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Research Article

Biofeedback As an Example of Modern Exercise Method Used in Cardiac Rehabilitation

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ABSTRACT

Biofeedback is defined as providing feedback about changes in the patient's physiological state, by means of stimuli other than those used by the body, usually with the use of technology. This article presents an analysis based on the surveys regarding the awareness of Polish society about biological feedback and its effectiveness in the rehabilitation of patients with cardiac problems. The study was conducted to justify the use in the therapy on people with cardiac problems. The analysis of the patients results after cardiovascular diseases was carried out during the cardiac rehabilitation in which the biofeedback was used.

Introduction

Biofeedback is a biological feedback used for example in the treatment of neurological disorders as an aid in the treatment of depression using EEG biofeedback, as well as in the treatment of coupled disability. Thanks to its use, the patient receives information about their physiological state during the exercise. Biofeedback therapy is also used as a form of cardiac rehabilitation [1-4]. The World Health Organization (WHO) defines cardiac rehabilitation as the sum of actions aimed at providing the patient with the best possible physical, mental and social conditions, so that he could return to normal private and professional life with his own participation [5]. Physical effort in patients with heart failure was contraindicated until the end of the 1980s and still raises controversies, fears and sometimes objections in medical circles. Until recently, for the sake of safety, patients with heart failure (HF) were excluded from rehabilitation programmes, and rest was considered as the primary treatment method [6, 7]. Cardiovascular diseases are the leading cause of disability and deaths in developed countries and their prevalence is increasing in developing countries [8].

Cardiac rehabilitation is a complex process consisting of many stages. It can be carried out by various methods, but all of them are aimed at restoring the condition as close as possible to the period before the occurrence of dysfunction. One example is therapy with cycloergometers. The aim of the work was to present the application of biofeedback in cardiac rehabilitation and to analyse its effectiveness on the basis of an exemplary rehabilitation programme. During its duration, cadence, that is, the number of the full revolutions of crank per minute, was visible on the screen, in addition patient received information in which load range he or she had to maintain. It allows to perform a training with the specific intensity, which ultimately translates into positive effects of rehabilitation and allows to select the appropriate load for each training session. This means that the patient controls his or her term of office, and the therapist's role is to determine the load. Thanks to this, rehabilitation is effective and translates directly into improving physical performance. Studies show the effectiveness and necessity of cardio feedback in the treatment of diseases in cardiological patients [2, 9-11]. There are still few reports, both in Polish and world literature, on the use of biofeedback in cardiac rehabilitation. Therefore, it was decided to conduct biofeedback training and to examine its impact on improving the functioning of patients with cardiological diseases.

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The Use of Cardio Biofeedback in the Rehabilitation of Cardiological Patients

Cardiac rehabilitation is a method that allows safe and effective increase of patients physical efficiency after myocardial infarction. It is useful in clinical practice, and it can minimize mental stress and risk factors for myocardial infarction. It combines physical activity with a change in the likelihood of recurrence of the disease and in the perspective of derivatives prevention, it aims to minimize symptoms related with disability in the case of cardiovascular incidents. It also provides improvement in the effectiveness of the exercises [12, 13]. According to Sinha, complex cardiac rehabilitation programmes are multi-component interference that includes elements of cardiological training with secondary prevention, relaxation, stress management and participates in the psychological adaptation of the participant. It consists of educational sessions and exercises conducted in the outpatient mode for 4 to 8 weeks by an interdisciplinary staff (psychologist, doctor, nurse, pharmacist and dietitian). Home, self-supervised models are more common cardiac rehabilitation, in which this method is conducted through various multimedia materials or information brochures given to patients before discharge from the hospital. The best results can be achieved by using a combination of both methods [14].

In the case of a home model, in order to ensure patient safety, it is important to educate the family in first aid and provide information on indications and contraindications for undertaking various types of physical activity [15, 16]. The cardiac rehabilitation system allows you to design the following types of training: interval training, training with heart stabilization, training with programmed increase or the reduction of a work load and combinations of the above-mentioned training. The system is used to conduct multi-position cardiological therapy or training with a load. This method allows each patient participating in the training group an individual course of exercises, medical supervision during the training and the creation of documentation of a rehabilitation session. When defining a workout, various parameters are determined depending on the type of training selected: individual duration, load, load increase, maximum heart rate (HR) and moments of automatic blood pressure measurement [17].

