Heart rate response differences in aerobic and anaerobic male exercisers

Diferencias en la respuesta de la frecuencia cardiaca en hombres que realizan ejercicio aeróbico y anaeróbico

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Abstract

Introduction: Long-term exercise induces physiological adaptations that differ between aerobic and anaerobic training, affecting heart rate responses requiring further exploration. Objective: This Study compares the heart rate responses of individuals who specialized in aerobic or anaerobic training when subjected to the same physical activity trial.
Method: This study conducted a stationary bike test to investigate heart rate fluctuations in 16 anaerobic (AN) and 25 aerobic (AE) male exercise enthusiasts who regularly exercise. The stationary bike test started at 50W, increased gradually by 30W until reaching 230W (peak), and then gradually decreased to 50W while the heart rate was recorded every 5 seconds. Result: The results indicated no significant difference (p>0.05) in heart rate between the two groups at low intensity. However, after reaching 200W (moderate intensity), the heart rate of the AN group appeared to be lower than that of the AE group. Additionally, the heart rate during the descending phase after reaching 230W was significantly higher (p<0.05) compared to the ascending phase before the peak, and the heart rate did not return to baseline, even during the resting period after the stationary bike test.
Conclusion: Anaerobic-trained individuals maintain a lower heart rate than aerobic-trained individuals at moderate or higher intensity. The post-peak heart rate is always higher than the pre-peak heart rate and does not immediately return to baseline.

Keywords

Aerob; anaerob; heart rate; response; stationary bike.

Resumen

Introducción: El ejercicio a largo plazo induce adaptaciones fisiológicas que difieren entre el entrenamiento aeróbico y anaeróbico, afectando las respuestas de la frecuencia cardíaca y requiriendo una mayor exploración.
Objetivo: Este estudio compara las respuestas de la frecuencia cardíaca en individuos especializados en entrenamiento aeróbico o anaeróbico cuando se someten a la misma prueba de actividad física.
Método: Se realizó una prueba en bicicleta estacionaria para investigar las fluctuaciones de la frecuencia cardíaca en 16 hombres con entrenamiento anaeróbico (AN) y 25 con entrenamiento aeróbico (AE), todos practicantes habituales de ejercicio. La prueba comenzó a 50W, aumentando gradualmente en 30W hasta alcanzar 230W (pico) y luego disminuyendo progresivamente hasta 50W, mientras se registraba la frecuencia cardíaca cada 5 segundos.
Resultado: Los resultados no mostraron diferencias significativas (p>0.05) en la frecuencia cardíaca entre los dos grupos en intensidades bajas. Sin embargo, después de alcanzar los 200W (intensidad moderada), la frecuencia cardíaca del grupo AN fue menor que la del grupo AE. Además, la frecuencia cardíaca en la fase descendente después de alcanzar los 230W fue significativamente más alta (p<0.05) en comparación con la fase ascendente antes del pico, y no regresó a los valores basales incluso durante el período de descanso posterior a la prueba.
Conclusión: Los individuos entrenados en anaeróbico mantienen una frecuencia cardíaca más baja que los entrenados en aeróbico en intensidades moderadas o superiores. La frecuencia cardíaca post-pico es siempre más alta que la pre-pico y no regresa inmediatamente a su valor basal.

Palabras clave

Aerob; anaerob; frecuencia cardiaca; respuesta; bicicleta estática.

Introduction

The intensity of physical activity is one of the key variables in implementing a healthy lifestyle (Bull et al., 2020). By paying attention to the intensity of physical activity and appropriate exercise load, exercisers can plan, monitor, and evaluate their exercise routines to ensure the success of their training programs. The intensity of physical activity is crucial for planning a workout session. A well-structured workout should be designed and programmed, ensuring clarity on what will be done during the session. Physical activity intensity is also important for monitoring ongoing physical activity. Exercisers need to know when to run faster and when to slow down, based on the intensity targets set beforehand. Furthermore, physical activity intensity is critical in evaluating completed workouts' effectiveness. Exercisers must ensure whether the intensity achieved in a session meets the targeted level, falls short, or exceeds it. If it falls short, the workout may not provide meaningful improvements; if it exceeds the target, it may lead to overload or fatigue, requiring more extended recovery periods than usual (Børsheim & Bahr, 2003).

