Ita. J. Sports Reh. Po.

Italian Journal of
Sports Rehabilitation and Posturology

Changes in heart rate during activity and Recovery

Mladen Savić[1], Milan Milivojević[1], Rosario D'Onofrio[2,3]

[1] *Faculty of Physical Education and Sports, University of East Sarajevo*

[2] *Faculty of Medicine and Surgery, Sapienza Universty of Rome*

[3] *3Member of the Multidisciplinary Medical - Scientific Commission, - L.A.M.I.CA - Italy*

Abstract: *Estimating the number of pulses is crucial when monitoring exercise intensity. The sample consisted of 30 students, aged 15 ± 6 years. The respondents are students of the "School of Mechanical and Electrical Engineering" from Priboj. Variables were tested: resting heart rate; maximum heart rate; central heart rate; recovery time after 1 minute after the end of the activity; recovery time after 3 minutes after the end of the activity; recovery time after 5 minutes after the end of the activity. The Fitness program was realized for 6 weeks with a load intensity (65-75%). After the implementation of the program, the following conclusions can be obtained: Recovery after the first, third and fifth minutes is faster after the program, which confirms the impact and better cardiorespiratory function. Also, resting heart rates, maximum values and average values were slightly lower compared to the first measurement, with statistical significance observed in the two variables.*

Keywords: *HR, ability, fitness, Polar, frequency*

Citation. *Mladen Savić, Milan Milivojević , Rosario D'Onofrio ; Changes in heart rate during activity and recovery - Ita. J. Sports Reh. Po. 2022; Vol. 9 ; Suppl 1 al n°1 ; 1 -9 -.; ISSN 2385-1988 [online]; IBSN 007-11119-55; CGI J OAJI 0.201). Published Online. Open Access (OA) publishing- Authorship Credit:* **:** *"Criteria authorship scientific article" has been used "Equal Contribution" (EC) .*

Introduction

Physical activities are a very important segment in the protection and development of health. Due to the increase in body involvement, physical activities act in a way to reduce heart rate and optimize heart rate[1]. Estimating the number of pulses is crucial when monitoring exercise intensity. By using the first two fingers of one hand and locating the artery, the pulse rate can be easily and accurately determined[2]. The normal heart rate is between 60 and 100 beats per minute. However, in young healthy people, a much lower heart rate can normally be found, especially in those who are physically active[3]. Heart rate variability is also a normal occurrence. Heart rate is subject not only to stress or inactivity, but also to stimuli such as pain and fear. Only in cases when the heart beats inappropriately fast (tachycardia) or slow (bradycardia) can we talk about an abnormal heart rhythm (arrhythmia)[4].

In the field of cardiovascular inheritance, hemodynamic parameters such as heart rate during physical activity, blood pressure and heart morphology are among those that are given special attention when analyzing cardiovascular sports abilities[5]. Over 20 loci that encode heart rate control information have been identified, but little is still known about the contribution of genetics in heart rate modulation, especially at the interindividual level[6]. The effects of PA on HR have not yet been thoroughly studied. Moreover, increased PA has been shown to reduce HR in other age groups such as young and middle-aged adults. Carter et al.[7] who reported that men have lower HR than women when performing exercises of similar intensity. Moreover, Rennie et al.[8] found that increased levels of moderate PA significantly reduced resting HR in men but not in women. Increased PA can cause physiological mechanisms that affect parasympathetic tone in healthy adults. Lower HR is, at least in part, the result of increased parasympathetic tone and may be associated with improved sympathetic control of PA[9]-induced vasomotor tone. The aging process reduces parasympathetic activity in the heart, and thus HRV indices.

The great advantage of fitness is that it can increase the cumulative time in which a high pace of work can be maintained, compared to training of the same intensity, until fatigue, and that fitness has a special effect on the cardiovascular system, whose main task is to maintain blood pressure[10] . It is important that the heart rate can be used to check that the training intensity is appropriate. During the activity (exercise), in work with a stable state, the heart rate increases sharply in the first 3-5 minutes. After establishing a stable state, the heart rate does not change significantly until the end of work. In the recovery process, depending on the type of work (light, moderate, submaximal or maximum), the heart rate returns to resting values at different speeds[11]. If it is a work of light or moderate intensity (as in fitness), the heart rate returns to resting values in a few minutes. The aim of the research is to determine changes in heart rate at rest and recovery.

