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Research Article

Impact of Resistance and Endurance Exercise Training on Heart Rate Variability

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Abstract:

Background: The Heart rate variability (HRV) test is a non-invasive way to check the hearts and autonomic nervous system (ANS) overall health and performance. The test finds the average and standard deviation of the time between heartbeats. **Aim:** The goal of this 12-week trial is to find out how different types of exercise, including resistance and endurance training, affect people's HRV. Autonomic control and cardiovascular health will be the primary outcomes of the study. **Materials & methods:** The 100 individuals in the research were randomized to either the control group or the exercise group. Measurements were made of physical attributes such height, weight, BMI, waist circumference, body fat percentage, blood pressure, resting heart rate, and heart rate variability. Additionally, the study assessed muscle strength, leg muscle strength, maximum oxygen absorption (VO2max), and VO2max. For 12 weeks, the exercise regimen included both resistance and aerobic workouts that were done three times a week. **Results:** Measurements gathered from the exercise group showed significantly decreased weight, body fat percentage, waist circumference, and systolic and diastolic blood pressure compared to the control group. As a consequence of becoming in better shape, we saw gains in VO2max, grip strength, leg strength (both sides), and endurance. There was no discernible difference in HRV between the two groups. **Conclusion:** More research with bigger samples is needed to confirm the findings of this study, which implies that exercise modalities may enhance cardiovascular function and autonomic balance. Furthermore, it implies that personalized exercise regimens are necessary for optimal health outcomes.

Key words: HRV, autonomic nervous system, resistance exercise training, endurance exercise training, parasympathetic activity.

Introduction:

Heart rate variability (HRV), or the variation in the time between consecutive heartbeats, is a non-invasive indicator of cardiovascular health and autonomic nervous system (ANS) function. An enhanced HRV suggests a robust and flexible ANS, whereas a lower HRV is linked to a higher risk of cardiovascular disease and a decreased capacity to tolerate stress [1,2]. Training with resistance and endurance exercises [1–3] has long been recognized to have a substantial effect on HRV, which in turn affects cardiovascular health [2].

HRV is significantly impacted by resistance exercise training (RET), which comprises exercises that increase muscle strength and endurance [2,3]. Acute bouts of resistance exercise have been shown to worsen cardiac parasympathetic modulation in young, healthy people more than aerobic exercise [4,5], increasing the likelihood of cardiovascular dysfunction following exercise. In contrast to its capacity to enhance parasympathetic regulation in middle-aged persons with autonomic dysfunction, chronic RET does not seem to impact resting HRV in young, healthy individuals [6]. The therapeutic potential of RET was shown in a randomized controlled trial including patients with coronary artery disease. The study found that after eight weeks of high-repetition, low-load resistance exercise, the participants' physical strength, endurance, and HRV markers all significantly improved [2,3].

Numerous studies have examined the effect of endurance exercise training (EET) on HRV. EET requires an extended duration of aerobic exercise, such as swimming, cycling, or running [4-6]. Frequent participation in EET can improve cardiovascular fitness, parasympathetic activity, and HRV measurements [5]. The best method to reduce resting heart rate, a related measure of cardiovascular efficiency, is through endurance exercise, per a meta-analysis published in the Journal [6]. Improved capillary infrastructure, heart health, stroke volume, VO_2 max, and endurance are also linked to the advantages of HRV. All of these are improved by prolonged steady-state exercise [5-8]. The current study compares and analyzes the effects of resistance and endurance exercise training on HRV in individuals over a 12-week period, with a focus on assessing cardiovascular health and autonomic function.

Materials & methods:

Fifty people were randomly allocated to the exercise group and fifty to the control group out of a total of one hundred. After providing the participants with a comprehensive explanation of the objectives, methods, and anticipated results of the exercise program, we were able to obtain their consent to take part in the study. We took care to adhere to the Declaration of Helsinki's ethical standards at every stage. The physical characteristics of the people were detailed in the documents.

We had our weight and height measured. The weight in kilograms was divided by the square of the height in meters squared to get the body mass index, or BMI. The subject's waist was measured to within 0.1 cm of the halfway between the top portion of the bilateral crista iliac and the bottom ribs as they stood with their back straight. The percentage of body fat was determined using a body composition analyzer. Before taking the patient's vitals while they were at rest, we gave them 10 minutes to unwind. To find the resting heart rate, we employed a wireless heart rate meter. The diastolic and systolic blood pressure were measured using an automated blood pressure monitor.