One of the applications of biological feedback (biofeedback) is the rehabilitation of cardiological patients using cycloergometers during which they receive feedback in the form of cadence. This gives them the ability to automatically control the number of revolutions per minute, which results in a stable pace of driving during classes, and the variable used by the physiotherapist is the load specified in watts (Watt, W). The aim of rehabilitation is to stabilize cardiovascular and respiratory parameters and improve physical performance, and with the duration of rehabilitation, increases the training load. The patient is expected to stabilize cardiovascular and respiratory parameters during exercise [2, 10, 11, 18].

Materials and Methods

The results of 12 patients with various cardiological diseases were analysed. Among the subjects were three women and nine men, the age of patients ranged from 51 to 79 years, and the training of each person was based on the same scheme. Each patient's rehabilitation cycle consisted of 24 trainings [19]. Participants were fully informed about the purpose and methods of the study as well as its risk, they voluntarily agreed to participate. Rehabilitation was carried out using bicycle cycloergometers, the physiotherapist adjusted the appropriate load recommended by the attending physician, each patient received feedback about his term and his task was to keep it constant (40-60 revolutions per minute) during all trainings in the rehabilitation cycle. By using the PubMed, Scopus, Web of Science database, articles about biofeedback and cardiac rehabilitation were reviewed.

Results

The average age for a statistical man participating in the study was 64.7 years and for a woman 66.0 years, after analysing the collected data, we can present averaged measurements. Separately for a statistical man and for statistical woman. These measurements are:

i. heart rate and blood pressure,
ii. workload in a group of women and men.

Rehabilitation in most of the patients brought the desired effect, increasing the load during rehabilitation without a significant increase in the reading of the electrocardiograph and is frequent that with a duration of the rehabilitation pulse readings were recorded lower at each stage of training (resting, maximum and final pulse). Systolic and diastolic pressure (resting pressure, pressure during training and final pressure) were also monitored. The analysis results are shown in (Figures 1 & 2).

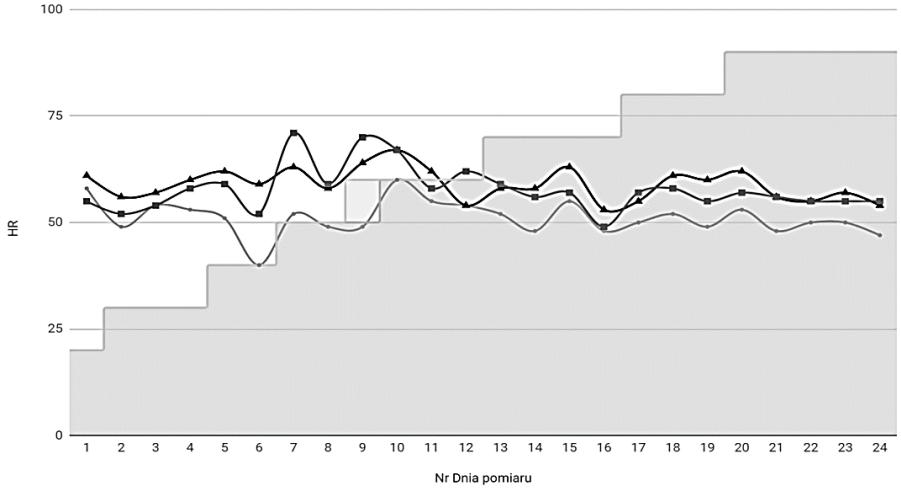

Figure 1: HR sample patient.

