



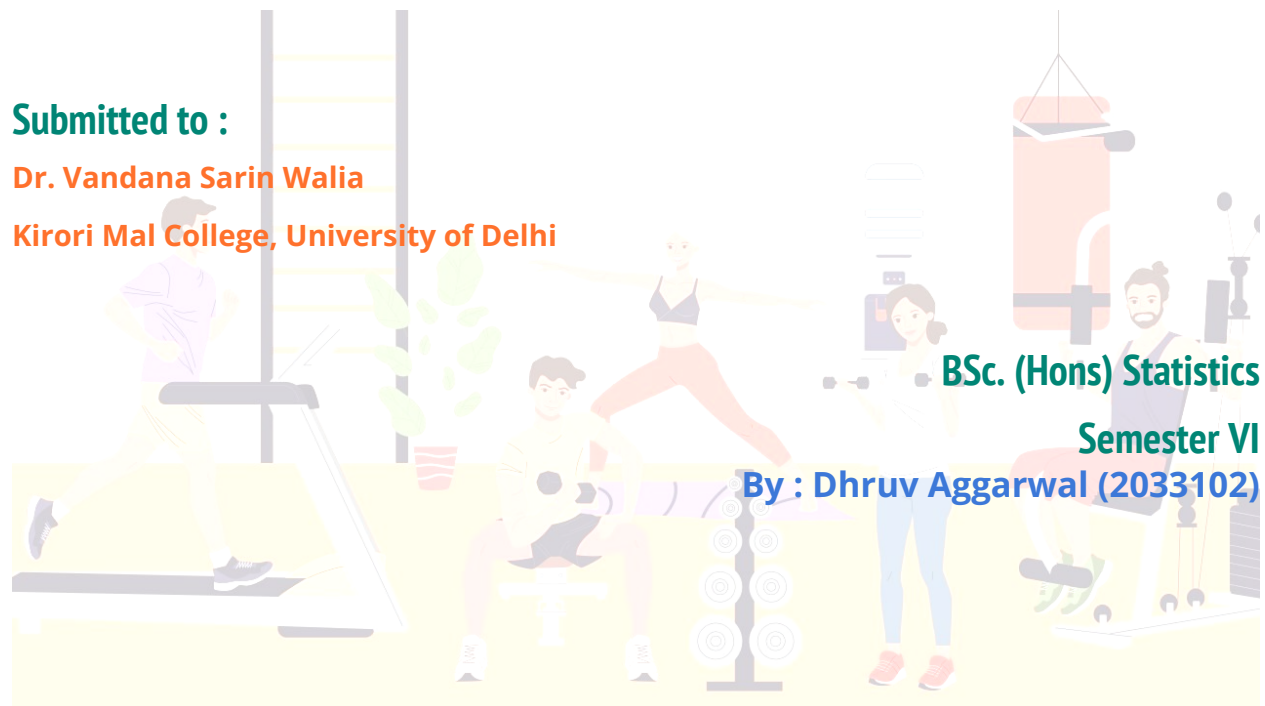
Design of Experiment

Impact of Different Exercise Regimen on Pulse Rate

Submitted to :

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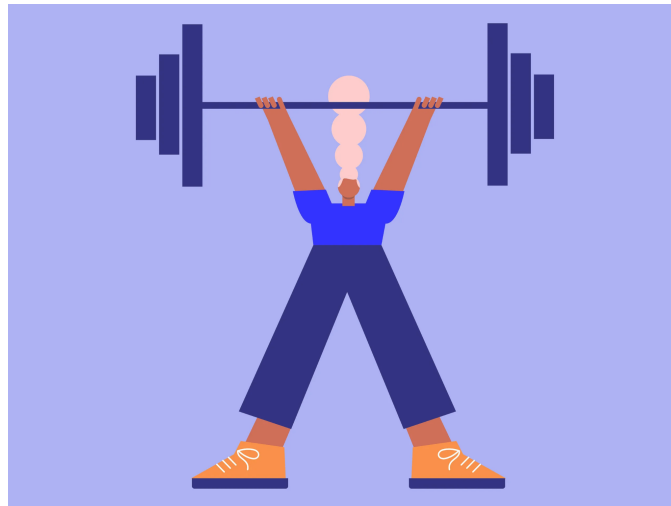
BSc. (Hons) Statistics

