ASPAM
PERFORMANCE ANALYSIS IN SPORTS
Application and Research Center

Performance Analysis in Sport and Exercise

Ankara University Performance Analysis in Sports Application and Research Center

Available online 5 December 2022

The Changes on HRV after a Wingate Anaerobic Test in Physically Active Adults

Veli Gül [1*]
[1] Independent Researcher

Abstract

The aim of the present study was to investigate the changes on heart rate variability (HRV) right after a Wingate Anaerobic Test (WAnT) in physically active men. The subjects performed a single 30-sec. WAnT. Their alactacid and lactacid relative power values were recorded. They participated a five-minute HRV test right before and after the WAnT. The time- and frequency-domain parameters of HRV were recorded and compared. According to the results all HRV parameters including the time- and frequency-domain parameters were significantly changed after the anaerobic loading (for HR, SDNN, SDSD, RMSSD, TP, LF, LF:HF ratio, and VLF $p<0.01$; and for HF $p<0.05$). It could be concluded that the time- and frequency-domain parameters of HRV are impaired after a supramaximal anaerobic loading. The future studies can examine the recovery process by measuring the HRV during for a long period of time after the loading.

Key Words: Anaerobic power, heart rate variability, wingate anaerobic power test

INTRODUCTION

Heart rate variability (HRV), which is a non-invasive indicator of autonomic heart functions (13) and is defined as the temporal variation between heart beats (14), is used in the field of exercise and sports sciences to determine the chronic effects of loading (10). In recent years, HRV has also been used as a measurement method to examine the effects of loading on cardiac autonomic regulation (8). In this respect, the change in the heart caused by different load types is measured and the relationship between the power values obtained and the intensity of the load can be investigated.

Anaerobic energy metabolism is energy metabolism, which is the main determinant of performance in many sports branches (3). Besides, it is also one of the skill-related elements of physical fitness, and expresses the amount of work done per unit time (15). The prerequisite for preparing a program, whether it is exercise or sports targeted, is based on the measurement of all the parameters that are desired to be developed. The Wingate anaerobic power test is also one of the most commonly used tests to determine anaerobic power (6). Unlike its counterparts, it gives information about both lactacid and alactacid power values when the standard protocol is followed and applied for 30 seconds. There are a few numbers of studies in the literature examining the relationship between HRV and short-term and intense loading. For example, in one study, the difference in HRV results measured at altitudes between 0 and about 3000 m was examined, and it was concluded that exposure to normobaric hypoxia did not have additional effects on anaerobic performance and HRV (2). In another study, HRV parameters before and after 50 m sprint swimming were examined and significant deteriorations were found in many time- and frequency-domain parameters (1).

The aim of the present study is to compare the HRV values of physically active men studying at the faculty of sports sciences before and after WAnT applied once for 30 seconds.

METHODS

Study Design

The study was carried out to examine the changes in HRV parameters of physically active men before and after a 30-second maximal anaerobic load.

Subjects

Eight physically active men who study in the faculty of sports sciences participated in the research voluntarily. The mean age of the participants was 24.25 ± 2.25 years, their height was 174.25 ± 5.09 cm, their body weight was 70.21 ± 6.94 kg, and their percent body fat was 18.70 ± 5.24%.

Procedures

The body compositions of the participants were determined with the Avis 333 plus (Korea) analyzer when the subjects were standing and wearing only shorts. Body height was measured with a Holtain brand stadiometer with a 1 mm interval (Holtain, U.K.).

Resting heart rate (HRrest) and HRV parameters were taken with an Omegawave 800 (Oregon, USA) model device. During the five-minute ECG recording, both time-domain and frequency-domain parameters of HRV were measured. The subject was placed on his back on a stretcher with only shorts on, and a total of 7 electrodes were connected to different parts of his body by applying gel. Participants were warned not to move in any way during the measurement and not to think about the subjects they would be excited about. Care was taken to ensure that the measurement room was as quiet and physically comfortable as possible. Measurements were taken twice for each person and applied as a pre- and post-test. In this study, time-domain parameters such as HR, SDNN, SDSD and RMSSD, and frequency-domain parameters such as TP, HF, LF, LF:HF ratio and VLF were recorded.

Anaerobic alactacid and lactacid strength were determined using the Wingate Test (WAnT) and the Monark Peak Bike bicycle ergometer (Varberg, Sweden). For the WAnT, a 4-minute warm-up period was applied to the participants. During the warm-up, the participants pedaled between 60-80 rpm, and at the 1.30 and 2.30 minutes, they did two sprints of 3 seconds on the ergometer without resistance. In this way, the participants were enabled to recognize the test while warming up. After warming up, passive rest was done for 5 minutes. Afterwards, the subject pedaled maximally for 30 seconds on a bicycle whose sitting height was adjusted according to his height against the weight corresponding to 7.5% of his body weight. Immediately after WAnT, subjects were taken to the second HRV measurement, so that the acute effect of the WAnT test on the heart could be examined. As a result of the test, relative peak power (PPr), average power (APr), minimum power (MPr), and power drop (PD) values were used.

