) sprzyja występowaniu złośliwych arytmii komorowych. Poprawy niekorzystnych zmian ANS można się spodziewać po zastosowaniu treningu fizycznego u takich chorych. Wzrost wrażliwości odruchu z baroreceptorów tętniczych (BRS) oraz odpowiednie zmiany w zakresie parametrów zmienności rytmu zatokowego serca (HRV) mogłyby być dowodem korzystnego przesunięcia równowagi ANS w stronę dominacji przywspółczulnej.

**Cel:** Celem pracy była ocena wpływu różnych sposobów treningu fizycznego na czynność ANS u chorych wypisywanych ze szpitala po AMI.

**Metody:** Badaniem objęto 38 pacjentów (59 ± 8 lat) z AMI, zakwalifikowanych do 2-miesięcznych treningów fizycznych: podgrupa 1 (19 osób) — przez pierwsze 3 tygodnie pacjenci byli poddani nadzorowanej rehabilitacji szpitalnej, a przez 5 kolejnych tygodni ćwiczyli samodzielnie w warunkach domowych; podgrupa 2 (19 osób) — chorzy ćwiczyli samodzielnie w domu przez 8 tygodni. U każdego pacjenta oceniano BRS i HRV (10-minutowe rejestracje ciśnienia skurczowego i długości cyklu serca) wykonywanych dzień przed wypisem ze szpitala i po 2 miesiącach treningów.

**Wyniki:** W całej grupie odnotowano istotny wzrost TP (ogólna moc widma), HF (względna moc widma w zakresie wysokich częstotliwości), rMSSD (pierwiastek kwadratowy ze średniej sumy kwadratów różnic między kolejnymi odstępami RR), pNN50 (odsetek różnic między kolejnymi odstępami RR przekraczających 50 ms) oraz trend w kierunku wzrostu SDNN (odchylenie standardowe od średniej wartości wszystkich odstępów RR rytmu zatokowego) i HFnu (względna moc widma w zakresie wysokich częstotliwości wyrażona w jednostkach znormalizowanych) oraz zmniejszenia LFnu (względna moc widma w zakresie niskich częstotliwości wyrażona w jednostkach znormalizowanych). Wśród osób z wyjściową wartością BRS ≤ 3 ms/mm Hg zanotowano znamienny wzrost BRS: z 2,2 ± 0,6 do 5,1 ± 2,2 ms/mm Hg (p = 0,01). U pacjentów z podgrupy 1 stwierdzono znamienny wzrost rMSSD, pNN50, HF, HFnu oraz zmniejszenie LFnu i LF/HF (iloraz LF do HF), natomiast w podgrupie 2 zanotowano istotne zwiększenie BRS.

**Wnioski:** Po zastosowaniu różnych rodzajów 2-miesięcznych treningów fizycznych stwierdzono cechy korzystnego przesunięcia równowagi autonomicznej w kierunku dominacji przywspółczulnej. Może to mieć ważne znaczenie praktyczne, wskazując na korzystny wpływ aktywności fizycznej u chorych po AMI.

**Słowa kluczowe:** autonomiczny układ nerwowy, trening fizyczny, zawał serca

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