Method

Sample of respondents

The sample consisted of 30 students, aged 15 ± 6 years. The respondents are students of the "School of Mechanical and Electrical Engineering" from Priboj. All subjects underwent experimental treatment with a modified fitness program within the school gym. The program was implemented as an extracurricular activity. Subjects were tested under the same environmental conditions (room temperature between 22-24°C). Testing was performed in the morning, starting at 9am. All respondents reported good general condition and absence of disease. Respondents voluntarily agreed to participate in the study.

Sample of measuring instruments

The following measuring instruments were used to assess the functional abilities of students, so that they correspond to the subject and goal of the work. The heart rate was measured telemetrically, using a Polar FT2 pulse monitor. After processing the data, possible differences between the first and second tests were examined, as well as their statistical significance, in the initial and final phase of training, as well as comparing their differences.

The sample of heart rate variables consisted of the following parameters: Fcmir. - resting heart rate; Fcmax. - maximum heart rate (during activity); Fcaver. - central value of heart rate; Time 1 - recovery time after 1 minute after the end of the activity; Time 2 - recovery time after 3 minutes after the end of the activity; Time 3 - recovery time after 5 minutes after the end of the activity.

Description of the experimental procedure

Respondents were told that they had their last meal at least three hours earlier before coming to the test. They are also explained the procedures and the way of testing. The duration of the experimental program was six weeks with a frequency of 2x per week during the Fitness Program was realized with a load intensity (65-75%). The duration of the introductory part is 8-10 min. and movements in place and space and complexes of shaping exercises (8-10 exercises, 10-12 repetitions) are realized. The main part of the training is performed with pre-prepared exercises that are divided into muscle partitions and each training has an emphasis on one large and one smaller muscle partition. The emphasis of the exercises is distributed on the leg muscles, back muscles, arm muscles, abdominal muscles, shoulder muscles and chest muscles. Exercises are performed with their own weight or additional load using the available props with the possibility of applying musical choreographies that are predetermined. The final part of the class lasting 5-8 min. aims to stretch and loosen all regions of the body, with a focus on proper breathing and controlled muscle stretching due to the possibility of injury.

Statistical data processing

The statistical method shows the basic descriptive parameters: Sample of respondents (N), Arithmetic mean (Mean), Minimum (Min.), Maximum (Max.), Standard deviation (SD). Univariate analysis of ANOVA variance was used to determine significant differences between the two measurements. In the Sig section. (significance), each no. equal to or less than the limit of 0.05 is considered a statistically significant indicator. The statistical procedure was conducted using the SPSS 20 software package.

Results with discussion

Descriptive analysis of heart rate results at the initial measurement showed that there was no statistically significant deviation of the distribution of results from the normal distribution of the applied variables.

Table 1. Heart rate parameters at the first measurement							
Variable	**N**	**Min.**	**Max.**	**Mean**	**SD**	**Skew.**	**Kurt.**
FCmir.	30	58	71	64.3	2.89	-0.44	-0.65
FCmax.	30	205	216	212.06	2.12	-1.02	1.41
FCaver.	30	134	141	137.73	1.57	-0.08	0.44
Time 1	30	190	205	199.87	3.11	-1.17	1.89
Time 2	30	160	183	167.77	6.42	1.03	0.25
Time 3	30	123	166	135.58	10.38	1.63	2.81

In the test results, there is a small variability of the results (coefficients of variability mostly below 0.10) and a slight asymmetry of the distribution towards the zone of higher values in the variables Time 1.

Table 2. Heart rate parameters on the second measurement							
Variable	**N**	**Min.**	**Max.**	**Mean**	**SD**	**Skew.**	**Kurt.**
FCmir.	30	56	68	62.97	2.76	-0.41	-0.26
FCmax.	30	201	214	211.23	2.77	-0.62	0.36
FCaver.	30	132.5	141.5	137.19	1.78	-0.73	1.58
Time 1	30	191	203	197.80	3.36	-1.28	1.27
Time 2	30	156	175	163.65	4.92	0.70	-0.05
Time 3	30	121	139	125.77	3.77	1.68	3.79

If we compare the numerical values of the results between the first and second measurements, we can see the largest changes in the variables Time 3 (-9.81), Time 2 (-4.10) and Fcmir. (-1.33). Numerical differences are also present in other variables, but the values are smaller compared to the previously mentioned variables.

