ORIGINAL ARTICLE

Correlation Between RMSSD-Indicated Parasympathetic Activity and Maximal Exercise Capacity (VO2 Max) in Indian Swimmers

Sneha Thirugnana Sambandam[1], Dobson Dominic[1], Harshavardhini Anburaj[1], Raju Balaji[2]

[1] Department of Sports Medicine and Sports Sciences, Saveetha Medical College and Hospitals, Saveetha Institute of Medical and Technical Sciences (SIMATS), Thandalam, Chennai-602105, Tamil Nadu, India

[2] Molecular Biology and Genomics Lab, Department of Orthopaedics, Saveetha Medical College and Hospital, Saveetha Institute of Medical and Technical Sciences (SIMATS), Thandalam, Chennai-602105, Tamil Nadu, India.

ABSTRACT

Introduction: Maximal oxygen consumption (VO2 Max) and parasympathetic activity (RMSSD) are critical indicators of aerobic capacity and recovery efficiency in endurance sports like swimming. The study aimed to explore the correlation between VO2 Max and parasympathetic activity (RMSSD) in competitive Indian swimmers. **Methods:** A cross-sectional study was conducted with 52 competitive swimmers (34 males, 18 females). RMSSD was measured using a five-minute ECG recording, while VO2 Max was assessed using the COSMED K5 metabolic analyzer using the Bruce treadmill protocol. Data analysis employed Pearson's correlation to determine the relationship between RMSSD and VO2 Max, with statistical significance set at $p < 0.05$. **Results:** The average VO2 Max for males was 41.24 ml/kg/min and for females was 36.39 ml/kg/min. The RMSSD mean was 49.37. Pearson's correlation revealed a moderately positive correlation between RMSSD and VO2 Max ($r=0.342$, $p=0.013$), indicating that athletes with higher aerobic capacity also exhibited better parasympathetic recovery. **Conclusion:** The study confirmed a significant correlation between VO2 Max and parasympathetic activity in Indian swimmers, emphasizing the role of HRV monitoring in performance and recovery management. Future research could explore this relationship across various training phases and in athletes from different sports.

Malaysian Journal of Medicine and Health Sciences (2026) 22(SUPP5): 67-72. doi:10.47836/mjmhs.22.s5.13

Keywords: Athlete, swimming, cardiorespiratory fitness, performance enhancement, heart rate variability

Corresponding Author:
Raju Balaji, Ph.D
Email: balajir24.smc@saveetha.com
Tel: +919865384408

INTRODUCTION

Maximal exercise capacity, often assessed by VO2 Max (Maximal Oxygen Uptake), and parasympathetic activity, commonly measured using RMSSD (Root Mean Square of Successive Differences), are two critical indicators of cardiovascular and autonomic health in athletes (1-3). These parameters not only provide insight into an individual's aerobic capacity but also offer a window into their physiological recovery, resilience, and the overall effectiveness of their training regimen (1-7). In endurance sports, these factors become even more critical for sustained performance and recovery (5-7).

In high-intensity endurance sports such as swimming, where performance depends heavily on both aerobic endurance and rapid recovery, understanding the interplay between VO2 Max and parasympathetic activity provides valuable insights into an athlete's physiological status (8,9). Swimming, an Olympic sport, requires participants to train at very high loads to reach their peak potential. The topic of optimizing swimming training has advanced significantly with the development of sports science research (5,6,10,11). For Indian swimmers aiming to achieve their personal best performance, understanding the physiological factors that affect performance and recovery is crucial.

The VO2max refers to the maximum rate at which an individual can consume oxygen during exhaustive exercise (7). VO2 Max, attained during a graded maximal exercise to voluntary exhaustion, has long been considered by the World Health Organization as the single best indicator of cardiorespiratory fitness (7). In swimming, VO2 Max is particularly important because it directly affects an athlete's ability to sustain high intensity efforts over prolonged periods. The nature of swimming, which involves both dynamic and static muscle contractions, places unique demands on the cardiovascular system (12). The horizontal body position and water resistance make swimming distinct from other endurance sports, leading to specific physiological adaptations in swimmers (12,13). For Indian swimmers, optimizing VO2 Max is essential to improving endurance and overall performance.