Physical activity is fundamentally a load on the body (Dasso, 2019), initially borne by the skeletal muscles. To perform their functions, skeletal muscles require energy from ATP, which is produced through glucose metabolism. The metabolic process to produce ATP generates byproducts of CO2 and lactic acid (Erecińska & Wilson, 1982; Rodwell et al., 2020). The immediate need for ATP, coupled with the accumulation of CO2 and lactic acid, triggers physiological responses. These physiological responses to physical activity vary depending on the characteristics and intensity of the activity, as well as the physiological condition of the exercisers at the time (MacInnis & Gibala, 2017).

Heart rate frequency is essential for assessing the body's physiological response to physical activity (Nazaret et al., 2023). It is also one of the most accessible and affordable parameters for the public who are just beginning to exercise. Many sensors are available to measure heart rate, ranging from chest straps placed on the diaphragm under the chest, upper arm straps, and smartwatch-integrated sensors to those integrated with specific exercise equipment such as treadmills and stationary bikes (Gordon et al., 2016; Plews et al., 2017). Heart rate sensors have also been widely used in research, including studies on students (Martinez-López et al., 2018).

When a sedentary individual decides to start exercising, they are often confused about what exercise to do and how intensely they should exercise. Cardiovascular endurance-based exercises like jogging, cycling, and swimming predominantly utilize the aerobic energy system, which does not heavily involve strong muscle contractions (lower intensity) but allows the activity to last long while heart rate frequency increases gradually. On the other hand, strength- and power-based exercises like weight training and martial arts involve rapid, strong muscle contractions (higher intensity) and are usually performed for shorter durations. The difference occurs due to the variation in energy systems used in metabolism (Hargreaves & Spriet, 2018, 2020). Strong and rapid muscle contractions rely on the quick availability of ATP, leading to anaerobic metabolism and significant lactic acid production. Anaerobic-based exercises depend on tolerance to lactic acid accumulation (Poole et al., 2021), resulting in sharper increases in heart rate frequency (Thimm & Meier zu Verl, 1984). The differences in exercise characteristics often influence individuals in determining their exercise preferences.

Physiological adaptations occur when physical training is performed regularly over an extended period (several months). These adaptations depend on the characteristics and intensity of the exercise, causing the body's physiology to specialize. Aerobic and anaerobic training have distinct characteristics, leading to different physiological responses. Over time, the body's physiology will adapt (specialize) according to these different characteristics (Gong et al., 2022; Hughes et al., 2018; Timmons, 2011). Individuals who engage in long-term aerobic training will likely experience physiological improvements related to the oxygen supply chain, such as increased lung capacity, active alveoli, red blood cell and hemoglobin levels, heart chamber size, myoglobin levels, and the number of mitochondria. Muscle fibers will contain more myoglobin, which is redder, often called red muscle (slow twitch/type I). These individuals can sustain exercise for extended periods but with less powerful muscle contractions (Hellsten & Nyberg, 2016; Hodgson, 2014). In contrast, those who choose anaerobic training in the long term will likely experience physiological enhancements related to muscle fiber performance, such as an increase in the number and size of muscle fibers, correlating with the physical load they can bear, but with less myoglobin, and the muscle appears paler, is often referred to as white muscle (fast twitch/type II)

(Plotkin et al., 2021; Qaisar et al., 2016). These individuals can lift heavy weights and perform fast movements, but they cannot sustain them for long periods. Lactic acid buildup occurs quickly.

