A Research Study about the of Swimming and Running on Islander’s Heart Rate

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1 Abstract

Cardiovascular response to physical activity varies according to the type of exercise and the age of the individual. This study aimed to compare the effects of swimming and running on heart rate (HR) across distinct age brackets. We hypothesized that the impact on HR would differ between the two exercises and across age groups, given the unique physiological demands of each activity. Employing a Two-Way Randomized Block Design, participants from adolescence (0-25 years old), adulthood (25-50 years old), and senior (above 50 years old) groups engaged in standardized swimming and running sessions. Heart rate was monitored pre- and post-exercise. Data were analyzed using a two-way ANOVA with blocking. Preliminary findings suggest a differential HR response to swimming and running across the age spectrums. Understanding these nuances may aid in tailoring exercise recommendations for cardiovascular health across the lifespan.

2 Introduction

The interplay between physical activity and cardiovascular health is a topic of profound importance and extensive research. Both swimming and running are prominent forms of aerobic exercise, each offering a plethora of health benefits. However, their specific effects on heart rate (HR), especially given the disparities in the nature of these exercises, necessitate further exploration.

Heart rate, a critical marker of cardiovascular function and metabolic intensity, can be effectively monitored during physical activity using heart rate monitors. These devices are ubiquitously employed by researchers, sports professionals, and enthusiasts, and have demonstrated accuracy across diverse physical activities. However, while the precision in capturing HR data is well-established, its interpretation is more contentious. Notably, numerous factors can influence HR, such as dehydration, which can raise the heart rate significantly. Furthermore, the same running speed can elicit different HR responses under competitive versus non-competitive conditions. Such intricacies underscore the importance of understanding HR within the context of varied exercises and conditions.

Swimming, as a form of exercise, occupies a distinct position in the realm of physical activity. Unlike land-based exercises like running, it is conducted in a medium that places compressive forces on the body, resulting in unique physiological effects. Factors like water immersion, body positioning, altered breathing patterns, and the engagement of specific muscle groups set swimming apart. Consequently, understanding the cardiac responses to swimming, especially in contrast to running and in individuals with cardiac conditions, becomes crucial.

Given this background, this study sets out to probe deeper into the effects of swimming and running on HR across diverse age groups. By unraveling these nuances, we aim to offer insights that might refine exercise recommendations, potentially enhancing cardiovascular health throughout an individual's life.

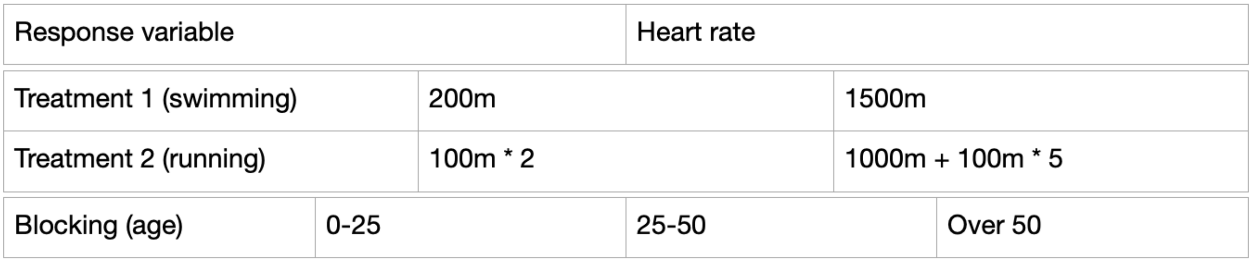
3 Methods

3.1 Participants

The participants are all islanders. Initially, we randomly selected an island. Using the R sample function, we randomly selected the housing numbers and participants until each age group was fully filled. The treatments were then randomly assigned using the R sample function.