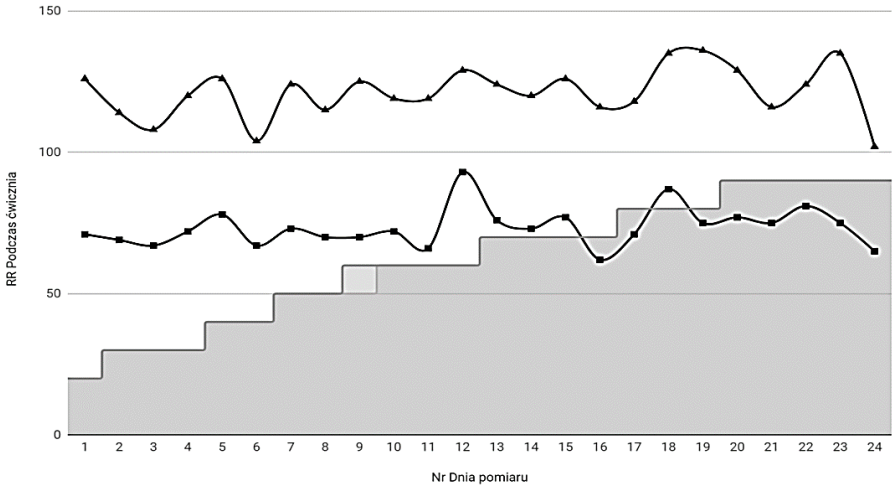

Figure 2: RR sample patient.

Evaluation of the Effectiveness of Biofeedback in Cardiac Rehabilitation

Cardio biofeedback is more effective during cardiac rehabilitation in some cases than its traditional form. It results in higher patients involvement in training which leads to greater therapy effects. The authors describe the use of biofeedback in cardiac rehabilitation as a method of stress management, which gives positive results in the pulse achieved by patients [20]. Biofeedback is also used in the learning of diaphragm breathing, which in cardiological patients is an extremely important element of therapy. It was also found that physical training in patients with spasmodic disorders reduces the number of hospitalizations due to heart failure, increases overall functional capacity and quality of life [21, 22]. Although, every physical training improves the quality of life and prognosis in patients with severe myocardial infarction after percutaneous coronary angioplasty [23]. One of the most important factors that help maintain health and good physical fitness is physical activity. This is a prerequisite for the proper development of the individual, maintaining balance in biological, psychophysical and social development [24, 25].

One of the methods used in cardio biofeedback is the analysis of Heart Rate Variability Biofeedback (HRV), it is performed using ECG, blood pressure measurement and ballistocardiography. Studies show a relationship between reduced HRV and reduced mortality after a myocardial infarction [26]. In order to show the spectrum of biofeedback application more broadly, research has been conducted which found that feedback can be used on training planning. The study was carried out on a group of 18 people aged 19-22 (39% men and 61% women) exercising on cycloergometer. For the purposes of the study, the "PELETON plus" system was used. The study used a central control station with two LCD monitors and 10 exercise units in the form of ERM-200 cyclic ergometers and wireless electrocardiography (ECG) modules. While performing the exercise in the research sample, the subjects had the opportunity to monitor their parameters such as: cadence, heart rate, power, duration of training; while in the control sample they were deprived of this feedback in order to check if it has an impact on the effectiveness of training and the implementation of planned rehabilitation assumptions [19, 27].

The results were analysed in terms of the effectiveness of the above-described form of training and the impact of biofeedback on maintaining pulse and cadence at a relatively constant level. It was also checked how the observation of parameters by the exercisers affects the broadly understood motivation, and thus increases the effectiveness of the exercise. The training has been scheduled for 36 minutes. When entering the study, patients were informed about the maximum load power of 300 W and about its gradual increase in individual parts of training. To control the body's response, systolic and diastolic blood pressure was measured several times. Exercisers were informed about the minimum and maximum cadence values that should be maintained during all phases of training - this value should be in the range of 60-80 revolutions per minute. The instructor informed the participants of the study about the possibility of stopping the training when the minimum cadence cannot be achieved at a given power - this moment verifies the maximum load assigned separately for each subject [9, 19, 27, 28]. The results of the study are presented in (Figure 3).