The autonomic nervous system (ANS) plays a vital role in regulating physiological functions, especially in athletes (3). The ANS is divided into two branches: the sympathetic nervous system, which activates the "fight or flight" response, and the parasympathetic nervous system, which is responsible for rest, recovery, and the "rest and digest" functions (3). A well-balanced autonomic nervous system is crucial for athletes to recover effectively between bouts of intense physical activity (3).

Heart rate variability (HRV) is a commonly used method to assess parasympathetic activity (3). It refers to the variations in time between successive heartbeats. RMSSD, a time-domain measure of HRV, specifically reflects parasympathetic activity (3). Higher RMSSD values indicate greater parasympathetic tone, which is associated with improved recovery, reduced stress, and better overall autonomic balance (3,4,11-14). In contrast, low RMSSD values suggest autonomic dysfunction, overtraining, or poor recovery, which can negatively impact athletic performance (4,11-14). For swimmers, maintaining a high parasympathetic tone can aid in faster recovery between training sessions, ensuring long-term performance gains.

While the relationship between VO2 Max and parasympathetic activity has been explored in various sports, specific research on swimmers, particularly in the Indian context, is limited (12-14). Understanding the correlation between VO2max and RMSSD could provide insight into how well an athlete's body adapts to and recovers from high-intensity training. A positive correlation between these two measures would suggest that athletes with higher aerobic capacities are also better able to recover from intense exercise, allowing them to perform at peak levels without risking overtraining or injury.

For Indian swimmers, understanding this correlation has practical implications. It could help sports and exercise scientists, sports physicians, coaches, and athletes themselves to tailor training programs that optimize both aerobic capacity and recovery. Monitoring RMSSD could serve as an early indicator of fatigue or overtraining, allowing timely interventions to adjust training loads. Ultimately, this understanding would ensure that athletes perform to their maximal capacity while minimizing the risk of injury.

This paper aims to bridge the research gap by exploring the association between RMSSD and VO2 Max in Indian swimmers. By investigating this relationship, the findings can contribute to more informed training regimens, improved recovery strategies, and enhanced overall performance in competitive swimming.

MATERIALS AND METHODS

Study Design
This cross-sectional study was conducted to evaluate the correlation between VO2 Max and RMSSD in Indian swimmers. The study was conducted at the exercise physiology laboratory within the Sports Medicine Department at Saveetha Medical College and Hospitals, Kancheepuram, Tamil Nadu, India. The controlled environment of the laboratory ensured accurate data collection for HRV and VO2 Max measurements. The data collection for the study spanned four weeks, from October 2023 to November 2023, which coincided with the off-season for competitive Indian swimmers. This phase was followed by an analysis period, bringing the total study duration to approximately eight months.

Ethical consideration
Ethical approval was obtained from the Institutional Ethical Committee board of Saveetha Medical College and Hospital before the commencement of the study (Ref No. 042/06/2023/IEC/SMCH). All participants received a participation information sheet that explained the purpose, benefits, and risk factors involved in the study. They were also informed that no remuneration would be given for their participation, and they were allowed to withdraw from the study at any time point. All participants signed an informed consent form establishing their willingness to participate in the study. In the case of minors, additional consent was sought from the parents. The participants were not involved in the design of the research, conduct, reporting, or dissemination of the study.

Study Participants
Participants were recruited in collaboration with the Tamil Nadu State Aquatic Association. Swimmers who volunteered were assessed at the Department of Sports Medicine and Sports Sciences at Saveetha Medical College for eligibility based on specific inclusion and exclusion criteria. The inclusion and exclusion criteria (Table I) were rigorously applied to select appropriate participants for the study. The sample size was estimated using G*Power software, with an 80% power, a significance level of 0.05, and a moderate effect size based on prior research. The required sample size was calculated to be 52 (15).