At ten in the morning, we conducted a five-minute HRV test using an HRV analyzer following a brief twenty-minute break. To investigate HRV, we used both frequency domain and temporal domain techniques. For the temporal domain analysis, we computed the root mean square successive differences (rMSSD) and the standard deviation of all normal R-R intervals (SDNN). While rMSSD shows brain activity associated to the parasympathetic nervous system, SDNN is used as a sign of overall variability. We were able to determine the low frequency (LF), high frequency (HF), and LF/HF ratio by doing research in the frequency domain. A low LF/HF ratio indicates a balanced sympathetic-parasympathetic nervous system. Whereas "HF" is only used for parasympathetic activity, "LF" stands for sympathetic and, to a lesser extent, parasympathetic activity.

By doing a submaximal exercise test on a cycle ergometer, we were able to calculate VO2max in a cardiorespiratory test. By measuring the highest heart rate (HR) at which a participant could maintain an increasingly demanding exercise regimen, we were able to calculate VO2max. The second finger joint width was adjusted using the dynamometer until it was almost straight. This was done to determine the strength of the muscles. The force generated by forcefully pushing the right and left feet together while the thighs and upper torso were restrained in a sitting position was measured using a leg muscle strength measuring device. The number of sit-ups a person could do on a sit-up measuring board after 30 seconds of sit-up motions was used to gauge their level of muscular endurance. These movements involve pulling up the knees, holding hands behind the neck, and bending and elevating the upper body forward.

The program included three sessions each week for 12 weeks of resistance and aerobic training. These routines were based on the American College of Sciences and Medicine's workout guidelines. Karvonen [9] calculated the degree of aerobic exercise using the following formula: By adding the resting heart rate to the exercise intensity and then deducting the maximum heart rate from the resting heart rate, one may get the goal heart rate. We employed Fleck and Kramer's 1-repetition maximum (RM) indirect measurement approach to ascertain and establish the resistance workouts' intensity [10]. Wo + W1, where W1 is Wo multiplied by 0.025 times R and Wo is a weight that may be contracted seven or eight times, equals one repetition, or RM. We stretched for ten minutes each time to warm up and cool down before starting the strength and cardio training regimens. Walking on a treadmill for 30 minutes at 60% heart rate was part of the aerobic workout. It was feasible to precisely ascertain if the aerobic activity was carried out within the intended heart rate range by using a Polar Heart Rate Analyzer. We were able to do this by maintaining a consistent level of training intensity. The resistance training, which consisted of two sets of nine weight machine exercises—curl-ups, leg presses, leg extensions, leg curls, calf raises, and lateral pulldowns—came after the aerobic session. You would perform one set of eight to twelve repeats for thirty minutes. The repetitions ranged from 60% to 80% of one's maximum.

Statistical analysis:

In order to analyze the data, SPSS was utilized. A two-way analysis of variance (ANOVA) with repeated measurements was carried out in order to investigate the influence that group and measurement time interactions had on the variables that were being examined. The criterion for statistical significance (α) was determined to be determined to be 0.05.

Results:

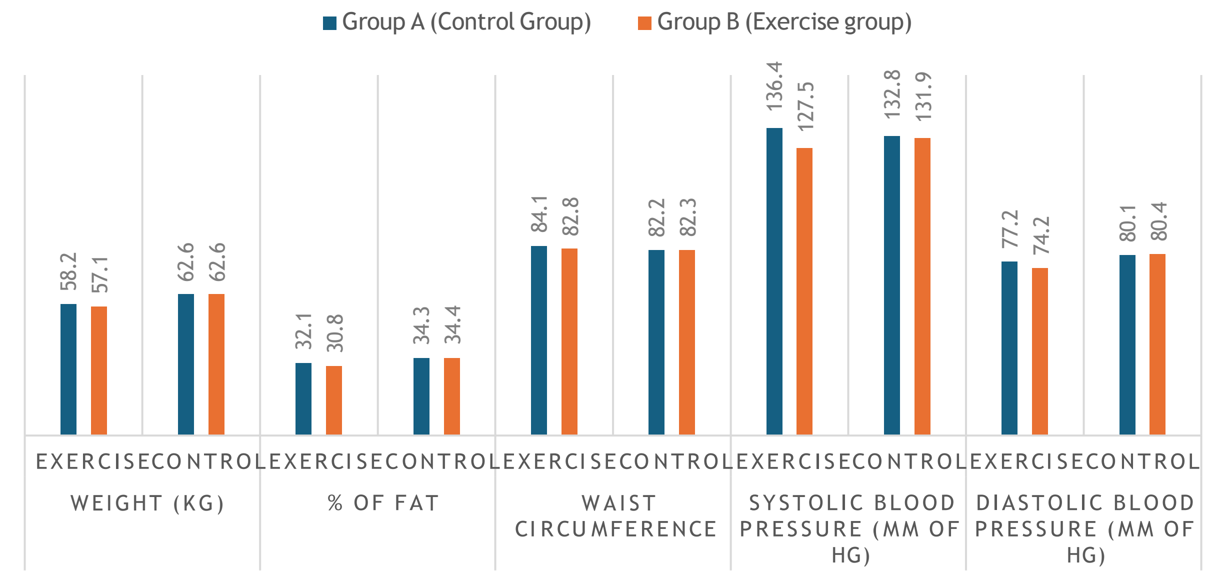
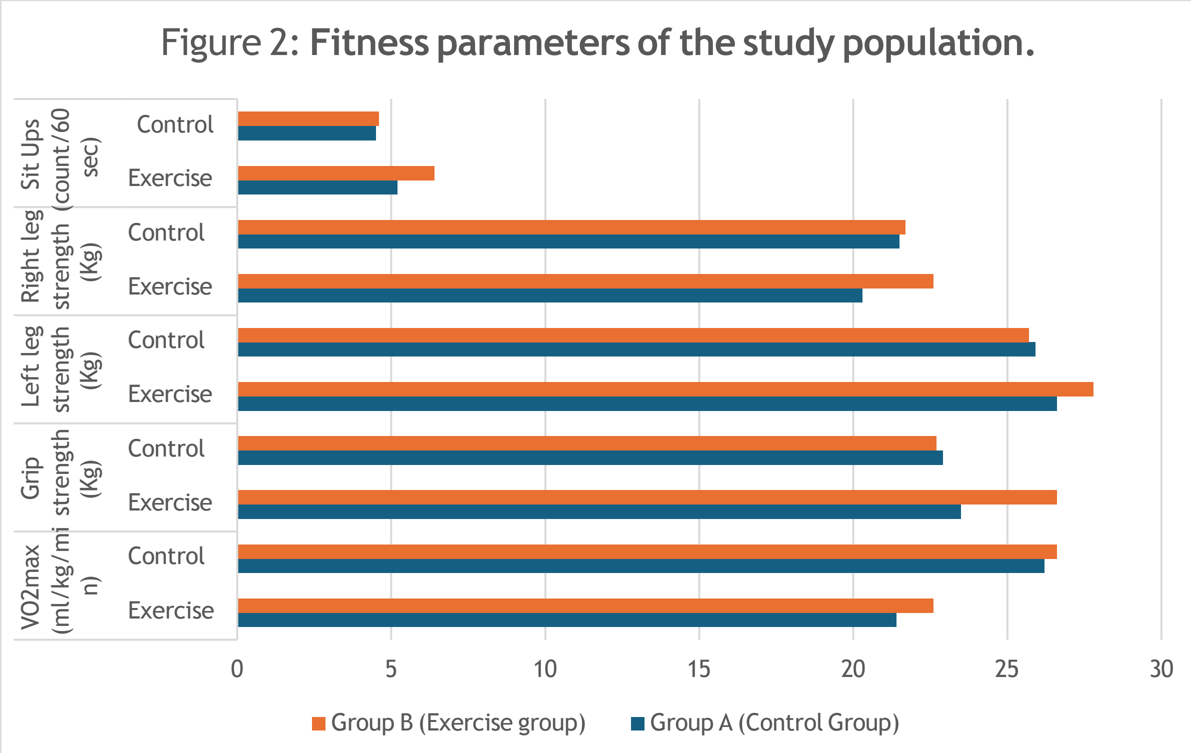


FIGURE 1: DEMOGRAPHIC PARAMETERS OF THE STUDY POPULATION.

In terms of body composition, the exercise group's weight, body fat percentage, and waist circumference were all considerably lower than their pre-exercise values ($p<0.001$, $p<0.001$, and $p<0.001$, respectively). Furthermore, the exercise group's systolic and diastolic blood pressures were considerably lower after the program than they were before ($p<0.001$ and $p<0.01$, respectively). Between the pre- and post-periods, none of the anthropometric index variables for the control group changed (Figure 1).

