Ethan Sellers
Biology 111: Briggs

An Examination of Post-Exercise Heart Rate and Recovery Time

Abstract

In this experiment we are examining the relation of variables including gender, smoking, fitness, and surface area to heart rate and recovery time following exercise. Our study was performed on Pennsylvanian college students with a mean age of 18.83 years old. We discovered that males always had slower heart rates and quicker recovery times than females except after six minutes of exercise. Athletes always had slower heart rates and quicker recovery rates than non-athletes. Smokers and non-smokers had nearly identical results except for their pulse after two minutes of exercise and their recovery time after six minutes of exercise. Finally, resting heart rate and surface area were negatively correlated at a correlation of -0.217.

Introduction

Heart rate is typically a good measure of general health. According to a recently published Harvard Heart Letter (2008), higher heart rates lead to an increase in arterial stress and therefore an increased prevalence of occurrences such as atherosclerosis and cardiovascular disease.

In our experiments we hoped to determine how various characteristics influence heart rate and recovery rate. Namely, we would like to discover the difference, if any, in heart rate and recovery rate between males and females, smokers and non-smokers, and athletes and non-athletes. We would also like to find any possible correlation between heart rate and obesity, and we will use surface area as a relative measurement of obesity.

Research has shown that males typically have a much lower heart rate and quicker recovery time than women. One study showed a significant difference in male and female heart rate so that in each decade age grouping the female heart rate was significantly higher (Yoshino et al., 2007).

Although we may expect smokers to have a higher heart rate and slower recovery rates than non-smokers, Ness (1978) found in his research that the cardiovascular fitness of young smokers is affected very little by their smoking tendencies. In his experience, the heart rate of young smokers showed no significant difference from that of non-smokers.

Also, athletes typically have lower heart rates and recovery rates than non-athletes. In a recent study of endurance athletes, the athletes were found to have significantly lower heart rates than more sedentary individuals of the same age and gender (Henriksen et al., 2008).

Obesity is typically linked to an increase in heart rate. In one study of 67 obese and normal patients, the 33 obese patients had an average heart rate 2 beats greater than that of the normal control group. Although this difference was not statistically significant due to a relatively small sample size, it was nonetheless apparent and viable. (Tumuklu et al., 2007).

My expectation is that males will have a slower heart rate and a quicker recovery rate than females, that smokers *may* have a faster heart rate and a slower recovery rate than non-smokers, and that athletes will have a slower heart rate and a quicker recovery rate than non-athletes. I also expect heart rate to increase with surface area.

Materials and Methods

To examine the effects of exercise we examined students from a Pennsylvanian college.

General Characteristic Statistics			
	N	Mean	
	Statistic	Statistic	Standard Error
Age	623	18.83	0.08
Height	623	170.16	0.40
Weight	623	70.38	0.63

The above table shows the participants' mean age, height, and weight, as well as the mean standard error for these measurements. The study examined 623 people, but only 593 participants completed all aspects of the study. Of the 623 participants, 225 were male, 398 were female, 299 were athletes, 324 were non-athletes, 47 were smokers, and 576 were non-smokers. It should also be noted that the label "athlete" was applied to any member of a fall or winter sports team or anyone who "works out" three times per week.

The experiment was performed by first finding the resting pulse of the individual manually at the carotid artery. Next, the participants stepped at a rate of 40 steps per minute for exercise increments of one minute, two minutes, and six minutes onto a 17-cm-tall wooden step. After each exercise period, the participant had five seconds to sit down before his or her partner again took his or her pulse manually at the carotid artery. This was recorded as the pulse for that specific exercise increment. Every minute thereafter the pulse was taken manually at the carotid artery until the pulse was within +/- six beats of the resting pulse. This was recorded as the recovery time after that specific exercise increment: one, two, or six minutes of exercise. Finally, the SPSS15 statistical analysis tool was used to find paired sample T-test results. The paired sample T-test was used for comparison of pulse or recovery rates after different exercise increments. Independent sample T-tests were used to compare athletes and non-athletes, smokers and non-smokers, and males and females.