Sampling Method
A simple random sampling technique was employed to recruit participants from the pool of eligible swimmers. This method ensured that the sample was representative of the target population, reducing selection bias and increasing the generalizability of the study's findings.

Study Tools

HRV Estimation
HRV was measured using the Biosignal Plux Explorer, a

Table I: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Swimmers aged between 15 to 30 years	Any medical contraindications to exercise
Swimmers who had participated or won at the national or international level	Any contraindications to performing VO2 Max testing according to American Thoracic Society guidelines
Swimmers had been training for at least two years prior to the start of the study	Acute injuries/illnesses
Swimmer's training 8 +/- 2 sessions per week	Recreational swimmers

VO2 Max, Maximal oxygen uptake

Table II: Bruce treadmill protocol

Stage	Treadmill speed	Treadmill inclination
1	1.7 mph	10% grade
2	2.5 mph	12% grade
3	3.4 mph	14% grade
4	4.2 mph	16% grade
5	5.0 mph	18% grade
6	5.5 mph	20% grade
7	6.0 mph	22% grade

Note: mph – miles per hour

validated wireless data acquisition device that records cardiac autonomic function through electrocardiogram (ECG) sensors (16). The data was auto analyzed using the device's integrated software to estimate RMSSD, a reliable marker of parasympathetic activity. To maintain consistency, HRV was recorded under controlled environmental conditions, ensuring homogeneity between the recordings of the participants. Five-minute ECG recordings were taken in the morning between 08:00 and 09:00 AM with participants in a seated position. The participants were asked to avoid strenuous activity 36 hours prior to the study and also avoid heavy food six hours prior to the study. They were also advised to abstain from alcohol consumption and smoking 24 hours prior to the study and caffeine intake four hours before the study.

VO2 Max Estimation

VO2 Max was measured using the COSMED K5 device, a state-of-the-art wearable metabolic system analyzer, which employs IntelliMET™ technology for gas exchange measurements (17). The VO2 Max data was expressed as milliliters per kilogram per minute (ml/kg/min) and analyzed in real-time using OMNIA software. The COSMED K5 has been validated for accuracy and reliability in previous studies, ensuring the precision of VO2 Max measurements in this study.

Testing Protocol

Maximal testing for VO2 Max was conducted using a COSMED treadmill, with Bruce's maximal treadmill protocol applied (Table II) (18,19). This protocol consists of progressively increasing treadmill speed and inclines to evaluate an athlete's cardiorespiratory fitness. Participants' VO2 Max values were determined using established criteria, including a plateau in VO2, peak respiratory exchange ratio > 1.10, a rate of perceived exertion of ≥8/10 on the Borg scale, and a heart rate within 10 beats of the predicted maximal heart rate.

Data Collection and Analysis

VO2max assessments and stored on Microsoft Excel. The collected data were analyzed using IBM SPSS Software for Windows, version 27 (IBM Corp., Armon, NY). Normality tests were conducted to analyze the distribution of data and descriptive statistics were used to establish the mean and standard deviations of study participants. Significance was set at $p < 0.05$. Pearson's correlation analysis evaluated the relationship between RMSSD and VO2max.

RESULTS

A total of 52 participants (34 males and 18 females) were included in the study. The mean age was 22.61 ± 4.02 years, with a mean height of 173.24 ± 10.69 cm, weight of 69.11 ± 10.79 kg, and BMI of 22.88 ± 1.41 kg/m (Table III). In terms of performance level, 72.22% were state-level medallists, 16.66% national-level, and 11.11% international-level athletes.