Semester VI

By : Dhruv Aggarwal (2033102)

Introduction

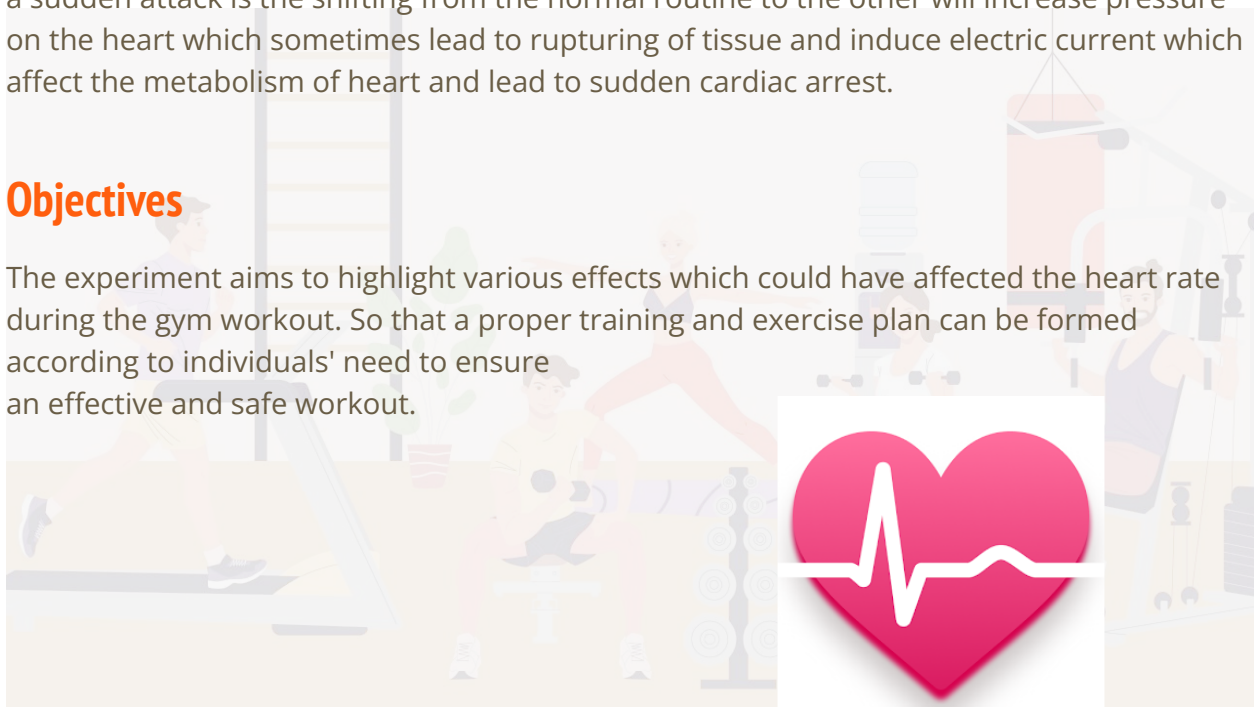
In today's generation it has become a trend and enthusiasm among youngsters for being in good shape and fitness. This fitness trend has changed the way we workout. High intensity workouts are the recent trend as it helps in burning more calories, provides a total body workout, and helps individuals attain fitness goals faster without spending a full day in a gym. Sometimes under improper supervision these workouts tend to be fatal.



According to the recent study in the US it is found that 16% of the indoor sudden cardiac arrest occurs in the exercise facility. Researchers claim that a major reason regarding such a sudden attack is the shifting from the normal routine to the other will increase pressure on the heart which sometimes lead to rupturing of tissue and induce electric current which affect the metabolism of heart and lead to sudden cardiac arrest.

Objectives

The experiment aims to highlight various effects which could have affected the heart rate during the gym workout. So that a proper training and exercise plan can be formed according to individuals' need to ensure an effective and safe workout.



Designing the Experiment

An experiment is designed to access various factors that which could have affected the heart rate keeping in mind the 3 basic principles of design of experiments i.e.

