PREGLED LITERATURE – REVIEW ARTICLE

Heart Rate Recovery a Useful Cardiovascular Health Biomarker

Oporavak srčane frekvencije - koristan biomarker kardiovaskularnog zdravlja

Ljiljana Bjelaković

Faculty of Sport and Physical Education, University of Niš, Serbia

Summary The time required for the heart to recover, to reduce its frequency after intense physical effort, most often measured in the first or second minute, is known as heart rate recovery (HRR). It can easily and accurately detect autonomic nervous system dysfunction that is known to carry a risk of sudden cardiac death. A drop in heart rate of less than 22 beats per minute is considered a low value and is associated with an increased mortality rate. Determining heart rate recovery is also used in the pediatric population for cardiovascular risk assessment and understanding the early development of metabolic abnormalities in obese children. Assessment of heart rate recovery as a biomarker in sports-medicine practice can find application in pre-participation screening, detection of some heart diseases, and overtraining syndrome. Given the fact that the risk of arrhythmia and sudden cardiac death increases during and after intense physical activity, especially in individuals with asymptomatic heart disease, assessment of heart rate recovery may be useful for athlete's cardiovascular health evaluation. The athlete trains to achieve their best performance by increasing load during the training process. However, if the load is extreme, it can lead to the development of overtraining syndrome. By regularly monitoring this parameter, athletes can monitor changes in training status. As the results of numerous studies confirm the importance of determining heart rate recovery, routine determination of this parameter could be important for everyday medical practice.

Key words: cardiovascular risk, assessment, fatigue, athletes

Sažetak Vreme potrebno srcu da smanji frekvencu nakon intenzivnog fizičkog napora, najčešće mereno u prvom ili drugom minutu predstavlja oporavak srčane frekvencije (HRR). Njime se može jednostavno i prilično tačno detektovati disfunkcija autonomnog nervnog sistema, a koja nosi rizik za naprasnu srčanu smrt. Pad srčane frekvence manji od 22 otkucaja u minuti smatra se niskom vrednošću i povezan je sa povećanim procentom smrtnosti. Određivanje oporavka srčane frekvence nalazi primenu i u dečjoj populaciji, za određivanje kardiovaskularnog rizika i razumevanje ranog razvoja metaboličkih abnormalnosti kod gojazne dece. Procena oporavka srčane frekvence kao biomarkera u sportsko-medicinskoj praksi može naći primenu u preparticipacionom skriningu, detekciji nekih srčanih oboljena i sindroma pretreniranosti. Uzimajući u obzir podatak da je rizik od aritmija i iznenadne srčane smrti povećan tokom, i posle intenzivne fizičke aktivosti naročito kod pojedinaca sa asimptomatskim srčanim oboljenjima, procena oporavka srčane frekvece može biti korisna za procenu kardiovaskularnog zdravlja sportista. Sportista trenira kako bi postigao što bolju performansu, a to postiže povećanjem opterećenja tokom trenažnog pocesa. Međutim, ako je opterećenje ekstremno može doći do razvoja sindroma pretreniranosti. Redovnim monitoringom ovog parametra, sportisti mogu da prate pomene u statusu utreniranosti. Kako rezultati brojnih istraživanja potvrđuju značaj određivanja oporavka srčane frekvence, rutinsko određivanje ovog parametra bi bilo od značaja za svakodnevnu medicinsku praksu.

Ključne reči: kardiovaskularni rizik, procena, zamor, sportisti

Introduction

The autonomic nervous system consists of a sympathetic (Sy) and parasympathetic part (PSy) which are synchronized, and affect how the heart works in quite opposite ways. Their mutual interaction includes complex and sensitive control on several levels, ranging from baroreceptors, and chemoreceptors, to local neural interactions. Since the autonomic nervous system is connected to numerous physiological systems, the indirect evaluation of its function, the quantification of its activities, and the sympathovagal balance can be useful tools in everyday clinical practice for the assessment of cardiorespiratory fitness, as well as the functional adaptation of the body to physical exercise. Simply put, heart rate recovery (HRR) represents the heart rate immediately after exercise. Measurements are taken at the end of the first or second minute after physical exercise (1). Therefore, HRR to a great extent depends on the proper functioning of the autonomic nervous system, the interaction of the parasympathetic and sympathetic systems, that is, the physiologically greater impact of the parasympathetic nervous system, and the progressive decrease in the tonus of the sympathetic nervous system after exercise. A rapid decrease in heart rate indicates a positive adaptation of the human body. Changes to the HRR in the sense of a rapid

recovery is in a positive correlation with improved cardiorespiratory fitness.