Table 3. Statistical significance of heart rate differences between the first and second measurements				
Variable	**N**	**AS1 / AS2**	**t**	**Sig.**
FCmir.	30	1.41	4.42	**.000**
FCmax.	30	-1.16	-3.64	**.001**
FCaver.	30	.129	.568	.574
Time 1	30	.124	.462	**.001**
Time 2	30	4.12	4.85	**.000**
Time 3	30	9.80	5.39	**.000**

In Table 3, univariate analysis of variance shows statistically significant differences between the first and second measurements. Looking at the table, we can conclude that in most of all variables there were statistically significant differences, except in the variable Fcaver. (.574), which represents the average heart rate during the activity, which is justified because the ratio of the minimum and maximum result in each activity oscillates very little, so that the numerical differences between measurements are quite small.

This study investigated changes in heart rate at rest, during activity, and in recovery. After a six-week fitness program, the results showed statistically significant differences in almost all monitored parameters.

During exercise, cardiovascular parameters are changed to supply oxygen to the muscles and to preserve the perfusion of vital organs, and vascular resistance and heart rate are controlled differently during physical activity[12]. Significant differences in heart rate recovery exist between athletes and physically inactive people[13,14] where the relationship of cardiorespiratory fitness with different physiological parameters is also known. In this study, statistically significant differences in heart rate after final measurement (FCmir, FCmax) were demonstrated, while in FCaver there were no differences. The ratio of heart rates, when looking at the differences between the initial and final measurements, showed statistical significance, which confirms the impact of the program on the mentioned parameters and its significance. Given lower resting heart rates, and without a large significant difference in maximum heart rate, there is a greater range to increase during physical activity, designated as the heart rate reserve[15]. Cardiac, metabolic and hormonal morphophysiological adaptations caused by physical activity are mainly observed, namely aerobic exercise, where eccentric hypertrophy of the heart associated with increased diameter and diastolic volume is observed. These adaptations are directly related to lower FC values at rest and greater FC decline during the recovery period, which is used as an important index of cardiovascular morbidity and mortality[16,17].

Recovery after the first (Time1), third (Time2) and fifth (Time3) minutes is faster after the program, which confirms the impact and better cardiorespiratory function, which is consistent with studies that have shown that aerobic training improves heart rate (FC) in healthy individuals, but also in patients with coronary heart disease or chronic heart failure, regardless of age[18,19]. Also, resting heart rates, maximum values and average values were slightly lower than in the first measurement, with statistical significance observed in FCmir ($p = .000$) and FCmax ($p = .001$), and in FCaver $p = .574$) was not. What is most important is that under the influence of physical activity, cardiorespiratory fitness was brought to a better condition, which confirms the values of statistical significance in Time1 ($p = .001$), Time2 ($p = .000$) and Time3 ($p = .000$).

The limitation of the study is reflected in the fact that a larger number of respondents had to be included and divided according to gender, in order to obtain differential values, as well as a larger number of tests to assess cardiorespiratory fitness of the selected population[20]. Thus, Astrand[21], 2003 defined as an indirect method, which is adapted to calculate VO2max, at submaximal heart rate, with respect to age, sex, height and maximum heart rate (FCmax).

Conclusion

Using heart rate and its recovery after physical activity as a reliable parameter, this study showed that there are statistically significant differences between initial and final measurements, after a fitness program, which shows the level of physical fitness, because there is faster recovery.

Declaration of conflicting interests

Declaration of conflicting interests The author (s) declared no potential conflicts of interest with respect to the research, authorship, and / or publication of this article.

Funding

The author (s) received no financial support for the research, authorship, and / or publication of this article. All authors have read and agreed to the published version of the manuscript.