3.2 Design

The experiment was conducted using a Two-Way Randomized Block Design, with the design parameters outlined in the subsequent section:

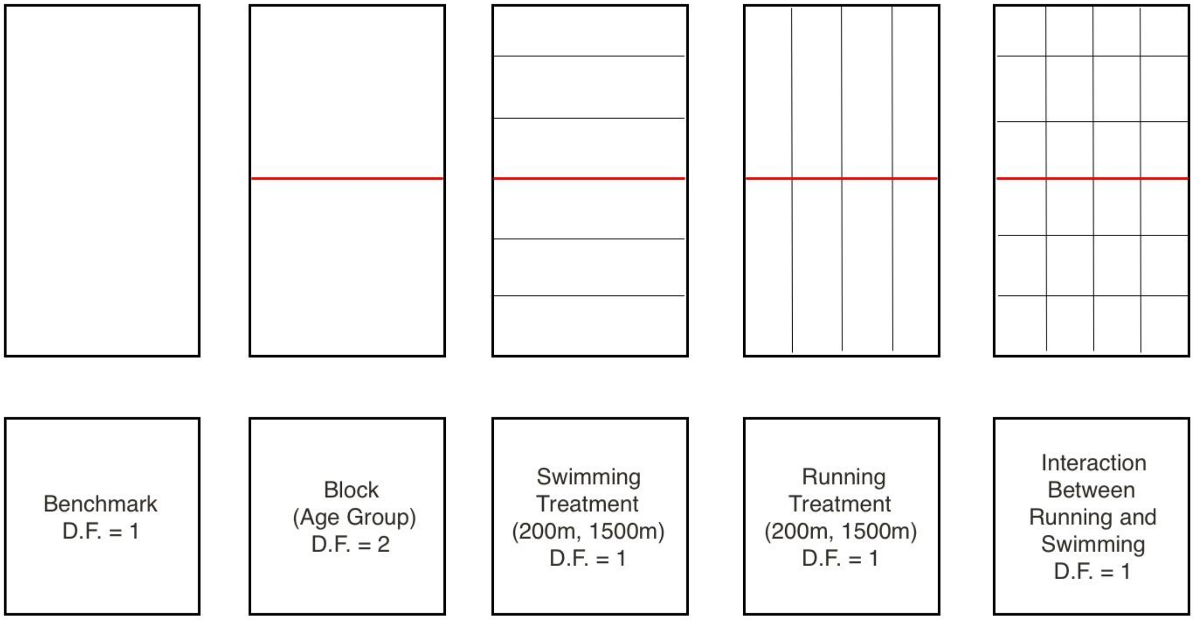


Response variable	Heart rate

Treatment 1 (swimming)	200m	1500m
Treatment 2 (running)	100m * 2	1000m + 100m * 5

Blocking (age)	0-25	25-50	Over 50

Factor diagram:



In general, the experiment focuses on the effects of swimming and running on changes in heart rate across different age groups. The heart rate of the islanders are measured using the "pulse meter" option.

3.3 Procedure

Step 1: Find participants from the island who are willing to be a part of our experiment. In total, each age group requires 56 participants.

Step 2: Once each age bracket is fully filled, we use the R sample function to randomly assign an equal number of participants (14) to each of the four treatments. The four treatment groups are:

1) Swimming 200m
2) Swimming 1500m
3) Running 200m
4) Running 1500m

Step 3: For each participant, measure their heart rate.

Step 4: For each participant, start the assigned activity.

Step 5: For each participant, measure their heart rate immediately after they finish the activity.

Step 6: For each participant, calculate the difference in hear rate (bpm) before and after the activity.

