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Abstract

This study aimed to assess the impact of physical training on heart rate variability (HRV) in male university ergo rowing athletes and middle- and long-distance track and field athletes. Ninety athletes, aged 19 to 25, underwent an intensive 8-week training program. HRV measurements were taken at baseline, after 4 weeks, and at the end of the 8 weeks using a Polar H10 strap. Results showed significant decreases in HRV across all sports: ergo rowing saw a 60% decrease, middle-distance events a 61% decrease, and long-distance events a 75% decrease from pre- to post-intervention. These reductions indicate a high physiological response to intensive exercise, suggesting that structured training positively affects autonomic function and cardiovascular health. The findings highlight the importance of physical training in maintaining autonomic balance and overall cardiovascular health in athletes.

Keywords: Heart Rate Variability, Ergo Rowing, Players, Physical Training

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Title

Investigating the Effect of Physical Training on Heart Rate Variability in University Male Players

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Abstract

This study aimed to assess the impact of physical training on heart rate variability (HRV) in male university ergo rowing athletes and middle- and long-distance track and field athletes. Ninety athletes, aged 19 to 25, underwent an intensive 8-week training program. HRV measurements were taken at baseline, after 4 weeks, and at the end of the 8 weeks using a Polar H10 strap. Results showed significant decreases in HRV across all sports: ergo rowing saw a 60% decrease, middle-distance events a 61% decrease, and long-distance events a 75% decrease from pre- to post-intervention. These reductions indicate a high physiological response to intensive exercise, suggesting that structured training positively affects autonomic function and cardiovascular health. The findings highlight the importance of physical training in maintaining autonomic balance and overall cardiovascular health in athletes.

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Contents

Introduction

Any nation's Heart rate variability (HRV) is among the critical measures that define autonomic nervous system (ANS) function and cardiovascular health. It is a measure of the interplay between sympathetic and parasympathetic functioning (Thomas et al., 2019). In this respect, HRV is of particular interest in sports science for gaining information about an athlete's physiological state, readiness for training, or recovery status. This research aims to investigate whether physical training will affect heart rate variability in university male athletes training in ergo rowing, middle distance, and long-distance events in track and field. It has been suggested that HRV is a good index for monitoring autonomic nervous system responses to different stimuli, such as physical training (Besnier et al., 2017).

The autonomic imbalance between sympathetic (fight or flight) and parasympathetic activities (rest and digest) influences the measure. In general, a high HRV would suggest a healthful heart, with great cardiovascular effectiveness and excellent autonomic regulation. The low values of such an index would be linked to stress-related conditions, fatigue, and impaired recovery. In sports, HRV becomes crucial for maximizing performance and preventing overtraining. Such monitoring of HRV can help coaches and athletes tailor individual training programs to evoke the best performance while ensuring proper recovery. This is of particular relevance to athletes participating in endurance sports, such as ergo rowing, and middle- and long-distance running. This proper balance of training intensity and recovery is important to elicit peak performance (Ghosh et al., 2023).

Hence, ergo rowing is considered one of the most physically demanding sports, requiring a better-than-usual amount of cardiovascular and muscular endurance. Such athletes usually undergo very intense training sessions, which would definitely affect autonomic function in a very prominent way. This way, monitoring HRV in rowers can provide valuable feedback about the physiological response to training loads of an athlete, and it helps in preventing overtraining by adjusting the volume and intensity of training according to the HRV trend (Egan-Shuttler et al., 2020). There is evidence that structured programs of endurance training improve HRV, reflecting improved autonomic balance and improved efficiency in cardiovascular performance. Events of middle and long-distance running induce a great load on the cardiovascular and muscular systems. This kind of athlete requires a definite training schedule to enable him to achieve his best possible performance without the menace of overtraining and injury. In these respects, HRV monitoring provides the follow-up of the athlete's recovery status and preparedness to train and therefore helps coaches decide on adjustments to training. Several studies demonstrated that HRV, as an index for parasympathetic activity and autonomic regulation, is improved after endurance training.