1. Principle of Replication: In the experiment, for each treatment combination we have taken the four observations.
2. Principle of Randomization: In each block, each treatment combination is applied to the Subject in the random order
3. Principle of Local Control: In order to control heterogeneity in the experimental material we have divided the material into 4 blocks

Utilizing these principles we have conducted a factorial experiment. The choice of such an experiment allows us to study a number of factors simultaneously in a single experiment.

In a factorial experiment we study not only the main effects of factors but also their interaction effects. These kinds of experiments are economically more viable than the single factor experiments (both cost efficient and time wise viable).

This is a 2^4 factorial experiment in 4 blocks that has 4 factors namely; A: ,B: ,C: ,D: which are at two levels 0 and 1 where

0: indicates the absence/lower level of the factor

1: indicates the presence/higher level of the factor

Hence

a_0	Low intensity
a_1	High intensity
b_0	15 minutes duration
b_1	30 minutes duration
c_0	Absence of caffeine intake
c_1	Presence of caffeine intake
d_0	Morning Workout
d_1	Evening Workout



Model

$$y_{ijklm} = \mu + a_i + b_j + c_k + d_l + ab_{ij} + ac_{ik} + ad_{il} + bc_{jk} + bd_{jl} + cd_{kl} + abc_{ijk} + abd_{ijl} + acd_{ikl} + bcd_{jkl} + abcd_{ijkl} + Blocks_m + \epsilon_{ijklm}$$

Where $\epsilon_{ijklm} \sim NID(0, \sigma^2)$

Hypothesis

The various hypothesis being tested during the analysis of the experiment

- 1) There is significant difference in various treatment effects
- 2) There is significant difference among the blocks
- 3) There is significant main effects due to different factors/treatments
- 4) There is significant 2 way interaction between factors
- 5) There is significant 3 way interactions between different factors
- 6) There is significant 4 way interaction between different factors

Methodology

To gather data, an experiment was conducted on nearby gyms. The willing people were selected and asked to do their daily respective workout exercises and the pulse rates were recorded before and after the workout with the help of an oximeter.

The following things were kept in mind:

- The same exercise plan is employed by different subjects while taking the observations for different treatment combinations
- There was no overdosage of caffeine given to any subject.

The following things could not be avoided:

- The subjects would have been in different physical and mental states.
- No test run was conducted to make the subjects familiar with the process.

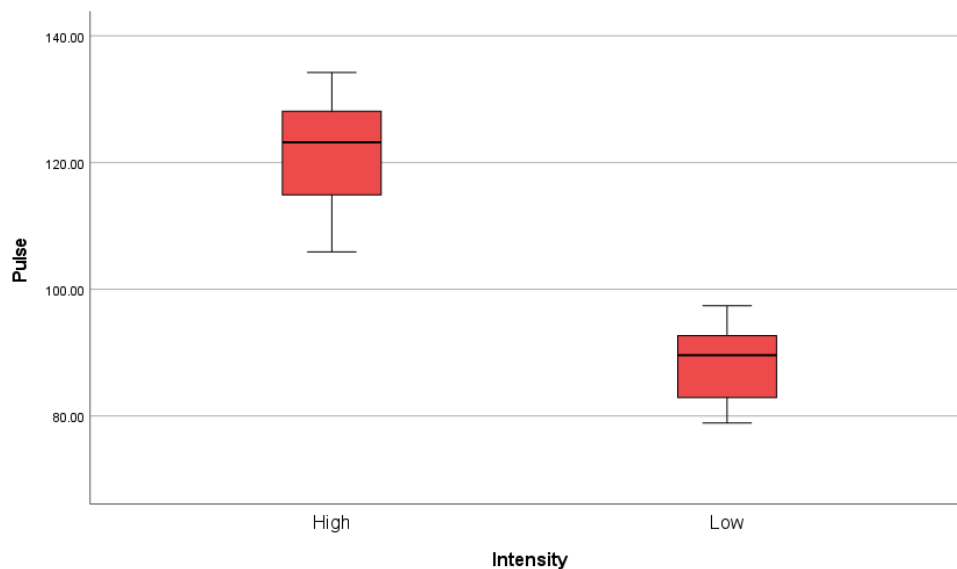
Limitations

- Since no pre-study was conducted, the impact level of effects and their interactions was unknown, hence a full factorial experiment was conducted.
- With limited time and resources, the data collection has been a challenge.

