The Impact of Birth Sex and Activity Level on Resting and Active Heart Rate

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Introduction

The heart is the muscle at the center of the circulatory system, pushing blood through the vessels of the body in order to circulate oxygen and nutrients to cells. Without this system in place, cells would not have the resources to perform functions like cellular respiration to provide energy for the body. Oxygenated blood gets delivered to the body's tissues through arteries while veins carry deoxygenated blood to the lungs. To keep up with the demand for oxygen, nutrients, etc., the human heart beats an average of 100,000 times per day, but a variety of factors can lead to a change in this pace, which is called heart rate. Heart rate is measured in beats per minute (BPM) with a normal resting heart rate being between 50 to 100 BPM, but age, gender, health status, and activity level can all influence heart rate. Heart rates, both resting (the rate blood is pumped when no activity is being performed) and active (its pace during and after exercise) can indicator an individual's state of health. These different rates will be examined under multiple conditions in this lab.

The impact of birth sex and activity level on heart rate were the conditions examined during this lab. Starting with birth sex, after puberty, there is a 15-30% increase in heart mass in males, meaning that a male's heart is typically larger than a female's (National Heart, Lung, and Blood Institute, 2022). The average male adult heart rate is between 70 to 72 BPM, while the average for a female adult is 78 to 82 BPM (National Heart, Lung, and Blood Institute, 2022). This difference can be accounted for by the size discrepancy between male and female hearts. The smaller female heart pumps less blood with each beat when compared to a male's, meaning that it needs to beat at a faster rate to match the male heart's output. Both male and female hearts improve in strength with repeated moderate and vigorous activity (Prabhavathi et al., 2014). As a result, athletes typically have a lower resting heart rate (Prabhavathi et al., 2014). In other words, fewer beats are required to supply the same amount of blood as a non-athlete. A non-athlete therefore will have a fast heart rate to meet the same demands of the body.

Hypothesis and Predictions

A person's exercise level will have an impact on heart rate before and after engaging in aerobic activity such as jumping jacks or running around. Those who have a high level of physical activity will have a lower heart rate than those with a moderate and low level of physical activity. This is because exercise strengthens the heart muscle, so more blood will be pumped per beat (Prabhavathi et al., 2014). Thus, fewer beats will be needed in a person who exercises frequently to meet the oxygen and nutrient demands of the body. I predict that if the heart rates of a group of people who exercise frequently (high exercise group), exercise moderately (medium exercise group), and do not exercise frequently (low exercise group), then the order of highest to lowest heart rate will be low exercise group, medium exercise group, and high exercise group. Exercise, therefore, has an inverse relationship with heart rate—more exercise means lower heart rate.

Birth sex will also have an impact on heart rate. Females will have a higher resting heart rate than males due to their hearts being smaller on average (National Heart, Lung, and Blood Institute, 2022). More beats will be needed to pump the same amount of blood as a male's heart. Since less blood will be pumped with each beat, I predict that if the resting heart rates of males and females are compared, then females will have a higher resting heart rate. Heart size, in other words, has an impact on heart rate, with a larger size equating to a slower heart rate.

Methods

A pulse oximeter was used to record blood oxygen levels in SpO2 and heart rate in beats per minute (BPM). Heart rate was taken before starting the aerobic activity as the recording for resting heart rate, and was taken 0 minutes after completing the activity, right after completing the activity, 1 minute after, 3 minutes after, 5 minutes after, 10 minutes after, and finally, 15 minutes after. However, before engaging in this activity, participants first grouped themselves according to exercise levels and recorded their birth sex. The different groups for exercise level were high, meaning the person exercises at least 5 times a week for 45 minutes, medium, meaning the person exercises between 3 to 4 times a week for 45 minutes, and low, meaning the person exercises at most 2 times a week for 45 minutes. Participants also chose a specific type of aerobic activity, some options, for example, being jumping jacks, running around, cycling, or pushups. Out of all 50 participants, 17 were male and 33 were female. 4 males recorded a low exercise level, 5 a medium, and 8 a high. 19 females recorded a low exercise level, 7 a medium, and 7 a high. Participants were college-aged students from 17 to 20 years old.