Literature Review:

Heart rate variability is an accepted measure of autonomic nervous system function and a classical determinant of cardiovascular health (Grégoire et al., 2023). The measure details how able and ready the heart is to respond to various physiological changes; the more significant the variability, the more resilient, robust, and adaptive the cardiovascular system, relating this to sports science, HRV forms an important technique in monitoring athletic performance, recovery, and training adaptations (Stephenson et al., 2021). The effect of physical training on heart rate variability is dramatic. Various modes of exercise training exert specific effects on autonomic function. Endurance training, HIIT, and resistance training specifically affect HRV measures. Systematic physical training seems to improve HRV in a manner that may suggest improved autonomic regulation and increased cardiovascular efficiency.

For example, Grässler et al. (2021) found that in the process of endurance training, the HRV was greatly improved, hence indicating an increase in parasympathetic activity and thus cardiovascular health. Another study reported that university athletes majoring in endurance sports, such as rowing, middle-distance running, and long-distance running, have concluded that HRV monitoring provides vital information concerning actual training status and recovery needs. In a study conducted on university rowers, 8 weeks of endurance training significantly increased HRV parameters, thus improving autonomic balance and reducing cardiovascular strain at rest (Santos et al., 2022). Such results led to the realization that rowing is probably one of the most highly demanding sports at both the cardiovascular and muscular levels, thus making HRV an important metric for tracking training adaptations and recovery in this sport. Heavy cardiovascular and muscular demands are characteristic for middle-distance and long-distance runners as well. For this reason, their training regimens have to be very precise to achieve perfect performance, avoiding overtraining (Parry-Williams & Sharma 2020), In this study it was found that elite long-distance runners had higher HRV than their recreational counterparts. It reflects better cardiovascular health and recovery capacity.

Research Methodology

Participants

This research involved 90 male university athletes from three famous universities in Lahore: The University of the Punjab, Government College University Lahore, and the University of Central Punjab, Lahore. PU contributed 60 athletes with 20 athletes in each sports category, while GCU and UCP contributed 15 athletes in each category. In this study, athletes were selected by convenient sampling, and categorized into three different groups: 30 each in ergo rowing, middle-distance running, and long-distance running.

Inclusion and Exclusion Criteria

Age Range: Participants were aged 19 to 25, meeting the eligibility requirements for the HEC Inter-varsity sports competitions.

Educational Background: Athletes were currently enrolled in public or private universities in Lahore.

Competition Participation: All participants actively competed in the 2022-23 HEC Inter-varsity sports competition.

Drug and Medication-Free: Participants using drugs or medications were excluded.

Health Requirements: Individuals with a history of endocrine disorders were excluded.

Heart Rate Variability Assessment

The Polar H10 strap was used for HRV testing. It was carefully placed at the sternum, aligned with the xiphoid process, following Souza et al. (2019). Participants abstained from caffeine and alcohol for 48 hours before data collection. They underwent a 5-minute adaptation period in a supine position, followed by a 10-minute HRV recording in the same position. The environment was kept quiet and free from disturbances, and participants were instructed to remain silent and still. Data collection was managed by the same research team to ensure consistency. The data were uploaded to the Elite HRV Team Dashboard App for processing and storage.

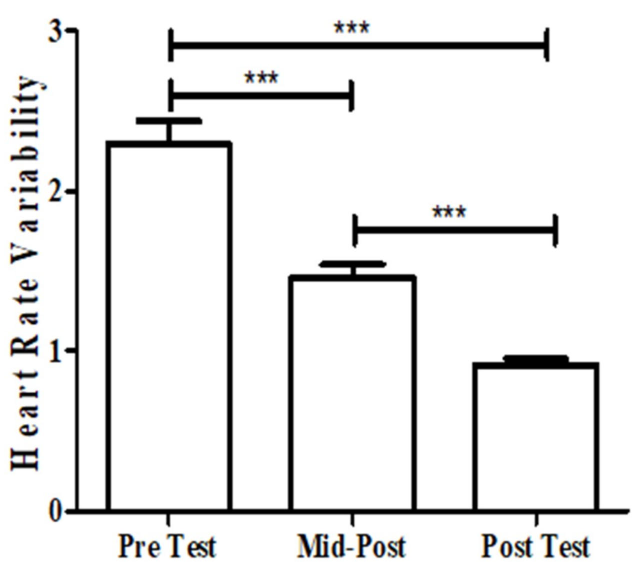
Statistical Analysis

Data were analyzed using GraphPad Prism version 6.0 software. Results were presented as Mean ± SEM and assessed using a two-tailed paired sample t-test to evaluate the effect of the physical training program on Heart Rate Variability (HRV). Analysis of Variance (ANOVA) was used to explore the effect of physical training on HRV for each sports category.