The overall mean RMSSD was 49.37 ± 16.29 ms, while the mean VO2 max was 39.56 ± 7.57 ml/kg/min. Gender-based comparisons showed that males exhibited higher RMSSD and VO2 max values compared to females, as presented in Table IV.

Pearson correlation analysis demonstrated a moderate positive correlation between RMSSD and VO2 max ($r = 0.342$, $n = 52$), which was statistically significant

Table III: Demographics of population

Variable	Group	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Age	Male	22.81	4.067	.783	21.21	24.42
	Female	22.41	4.041	.778	20.81	24.01
Height	Male	172.37	10.430	2.007	168.24	176.50
	Female	174.11	11.071	2.131	169.73	178.49
Weight	Male	67.33	10.381	1.998	63.23	71.44
	Female	70.89	11.095	2.135	66.50	75.28
BMI	Male	22.5296	1.42257	.27377	21.9669	23.0924
	Female	23.2222	1.33800	.25750	22.6929	23.7515

Note: BMI-Body mass index; Std-Standard

Table IV:. Comparison of RMSSD and VO2 Max by Gender (n = 52)

Variable	Gender	N	Mean ± SD	95% CI
RMSSD (ms)	Male	34	57.41 ± 13.78	52.60 – 62.22
	Female	18	34.17 ± 7.30	30.54 – 37.80
VO2 max (ml/kg/min)	Male	34	41.24 ± 8.11	38.41 – 44.06
	Female	18	36.39 ± 5.32	33.75 – 39.03

Notes: Values are presented as mean ± standard deviation (SD). RMSSD = Root Mean Square of Successive Differences; VO2 max = maximal oxygen uptake.

(p = 0.013). This relationship is presented in Table V and illustrated in Figure 1, showing a positive linear association between the two variables.

Table VI: Pearson correlation analysis

	Variable	RMSSD	VO2Max
RMSSD	Pearson Correlation	1	.342**
	Sig. (2-tailed)		.013
	N	52	52
VO2Max	Pearson Correlation	0.342**	1
	Sig. (2-tailed)	0.013	
	N	52	52

**. Correlation is significant at the 0.01 level (2-tailed).
Note: RMSSD, Root mean square of the successive differences; VO2 Max, Maximal oxygen uptake; N, Sample size; Sig., Significance

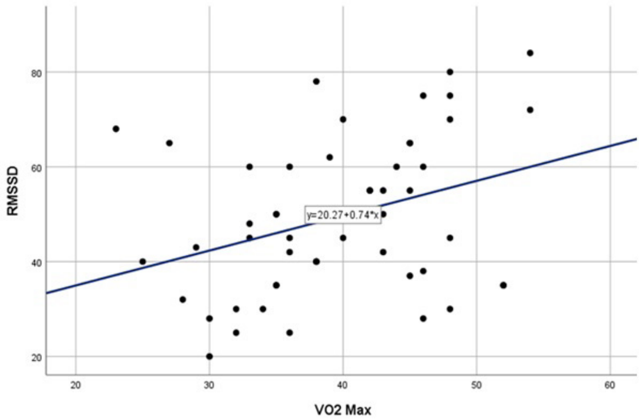

Figure 1: Correlation between RMSSD and VO2 Max
Note: Scatter plot showing VO2 Max values in the X-axis and RMSSD scores in the Y-axis. There is a positive linear relationship between VO2 Max and RMSSD, as shown by the upward-sloping trend line. As VO2 Max increases, RMSSD tends to increase. RMSSD, Root mean square of the successive differences; VO2 Max, Maximal oxygen uptake

DISCUSSION

The study demonstrates a statistically significant moderate positive correlation between parasympathetic activity, measured via RMSSD and VO2 Max in Indian swimmers (r = 0.342, p = 0.013). This finding suggests that athletes with higher aerobic capacity, as indicated by VO2 Max, also display enhanced parasympathetic recovery, reflected by increased RMSSD values. This correlation provides critical insight into the autonomic balance of swimmers and underscores the role of HRV as an important physiological marker in high-performance sports. While the relationship between VO2 Max and HRV has been studied across various athletic populations, the specific physiological demands of swimming and its unique influence on cardiovascular function make these findings particularly relevant.