The importance of determining heart rate recovery in clinical practice

Today, HRR has found its application in clinical practice in the assessment of autonomic dysfunction, which is known to carry increased risk of sudden cardiac death. A decrease in heart rate to less than 22 beats/min immediately after exercise is considered a low value, and an increased mortality rate was noted in a group of patients with these values, when compared to a group of participants with normal HRR values (2). In addition, authors indicate that HRR<12/min represents an unfavorable prognostic sign among post-infarction patients for the onset of sudden cardiac death. When comparing different markers used to assess the functions of the autonomic nervous system, Cole et al. (1999) point out that other markers can be used to assess autonomic function, such as heart rate variability and tests of baroreflex sensitivity. The authors give an advantage to HRR as a parameter for assessment, due to its simplicity of determination and minor errors (2). HRR can also be measured over various time intervals. The data in the relevant literature indicate that there are discrepancies among the findings regarding the reliability of measuring HRR only in the first or only in the second minute after exercise (2). Bosquet et al. state that there are no differences in the reliability of measuring HRR during the first and during the second postexercise minute (3). Lamberts et al. clearly point out that measurements of changes in heart rate are far more precise if measured during the first postexercise minute (4). Lamberts et al. calculated the average heart rate value during the final 15 seconds, and the heart rate values measured between second 45 and 60 (4). This method of measurement is more objective than measuring heart rate values immediately after exercise.

A delay in HRR in medical practice is linked to unwanted cardiovascular events and insulin resistance.

Minai et al. point out that HRR values measured following a six-minute walk test are a predictive biomarker of clinical deterioration among individuals suffering from idiopathic pulmonary arterial hypertension (5).

Yu Tai et al. concluded that a delay in HRR represents a predictive sign of unwanted cardiovascular events. Both studies point out that only HRR measured during the first minute has clinical significance (6).

Measuring HRR has also found application among the population of children. Bjelakovic et al. (2017) compared the values of HRR among obese metabolically unhealthy and metabolically healthy children. The research results are congruent with the results of existing studies and confirm the importance of determining HRR as a marker of risk factor prediction, and of understanding the early development of metabolic abnormality among obese children (7).

The importance of determining heart rate recovery in sports medicine

Monitoring HRR is also a useful parameter for the study of autonomic balance among the population of athletes. HRR in this population can be measured after one, two, or three minutes, or 30 seconds after exercise, depending on the intensity, type, and duration of the physical exercise. However, the methodology which is used to determine and analyze HRR is still not adequately defined. Primarily, it is necessary to define an adequate protocol for the load test which is used for that purpose, and then to select a suitable ergometer. It is also necessary to define the recovery period protocol (whether the recovery period will be active or passive), considering that the selected protocol has an impact on the obtained values. The interpretation of the obtained values varies from study to study, so researchers have the freedom to select a means of interpretation which best suits the needs of their research.

An athlete trains to achieve a better sports performance. Exercise presents a stimulus whereby the human body, primarily the ANS, is activated to maintain homeostasis. In contemporary theory, a well-planned training process should dose the intensity of the training and enable a gradual increase in the load, while the rest intervals during this process should be strong enough to provide the regeneration of the muscle function (8). With an inadequate recovery time, such loads can lead to unwanted effects, including chronic fatigue and a lack of progress in sports performance (9). A series of symptoms and signs of maladaptation ensue, so that days, weeks, and even months are needed for the athlete to regain their top form (10,11). This state of reduced fitness levels is described in the literature as Sy overtraining (10,11). As a result, a simple and quick evaluation of physiological parameters should represent the primary method in the detection of overtrained athletes (12). Some authors suggest that HRR quickly responds to the relatively recent training load, which makes it a sensitive parameter in monitoring fatigue. However, the findings of Boresen and Lambert do not agree with those of other studies. The authors point out that the values of HRR decrease with the increase in load. They try to explain these results with the rapid increase in load during training, which leads to the development of symptoms and signs of overload among the participants, and that one of them is certainly a decrease in the values of HRR (13). Short and Sedlock state that athletes with superior aerobic capacity had the same HRR values as a control group of untrained athletes, without a clear explanation for this phenomenon (14). HRR has greater values among trained than untrained individuals (15, 16). The findings from two of the most frequently cited longitudinal studies confirm previous findings and point out that the values of HRR do not change when there is no change in training status (17,18). Lehman et al. speculate that a slower decrease in HRR should be related to a state of chronic fatigue. These results suggest that HRR can potentially be a useful tool for identifying not only changes in training status and for monitoring fatigue, but also for detecting potential risk for the development of Sy overtraining.

Vicente - Campos et al. (2014) point out a connection with VO2 Max, and indicate that only heart rate recovery

mesured in third minute (HRR3) can be used as an indicator of aerobic capacity among athletes (19). Suzic Lazic et al. (2015) confirm the results of a previous study and indicate that these two studies are a part of a mosaic for the acceptance of an assessment model of the aerobic capacity of an athlete which is different from the established one (20).

Conclusion

Even though the precise mechanism of the cardioprotective effects of the parasympathetic system has still not been defined, there is scientific evidence that greater values of HRR are related to decreased VS risk. Taking into consideration the data regarding the risk of arrythmia and sudden cardiac death during and after intense physical exercise, especially among individuals with asymptomatic heart disease, the assessment of HRR can be useful in determining cardiovascular risk among elite athletes. Even though the results of numerous studies confirm the importance of determining HRR among athletes, such as the risk of arrythmia, the routine application of this biomarker has still not been introduced into sports medicine protocols. Due to the simplicity of its determination and its prognostic importance, this biomarker could be of importance for the assessment of cardiovascular risk if implemented in everyday clinical practice.

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Correspondance to:
Prof. dr Ljiljana Bjelaković
Faculty of Sport and Physical Education, University of Niš, Serbia
Mail: ljilja975@gmail.com