Results

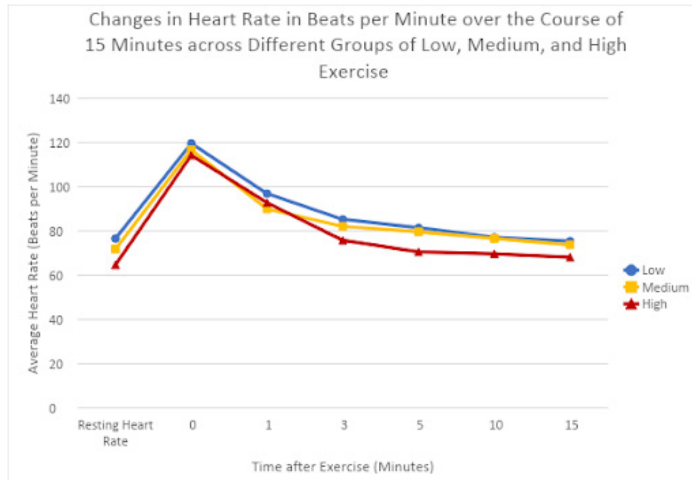

Figure 1. Changes in heart rate in BPM over the course of 15 minutes. Resting heart rate refers to heart rate before exercise and 0 minutes is immediately following the exercise. The line graph shows that people with a high exercise level have a lower heart rate at almost all points before and after completing an exercise. The only point where the high exercise group did not have the lowest heart rate was at 1 minute after completing the exercise. Overall, the trend of the low exercise group having the highest heart rate, followed by the medium exercise group, and then the high exercise group was displayed in this graph. Data relates to the first hypothesis and prediction.

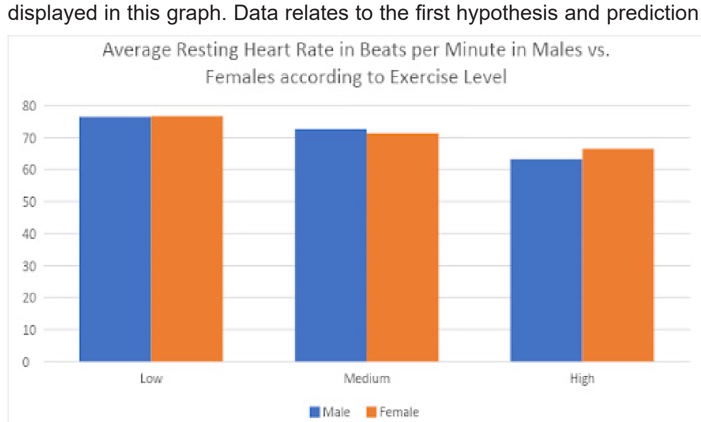

Figure 2. Average resting heart rate in males vs. females in BPM with groupings based on activity level. The bar graph shows that females with a low exercise level have a higher resting heart rate than males, but males with a medium exercise level have a higher resting heart rate than females with a medium exercise level. In the high exercise level group, females have a higher heart rate than males. Data relates to the second hypothesis and prediction.

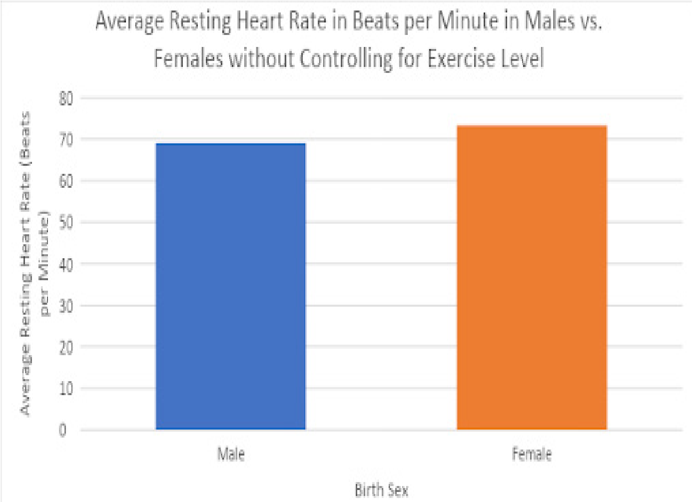

Figure 3. Average resting heart rate in males vs. females in BPM without taking exercise levels into account. The bar graph shows that when average the resting heart rates of males and females across all exercise groups, females, on average, have a higher resting heart rate than males. Data relates to the second hypothesis and prediction.