Comparing these results with recent literature, Plews et al. found a stronger positive correlation in elite tri-athletes, particularly during the tapering phase of training when recovery is emphasized (20). This suggests that the relationship between VO2 Max and HRV may be more pronounced when athletes are well rested, pointing to the potential influence of training cycles on this correlation (20). This study, conducted during the off-season, provides a baseline understanding of the VO2 Max-HRV interaction in swimmers, but future research could explore how this relationship evolves throughout different phases of training, particularly during periods of peak intensity or tapering.

Furthermore, the findings of this study are complemented by the results of the study by Grant et al., where the authors examined the broader implications of heart rate and heart rate variability as indicators of cardiac health (21). The results of this study showed that a moderate positive correlation exists between RMSSD and VO2 Max. This aligns with the conclusions drawn by Grant et al., which emphasize the importance of HRV as a crucial marker for assessing physiological readiness and autonomic function (21). The results highlight the significance of HRV monitoring in optimizing training regimens and ensuring effective recovery strategies across various athletic contexts (21).

In a 2022 study conducted on young overweight adults, a similar positive relationship between VO2 Max and HRV was observed, although the correlation appeared weaker (22). This weaker association could likely be attributed to the lower baseline fitness levels and higher BMI present within the overweight cohort, which may have attenuated the strength of the VO2 Max-HRV relationship (22). While both studies reinforce the role of HRV as a marker of cardiorespiratory fitness, the higher level of conditioning observed in swimmers likely contributed to the stronger association between VO2 max and parasympathetic activity in the current study (22).

A systematic review and meta-analysis by Granero-Gallegos et al. showed that HRV-based training significantly improved VO2 Max in endurance athletes (23). However, the meta-analysis did not directly present correlation coefficients between HRV and VO2 Max but highlighted the effectiveness of using HRV as a feedback mechanism for training (23). The authors found that athletes who used HRV-based training demonstrated greater improvements in VO2 Max compared to those on traditional training regimens, reinforcing the utility of HRV in guiding endurance training adjustments (23). Additionally, oxidative stress defined as an imbalance between reactive oxygen species and antioxidant defences-has been linked to various cardiovascular and metabolic dysfunctions that can negatively impact athletic performance, further emphasizing the importance of monitoring the autonomic nervous system in athletes (24,25).

The moderate positive correlation between VO2 Max and RMSSD observed in this study has significant practical implications for optimizing both performance and recovery in Indian swimmers. Monitoring HRV allows coaches to assess an athlete's readiness for training and can serve as an early indicator of fatigue or autonomic imbalance. By regularly evaluating RMSSD, coaches can make informed decisions about training intensity, recovery periods, and tapering strategies. This is particularly important in swimming, where the physical demands are high, and maintaining a balance between training stress and recovery is crucial for sustained performance. Additionally, higher RMSSD values in swimmers with superior aerobic capacity suggest that these athletes are better equipped to recover between high-intensity training sessions, further supporting the use of HRV as a critical tool in high-performance sports. Despite the strengths of this study, several limitations should be acknowledged. The relatively small sample size (n = 52) limits the generalizability of the findings, particularly to larger or more diverse populations of athletes. Future studies should aim to replicate these results in broader samples, including athletes from different swimming disciplines and age groups. Furthermore, this study employed a cross-sectional design, which captures the relationship between VO2 Max and HRV at a single time point. Longitudinal research is needed to assess how this relationship evolves throughout the training cycle and across different phases of competition preparation, providing a more comprehensive understanding of the dynamic nature of the VO2 Max-HRV interaction.