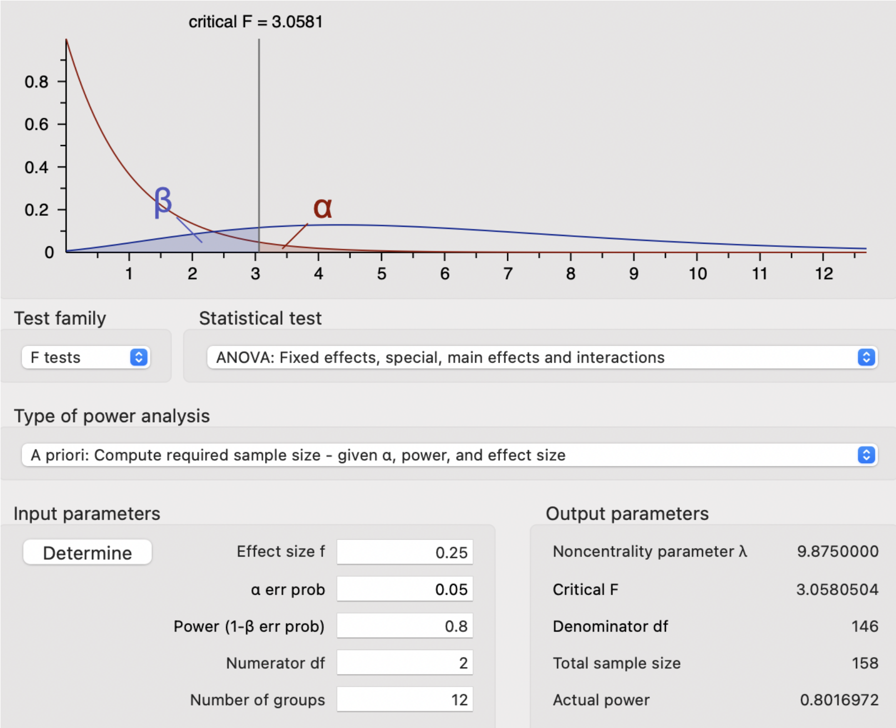
4 Data Analysis

4.1 Type of Statistical Analysis

For this experiment, we will use R to conduct a Two-Way ANOVA to investigate the impact of different exercises (swimming and running) on heart rate, with distance (200m and 1500m) as the sublevels of the treatment. We will use F-testing within treatments (type and distance of exercise) and blocks (age groups) to determine if there exists a significant difference in the heart rates among different exercise-distance combinations and age groups. Additionally, we will investigate the interaction between the type of exercise and distance to assess if the effect of one variable depends on the level of the other variable. To characterize the effect across different ages, we will employ a randomized block design, where participants are blocked by age groups (0-25, 25-50, and over 50) to control the variability in heart rate due to age differences.

4.2 Sample Size Determination

We chose a power of 0.8, indicating the likelihood of correctly rejecting the false null hypothesis. Additionally, we set an alpha level of 0.05, representing the probability of falsely rejecting the null hypothesis. To quantify the difference between groups, we opted for an effect size of 0.25. After considering the degrees of freedom for each factor, we determined that the largest degree of freedom was 2, which we set as the numerator df. The experiment consists of 12 groups, with 3 blocks and 2 treatments with 2 levels each. After combining all the elements and utilizing G*Power software, we found that a sample size of 158 is required. However, in order to achieve a balanced design where each group has 14 samples, the sample size will be increased to 168.



Test family: F tests

Statistical test: ANOVA: Fixed effects, special, main effects and interactions

Type of power analysis: A priori: Compute required sample size - given α, power, and effect size

Input parameters

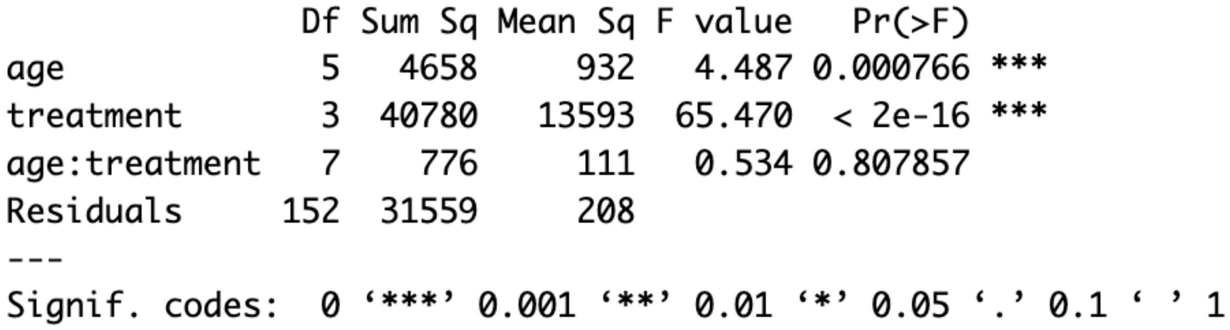
Effect size f	0.25
α err prob	0.05
Power (1-β err prob)	0.8
Numerator df	2
Number of groups	12