The physiological specialization in both types of exercise inevitably impact heart performance. CO2 and lactic acid caused acidosis and stimulate increased heart rate when detected by the carotid bodies (Iturriaga et al., 2021; Ortega-Sáenz & López-Barneo, 2020). Therefore, the physical load from both types of exercise places a burden on the cardiorespiratory system. An increased heart rate is the most noticeable cardiorespiratory response. However, it is not yet known how heart rate responses occur in specialized individuals when subjected to the same physical activity. Previous research has explored how heart rate responds to anaerobic activities such as push-ups, sit-ups, and squats. However, previous studies primarily focused on fundamental comparisons between physically active and sedentary subjects (Putra et al., 2023). Previous studies have extensively discussed heart rate (HR) responses to various types of physical loading (D'Unienville et al., 2022) or discussed heart rate recovery (Del Rosso et al., 2017), with most comparisons being between physically active and sedentary individuals. However, research exploring HR responses in individuals specialized in aerobic or anaerobic training remains limited. Further studies on subjects specialized in aerobic or anaerobic exercise are needed to understand how the cardiovascular system responds when physiological status has reached a specialized level.

In this study, the researcher compares the heart rate responses of individuals who specialized in aerobic or anaerobic training when subjected to the same physical activity trial. The physical activity trial administered is a stationary bike test. The stationary bike test is chosen because stationary cycling is considered one of the most easily controlled physical activities in terms of workload, making it suitable for individuals who are just beginning an active lifestyle. Studying heart rate (HR) is more urgent than heart rate variability (HRV) because it is easier for the general public to understand and is supported by the popularity of devices like smartwatches that measure HR in real time. HR is also relevant for regulating exercise intensity and monitoring health and has universal practical applications. HR measurement is simple, quick, and can be directly utilized by all groups, whereas HRV requires advanced tools and more profound knowledge. HR research can provide broader and more immediate applicable benefits to society. The researcher hypothesizes that individuals specializing in aerobic exercise will exhibit lower heart rate frequencies than those specializing in anaerobic exercise. A study found that aerobic athletes have a larger left ventricular end-diastolic internal diameter accompanied by thickening of the ventricular wall, indicating adaptation to training (Pluim et al., 2000). The larger ventricular chamber allows a greater blood volume to be pumped, requiring fewer heartbeats.

Method

This study employs a quasi-experimental design because the subjects were not randomly selected but rather chosen based on their physical activity history, specifically aerobic (AE) and anaerobic (AN) exercise practitioners. Although the intervention involved a stationary bike test applied to both groups, randomization in group assignment was not conducted. Both groups underwent the stationary bike test with identical procedures, including the same maximal limit (peak load), same heart rate sensor unit, and same stationary bike. Heart rate was continuously monitored throughout the test duration.

The heart rate data captured by the Polar H10 sensor provides real-time frequency readings in beats per minute (bpm). However, to allow for meaningful analysis, all recorded data is converted from bpm into Percentage (%) of Heart Rate Reserved (HRR) using the Karvonen formula (Karvonen & Vuorimaa, 1988). While each individual's heart rate range in bpm may differ, converting the data into percentages standardizes the results, creating a uniform range from 0% to 100% HRR. Maximum heart rate (MHR) is calculated using the traditional formula of 220-age, which is the simplest method for predicting MHR in healthy individuals. The choice to use the Karvonen formula in this study was intentional. The researchers recognized that it offers the most logical calculation by excluding any values below the Resting Heart Rate (RHR)—biologically impossible numbers for healthy humans. By eliminating these outliers, the Karvonen method ensures a more accurate representation of the heart rate frequency.

The recorded heart rate frequencies (%) were averaged within each group and then compared between the two groups using an independent t-test. Additionally, heart rate during the ascend phase (before peak load) was compared with heart rate during the descend phase (after peak load) using a paired t-test. A normality test was conducted before the t-tests to ensure the normality of the data distribution. This study has been reviewed and approved by the Research Ethics Committee of the Faculty of Medicine and Health Sciences, Satya Wacana Christian University, with Ethical Approval number 6/15.07/2024062602/EA/2024.

Participants

The subjects in this study were divided into two groups: the AE group consisted of aerobically trained individuals, and the AN group consisted of anaerobically trained individuals. Aerobic participants were recruited from running communities to homogenize the recruitment of subjects, while anaerobic participants were sought from weight training communities (gyms/fitness centers). The population in this study consists of members of the weightlifting community in Salatiga and the running community in Salatiga who meet the research criteria. Based on the required criteria, this study involved 16 participants in the anaerobic group (AN) and 25 in the aerobic group (AE), with a total of 41 subjects, constituting the entire population willing to participate as subjects in the study. Community members who did not meet the criteria or refused participation were excluded from this study.