When compared to before the training program, the exercise group's VO2max ($p<0.05$), grip strength ($p<0.05$), left leg strength ($p<0.01$), right leg strength ($p<0.01$), and muscular endurance ($p<0.01$) all shown substantial gains in physical fitness. Figure 2 illustrates that there were no changes in the physical fitness of the control group between the pre- and post-partum periods. Regarding HRV, neither group's pre- and post-periods showed any appreciable changes in SDNN, rMSSD, LF, HF, or LF/HF.



Discussion:

The results of this study show that those who engage in structured exercise programs significantly improve the number of anthropometric and cardiovascular characteristics. Following the intervention, the exercise group saw substantial decreases in body weight, body fat percentage, and waist circumference ($p<0.001$, $p<0.001$, and $p<0.001$, respectively). Furthermore, systolic and diastolic blood pressure were significantly lowered ($p<0.001$ and $p<0.01$, respectively) in response to physical exercise. All of the characteristics that were assessed, however, showed no discernible changes in the control group.

The observed reduction in body weight and adiposity-related indicators is positive and consistent with other research showing the ability of well-planned exercise to control metabolic diseases and obesity. Regular exercise, for example, has been demonstrated to be essential for enhancing metabolic health; in patients with type 2 diabetes, for example, a combination of aerobic and strength training dramatically decreased waist circumference and body fat percentage [11,12]. Additionally, a meta-analysis conducted by Wewege et al. [13] shown that strength training successfully lowers adiposity markers in diabetics, whether it is performed alone or in conjunction with aerobic exercise.

Furthermore, due of its significant correlation with insulin resistance and cardiovascular risk, the decrease in waist circumference, a crucial measure of visceral fat is especially pertinent [14]. Consistent with earlier findings, the exercise group's statistically significant decrease in waist circumference raises the possibility that the intervention may improve glycemic management and lower cardiometabolic risk [15].

The results support previous studies showing that exercise routines dramatically reduce both systolic and diastolic blood pressure measurements. Although resistance and aerobic training both dramatically reduce blood pressure, research [16] found that the effects of aerobic exercise are stronger. These decreases are the result of increased autonomic regulation, decreased arterial stiffness, and enhanced endothelial function, all of which help to return blood pressure to normal [17].

Exercise is crucial for managing cardiovascular health and body composition, as evidenced by the fact that the control group did not exhibit any notable changes. The results are consistent with the study [18], which showed that those who are sedentary or do not exercise frequently do not see appreciable changes in their anthropometric or hemodynamic parameters over time. These results suggest that one of the most significant non-pharmacological strategies for managing diabetes and lowering the risks to cardiovascular health is regular exercise. Future studies should evaluate the effectiveness of various exercise regimens and examine how these benefits persist over time in populations with diabetes.

This research monitored the impact of an exercise program on participants' HRV and fitness levels over a 12-week period. Physical fitness metrics such as VO2max ($p<0.05$), grip strength ($p<0.05$), left leg strength ($p<0.01$), right leg strength ($p<0.01$), and muscular endurance ($p<0.01$) significantly improved in the exercise group after the intervention. Neither the exercise group nor the control group exhibited any appreciable changes in HRV indicators including SDNN, rMSSD, LF, HF, and LF/HF.

The increases in physical fitness metrics support other studies showing the advantages of organized exercise regimens for people. Combining aerobic and resistance exercise can improve cardiovascular fitness, muscle strength, and endurance [19,20]. The exercise group's notable increase in VO2max indicates that aerobic training raises oxygen consumption and cardiorespiratory efficiency [21]. Resistance training is essential for improving neuromuscular function and mobility, as evidenced by gains in grip strength and lower extremity strength [22, 23].

For type 2 diabetics, exercise intervention was required to provide quantifiable gains in fitness when compared to the control group, which shown no change in their physical fitness markers. According to this study, structured exercise programs are essential for the physical well-being of people with metabolic diseases [24].

It's interesting to see that HRV levels did not significantly alter after the workout program. This result contradicts earlier research showing that organized exercise regimens improved autonomic function [25, 26]. However, a number of studies have demonstrated that in order to induce detectable autonomic changes in HRV, longer intervention durations or more intense exercise are required [27, 28]. The reported results may also have been impacted by inter-individual heterogeneity, medication use, and baseline autonomic dysfunction in type 2 diabetic patients [29].

The brief duration of the intervention is one of the study's limitations, since it is clearly insufficient to make any definitive conclusions on its effect on autonomic regulation. Furthermore, unrelated variables like nutrition, sleep patterns, and mental stress may have an impact on HRV readings; these were not examined in this study. To further evaluate their effects on HRV, future studies should examine longer-lasting and more intense exercise regimens.