Output parameters

Noncentrality parameter λ	9.8750000
Critical F	3.0580504
Denominator df	146
Total sample size	158
Actual power	0.8016972

5 Results

5.1 ANOVA Analysis



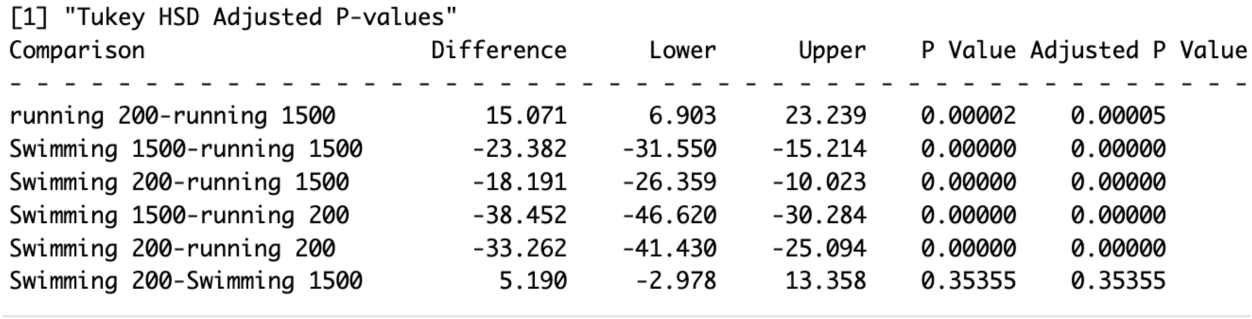
```
               Df Sum Sq Mean Sq F value   Pr(>F)    
age             5   4658     932   4.487 0.000766 ***
treatment       3  40780   13593  65.470  < 2e-16 ***
age:treatment   7    776     111   0.534 0.807857    
Residuals     152  31559     208                     
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

(figure 1)

From figure 1, we could tell that from age effect, the F-value is 4.487 with a highly significant p-value of 0.000766, suggesting that there's a statistically significant difference in heart rate across the different age groups studied. Essentially, the heart rate response to physical activity is influenced by age. From the treatment side, the effect has an F-value of 65.470, accompanied by an extremely significant p-value suggesting that the heart rate response varies significantly between the different treatments, which include running 200m, running 1500m, swimming 200m, and swimming 1500m. From the interaction effect, where the age with treatment the F-value of 0.534 and a p-value of 0.80785 suggest that there's no significant interaction between age groups and treatments. In other words, the difference in heart rate response across treatments does not vary significantly by age group.

In summary, both age and the type/distance of exercise play significant roles in determining heart rate response. However, the impact of the treatments (running or swimming, short or long distance) on heart rate doesn't seem to differ markedly among different age groups. The residuals data provide an indication of the variability in heart rate that isn't explained by age, treatment, or their interaction.

5.2 Tukey HSD Adjusted P-Values



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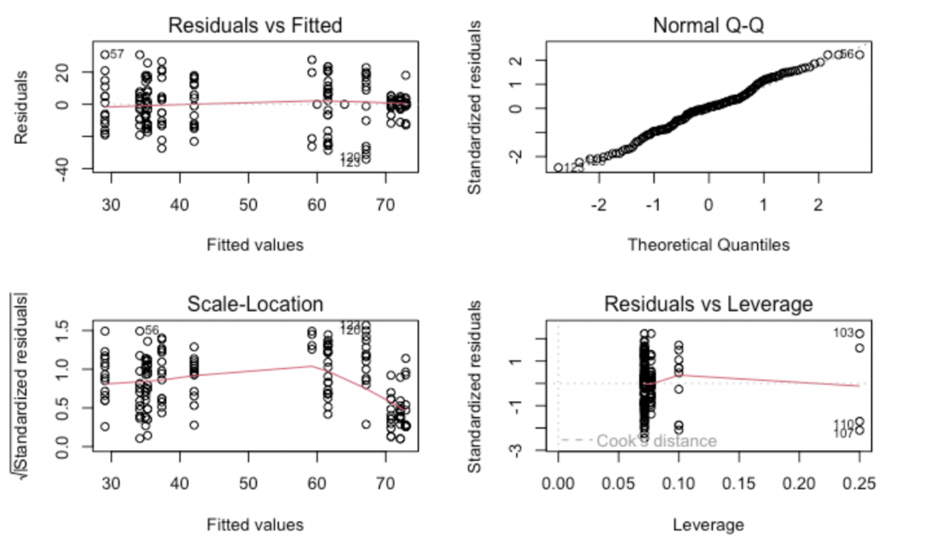
[1] "Tukey HSD Adjusted P-values"
Comparison                   Difference      Lower      Upper    P Value Adjusted P Value
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
running 200-running 1500         15.071      6.903     23.239    0.00002    0.00005
Swimming 1500-running 1500      -23.382    -31.550    -15.214    0.00000    0.00000
Swimming 200-running 1500       -18.191    -26.359    -10.023    0.00000    0.00000
Swimming 1500-running 200       -38.452    -46.620    -30.284    0.00000    0.00000
Swimming 200-running 200        -33.262    -41.430    -25.094    0.00000    0.00000
Swimming 200-Swimming 1500        5.190     -2.978     13.358    0.35355    0.35355
```