The same criteria were applied for subject selection: male, aged between 22-35 years, non-smokers, body fat percentage below 30%, with no history of cardiorespiratory-related diseases, not taking medication, willing to abstain from alcohol, avoid staying up late, and refrain from consuming caffeine for three days before the stationary bike test, and willing to participate in the study as evidenced by signing an informed consent form. Specific criteria for determining whether a subject would be placed in the aerobic or anaerobic group included having engaged in regular physical exercise (aerobic or anaerobic) for at least the past three months, with a minimum frequency of twice a week.

Procedure

Subjects who signed the informed consent were scheduled for the stationary bike test. The test was conducted in a room with good air circulation at the Faculty of Medicine and Health Sciences, Satya Wacana Christian University, at temperature between 25-27 degrees Celsius, the normal temperature in Salatiga. Since the air temperature was stable, neither air conditioning nor heating was used.

Subjects arrived at the research site wearing athletic clothing, specifically short sports shorts. The shorts were standardized to avoid any resistance on the thigh area that could occur with long pants, which might add resistance during the stationary bike test. All subjects were required to wear shoes and remove accessories during the test.

Subjects were selected based on criteria evaluated three days before the test day using an interview method. On the test day, height, weight, and body fat percentage were measured to ensure the subjects met the study criteria. Blood pressure and oxygen saturation (SpO2) were also measured to ensure that subjects were healthy and could perform the stationary bike test. Body fat percentage was measured using the Bio-Impedance Analysis (BIA) method with the TANITA BC545N, a non-invasive body composition measurement device. After the body fat percentage measurement, the subjects were asked to sit quietly for 10 minutes to lower their heart rate as low as possible. Subjects were instructed to wear a Polar H10 heart rate sensor placed on the diaphragm. This sensor was directly connected to the researcher's smartphone via Bluetooth using the EliteHRV Android application. The application allowed real-time heart rate monitoring, enabling the determination of the resting heart rate (RHR). The EliteHRV application also facilitated the measurement of heart rate variability (HRV), thus providing HRV values. The researcher confirmed the lowest heart rate as the initial resting heart rate (Pre RHR). Heart Rate Variability (HRV) was also measured at the same time. Once confirmed, the subjects proceeded to the stationary bike test.

After establishing RHR and HRV, subjects were asked to mount the stationary bike. The stationary bike was an iReborn New Noris model, which employed a magnetic resistance mechanism and load sensors and could connect with the Kinomap Android application via Bluetooth. The Kinomap application allowed simultaneous connections with the stationary bike and the Polar H10 sensor, displaying the real-time load in watts transmitted by the bike. The researcher continuously monitored and recorded the load (watts) and heart rate (bpm) data displayed on the Kinomap application.

During the stationary bike test, subjects were instructed to pedal against a predetermined load set by the researcher. Load progression in the stationary bike test was based on Table 1. The initial load was set at 50 watts, which had to be achieved at level 2 on the stationary bike. If a subject pedaled too quickly, the load would exceed 50 watts, prompting the researcher to ask the subject to reduce their pedaling speed. Conversely, if the subject pedaled too slowly, resulting in a load of less than 50 watts, the researcher would instruct the subject to pedal faster.

Table 1 Load Progression in the Stationary Bike Test Procedure

	Level	Watt
Pre RHR	Rest	0
Load Increases	2	50
	3	80
	4	110
	5	140
	6	170
	7	200
Peak	8	230
Load Decreases	7	200
	6	170
	5	140
	4	110
	3	80
	2	50
Post RHR	Rest	0

Heart rate was recorded every 5 seconds from when the subject began pedaling until the stationary bike test was completed. The load would increase by 30 watts by raising one level on the stationary bike once the subject successfully maintained a pedaling rate at 50 watts, with heart rate data showing stability within a maximum difference of 4 bpm. This procedure continued with increasing loads until reaching 230 watts (level 8). After reaching 230 watts, the load reduction procedure commenced using the same method, but the load would be decreased by 30 watts by lowering one level on the stationary bike once pedal stability and heart rate stability were achieved. The load reduction procedure continued until the load returned to 50 watts at level 2, the initial load. After attaining the pedaling stability and the final heart rate, the subjects were instructed to stop, dismount from the stationary bike, and rest and hydrate. Once the subjects dismounted from the bike, heart rate was recorded every 15 seconds until the lowest stability was reached. The lowest heart rate during post-test recovery was confirmed as the second resting heart rate (post-RHR).