Discussion

The first hypothesis was that exercise level has an impact on both resting and active heart rates. The data showed differences across the different groups of high, medium, and low exercise, meaning that the hypothesis was supported. The first prediction was that people in the high exercise group would have a lower heart rate before and after completing an aerobic physical activity. Looking at the data in Figure 1, this prediction was mostly supported: the only time that the high exercise group did not have the lowest average heart rate was 1 minute after the exercise concluded. It was also predicted that the moderate exercise group would have a lower heart rate than the low exercise group, and this prediction was also supported.

The second hypothesis was that birth sex has an impact on resting heart rate. The data showed differences in average heart rate in males vs. females whether or not the exercise level was controlled. The second prediction was that regardless of their exercise group females have a higher resting heart rate than males, and the data somewhat supported this prediction. In the low and high exercise group, females had a higher resting heart rate, but males had a higher resting heart rate in the medium exercise group. When averaging heart rates purely on birth sex (not considering exercise level), females had a higher average resting heart rate.

Taking this data into account, given the reasoning behind the predictions, first being that exercise strengthens the heart muscle and second that a larger heart means a slower heart rate, heart size has an impact on heart rate. People with high exercise levels have stronger heart muscles than those with lower exercise levels, while males have larger hearts than females. This data helps to support the conclusion that a larger and stronger heart means a lower heart rate since more blood will be pumped throughout the body with each beat. So, while the two conditions tested do not seem to relate very much, both connect back to the idea of heart size and pumping efficiency. However, some sources of error may have existed in the experiment. For example, the exercise that participants performed was not standardized, so some people may have performed a more rigorous activity than others, leading to a higher heart rate. The pulse oximeter may have not been incredibly accurate in its readings as well, leading to skewed heart rate measurements that reflected in accurate trends. Misreadings may have led to males in the medium exercise level group having a higher resting heart rate. Additionally, there were a lot more female participants than males in the experiment, making it so male heart rate outliers would affect the data more than outliers in the female group. The exercise groups of low, medium, and high were also unequal with most females falling into the low exercise group and most males being in the high exercise group. Standardizing participants so that there is an exact number in each exercise group may help data to be more accurate.

Finally, a new experiment that could be conducted could be examining the link between heart size and heart rate. Using plain chest radiography, heart size can be measured, and then by using a similar method to this experiment, a pulse oximeter could be used to record heart size (Brakohiapa et al., 2017). Then, this data could be compared to find whether there is a correlation between heart size and heart rate with the prediction that a larger heart will lead to a lower heart rate.

References

Brakohiapa, E. K. K., Botwe, B. O., Sarkodie, B. D., Ofori, E. K., & Coleman, J. (2017, July 14). Radiographic determination of cardiomegaly using cardiothoracic ratio and transverse cardiac diameter: Can one size fit all? part One. T**he Pan African medical journal.** Retrieved May 3, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5579422/.
National Heart, Lung, and Blood Institute. (2022, March 24). Physical Activity and Your Heart: Benefits. **National Heart, Lung, and Blood Institute**. Retrieved May 3, 2023, from https://www.nhlbi.nih.gov/health/heart/physical-activity/benefits#:~:text=When%20done%20regularly%2C%20moderate%2D%20and,levels%20in%20your%20blood%20rise.
Prabhavathi, K., Selvi, K. T., Poornima, K. N., & Sarvanan, A. (2014, August). Role of biological sex in normal cardiac function and in its disease outcome - A Review. Journal of clinical and diagnostic research: **JCDR**. Retrieved May 3, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4190707/.