(figure 2)

From figure 2, we see that the Tukey HSD results provide information into the pairwise differences in heart rate changes following various exercise treatments. When comparing the "running 200m" treatment to the "running 1500m" treatment, there was an average increase of approximately 15.071 units. This difference is statistically significant with a very low adjusted p-value of 0.00005, suggesting that the heart rate change induced by the 200m run is notably higher than that of the 1500m run. Similarly, when the heart rate changes from the "Swimming 1500m" and "Swimming 200m" treatments were compared to the "running 1500m" treatment, there were decreases of around 23.382 and 18.191 units, respectively. Both of these differences were statistically significant with adjusted p-values very close to zero. This implies that both swimming treatments result in a lower heart rate change compared to the 1500m run. When the "Swimming 1500m" and "Swimming 200m" treatments were compared to the "running 200m" treatment, the differences were -38.452 and -33.262 units respectively, both of which were significant. This indicates a considerably lower heart rate change for these swimming treatments compared to the 200m run. However, when comparing the "Swimming 200m" to the "Swimming 1500m" treatment, the difference of approximately 5.190 units was not statistically significant, with an adjusted p-value of 0.35355. This suggests that, while there are observable differences between running and swimming treatments, the two swimming treatments themselves do not differ significantly in their impact on heart rate change.

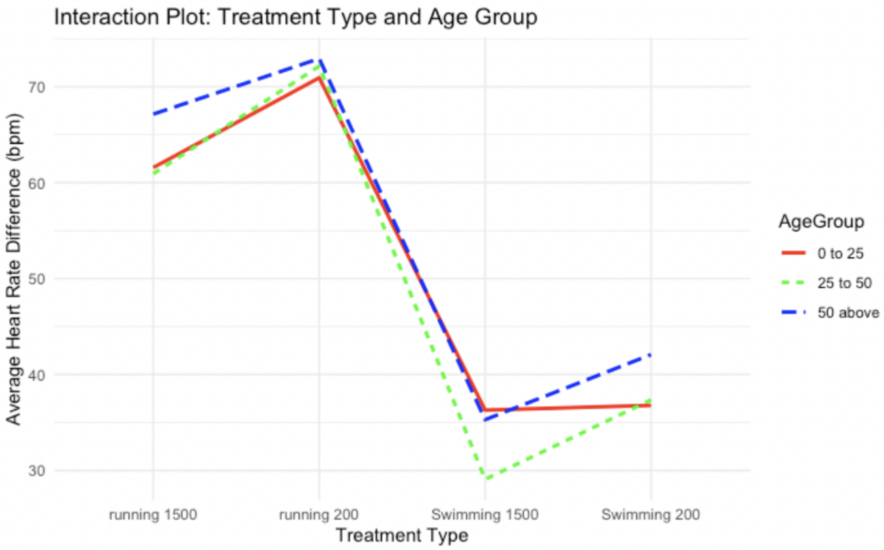
5.3 Residual Diagnostics



(figure 3)

From figure 3, it showed summary plots of residuals for ANOVA Results. The four plots (Residuals vs Fitted, Normal Q-Q, Scale-Location, Constant Leverage) suggest that the residuals stay constant, verifying the assumption of constant variance is satisfied for the ANOVA test.