Literature

1. Preßler, A. (2020). Be patient in the heart of the heart! : Heart and movement [Physical activity and exercise in chronic heart failure]. MMW Fortschritte der Medizin, 162 (10), 40–44. https://doi.org/10.1007/s15006-020-0521-9
2. Catai, AM, Pastre, CM, Godoy, MF, Silva, ED, Takahashi, A., & Vanderlei, L. (2020). Heart rate variability: are you using it properly? Standardization checklist of procedures. Brazilian journal of physical therapy, 24 (2), 91–102. https://doi.org/10.1016/j.bjpt.2019.02.006
3. Schwerdtfeger, AR, Schwarz, G., Pfurtscheller, K., Thayer, JF, Jarczok, MN, & Pfurtscheller, G. (2020). Heart rate variability (HRV): From brain death to resonance breathing at 6 breaths per minute. Clinical neurophysiology: official journal of the International Federation of Clinical Neurophysiology, 131 (3), 676–693. https://doi.org/10.1016/j.clinph.2019.11.013
4. Bertero, E., & Maack, C. (2018). Metabolic remodeling in heart failure. Nature reviews. Cardiology, 15 (8), 457–470. https://doi.org/10.1038/s41569-018-0044-6
5. Pankova, NB, Alchinova, IB, Cherepov, AB, Yakovenko, EN, & Karganov, MY (2020). Cardiovascular system parameters in participants of Arctic expeditions. International Journal of Occupational Medicine and Environmental Health, 33 (6), 819–828. https://doi.org/10.13075/ijomeh.1896.01628
6. Al-Shafei, AI, Musa, SM, Rayis, DA, Lutfi, MF, El-Gendy, OA, & Adam, I. (2020). Heart rate variability and hematological parameters in pregnant women. Journal of clinical laboratory analysis, 34 (6), e23250. https://doi.org/10.1002/jcla.23250
7. Carter, R., Hinojosa-Laborde, C., Convertino, VA (2015) Sex comparisons in muscle sympathetic nerve activity and arterial pressure oscillations during progressive central hypovolemia. Physiol Rep 3: e12420.
8. Rennie, KL, Hemingway, H., Kumari, M., Brunner, E., Malik, M., et al. (2003) Effects of moderate and vigorous physical activity on heart rate variability in a British study of civil servants. Am J Epidemiol 158: 135-143.
9. Koçer, G., Nasircilar Ülker, S., & Şentürk, Ü. K. (2018). The contribution of carbon monoxide to vascular tone. Microcirculation (New York, NY: 1994), 25 (7), e12495. https://doi.org/10.1111/micc.12495
10. Zgierski-Johnston, CM, & Dean, D. (2021). Mechanobiology of the cardiovascular system. Progress in biophysics and molecular biology, 159, 1–2. https://doi.org/10.1016/j.pbiomolbio.2020.11.003
11. Obas, V., & Vasan, RS (2018). The aging heart. Clinical Science (London, England: 1979), 132 (13), 1367–1382. https://doi.org/10.1042/CS20171156
12. O'Leary D (1993). Autonomic mechanisms of muscle metaboreflex control of heart rate. Journal of Applied Physiology, 74: 1748-1754.
13. Imai K, Sato H, Hori M, Kusuoka H, Ozaki H, Yokoyama H, et al. Vagally mediated heart rate recovery after exercise is accelerated in athletes but blunted in patients with chronic heart failure. J Am Coll Cardiol. 1994; 24: 1529–1535.
14. Otsuki T, Maeda S, Iemitsu M, Saito Y, Tanimura Y, Sugawara J, et al. Postexercise heart rate recovery accelerates in strength-trained athletes. With Sci Sports Exerc. 2007; 39: 365–370.
15. Al-Ani M, Robins K, al-Khalidi AH, Vaile J, Townend J, Coote JH. Isometric contraction of arm flexor muscles as a method of evaluating cardiac vagal tone in man. Clin Sci (London). 1997; 92 (2): 175-80.
16. Qiu, S. et al. Heart rate recovery and risk of cardiovascular events and all-cause mortality: A meta-analysis of prospective cohort studies. J. Am. Heart Assoc. 6 (5), e005505 (2017).
17. van de Vegte, YJ, van der Harst, P. & Verweij, N. Heart rate recovery 10 seconds after cessation of exercise predicts death. J. Am.Heart Assoc. 7 (8), e008341 (2018).

18. Sugawara J, Murakami H, Maeda S, Kuno S, Matsuda M (2001) Change in post-exercise vagal reactivation with exercise training and detraining in young men. Eur J Appl Physiol 85: 259–263
19. Javorka M, Zila I, Balharek T, Javorka K (2002) Heart raterecovery after exercise: relations to heart rate variability andcomplexity. Braz J Med Biol Res 35: 991–1000
20. Bjelica, B., Milanović, Lj., Aksović, N., Zelenović, M., & Božić, D. (2020). Effects of physical activity to cardiorespiratory changes. Turkish Journal of Kinesiology, 6 (4), 164-174
21. Astrand PO, Kaare R, Dahl HA, Stromme SB (2003) Textbook ofwork physiology, 4th edn. Human kinetics, Champaign, p 281

Italian Journal of Sports Rehabilitation and Posturology