During all the measurements, the laboratory temperature was kept between 20-22 °C and the humidity was kept below 60%, by using the air-conditioner. Measurements were made between 2 and 4 o'clock in the afternoon. Subjects were warned to stop eating until two hours before the measurements, not to do strenuous activities the day before, and not to consume caffeine until 12 hours before the measurements. Participants were also asked not to use drugs in the last 24 hours.

Statistical Analyses

SPSS (version 16) program was used for data analysis. The distribution of the data was first examined to determine whether parametric or non-parametric tests would be used to compare the pre- and post-test mean differences. The normality of the distribution was determined by the Shapiro-Wilk test, since the number of participants was less than 50. The pre- and post-test mean of the normally distributed data were compared with the paired sample t-test, and the pre- and post-test mean of the data without normal distribution were compared with the Wilcoxon test. The alpha value of 0.05 was accepted for all statistical analyses.

FINDINGS

The results of some of the relative values obtained from the WAnT test of the participants are shown in Table 1.

Table 1. The WAnT results.

PPr (W/kg)	11.28 ± 1.54
APr (W/kg)	8.24 ± 0.43
MPr (W/kg)	5.12 ± 0.65
PD (%)	53.77 ± 7.90

The Table 2. shows the mean values of HRV parameters before and after WAnT, and the significance of the difference between the two tests. According to the results, all time- and frequency-domain parameters changed significantly after anaerobic loading. While SDNN, SDSD, RMSSD, TP, HF, LF and VLF decreased; increases were noted in HR and LF:HF ratio.

Table 2. Comparison of HRV responses and their average values obtained before and after an anaerobic power test.

	Pre-test	**Post-test**	**p**
HR	65.75 ± 7.24	104.87 ± 13.50	0.000
SDNN	60.37 ± 20.66	16.50 ± 4.59	0.001
SDSD	68.62 ± 31.36	6.37 ± 3.11	0.001
RMSSD	53.62 ± 24.14	5.12 ± 2.69	0.001
TP	1277.62 ± 884.67	55.00 ± 28.19	0.006
LF:HF ratio	1.40 ± .95	6.78 ± 3.44	0.002
HF	599.50 ± 626.99	5.75 ± 5.47	0.012
LF	535.62 ± 292.06	31.25 ± 20.25	0.002
VLF	142.62 ± 68.61	18.00 ± 7.07	0.001

HR: Heart rate, SDNN: standard deviation of RR interval, SDSD, RMSSD: root mean square of successive differences in RR intervals, TP: total power, LF:HF: low frequency/high frequency ratio , HF: high frequency component , LF: low frequency , VLF: very low frequency components .

DISCUSSION

The aim of this study was to compare the results of HRV before and after WAnT, which is considered a supramaximal test and applied for 30 seconds in physically active men. When the results were examined, it was understood that there was a significant deterioration in all HRV parameters measured before and after loading. From the time-domain measurements of HRV, HR increased ($p<0.01$), while SDNN, SDSD and RMSSD decreased ($p<0.01$). Similar changes were seen in the frequency domain parameters. Decreases were observed in TP, LF and VLF ($p<0.01$) and HF ($p<0.05$). LF:HF ratio was recorded as high ($p<0.01$). All these changes; increasing HR, LF:HF ratio and decreasing SDNN, SDSD, RMSSD, TP, HF, LF and VLF show that the dominance of sympathetic activity increases and the effect of parasympathetic activity decreases over cardiac autonomic regulation. In addition, these changes observed in the time- and frequency-domain parameters of HRV are consistent.

In the literature, the effects of exercise or sports on HRV have been studied generally after long-term training programs. Many of the studies have investigated chronic changes. Because having HRV values below the optimal level has been associated with mortality and many diseases (4, 11, 16).

Therefore, many studies have examined whether HRV can be improved with exercise in both healthy and chronically ill groups. For example, in a study Heydari et al. (2013) reported that high-intensity interval training produced improvement in some HRV parameters of untrained men when applied for 12 weeks. Similarly, a 10-week hatha yoga program was noted to improve some HRV data of untrained healthy adults (5). Unlike these results, Monohan et al. (2000) reported that a three-month aerobic exercise program did not produce significant HRV changes in middle-aged participants. In another study, it was concluded that static streching and resistance exercises did not have an effect on HRV in postmenopausal women (7).

The number of studies examining the acute effects of an exercise application on HRV is limited in the literature. In one of these studies, changes in HRV after WAnT application in normobaric hypoxia were examined on male and female university students (2). The change in HRV parameters after WAnT at 162, 1015, 2146, and 3085 meters altitudes was investigated. According to the results, changes were observed in the HR, SDNN, SDSD, RMSSD, TP, LF:HF ratio, HF, HFnu, LF, LFnu and VLF parameters used in the study, parallel to those in the current research. All results showed that sympathetic activity increased after loading. However, no change was detected depending on altitude.