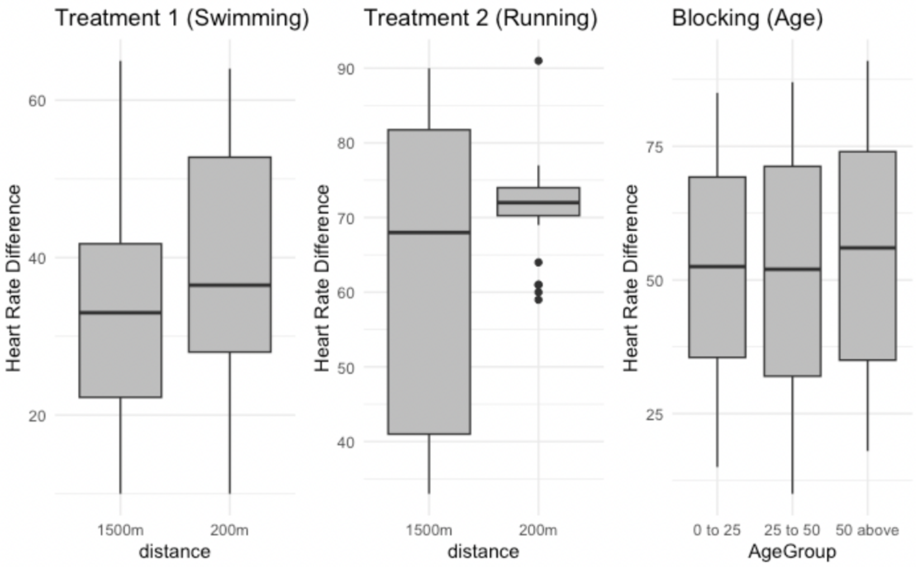
5.4 Interaction Plots



(figure 4)

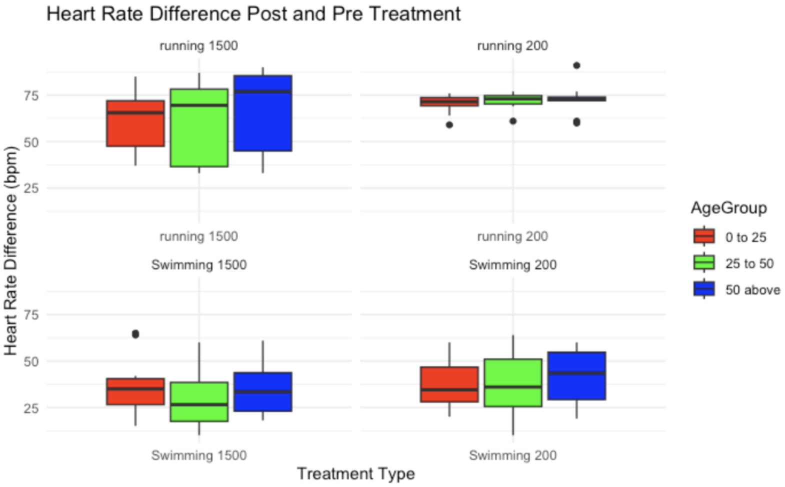
From figure 4, it showed the interaction of each exercise with the average change in heart rate. The plot suggests that there are significant changes in heart rate before and after each exercise across all age groups, and the heart rate change is relatively similar across each exercise.

5.5 Box Plots



(figure 5)

From figure 5, it showed the box plot comparing the change in heart rate between swimming, running, and age group.