Data analysis

All heart rate recordings from the beginning to the end of the stationary bike test were compiled into a Microsoft Excel file. In Excel, the researcher carefully reviewed the recorded heart rates, mainly focusing on the points of stability, which served as the basis for decisions to increase or decrease the bike resistance levels. Stability was considered valid if the recorded heart rate was consistent or had a variation of no more than four bpm for at least 15 consecutive seconds. It was considered unstable if the heart rate fluctuated over four bpm during those 15 seconds. Heart rates that remained stable for over 15 seconds were marked and averaged. This average was recorded as the stable heart rate achieved at a given resistance level. This method was applied to each resistance level, resulting in data that, when plotted, would show a hill-shaped pattern with a single peak. The data obtained from both groups were then analyzed for differences using SPSS software.

Results

Figure 1 shows the heart rate stability achieved by both groups. At a glance, the heart rate stability observed in both groups appear similar and nearly identical. Differences are only clearly evident at above 110W. The normality test results on the data from both groups indicate that all data at each resistance level are normally distributed, including the RHR post and HRV (Table 2 and Table 3). The variance test results (Table 4) indicate that the assumption of homogeneity of variances is met.

Figure 1 Stable Heart Rate Achieved in Both Groups

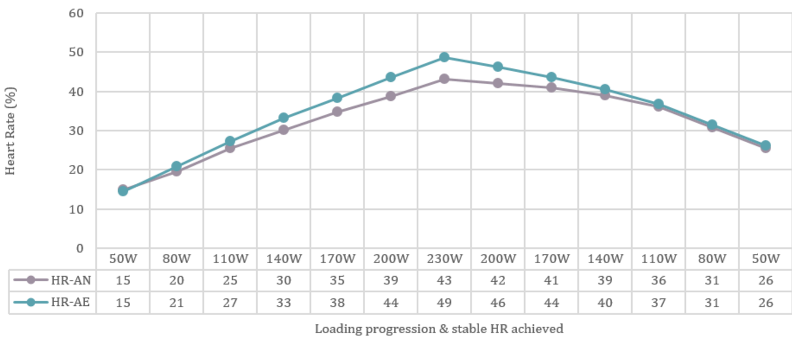

Table 2 Results of The Normality Test for Heart Rate Stability in the AN Group

	Tests of Normality					
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
AN RHR	0.149	16	0.200*	0.955	16	0.572
AN 50W ascend	0.099	16	0.200*	0.970	16	0.843
AN 80W ascend	0.138	16	0.200*	0.929	16	0.235
AN 110W ascend	0.119	16	0.200*	0.973	16	0.882
AN 140W ascend	0.192	16	0.119	0.946	16	0.433
AN 170W ascend	0.112	16	0.200*	0.980	16	0.962
AN 200W ascend	0.143	16	0.200*	0.958	16	0.629
AN 230W peak	0.113	16	0.200*	0.982	16	0.980
AN 200W descend	0.156	16	0.200*	0.960	16	0.659
AN 170W descend	0.104	16	0.200*	0.967	16	0.785
AN 140W descend	0.122	16	0.200*	0.950	16	0.490
AN 110W descend	0.115	16	0.200*	0.970	16	0.839
AN 80W descend	0.103	16	0.200*	0.958	16	0.634
AN 50W descend	0.143	16	0.200*	0.949	16	0.475
AN HRV	0.137	16	0.200*	0.957	16	0.601

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 3. Results of The Normality Test for Heart Rate Stability in the AE Group