By analysing the results of the exercisers, it can be stated that the HR value increased significantly in subsequent training phases. There were no abnormal heart rate spikes. The ability to monitor and control exercisers' cadence has allowed them to maintain training parameters in accordance with the instructor's guidelines. Biofeedback influenced the motivation of the respondents and allowed to obtain a good result thanks to the possibility of self-control, which increased its effectiveness. The control trial was based on the same training plan, however the participants received only one feedback to interrupt the training at the moment when unexpected changes occur (excessive fatigue, dizziness, etc.) or if they will be unable to continue training due to fatigue. They have not been given the value of the minimum cadence they are supposed to maintain or feedback on the current pulse, pressure and cadence (Figure 4).

Lack of feedback during the control sample prevented the participants from self-control, which reduced the effectiveness of training and the deprivation of the ability to control the term meant that it was not maintained at the appropriate level. The participant reported their desire to end the exercise much faster because of fatigue, however, their heart rate did not reach as high as in the test sample.

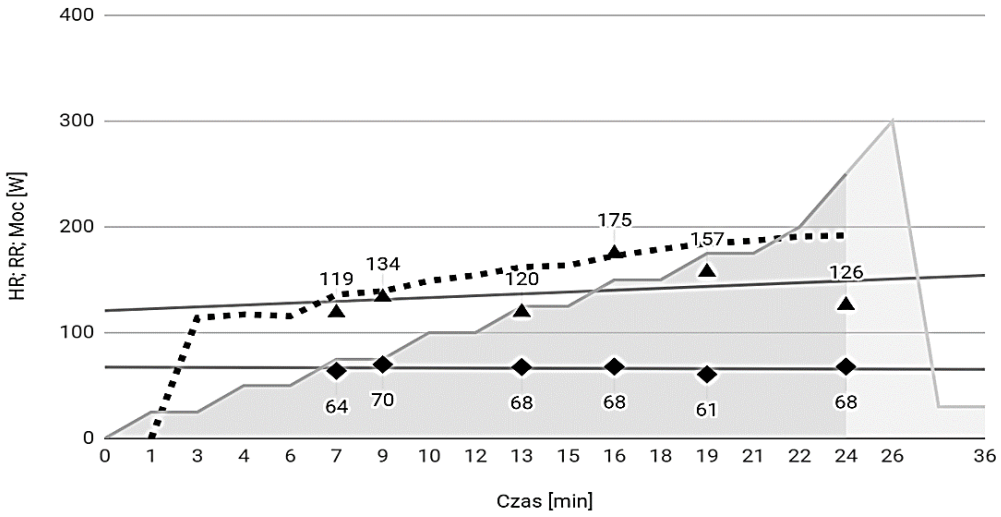

Figure 3: Results of average measurements during the control sample.

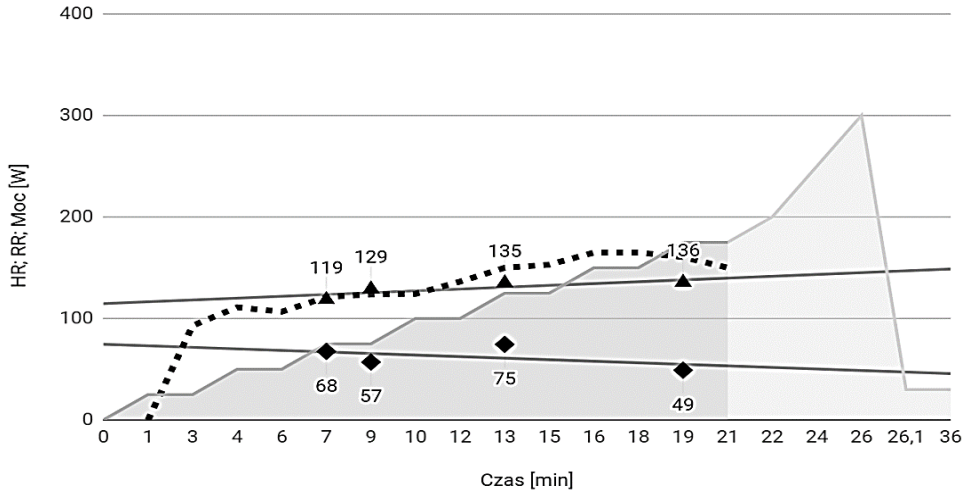

Figure 4: Results of average measurements during the test sample.