Conclusion:

The findings suggest that the two types of exercise may enhance cardiovascular and autonomic balance since they had different impacts on HRV measurements. Given these results, it seems sense to believe that regular exercise may improve autonomic function, which may reduce the risk of cardiovascular disease. These findings clearly demonstrate the need of tailored exercise regimens in achieving optimal cardiovascular and autonomic health. To validate and build on these findings, more research with larger sample sizes and longer follow-up times is required.

Conflict of interest:

There is no conflict of interest among the present study authors.

References:

1. Caruso FR, Arena R, Phillips SA, Bonjorno Jr JC, Mendes RG, Arakelian VM, Bassi D, Nogi C, Borghi-Silva A. Resistance exercise training improves heart rate variability and muscle performance: a randomized controlled trial in coronary artery disease patients. Eur J Phys Rehabil Med. 2015 Jun 1;51(3):281-9.
2. Kingsley JD, Figueroa A. Acute and training effects of resistance exercise on heart rate variability. Clinical physiology and functional imaging. 2016 May;36(3):179-87.
3. Turner W, Brühl A, Böker H, Schulze B, Marschall K, La Marca R, Pfaff M, Russmann T, Schmidt-Trucksäss A. Heart rate vARiability and physical activity in inpatient treatMent of burnOut and DepressIon (HARMODI): protocol of a cross-sectional study with up to 8-week follow up. BMJ open. 2024 Jun 1;14(6):e081299.
4. Nicholson M, Poulus D, Robergs R, Kelly V, McNulty C. How much energy do e'athletes use during gameplay? Quantifying energy expenditure and heart rate variability within e'athletes. Sports medicine-open. 2024 Apr 17;10(1):44.
5. https://www.verywellhealth.com/hiit-workout-vs-steady-state-cardio-8760240?utm_source=chatgpt.com
6. Li R, Yan R, Cheng W, Ren H. Effect of resistance training on heart rate variability of anxious female college students. Frontiers in Public Health. 2022 Dec 1;10:1050469.
7. Kaikkonen P, Hynynen E, Hautala A, Ahtiainen JP. The effects of an intensive 2-wk resistance training period on strength performance and nocturnal heart rate variability. International Journal of Sports Physiology and Performance. 2020 Sep 1;15(10):1448-54.
8. Masroor S, Bhati P, Verma S, Khan M, Hussain ME. Heart rate variability following combined aerobic and resistance training in sedentary hypertensive women: a randomised control trial. Indian heart journal. 2018 Dec 1;70:S28-35.
9. Mj K. The effects of training on heart rate: a longitudinal study. Ann med exp biol fenn. 1957;35:307-15.
10. Kraemer WJ, Fleck SJ. Resistance training: exercise prescription (part 4 of 4). The Physician and Sportsmedicine. 1988 Jun 1;16(6):69-81.
11. Yang JM, Ye H, Zhu Q, Zhang JH, Liu QQ, Xie HY, Long Y, Huang H, Niu YL, Luo Y, Wang MY. Effects of

resistance training on body composition and physical function in elderly patients with osteosarcopenic obesity: a systematic review and meta-analysis. Archives of Osteoporosis. 2022 Dec;17(1):82.