Results

Figure 1

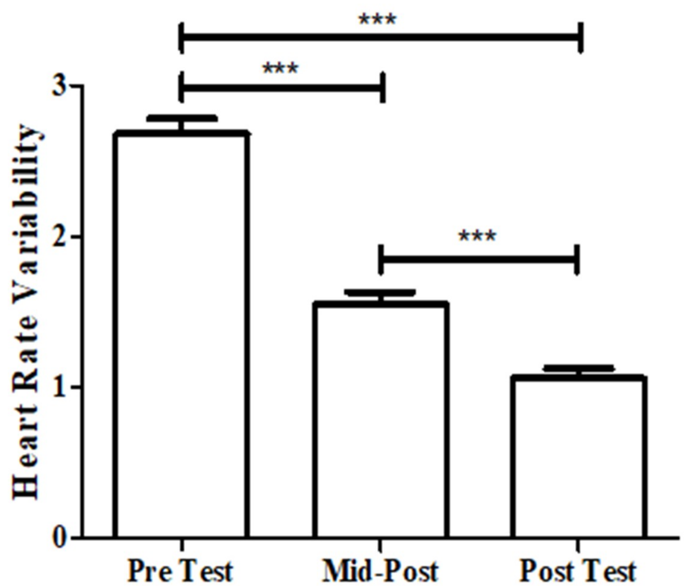
*Average heart rate variability score in comparable ergo-rowing groups. Values are Mean ± SEM, ***indicate significance at $P \leq 0.001$*



Ergo Rowing

Figure 2

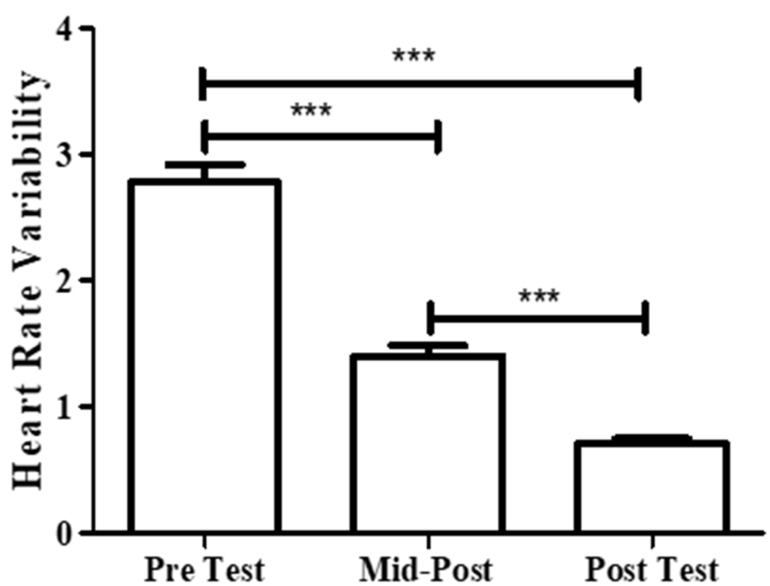
*Average score of heart rate variability in comparable groups of middle distance. Values are Mean ± SEM, ***indicate significance at P ≤ 0.001*



Middle Distance

Figure 3

*Average heart rate variability score in comparable long-distance groups. Values are Mean ± SEM, ***indicate significance at P ≤ 0.001*



Long Distance

Table 1

Group Comparison of Heart Rate Variability in Ergo Rowing, Middle Distance and Long Distance

Group Comparison			
Heart Rate Variability in Ergo-rowing			
Group Comparison	Means ± SEM	Means ± SEM	Percentage difference
Pre-Test vs Mid-Post	2.29 ± 0.14	1.45 ± 0.08	36↓***
Pre-Test vs Post-Test	2.29 ± 0.14	0.91 ± 0.03	60↓***
Mid-Post vs Post-Test	1.45 ± 0.08	0.91 ± 0.03	37↓***
Heart Rate Variability in Middle Distance			
Pre-test vs Mid-Post	2.68± 0.09	1.54± 0.08	42↓***
Pre-test vs Post-test	2.68± 0.09	1.05± 0.06	61↓***
Mid-Post vs Post-Test	1.54± 0.08	1.05± 0.06	32↓***
Heart Rate Variability in Long Distance			
Pre-Test vs Mid-Post	2.78 ± 0.13	1.40 ± 0.08s	51↓***
Pre-Test vs Post-Test	2.78 ± 0.13	0.70 ± 0.04	75↓***
Mid-Post vs Post-Test	1.4 ± 0.08	0.70 ± 0.04	50↓***