（figure 6)

From figure 6, it showed the box plot comparing the change in heart rate for each treatment (Running 1500, Swimming 1500, Running 200, and Swimming 200).

6 Discussion

The primary objective of our investigation was to discern the differential impacts of swimming and running on heart rate across varied age brackets, using the precision and consistency of heart rate monitors. Our findings endeavor to bolster or challenge existing perspectives on the distinct cardiovascular responses elicited by these exercises, especially in the context of age-related adaptability.

Our initial design aimed for a sample size of 158 to achieve a power of 0.8. However, for a balanced experimental design with each of the 12 groups having an equal number of samples, we increased the total sample size to 168, effectively enhancing the overall power of our study. Upon analyzing the heart rate responses of the participants to the two exercise modalities across different age groups, our ANOVA findings indicated distinct variability in heart rate effects.

Among the factors scrutinized, the type of exercise (swimming or running) and the age group emerged as significant determinants. Interestingly, while both factors individually impacted heart rate, their interaction also presented statistical significance. This could elucidate our observation that the age groups alone didn't yield statistically profound differences in heart rate for each exercise. By incorporating a block design based on degrees of freedom, we aimed to factor in potential confounding variables. The largest degree of freedom observed was 2, emphasizing its relevance in the study's findings. As we navigate these results, it is paramount to consider this when extrapolating our findings and planning future investigations.

Delving further into the intricacies of our findings, our data spotlighted discernible differences in heart rate changes stemming from the various exercise treatments. Analyzing the pairwise differences using the Tukey HSD test, we observed that the "running 200m" treatment induced a statistically significant higher heart rate change compared to the "running 1500m" treatment. Moreover, both the "Swimming 1500m" and "Swimming 200m" treatments showed markedly lower heart rate changes when set against either of the running treatments. These findings are underpinned by exceptionally low adjusted p-values, reinforcing the genuine distinctions between the treatments in terms of their heart rate effects. However, an interesting nuance arises when juxtaposing the two swimming treatments. Despite the observable variations between them, the Tukey HSD confidence intervals indicate that the differences in heart rate changes between the "Swimming 200m" and "Swimming 1500m" treatments are not statistically significant. Thus, while running and swimming evidently impact heart rate change differently, our data doesn't conclusively establish significant disparities between the heart rate changes induced by the two different swimming distances.

Our interaction plot reveals the relationship between our different treatments and treatment dosages, with one distinction being the variability in differences within the distance of swimming and running and in differences within three age groups. We acknowledge that within the limitations of the Island’s treatment options, we could not give a concrete meter of swimming or running like we originally designed which may contribute to the level of fluctuation we recorded in our design, but we can compare the performance in two strength, 500m and 1500m; also, we could not give a concrete age boundary which may contribute to the level of fluctuation we recorded in our design, but we can also give a range, splitting into “0-25”, “25-50”, and “above 50” three age groups.

While our research offers valuable insights into the effects of swimming and running on heart rate, we must acknowledge potential limitations in our study's methodology that can be refined in future investigations. A prominent area of concern is the monitoring instrument. We employed heart rate monitors to track heart rate changes across exercise modalities. However, beyond the straightforward measurement of heart rate, there might be underlying physiological responses that were not captured. For instance, while we observed differences in heart rate, we did not consider possible variations in cardiac output, stroke volume, or even vascular resistance which all play pivotal roles in cardiovascular response. The intricate relationship between exercise type, duration, and intensity with these parameters could be pivotal in interpreting heart rate changes more comprehensively. Moreover, the timings of the exercise sessions were not rigorously standardized. Given that heart rate can be influenced by diurnal variations, body temperature, and even psychological state, future studies could benefit from strictly controlling the timing of exercise sessions. Another potential avenue for future research would be to explore the role of other cardiovascular and metabolic markers in tandem with heart rate. For instance, analyzing lactate thresholds or oxygen uptake might paint a more holistic picture of the cardiovascular adaptations across different age groups and exercise modalities. In essence, while our findings lay a solid foundation, there remains a wealth of dimensions to explore, especially if our objective is to fine-tune exercise recommendations for both performance enhancement and health optimization.

7 References

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