12. Wang Y, Yang X, Deng J, Wang Z, Yang D, Han Y, Wang H. Combined high-intensity interval and resistance training improves cardiorespiratory fitness more than high-intensity interval training in young women with overweight/obesity: a randomized controlled trial. Frontiers in Endocrinology. 2024 Nov 11;15:1450944.
13. Wewege MA, Thom JM, Rye KA, Parmenter BJ. Aerobic, resistance or combined training: A systematic review and meta-analysis of exercise to reduce cardiovascular risk in adults with metabolic syndrome. Atherosclerosis. 2018 Jul 1;274:162-71.
14. Ross LJ, Barnes KA, Ball LE, Mitchell LJ, Sladdin I, Lee P, Williams LT. Effectiveness of dietetic consultation for lowering blood lipid levels in the management of cardiovascular disease risk: a systematic review and meta-analysis of randomised controlled trials. Nutrition & Dietetics. 2019 Apr;76(2):199-210.
15. Bhatt DL, Steg PG, Miller M, Brinton EA, Jacobson TA, Ketchum SB, Doyle Jr RT, Juliano RA, Jiao L, Granowitz C, Tardif JC. Cardiovascular risk reduction with icosapent ethyl for hypertriglyceridemia. New England Journal of Medicine. 2019 Jan 3;380(1):11-22.
16. Smart NA, Gow J, Bleile B, Van der Touw T, Pearson MJ. An evidence-based analysis of managing hypertension with isometric resistance exercise—are the guidelines current?. Hypertension Research. 2020 Apr;43(4):249-54.
17. Ashor AW, Chowdhury S, Oggioni C, Qadir O, Brandt K, Ishaq A, Mathers JC, Saretzki G, Siervo M. Inorganic nitrate supplementation in young and old obese adults does not affect acute glucose and insulin responses but lowers oxidative stress. The Journal of nutrition. 2016 Nov 1;146(11):2224-32.
18. Pescatello LS, Wu Y, Panza GA, Zaleski A, Guidry M. Development of a novel clinical decision support system for exercise prescription among patients with multiple cardiovascular disease risk factors. Mayo Clinic Proceedings: Innovations, Quality & Outcomes. 2021 Feb 1;5(1):193-203.
19. Colberg SR, Sigal RJ, Fernhall B, Regensteiner JG, Blissmer BJ, Rubin RR, Chasan-Taber L, Albright AL, Braun B. Exercise and type 2 diabetes: the American College of Sports Medicine and the American Diabetes Association: joint position statement. Diabetes care. 2010 Dec 1;33(12):e147-67.
20. Yang J, Tan H, Yu H, Li J, Cui Y, Lu Y, Liu X, Chen Q, Zhou D. Association between remote resistance exercises programs delivered by a smartphone application and skeletal muscle mass among elderly patients with type 2 diabetes–a retrospective real-world study. Frontiers in Endocrinology. 2024 Jun 11;15:1407408.
21. Francois ME, Little JP. Effectiveness and safety of high-intensity interval training in patients with type 2 diabetes. Diabetes spectrum: a

publication of the American Diabetes Association. 2015 Jan;28(1):39.

22. Jelleyman CL. *High-intensity physical activity for improving glucose regulation: can science justify IT?* (Doctoral dissertation, University of Leicester).
23. Ma X, Ai Y, Lei F, Tang X, Li Q, Huang Y, Zhan Y, Mao Q, Wang L, Lei F, Yi Q. Effect of blood flow-restrictive resistance training on metabolic disorder and body composition in older adults with type 2 diabetes: a randomized controlled study. Frontiers in Endocrinology. 2024 Jun 6;15:1409267.
24. Umpierre D, Ribeiro PA, Kramer CK, Leitao CB, Zucatti AT, Azevedo MJ, Gross JL, Ribeiro JP, Schaan BD. Physical activity advice only or structured exercise training and association with HbA1c levels in type 2 diabetes: a systematic review and meta-analysis. Jama. 2011 May 4;305(17):1790-9.
25. Rathore A, Lom B. The effects of chronic and acute physical activity on working memory performance in healthy participants: a systematic review with meta-analysis of randomized controlled trials. Systematic reviews. 2017 Dec;6:1-6.
26. Ramírez-Vélez R, Tordecilla-Sanders A, Téllez-T LA, Camelo-Prieto D, Hernández-Quiñonez PA, Correa-Bautista JE, Garcia-Hermoso A, Ramírez-Campillo R, Izquierdo M. Effect of moderate-versus high-intensity interval exercise training on heart rate variability parameters in inactive Latin-American adults: a randomized clinical trial. The Journal of Strength & Conditioning Research. 2020 Dec 1;34(12):3403-15.
27. Raje S, Maiya GA, Prabhu MA, Nayak K, Kn S, Shastry BA, Nataraj M. Effect of exercise training on cardiac autonomic function in type 2 diabetes mellitus: a systematic review and meta-analysis. Systematic Reviews. 2025 Feb 4;14(1):34.
28. Chiang JK, Lin YC, Hung TY, Kao HH, Kao YH. The Impact on Autonomic Nervous System Activity during and Following Exercise in Adults: A Meta-Regression Study and Trial Sequential Analysis. Medicina. 2024 Jul 28;60(8):1223.
29. Zaki S, Alam MF, Sharma S, Naqvi IH, Nuhmani S. Impact of concurrent training sequence on heart rate variability, glycemic control, body composition, lipid profile, and cardiorespiratory fitness in type 2 diabetes patients with cardiac autonomic neuropathy: A randomized controlled trial. Clinical Epidemiology and Global Health. 2024 Sep 1;29:101747.