Discussion

Biofeedback is increasingly common form of therapy used to treat a variety of deficits and problems of a physiological nature, as well as psychological. Many people are unaware of its widespread use. This therapy can be used e.g., in cardiac rehabilitation, in the fight against stress, in the treatment of depression. Numerous publications present arguments for the use of biofeedback not only as an addition to traditional therapy, but as an integral part of it. However, the authors also point out that there are many insufficiently studied aspects in the case of biofeedback, which would require undertaking research on a wider group of patients. Literature data on the impact of mental state on participation in cardiac rehabilitation programmes are contradictory [29]. Depression increases the risk of not completing the cardiac rehabilitation programme [30]. According to Cooper, depression and anxiety reduce the likelihood of participating in a rehabilitation programme [31]. In other studies, patients participating in cardiac rehabilitation had a higher level of anxiety and depression than people who did not participate in the study [32]. Research proves its effectiveness and a wide range of applications. It can be used regardless of gender, age and accompanying diseases. [1, 2, 10, 11, 33, 34]. Articles on biofeedback confirm the need for its use in cardiac rehabilitation. The authors confirm the above-mentioned results in the conclusions - biofeedback positively affects the physical efficiency of patients [18, 27].

A frequently discussed problem regarding this therapy is the lack of control tests in various forms of therapy, which is a big problem because it undermines the credibility of these studies [11]. The defensive argument is the difficulty of making a control sample, e.g., in the treatment of some cognitive deficits, because the problem is multifaceted and it is difficult to determine the direct impact of one of the factors, i.e., biofeedback. Its undoubted advantage is universality. During therapy, e.g., conjugated disability, we can affect several aspects at the same time, e.g., concentration, memory and cognitive function [27, 33-38]. Apart from treating specific physical or psychological diseases, biofeedback can be used to prevent various diseases, but unfortunately few people are aware of this, which leaves untapped potential in this method [39].

Conclusion

Biofeedback is an increasingly developing branch, which is more and more often used in rehabilitation. It has a wide spectrum of use in curation of different deficits. The training with biofeedback support

carries the improvement of health condition and physiological parameters in cardiac patients and contribute to training conduction with unifying the conditions for each session. This tool enables patient's self-control (in cardiac patients cases, it was pace self-control during a training on cycloergometer), which improves the efficiency of rehabilitation and provides the limitation of variables during therapy. It aims to efficient and directed rehabilitation at the highest level and ensure the comparability of results.

Conclusions relating to control sample and research sample unequivocally shows the importance and necessity of feedback use for patients during cardiac rehabilitation. The group of research sample patients kept pace on effective level for this kind of attempts, which was not registered on control sample. Their pace was unstable, low and increased the amount of variables, therefore it is impossible to use the gradual increase of difficulty degree in the process of training. Furthermore, attendees of control sample, finished faster their participation in training. They did not reach the desired heart rate. Application of feedback during attempt is crucial and advantageous, on the other hand the lack of feedback can occur effective training preclusion, due to the occurrence of many variables. Without the feedback practice, the influence on training is lesser and it is harder to conduct each training session in uniform shape.

Consent

We have obtained the consent of the resolution No. 4/03/2019 of the Bioethics Committee at the University of Rzeszow to conduct the following tests.

Abbreviations

WHO: World Health Organization
HF: Heart Failure
W: Watt
HR: Heart Rate
ECG: Electrocardiography
EEG: Electroencephalography
HRV: Heart Rate Variability Biofeedback