	Tests of Normality					
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
AE RHR	0.136	25	0.200*	0.956	25	0.346
AE 50W ascend	0.100	25	0.200*	0.979	25	0.870
AE 80W ascend	0.102	25	0.200*	0.965	25	0.519
AE 110W ascend	0.091	25	0.200*	0.964	25	0.503
AE 140W ascend	0.124	25	0.200*	0.975	25	0.764
AE 170W ascend	0.108	25	0.200*	0.979	25	0.865
AE 200W ascend	0.149	25	0.155	0.951	25	0.265
AE 230W peak	0.095	25	0.200*	0.955	25	0.322
AE 200W descend	0.155	25	0.126	0.932	25	0.098
AE 170W descend	0.131	25	0.200*	0.932	25	0.095
AE 140W descend	0.108	25	0.200*	0.964	25	0.492
AE 110W descend	0.108	25	0.200*	0.975	25	0.770
AE 80W descend	0.063	25	0.200*	0.985	25	0.964
AE 50W descend	0.108	25	0.200*	0.952	25	0.272
AE HRV	0.090	25	0.200*	0.975	25	0.772

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

The independent t-test results (Table 4) between the two groups showed that significant differences ($p<0.05$) in heart rate achieved only occurred at the first 200W during the ascend and at 230W, which marked the peak load. The AN group exhibited a more flattened and lower curve starting from 110W at the ascending phase to 140W at the descending phase. Interestingly, despite the clear difference from 110W during the ascending phase to 140W during the descending phase, as seen in Figure 1, the independent t-test showed that significant differences only occurred at 200W during the ascending phase and at the peak of 230W ($p<0.05$). The researchers suspect that larger differences would emerge if the load exceeded 230W. This finding contradicts the initial hypothesis that the AE group would achieve lower heart rates at each load level; in reality, the AN group appeared to maintain lower heart rates. This opens the potential for future research with loads beyond 230W to explore the pattern at higher intensities.

Table 4 The Results of The Independent T-Test Between the Two Groups for The Heart Rate Data at Each Resistance Level

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
50W ascend	0.112	0.740	-0.231	39	0.818	-0.437	1.892	-4.265	3.390
80W ascend	0.075	0.786	0.555	39	0.582	1.353	2.439	-3.581	6.287
110W ascend	0.318	0.576	0.883	39	0.382	1.814	2.054	-2.340	5.969
140W ascend	0.000	0.988	1.286	39	0.206	3.068	2.385	-1.756	7.893
170W ascend	1.415	0.241	1.557	39	0.128	3.463	2.224	-1.036	7.961
200W ascend	0.284	0.597	2.036	39	0.049*	4.904	2.408	0.032	9.775
230W peak	0.176	0.677	2.207	39	0.033*	5.653	2.562	0.471	10.834
200W descend	0.218	0.643	1.637	39	0.110	4.159	2.540	-0.979	9.297
170W descend	0.295	0.590	1.029	39	0.310	2.563	2.492	-2.477	7.604
140W descend	0.028	0.867	0.550	39	0.586	1.440	2.620	-3.859	6.740
110W descend	0.032	0.859	0.262	39	0.794	0.631	2.403	-4.230	5.491
80W descend	0.024	0.879	0.266	39	0.791	0.608	2.283	-4.009	5.225
50W descend	1.450	0.236	0.233	39	0.817	0.555	2.382	-4.264	5.374
RHR	1.316	0.258	1.204	39	0.236	2.101	1.745	-1.429	5.631
HRV	3.087	0.087	-0.686	39	0.497	-2.075	3.027	-8.197	4.047

*significant difference

The HRV between the two groups showed no significant difference (p>0.05). The AN group had an average HRV of 59.9 ms, with a minimum of 45 ms and a maximum of 70 ms. Meanwhile, the AE group had an average HRV of 57.8 ms, with a minimum of 37 ms and a maximum of 77 ms. The AE group appeared to have a broader range than the AN group.

The following finding is that the heart rate post-peak, when the load was decreased to the same magnitude, did not return to the initial value as it did during the ascend. Even after completing the stationary bike test, the post-RHR did not equal the pre-RHR. This indicates that the resting heart rate did not return to its original condition. This may be because higher intensities of physical activity result in greater production of lactic acid and CO_2. The accumulated lactic acid and CO_2 require time to be eliminated from the bloodstream, and their levels remain elevated, as acidosis detected by the carotid bodies (Iturriaga et al., 2021). Consequently, the heart rate remains high in the minutes following the peak load. It is still unknown how long it will take for each group's heart rate to return to the initial RHR condition fully. Further studies are needed to address this issue.