Results

Statistical Relationships Between Characteristics (Table 1)				
		Mean	Standard Error Mean	Significance
Pair One	Normal Pulse	78.47	0.52	P<0.001
	Pulse After One Minute of Exercise	137.05	1.10	
Pair Two	Normal Pulse	78.48	0.52	P<0.001
	Pulse After Two Minutes of Exercise	148.81	1.10	
Pair Three	Normal Pulse	78.34	0.52	P<0.001
	Pulse after Six Minutes of Exercise	165.12	1.17	
Pair Four	Pulse After One Minute of Exercise	136.98	1.11	P<0.001
	Pulse After Two Minutes of Exercise	148.69	1.10	
Pair Five	Pulse After One Minute of Exercise	136.36	1.11	P<0.001
	Pulse after Six Minutes of Exercise	164.99	1.17	
Pair Six	Pulse After Two Minutes of Exercise	148.48	1.12	P<0.001
	Pulse after Six Minutes of Exercise	165.01	1.17	
Pair Seven	Recovery Time After One Minute of Exercise	1.78	0.04	P<0.001
	Recovery Time After Two Minutes of Exercise	2.76	0.06	
Pair Eight	Recovery Time After One Minute of Exercise	1.76	0.04	P<0.001
	Recovery Time After Six Minutes of Exercise	4.01	0.07	
Pair Nine	Recovery Time After Two Minutes of Exercise	2.75	0.06	P<0.001
	Recovery Time After Six Minutes of Exercise	4.01	0.07	

As the period of time spent exercising increased, the corresponding pulses also increased, signifying a direct relationship. A direct relationship can be seen between the amount of time spent exercising and the recovery time; as the exercise time increased, the recovery pulse and time also increased.

Statistical Comparison of the Genders (Table 2)				
	Gender	Mean	Standard Error Mean	Significance
Normal Pulse	Male	74.52	0.76	P<0.001
	Female	80.66	0.65	
Pulse After One Minute of Exercise	Male	125.87	1.70	P<0.001
	Female	143.36	1.32	
Pulse After Two Minutes of Exercise	Male	139.74	1.79	P<0.001
	Female	153.81	1.33	
Pulse After Six Minutes of Exercise	Male	157.18	1.96	P<0.001
	Female	169.52	1.41	
Recovery Time After One Minute of Exercise	Male	1.59	0.06	P<0.001
	Female	1.89	0.05	
Recovery Time After Two Minutes of Exercise	Male	2.58	0.11	0.023
	Female	2.88	0.08	
Recovery Time After Six Minutes of Exercise	Male	3.85	0.13	0.117
	Female	4.10	0.09	

Males always had lower pulse rates than females and a faster recovery rate after one and two minutes of exercise. However, after six minutes, the recovery time was not significantly different between males and females.

Statistical Comparison of Smokers and Nonsmokers (Table 3)				
	Smoker?	Mean	Standard Error Mean	Significance
Normal Pulse	Yes	78.94	1.74	0.787
	No	78.41	0.54	
Pulse After One Minute of Exercise	Yes	140.47	4.14	0.372
	No	136.77	1.14	
Pulse After Two Minutes of Exercise	Yes	157.43	3.53	0.025
	No	148.05	1.15	
Pulse after Six Minutes of Exercise	Yes	170.98	4.48	0.147
	No	164.53	1.21	
Recovery Time After One Minute of Exercise	Yes	1.83	0.15	0.726
	No	1.78	0.04	
Recovery Time After Two Minutes of Exercise	Yes	3.02	0.21	0.268
	No	2.75	0.07	
Recovery Time After Six Minutes of Exercise	Yes	4.76	0.26	0.004
	No	3.95	0.08	

Smokers and non-smokers are not different in their pulse and recovery rates except for the pulse rate after two minutes—at which point the non-smokers have a lower pulse rate—and the recovery time after six minutes of exercise—at which point the non-smokers have a quicker recovery time.

Statistical Comparison of Athletes and Non-athletes (Table 4)				
	Athlete?	Mean	Standard Error Mean	Significance
Pulse After One Minute of Exercise	No	140.97	1.50	P<0.001
	Yes	132.79	1.58	
Pulse After Two Minutes of Exercise	No	155.41	1.40	P<0.001
	Yes	141.58	1.63	
Pulse after Six Minutes of Exercise	No	170.31	1.51	P<0.001
	Yes	159.46	1.74	
Recovery Time After One Minute of Exercise	No	2.02	0.06	P<0.001
	Yes	1.53	0.05	
Recovery Time After Two Minutes of Exercise	No	3.26	0.09	P<0.001
	Yes	2.25	0.08	
Recovery Time After Six Minutes of Exercise	No	4.38	0.10	P<0.001
	Yes	3.63	0.11	

Athletes always had lower pulse rates and faster recovery rates than non-athletes.

Relationship between Surface Area and Normal Pulse (Table 5)		
		Normal Pulse
Surface Area	Correlation	-0.217
	Significance	P<0.001

The surface area and Normal pulse are negatively correlated with a Pearson correlation of -0.22 and this correlation is significant as evidenced by a p value less than 0.001.