REFERENCES

1. Jureczko M, Włoka J (2013) Analiza tolerancji wysiłku fizycznego u pacjentów po przebytym zawale serca. *Folia Cardiologica* 8: 37-43.
2. Angoules AG, Balakatounis KC, Panagiotopoulou KA, Mavrogenis AF, Mitsiokapa EA et al. (2008) Effectiveness of electromyographic biofeedback in the treatment of musculoskeletal pain. *Orthopedics* 31. [Crossref]
3. Wilson AM (2017) Heart Rate Variability Biofeedback Training as an Intervention for Chronic Pain.
4. Jo E, Lewis K, Directo D, Kim MJ, Dolezal BA (2016) Validation of Biofeedback Wearables for Photoplethysmographic Heart Rate Tracking. *J Sports Sci Med* 15: 540-547. [Crossref]
5. BROWN RA (1964) REHABILITATION OF PATIENTS WITH CARDIOVASCULAR DISEASES. REPORT OF A WHO EXPERT COMMITTEE. *World Health Organ Tech Rep Ser* 270: 3-46. [Crossref]
6. Zielińska D, Rynkiewicz A, Zajt Kwiatkowska J, Bellwon J, Bakuła S (2006) Wpływ kompleksowej rehabilitacji kardiologicznej na wydolność fizyczną i jakość życia chorych z upośledzoną czynnością lewej komory. *Folia Cardiologica* 13: 208-217.
7. Working group on Cardiac Rehabilitation & Exercise Physiology and Working Group on Heart Failure of the European Society of Cardiology (2001) Recommendations for exercise training in chronic heart failure patients. *Eur Heart J* 22: 125-135. [Crossref]
8. Chaturvedi N (2003) Ethnic differences in cardiovascular disease. *Heart* 89: 681-686. [Crossref]
9. Frank DL, Khorshid L, Kiffer JF, Moravec CS, McKee MG (2010) Biofeedback in medicine: who, when, why and how? *Ment Health Fam Med* 7: 85-91. [Crossref]
10. Okupińska A, Krzywowiąza A (2013) Biofeedback jako efektywna metoda w terapii deficytów poznawczych w ujęciu teorii umysłu, Neurokognitywistyka w patologii i zdrowiu. *Pomorski Uniwersytet Medyczny w Szczecinie* 195-202.
11. Sherman RA, Herman C (2006) Clinical Efficacy of Psychophysiological Assessments and Biofeedback. *Interv Chronic Pain Disord Publ*.
12. Caccamo F, Saltini S, Marogna C, Sava V, Carlon R et al. (2018) The positive impact of a four-week Cardiac Rehabilitation program on depression levels of cardiological patients. *Cor et Vasa* 60: e582-e588.
13. Rutledge T, Redwine LS, Linke SE, Mills PJ (2013) A meta-analysis of mental health treatments and cardiac rehabilitation for improving clinical outcomes and depression among patients with coronary heart disease. *Psychosom Med* 75: 335-349. [Crossref]
14. Sinha S, Krishna V, Mishra V, Singh K, Kumar A et al. (2017) Yoga and Cardiac Rehabilitation (Yoga-CaRe) in post-acute coronary syndrome patients. *Folia Cardiologica* 12: 179-186.
15. Cieślik B (2017) Udział pacjentów w rehabilitacji kardiologicznej i formach aktywności fizycznej-przegląd piśmiennictwa. *Acta Bio-Optica et Informatica Medica. Inżynieria Biomedyczna* 23: 120-132.
16. Izabela P, Piotr D, Janusz B, Sławomira BB, Małgorzata W (2006) Nadzór nad treningiem rehabilitacyjnym u pacjentów po zabiegach kardiochirurgicznych - zadania dla fizjoterapeutów. *Kardiochir Torakochi Pol* 3: 223-226.
17. Szczurek Z, Curyło A, Kowalski P (2008) System rehabilitacji kardiologicznej PELETON plus. *Acta Bio-Optica et Informatica Medica* 14: 226.
18. Kielnar R, Janas M, Domka Jopek E (2008) Wpływ usprawniania ambulatoryjnego na wydolność fizyczną pacjentów po zawale mięśnia sercowego. *Przegląd Medyczny Uniwersytetu Rzeszowskiego* 3: 220-225.
19. Kwolek A, Podgórska J, Rykała J, Leszczak J (2013) Zastosowanie biofeedbacku w rehabilitacji neurologicznej. *Prz Med Uniw Rzesz Inst Leków* 3: 379-388.
20. Moravec CS (2008) Biofeedback therapy in cardiovascular disease: rationale and research overview. *Cleve Clin J Med* 75: S35-S38. [Crossref]
21. Klempfner R, Kamerman T, Schwammenthal E, Nahshon A, Hay I et al. (2015) Efficacy of exercise training in symptomatic patients with hypertrophic cardiomyopathy: results of a structured exercise training program in a cardiac rehabilitation center. *Eur J Prev Cardiol* 22: 13-19. [Crossref]
22. O'Connor CM, Whellan DJ, Lee KL, Keteyian SJ, Cooper LS et al. (2009) Efficacy and safety of exercise training in patients with chronic heart failure: HF-ACTION randomized controlled trial. *JAMA* 301: 1439-1450. [Crossref]