The paired t-test results in Tables 5 and 6 indicate that both the AN and AE groups exhibit a significant difference (p<0.05) in heart rate during descend compared to the heart rate during ascend. This difference is observed at every level of load in both groups. Figure 2 shows that the difference in heart rate between the ascend and descend is smaller at higher intensities. Conversely, at lower intensities, approaching rest, the difference is larger. Additionally, this difference is also noted in RHR. The results of the one-sample test in Table 7 show that the post-exercise heart rate (Post RHR) is significantly different from the baseline condition (Pre RHR), which serves as the 0% (reference value). The AN group was restrained at 3.1%, while the AE group was restrained at 5.2%.

Table 5. The Results of the Paired T-Test Between Heart Rates during Ascend and Descend in the AN Group

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	SD	SE Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	AN 50W descend - AN 50W ascend	10.60	8.40	2.10	6.13	15.07	5.05	15	0.00
Pair 2	AN 80W descend - AN 80W ascend	11.27	6.55	1.64	7.79	14.76	6.89	15	0.00
Pair 3	AN 110W descend - AN 110W ascend	10.64	6.72	1.69	7.06	14.23	6.33	15	0.00
Pair 4	AN 140W descend - AN 140W ascend	9.00	6.06	1.51	5.77	12.23	5.94	15	0.00
Pair 5	AN 170W descend - AN 170W ascend	6.18	4.00	1.00	4.05	8.30	6.18	15	0.00
Pair 6	AN 200W descend - AN 200W ascend	3.23	2.91	0.73	1.67	4.78	4.43	15	0.00

Table 6. The Results of The Paired T-Test Between Heart Rates during Ascend and Descend in the AE Group

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	SD	SE Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	AE 50W descend - AE 50W ascend	11.59	6.62	1.32	8.86	14.32	8.76	24	0.00
Pair 2	AE 80W descend - AE 80W ascend	10.52	7.56	1.51	7.40	13.64	6.96	24	0.00
Pair 3	AE 110W descend - AE 110W ascend	9.46	6.16	1.23	6.92	12.00	7.69	24	0.00
Pair 4	AE 140W descend - AE 140W ascend	7.37	4.30	0.86	5.60	9.15	8.57	24	0.00
Pair 5	AE 170W descend - AE 170W ascend	5.87	4.95	0.99	3.23	7.32	5.33	24	0.00
Pair 6	AE 200W descend - AE 200W ascend	2.48	3.29	0.66	1.12	3.84	3.77	24	0.00

Table 7. Results of The One-Sample Test for Post-Exercise Heart Rate (Post RHR) Compared to Baseline (Pre RHR)

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
AN RHR	3.189	15	0.006	3.119	1.034	5.203
AE RHR	4.194	24	0.000	5.220	2.651	7.789

Figure 2. The Difference between Descend HR and Ascend HR at Each Load Level in Both Groups

The results of this study indicate that both the AN and AE groups did not reach 50% intensity of physical activity, even when subjected to a load of 230W during the stationary bike test. Below 40% is considered light intensity, while above 40% is categorized as moderate intensity (MacIntosh et al., 2021). For both groups, 230W still represents moderate physical activity. A difference is observed at the 200W load; for the AN group, 200W remains in the light intensity category (<40%), whereas for the AE group, it falls into the moderate intensity category (>40%). This may be attributed to the fact that the leg muscles of the AN group are more frequently trained under load (anaerobic), resulting in a higher lactate threshold. As the load increases, stronger contractions are required, and the AN group may be more accustomed to such strong contractions in their training regimen.

Discussion

The findings of this study indicate that 230W on the stationary bike constitutes moderate-intensity activity for individuals specialized in both aerobic and anaerobic exercises, resulting in heart rates nearing 50%. A load of 200W can elicit a heart rate of 38.7% (almost moderate) for individuals specialized in anaerobic exercise, while it reaches 43.7% (already moderate) for those specialized in aerobic exercise. Loads below 200W represent light physical activity for both groups.