CONCLUSION

This study demonstrated a significant, moderately positive correlation between parasympathetic activity indicated by RMSSD and VO2 Max in Indian swimmers, highlighting the crucial interplay between aerobic capacity and autonomic recovery. The findings suggest that swimmers with higher VO2 Max levels also exhibit enhanced parasympathetic activity, as indicated by increased RMSSD values. This relationship reinforces the importance of monitoring HRV as a reliable indicator of recovery and training readiness, providing valuable insights for optimizing performance in high-intensity endurance sports. These results have practical implications for coaches, sports scientists, and athletes, suggesting that regular assessment of HRV can facilitate personalized training regimens that enhance performance while mitigating the risks of overtraining and injury. By analyzing HRV data, practitioners can make informed decisions about training loads and recovery strategies, ultimately fostering a more sustainable approach to athletic development. Furthermore, this study underscores the need for continued research into the dynamics of VO2 Max and HRV across different training phases and athlete populations. Future investigations could expand upon these findings by exploring the impact of varying training intensities and recovery protocols on the VO2 Max and HRV relationship.

ACKNOWLEDGEMENT

The authors, STS, HA, and RB, would like to express their sincere gratitude to Prof. Dr. Dobson Dominic, Head of the Department of Sports Medicine & Sports Science, for his invaluable guidance and support. The authors also extend their deepest thanks to all the participants.

REFERENCES

1. Bourdon PC, Cardinale M, Murray A, et al.: Monitoring athlete training loads: Consensus statement. Int JSports Physiol Perform. 2017; 12(2):S2161-70. doi: 10.1123/IJSPP.2017-0208
2. Pyne D: Monitoring training load in and out of the pool, optimal load and periodisation in young swimmers . Swimming: Science and performance. Renshaw I,Komar J, Garcнa-Ramos A, Gardiner S (ed): Routledge, London, UK; 2020. 12.
3. Shaffer F, Ginsberg JP: An overview of heart rate variability metrics and norms . Front Public Health. 2017; 5:258. doi: 10.3389/fpubh.2017.00258
4. Davletyarova K, Vacher P, Nicolas M, Kapilevich LV, Mourot L: Associations between heart rate variabilityderived indexes and training load: Repeated measures correlation approach contribution. J Strength CondRes. 2022; 36(7):2005-10. doi: 10.1519/JSC.0000000000003760
5. Gonzбlez-Ravй JM, Hermosilla F, Gonzбlez-Mohнno F, Casado A, Pyne DB: Training intensity distribution, training volume, and periodization models in elite swimmers: A systematic review. Int J Sports PhysiolPerform. 2021; 16(7):913-26. doi: 10.1123/ijspp.2020-0906
6. Pugliese L, Porcelli S, Bonato M, et al.: Effects of manipulating volume and intensity training in masters swimmers. Int J Sports Physiol Perform. 2015; 10(7):907-12. doi: 10.1123/ijspp.2014-0171
7. Hawkins MN, Raven PB, Snell PG, Stray-Gundersen J, Levine BD: Maximal oxygen uptake as a parametric measure of cardiorespiratory capacity. Med Sci Sports Exerc. 2007; 39(1):103-7. doi: 10.1249/MSS.0b013e3181617350
8. Seiler S: What is best practice for training intensity and duration distribution in endurance athletes? Int J Sports Physiol Perform. 2010; 5(3):276-91. doi: 10.1123/ijspp.5.3.276
9. MacInnis MJ, Gibala MJ: Physiological adaptations to interval training and the role of exercise intensity. JPhysiol. 2017; 595(9):2915-30. doi: 10.1113/