As shown in Table 1, the data offers significant reductions in HRV variables across different modalities, exercise types, and testing points. Among those is ergo-rowing, with a decrease of 36% from pre-test to mid-post, 60% from pre-test to post-test, and 37% from mid-post to post-test all highly significant (< 0.001). For middle distance, there was a 42% decrease from pre-test to mid-post, a 61% decrease from pre-test to post-test, and a 32% decrease from mid-post to post-test; this was also highly significant (< 0.001). The long-distance HRV had a 51% decrease from pre-test to mid-post, an absolute 75% decrease from pre-test to post-test, and a 50% decrease from mid-post to post-test all significantly significant (< 0.001) as well. These were consistent, and quite major, reductions, suggesting a robust physiological response to the long and intense physical activity with the greatest changes from pre- to post-test across all modalities.

Discussion

The objective of the study was to monitor the effect of 8 weeks of physical training on heart rate variability of the ergo rowing, middle, and long-distance players before the start of training after four months of training and before the competition.

The heart is essential for the proper functioning of the human body, and a well-operating cardiac system is necessary for a healthy life. The heart possesses its nervous system, known as the neuro-cardiac system, in which the autonomic nervous system (ANS) plays a crucial role. The interplay between the sympathetic and parasympathetic systems within the ANS is instrumental in regulating heart rate variability (HRV) (Lenger et al., 2022). In elite players, there is a constant requirement for a delicate balance between psychological and physiological stress levels and recovery to achieve maximum output. The evaluation of heart rate variability (HRV) furnishes a non-invasive approximation of physiological and psychological stress levels, presenting potentially significant insights into health, performance, and adaptability (Deblauw et al., 2023). The fluctuations of a robust heart are intricate and perpetually dynamic, enabling the cardiovascular system to adapt to abrupt physiological and psychological disturbances to equilibrium swiftly (Saghiv et al., 2020). While the high-frequency (HF) peak is generally accepted as a marker of cardiac parasympathetic nervous activity, the more complex low-frequency (LF) peak is usually considered to have a prevailing sympathetic component (Hayano et al., 2021; Lee, 2021). A low LF/HF ratio is an indication of cardiac abnormality, while a high LF/HF ratio indicates some kind of pathology. This ratio is modulated by genetic predispositions, physiological and pathological states, psychological influences, environmental conditions, and lifestyle choices (Tiwari et al., 2021). Rowing is a high-intensity game requiring pronounced force in anaerobic and aerobic capacity (Treff et al., 2021; Held et al., 2023).

In our investigation, a prominent reduction in the LF/LH was evidenced after the mid-post competition, which indicates that heart variability decreases after continuous training. Moreover, a similar trend was noticed after the post-test condition. This shows that training for two months significantly improves the cardiac output of the players. Generally, LF/HF demonstrates autonomic nervous system balance. Pertinently, a low LF/HF ratio indicates parasympathetic nervous system (PSNS) dominance, whereas an increased LF/HF ratio shows sympathetic nervous system (SNS) dominance (El-Malahi et al., 2024) in an investigation by Deblauw et al. (2023), five female elite rowers were recruited. In this investigation, HRV and psychometrics were measured. This research did not attribute an HRV score to on-water rowing performance during an elite competition.

Hence, the reduced score of LF/HF in ergo-rowing, middle-distance, and long-distance players after two months of training indicates that their player's cardiac health improves after training. This phenomenon further forecasts the enhanced performances of elite athletes in intensely competitive environments. Different investigations have documented different HRV trends in their settings. In an investigation by Martinelli et al. (2005), 11 nonactive men and 10 trained cyclists (C) were recruited. Participants underwent dynamic electrocardiogram (ECG) Holter monitoring to evaluate heart rate variability (HRV) at rest and during a 70-degree head-up tilt (HUT). In this study, the superior aerobic capacity of athletes was indicated by elevated oxygen consumption (VO2) values at both the anaerobic threshold and peak conditions. The findings suggest that the resting bradycardia observed in athletes may be attributed more to changes in intrinsic metabolism than to alterations in autonomic regulation. Besides, HUT induced similar changes in both groups for sympathetic and parasympathetic modulation of the sinus node. According to the results obtained from the study, Pagani and his group suggested that the ratio of LF to HF, LF/HF, would be a quantitative index explaining the dynamic balance between the sympathetic and parasympathetic nervous activities in health and in a variety of diseases (Nicolini et al., 2024).