In another study, HRV changes of 13-14-year-old male swimmers were followed after 50 m freestyle sprint swimming. In this study, the swimming time was specified as 32.14 sec, and this time and the intensity of loading were similar to those in the current study. As a result, significant impairments were noted in HR, TP, LF:HF ratio, HF, HFnu, LFnu ($p<0.01$), and SDNN, SDSD, RMSSD, and LF ($p<0.05$) (1).

Tuna et al. (2020) examined changes in HRV with energy expenditure during and after one hour of hatha yoga practice. According to the results, HR was recorded significantly higher during yoga and returned to baseline at the 10th minute of recovery. Similarly, the changes observed in SDNN, RMSSD, SDSD, NN50, TRI, LF:HF ratio, HF and VLF show that practices such as yoga with long-term static contractions increase the activity of the sympathetic nervous system.

CONCLUSION

According to the results obtained from this study, it is seen that the efficiency of the sympathetic nervous system increases significantly after anaerobic loading. Accordingly, it can be said that cardiac autonomic responses are impaired after such loadings. In future studies, researchers can measure HRV until recovery after loading to examine the recovery process. In addition, measurement of lactate immediately after such a load and during the recovery period may provide additional results about the intensity of physiological overload in addition to the HRV results.

REFERENCES

1. Aras D, Akça F, Akalan C. The Effect of 50 m Sprint Swimming on Heart Rate Variability in 13-14 Year-Old Boys. SPORMETRE XI (1): 13-18, 2013.
2. Aras D, Coşkun B. The Changes on the HRV after a Wingate Anaerobic Test in Different Simulated Altitudes in Healthy, Physically-Active Adults. Acta Med Mediterr 32: 1683, 2016.
3. Bompa TO, Buzzichelli CA. Periodizaiton, Theory and Methodology of Training. Champaign, IL: Human Kinetics, 2019.
4. Borresen J, Lambert MI. Autonomic Control of Heart Rate During and after Exercise: Measurements and Implications for Monitoring Training Status. Sports Med 38 (8): 633-46, 2008.
5. Cheema BS, et al. Effect of an Office Worksite-Based Yoga Program on Heart Rate Variability: Outcomes of a Randomized Controlled Trial. BMC Complement Altern Med 13: 82, 2013.
6. Gacesa JZP, Barak OF, Grujic NG. Maximal Anaerobic Power Test in Athletes of Different Sport Disciplines. J Strength Cond Res 3 (3): 751-755, 2009.
7. Gerage AM, Forjaz CL, Nascimento MA, Januário RS, Polito MD, Cyrino ES. Cardiovascular Adaptations to Resistance Training in Elderly Postmenopausal Women. Int J Sports Med 34 (9): 806–813, 2013.
8. Gronwald T, Hoos O. Correlation properties of heart rate variability during endurance exercise: A systematic review**.** Ann Noninvasive Electrocardiol 25:e12697, 2020.
9. Heydari M, Boutcher YN, Boutcher SH. High-intensity Intermittent Exercise and Cardiovascular and Autonomic Function. Clin Auton Res 23: 57-65, 2013.
10. Hnidawei MA, Mjall M, Zayed Z. The upper limit of physiological cardiac hypertrophy in elite male athletes. Am J Appl Sci 7 (10): 1327-1333, 2010.
11. Lehrer PM, Vaschillo E, Vaschillo B, Lu SE, Eckberg DL, Edelberg R, Shih WJ, Lin Y, Kuusela TA, Tahvanainen KU, Hamer RM. Heart Rate Variability Biofeedback Increases Baroreflex Gain and Peak Expiratory Flow. Psychosom Med 65 (5): 796-805, 2003.
12. Monahan KD, Dinenno FA, Tanaka H, Clevenger CM, DeSouza CA, Seals DR. Regular Aerobic Exercise Modulates Age-Associated Declines in Cardiovagal Baroreflex Sensitivity in Healthy Men. J Physiol 529 (1): 263-271, 2000.
13. Myllymaki T, Rusko H, Syvaoja H, Juuti T, Kinnunen ML, Kyrolainen H. Effects of exercise intensity and duration on nocturnal heart rate variability and sleep quality. Eur J Appl Physiol 112: 801-809, 2012.
14. Pagani M et al. Power spectral analysis of heart rate and arterial pressure variabilities as a marker of sympa-tho-vagal interaction in man and conscious dog. Circ Res 59: 178-193, 1986**.**
15. Riebe D, Ehrman JK, Liguori G, Magal M. ACSM’S Guidelines for Exercise Testing and Prescription. Philadelphia, PA: Wolters Kluwer Health, 2018.
16. Schmidt H, et al. Autonomic Dysfunction Predicts Mortality in Patients with Multiple Organ Dysfunction Syndrome of Different Age Groups. Crit Care Med 33:1994-002, 2005.
17. Tuna ME, Aras D, Aras N, Özçelik MA, Aktop A. Acute Changes in Energy Expenditure and Heart Rate Variability during and right after One Hour of Hatha Yoga Practice. Pol J Sport Tourism 27 (4): 29-35, 2020.