23. Zaczek R, Balsam P, Peller M, Gawałko M, Łyżwiński Ł et al. (2017) *Kardiol Inwazyjna* 12: 48-55.
24. Grzegorczyk J, Mazur E, Domka E (2008) Ocena aktywności fizycznej gimnazjalistów dwóch wybranych szkół na Podkarpaciu. *Przegląd Medyczny Uniwersytetu Rzeszowskiego* 3: 226-234.
25. Jurczak A (2004) Samodzielna aktywność ruchowa młodzieży w czasie wolnym. *Wychowanie Fizyczne i Zdrowotne* 10: 20-27.
26. Moss D (2004) Heart Rate Variability (HRV) Biofeedback. *Psychophysiol Today: Magazine Mind-Body Med* 1: 1: 4-11.
27. Cieślik B (2016) Fizyczne i psychologiczne efekty rehabilitacji kardiologicznej− przegląd piśmiennictwa. *Acta Bio-Optica et Informatica Medica*. *Inżynieria Biomedyczna* 22: 71-97.
28. Sattar FA, Valdiya PS (1999) BIOFEEDBACK IN MEDICAL PRACTICE. *Med J Armed Forces India* 55: 51-54. [Crossref]
29. Makowiecki K, Mamcarz A (2009) [Ambulatory cardiac rehabilitation - can its utilization be improved?] *Kardiol Pol* 67: 639-641. [Crossref]
30. Cooper AF, Jackson G, Weinman J, Horne R (2002) Factors associated with cardiac rehabilitation attendance: a systematic review of the literature. *Clin Rehabil* 16: 541-552. [Crossref]
31. Cooper A, Lloyd G, Weinman J, Jackson G (1999) Why patients do not attend cardiac rehabilitation: role of intentions and illness beliefs. *Heart* 82: 234-236. [Crossref]
32. King KM, Humen DP, Smith HL, Phan CL, Teo KK (2001) Psychosocial components of cardiac recovery and rehabilitation attendance. *Heart* 85: 290-294. [Crossref]
33. Pinkowicka M (2015) Wpływ treningu EEG-Biofeedback na wybrane funkcje poznawcze u dzieci z ADHD. *Psychiatria (Psychiatry)* 12: 255-264.
34. Zivoder I, Martic Biocina S, Kosic AV (2018) Biofeedback and Neurofeedback in the Treatment of Migraine. *Biofeedback*.
35. Bondyra K (2015) Biofeedback szansą na aktywizację osób 50+. *M-Druk Zakład Poligraficzno-Wydawniczy Janusz Muszyński*.
36. Lavie CJ, Milani RV, Cassidy MM, Gilliland YE (1999) Effects of cardiac rehabilitation and exercise training programs in women with depression. *Am J Cardiol* 83: 1480-1483. [Crossref]
37. Leitch JW, Newling RP, Basta M, Inder K, Dear K et al. (1997) Randomized trial of a hospital-based exercise training program after acute myocardial infarction: cardiac autonomic effects. *J Am Coll Cardiol* 29: 1263-1268. [Crossref]
38. Makowiec Dąbrowska T (2012) Wpływ aktywności fizycznej w pracy i życiu codziennym na układ krążenia. *Forum Medycyny Rodzinnej* 6: 130-138.
39. Złotkowska R, Skiba M, Mroczek A, Bilewicz Wyrozumska T, Król K et al. (2015) Negatywne skutki aktywności fizycznej oraz uprawiania sportu. *Hygeia Public Health* 50: 41-46.