Future Direction

Several key areas would show a necessary future step in research into the effect of physical training on heart rate variability in university male athletes, with the aim to help enhance understanding and application of results.

Wider demographics of participants

Including female athletes and wider age ranges would generalize findings on HRV responses.

Longer Study Period

Investigations involving athletes for a period exceeding the first eight weeks could clarify long-term physiological adaptations and whether HRV changes are maintained with more prolonged training.

Other Athletic Events

Athletes specializing in various sports team games, and individual events might point to possible sport-specific effects on HRV and, consequently, specify unique adaptations in training.

Advanced HRV metrics

Calculation of further advanced metrics in HRV, with the consideration of other physiological markers, such as blood biomarkers, hormonal profiling, and genetic predisposition, may help in further elucidating the mechanisms of change in HRV.

Manipulation of training intensity and volume

Knowing how this varied training intensity and volume impacts HRV would allow coaches and athletes to devise suitable training programs to elicit maximum cardiovascular and autonomic adaptations.

Psychological Correlates

The relationship between HRV and psychological variables, such as stress, anxiety, and mental fatigue, can be explored in research to help more fully define the holistic effects of training on an athlete's mental and physical health.

Recovery Modalities

Any such studies that relate to the effectiveness of recovery interventions, such as sleep, nutrition, and relaxation techniques, on HRV, can prove to be very significant in terms of constructing multidimensional recovery programs for athlete well-being.

Wearable technology integration:

Wearable devices could constantly monitor the HRV, thus making the HRV research, in the application, more relevant to sports.

These suggestions will enable future studies to progress from the existing knowledge toward a deeper understanding of the impact of physical training on HRV and support optimizing athletic performance and, generally, health

References

Besnier, F., Labrunée, M., Pathak, A., Traon, A. P., Galès, C., Sénard, J., & Guiraud, T. (2017). Exercise training-induced modification in autonomic nervous system: An update for cardiac patients. *Annals of Physical and Rehabilitation Medicine*, *60*(1), 27–35. https://doi.org/10.1016/j.rehab.2016.07.002

Google Scholar Worldcat Fulltext

DeBlauw, J. A., Stein, J. A., Blackman, C., Haas, M., Makle, S., Echevarria, I., Edmonds, R., & Ives, S. J. (2023). Heart rate variability of elite female rowers in preparation for and during the national selection regattas: a pilot study on the relation to on-water performance. *Frontiers in Sports and Active Living*, *5*. https://doi.org/10.3389/fspor.2023.1245788

Google Scholar Worldcat Fulltext

Egan-Shuttler, J. D., Edmonds, R., & Ives, S. J. (2020). The efficacy of heart rate variability in tracking travel and training stress in youth female rowers: a preliminary study. *The Journal of Strength and Conditioning Research*, *34*(11), 3293 3300. https://doi.org/10.1519/jsc.0000000000002499

Google Scholar Worldcat Fulltext

El-Malahi, O., Mohajeri, D., Bäuerle, A., Mincu, R., Rothenaicher, K., Ullrich, G., Rammos, C., Teufel, M., Rassaf, T., & Lortz, J. (2024). The Effect of Stress-Reducing Interventions on Heart Rate Variability in Cardiovascular Disease: A Systematic Review and Meta-Analysis. *Life*, *14*(6), 749. https://doi.org/10.3390/life14060749

Google Scholar Worldcat Fulltext

Ghosh, S., Bera, S. J., Ghosh, K., Singha, P., Jana, A., & Manna, I. (2023). Impact of short term training on morphological, physical fitness and physiological variables of middle distance runners. *Scientific Journal of Sport and Performance*, *2*(4), 527–539. https://doi.org/10.55860/babf3856