JP273196
10. Pla R, Le Meur Y, Aubry A, Toussaint JF, Hellard P: Effects of a 6-week period of polarized or threshold training on performance and fatigue in elite swimmers. Int J Sports Physiol Perform. 2019; 14(2):183-189. doi: 10.1123/ijspp.2018-0179
11. Merati G, Maggioni MA, Invernizzi PL, Ciapparelli C, Agnello L, Veicsteinas A, Castiglioni P: Autonomic modulations of heart rate variability and performances in short-distance elite swimmers. Eur J Appl Physiol.2015; 115(4):825-835. doi: 10.1007/s00421-014-3064-x
12. Atlaoui D, Pichot V, Lacoste L, Barale F, Lacour J-R, Chatard J-C: Heart rate variability, training variation and performance in elite swimmers. Int J Sports Med. 2007; 28(5):394-400. doi: 10.1055/s-2006-924490
13. Kamandulis S, Juodsnukis A, Stanislovaitiene J, et al.: Daily resting heart rate variability in adolescent swimmers during 11 weeks of training. Int J Environ Res Public Health. 2020; 17(6):2097. doi: 10.3390/ijerph17062097
14. Barragбn R, Gonzбlez-Mohнno F, Veiga S, Juбrez Santos-Garcнa D: Effects of 8-week of training on heart rate variability, overtraining state and performance in international young swimmers. Sci Sports. 2023; 38(4):362-9. doi: 10.1016/j.scispo.2022.09.004
15. Michael S, Graham KS, Davis GM Oam: Cardiac autonomic responses during exercise and post-exercise recovery using heart rate variability and systolic time intervals-A review. Front Physiol. 2017; 8:301. doi: 10.3389/fphys.2017.00301
16. Plux Biosignals. HeartBIT. (2024). Accessed: Jun 29, 2024; https://www.pluxbiosignals.com/collections/bitalino/products/heartbit
17. COSMED - K5: Wearable Metabolic System for both laboratory and field testing. (2024). Accessed: Sep 9, 2024; https://www.cosmed.com/en/products/cardio-pulmonary-exercise-test/k5
18. Vilela EM, Oliveira C, Oliveira C, et al.: Sixty years of the Bruce protocol: Reappraising the contemporary role of exercise stress testing with electrocardiographic monitoring. Porto Biomed J. 2023; 8(5):e235. doi: 10.1097/j.pbj.0000000000000235
19. Sarma S, Levine BD: Beyond the Bruce protocol: Advanced exercise testing for the sports cardiologist. Cardiol Clin. 2016; 34(4):603-8. doi: 10.1016/j.ccl.2016.06.009
20. Plews DJ, Laursen PB, Kilding AE, Buchheit M: Heart rate variability in elite triathletes, is variation in variability the key to effective training? A case comparison. Eur J Appl Physiol. 2012; 112(11):3729-41. doi: 10.1007/s00421-012-2354-4
21. Grant CC, Murray C, Janse van Rensburg DC, Fletcher L: A comparison between heart rate and heart rate variability as indicators of cardiac health and fitness. Front Physiol. 2013; 4:337. doi: 10.3389/fphys.2013.00337
22. Nataraj M, Sinha MK, Bhat A, Vaishali K: Correlation between physical activity, cardiorespiratory fitness and heart rate variability among young overweight adults. J Taibah Univ Med Sci. 2022; 17(2):304-310. doi: 10.1016/j.jtumed.2021.11.011
23. Granero-Gallegos A, Gonzбlez-Quнlez A, Plews D, Carrasco-Poyatos M: HRV-based training for improvingVO2max in endurance athletes. A systematic review with meta-analysis. Int J Environ Res Public Health. 2020; 17(21):7999. doi: 10.3390/ijerph17217999
24. Shaik Mohamed Sayed UF, Moshawih S, Goh HP, et al.: Natural products as novel anti-obesity agents: Insights into mechanisms of action and potential for therapeutic management. Front Pharmacol. 2023; 14:1182937. doi: 10.3389/fphar.2023.1182937
25. Manivel R, Sivalingam AM. New Perspectives on Sleeve Gastroplasty Trials for Patients with Autonomic and Hypothalamic Obesity. Obes Surg. 2024; 34(10):3911-3912. doi: 10.1007/s11695-024-07480-2