The average heart rate of the AN group appeared lower than that of the AE group (although the t-test results before 200W were not significant), from 110W during the ascend phase to 140W during the descend phase. This difference may occur because the higher the workload, the greater the muscle contractions required to bear the load. The stronger muscle contractions stimulate anaerobic metabolism with lactic acid emission (Cairns, 2006). The higher the load, the stronger the muscle contractions, the more lactic acid is produced (Messonnier et al., 2013). If performed over time, the lactate threshold increases, allowing the body to tolerate higher levels of lactic acid in the blood. The AN group seems to have a higher lactate threshold, so when subjected to a heavier workload on the stationary bike, their heart rate does not increase as quickly as the AE group. However, the relationship between heart rate and lactate threshold needs to be further studied to confirm this theory.

At low workloads (below 200W), no significant differences in heart rate responses were observed, possibly due to the minimal occurrence of muscular muscle contractions at low intensities, leading to limited lactate accumulation and metabolism still predominantly reliant on aerobic processes. At this level, both aerobically and anaerobically specialized individuals are unaffected by the muscle contractions' load. However, from 200W onwards, lactate appears to accumulate significantly, making tolerating lactate a determining factor in performance.

The researcher assumes that sedentary individuals (untrained) would exhibit higher heart rate responses; however, further studies are needed to determine the extent of this difference. This research did not include subjects from the sedentary group because the peak load applied in this study had not been established to indicate the intensity levels it would elicit, making it potentially risky to conduct experiments directly on sedentary individuals. The concern is that sedentary individuals may have lower fitness levels or specific physiological disorders related to the cardiorespiratory system that they may not recognized (Lavie et al., 2019), thus necessitating assurance regarding the impact of peak loading on specialized individuals before involving the sedentary group.

The heart rate achievements depicted in Figure 1 can serve as a standard reference for the community in planning their exercise sessions. This is particularly relevant for sedentary individuals who wish to adopt a healthier lifestyle, as training on a stationary bike at loads of up to 200W represents a light to moderate intensity that is relatively easy and safe to undertake at the start of their fitness journey.

People may consider using real bicycles like mountain bikes or cycling around their neighborhoods. However, when using real bicycles, a potential challenge is accurately gauging the load applied unless a load sensor is added to the bicycle. The researcher believes that stationary bikes are the safest method for initiating a healthy lifestyle due to the ease of controlling and monitoring the load. From a seating posture perspective, recumbent bikes may be the safest option, especially for obese and older people. Personal trainers or physical coaches ensure that individuals new to active lifestyles receive an appropriate load for their condition, neither too little nor too much. They also help create a positive exercise experience, making it more likely for people to enjoy physical activity and adopt it as a part of their lifestyle.

In this study, only male subjects were selected because women have different morphology and body composition (Heitmann & Garby, 1998; Schorr et al., 2018), and the researchers believe this would affect the data. Additionally, only individuals who have been consistently training were chosen, excluding sedentary individuals or those who are new to exercise, as the researchers were unsure whether the given workload would lead to a high level of fatigue, which could pose a risk if directly applied to subjects who rarely engage in physical activity, which is become unethical. The limitation of this study is that only male subjects were selected, as females have different morphology and body composition, which the researchers believe would affect the data. Additionally, only individuals who have been regularly training were included, excluding sedentary individuals or those who have just started training. The researchers were unsure whether the given training load would cause high fatigue levels, which could pose risks if directly applied to subjects who seldom engage in physical activity.

Conclusions

The study reveals that the anaerobic (AN) and aerobic (AE) groups did not achieve 50% intensity during the stationary bike test at a load of 230W, categorizing it as moderate activity. Individuals specialized in anaerobic exercise can maintain a lower heart rate than those specialized in aerobic exercise during physical activities of moderate intensity or higher; however, at low intensity, their heart rates are similar. Post-peak heart rate is always higher compared to pre-peak heart rate. Additionally, post-exercise resting heart rates did not return to baseline values, suggesting prolonged physiological effects following higher-intensity exercise.

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