Discussion

Our results, as seen in table 2, show that males have significantly slower heart rates and recovery rates than females over all time periods except for recovery time after six minutes. With the exception of the recovery time after six minutes, this result was expected and is supported by many previous experiments. One possible explanation is the difference between genders for the method by which heart rate is controlled in the autonomic nervous system. One study notes that heart rates between males and females do not begin to significantly differ until puberty. The same study also found that there is also no difference in the heart rates of postmenopausal women and men of similar age. This would suggest a possible hormonal influence on heart rate in women and would explain the heart rate difference between males and females (Salameh et al., 2008).

A second difference in males and females was found in a study of athletes, where the female athletes showed a significantly smaller left ventricular wall thickness—23% less—than their male athlete counterparts (Antonio et al., 1996).

Yet another difference observed between males and females occurs in the actual composition of the blood and relative size of the heart. Stephens (1996) says that female blood contains 10% less hemoglobin than male blood and that the female heart itself is slightly smaller than the male heart. Both variables would necessitate a quicker heart rate in women to distribute the same amount of relative oxygen as their male counterparts.

The discrepancy between our data and the results of other literature and our expectations is found in the recovery time after six minutes of exercise. I would suggest that this similarity in recovery time can be explained because after two minutes of exercise, many of the females have already reached a steady cardiovascular heart rate, whereas many of the males have still not yet achieved a steady cardiovascular heart rate. This would allow for quicker recovery time in males after the two-minute exercise period. However, after six minutes of exercise, I think that both males and females have all achieved a steady cardiovascular heart rate, creating the relative similarity in the resulting recovery rates.

Our results show no significant differences in the heart rate and recovery rate of smokers and non-smokers, except for the pulse rate after two minutes of exercise and the recovery rate after six minutes of exercise, at which points the non-smokers showed a slower pulse rate and a quicker recovery rate respectively (see table 3). Although I expected to see a significant difference in heart rate and recovery rate between smokers and non-smokers, these findings do support the prior research of Ness (1978), which also found little difference in cardiovascular fitness of young smokers and non-smokers. According to Ness, this is likely because at a young age and otherwise good health, the negative cardiovascular side effects of smoking have not yet manifested in the smokers. Among older participants a significant difference in heart rate and recovery time between smokers and non-smokers would be expected.

Our results, as seen in table 4, showed that athletes always had slower heart rates and quicker recovery rates than non-athletes, which also supported my expectations and confirmed earlier research which found the same difference. The significantly lower heart rates and quicker recovery rates of athletes is simply a result of having a more fit heart. Gray and Hammond (1981) assert that frequent physical activity reduces levels of blood fat and helps to break down fibrin, a clotting material, found in blood. They have also found that the overall volume of blood in the body increases slightly. These changes allow for greater oxygen-carrying capacity of blood and lead to a lower heart rate and a quicker recovery time.

Another study even found that when implementing physical exercise following stressful situations that cause a significant increase in heart rate, test subjects' recovery rates increase—yet another influence of physical activity on heart rate and recovery rate (Chafin et al., 2008).

Furthermore, researchers have found that athletes have left ventricular end-diastolic cavity dimensions six percent greater than non-athletes and a maximal wall thickness fourteen percent larger than non-athletes (Pelliccia et al., 1996).

Our results found in table 5 show a significant negative correlation between surface area and heart rate, contrary to my prediction. The much lower male heart rate (74.52 versus the female's higher heart rate of 80.66), in conjunction with the difference in surface area (2.02 for males and 1.69 for females), is the cause of the negative correlation between surface area and heart rate.

Obesity leads to increased strain upon the heart due to arterial blockage by fatty build up and movement of a more massive body, which in turn causes an increase in heart rate and recovery rates. In one experiment, obese children were found to have significantly higher VO_2 max, which is calculated in part from heart rate, than fit children of the same age and gender (Berndtsson et al., 2007).

Heart rate is also affected by a multitude of other factors not examined in our study, such as age and stress. Heart rate decreases predictably as age increases. In a study of children from newborn babies to 16 year olds, the heart rate decreased by over 40 beats per minute (Semizel et al., 2007). However, once age reaches 50 the heart rate remains relatively stable, decreasing by very small amounts until death. This predictable pattern is thought to be the result of a rapid response to growth and subsequent decline in physical activity as age increases (Zhang, 2007). In fact, according to Stephens (1996) the simple formula "220-AGE" can be used to provide a relatively accurate estimate of average heart rate.

Stress has been found to cause a significant increase and immediate—although transient—increase in heart rate. In a recent study performed on children, a provoking comment was made and nearly immediately the heart rate rose until it peaked after roughly ten seconds before falling back to normal after another ten second period of time (Hessler & Fainsilber, 2007).

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