Google Scholar Worldcat Fulltext

Grässler, B., Thielmann, B., Böckelmann, I., & Hökelmann, A. (2021). Effects of different exercise interventions on heart rate variability and cardiovascular health factors in older adults: a systematic review. *European Review of Aging and Physical Activity/European Review on Aging and Physical Activity*, *18*(1). https://doi.org/10.1186/s11556-021-002786

Google Scholar Worldcat Fulltext

Grégoire, J., Gilon, C., Carlier, S., & Bersini, H. (2023). Autonomic nervous system assessment using heart rate variability. *Acta Cardiologica*, *78*(6), 648–662. https://doi.org/10.1080/00015385.2023.2177371

Google Scholar Worldcat Fulltext

Hayano, J., & Yuda, E. (2021). Assessment of autonomic function by long-term heart rate variability: beyond the classical framework of LF and HF measurements. *Journal of Physiological Anthropology*, *40*(1). https://doi.org/10.1186/s40101-021-00272-y

Google Scholar Worldcat Fulltext

Held, S., Rappelt, L., & Donath, L. (2023). Acute and Chronic Performance Enhancement in Rowing: A network meta analytical approach on the effects of nutrition and training. *Sports Medicine*, *53*(6), 1137–1159.

Google Scholar Worldcat Fulltext

Lenger, M., Dalkner, N., Schwalsberger, K., Hagendorfer, B., Schönthaler, E., Rieger, A., Maget, A., Fellendorf, F., Hamm, C., Gramer, M., Hufnagl, A., Reininghaus, B., & Reininghaus, E. (2022). Examining the Autonomic Nervous System in the Relationship among Heart Rate Variability, Stress Coping, and Cognitive Ability in Individuals with Psychiatric Disorders. *Journal of Clinical Medicine*, *11*(12), 3277. https://doi.org/10.3390/jcm11123277

Google Scholar Worldcat Fulltext

Martinelli, F., Chacon-Mikahil, M., Martins, L., Lima-Filho, E., Golfetti, R., Paschoal, M., & Gallo-Junior, L. (2005). Heart rate variability in athletes and nonathletes at rest and during head-up tilt. *Brazilian Journal of Medical and Biological Research*, *38*(4), 639–647. https://doi.org/10.1590/s0100-879x2005000400019

Google Scholar Worldcat Fulltext

Nicolini, P., Malfatto, G., & Lucchi, T. (2024). Heart Rate Variability and Cognition: A Narrative Systematic review of Longitudinal studies. *Journal of Clinical Medicine*, *13*(1), 280. https://doi.org/10.3390/jcm13010280

Google Scholar Worldcat Fulltext

Parry-Williams, G., & Sharma, S. (2020). The effects of endurance exercise on the heart: panacea or poison? *Nature Reviews. Cardiology*, *17*(7), 402–412. https://doi.org/10.1038/s41569-020-0354-3

Google Scholar Worldcat Fulltext

Santos, A. C., Turner, T. J., & Bycura, D. K. (2022). Current and future trends in strength and conditioning for female athletes. *International Journal of Environmental Research and Public Health*, *19*(5), 2687. https://doi.org/10.3390/ijerph19052687

Google Scholar Worldcat Fulltext

Stephenson, M. D., Thompson, A. G., Merrigan, J. J., Stone, J. D., & Hagen, J. A. (2021). Applying heart rate variability to monitor health and performance in tactical personnel: A narrative review. *International Journal of Environmental Research and Public Health*, *18*(15), 8143.

Google Scholar Worldcat Fulltext

Thomas, B. L., Claassen, N., Becker, P., & Viljoen, M. (2019). Validity of commonly used heart rate variability markers of autonomic nervous system function. *Neuropsychobiology*, *78*(1), 14–26. https://doi.org/10.1159/000495519

Google Scholar Worldcat Fulltext

Tiwari, R., Kumar, R., Malik, S., Raj, T., & Kumar, P. (2021). Analysis of heart rate variability and implication of different factors on heart rate variability. *Current Cardiology Reviews*, *17*(5). https://doi.org/10.2174/1573403x16999201231203854

Google Scholar Worldcat Fulltext

Treff, G., Winkert, K., & Steinacker, J. (2021). Olympic Rowing – Maximum Capacity over 2000 Meters. *German Journal of Sports Medicine*, *72*(4), 203–211. https://doi.org/10.5960/dzsm.2021.485

Google Scholar Worldcat Fulltext