- The study was conducted on the age group of 18-25 years. Hence, the results are not useful for other age groups

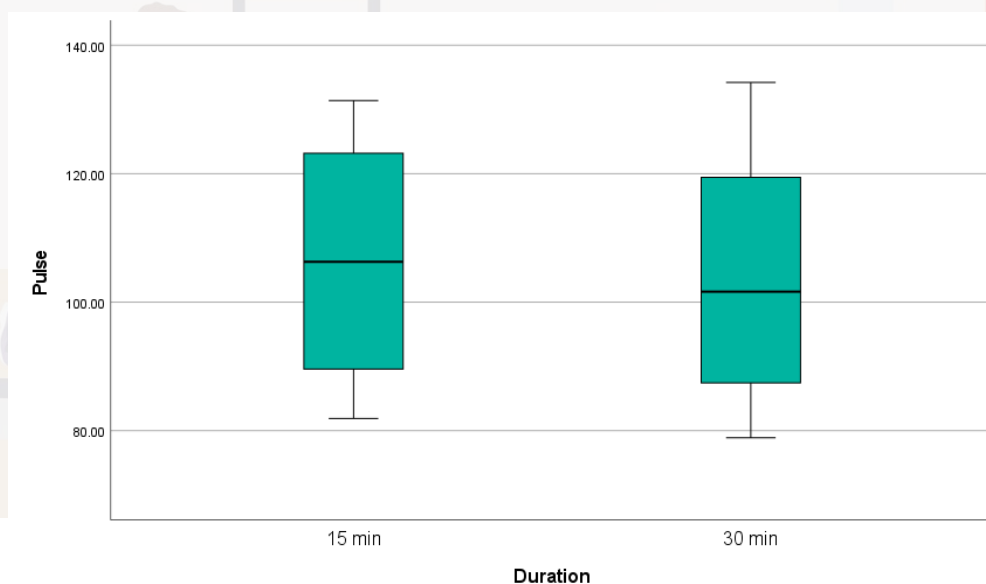
Exploratory Data Analysis

Pulse vs Intensity



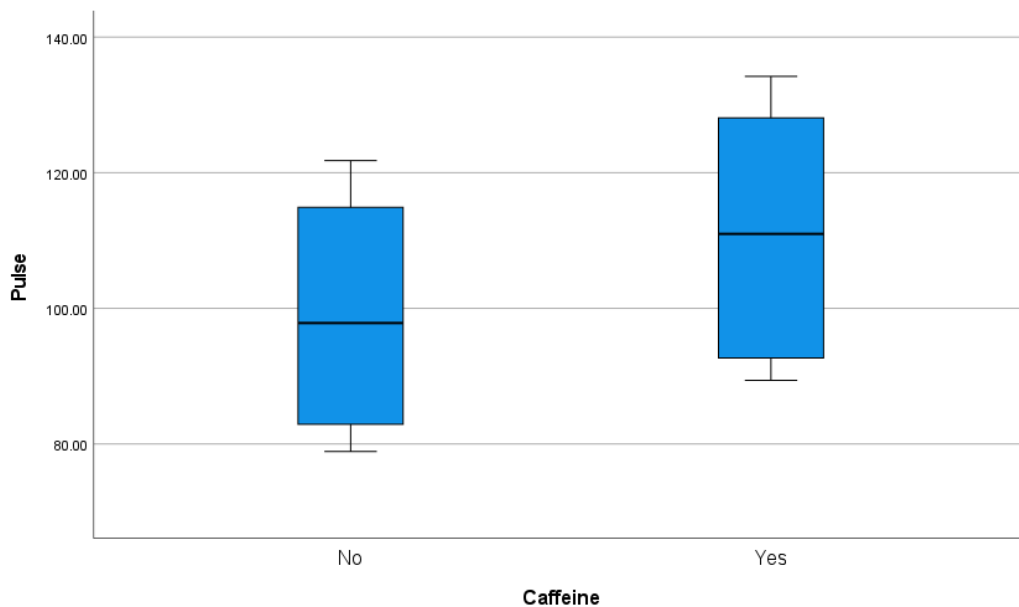
From this plot, we can infer that the high intensity workout leads to an increase in pulse rate. During low-intensity exercises, the heart beats well below its maximum rate. As exercise intensity increases, the heart rate moves closer to its maximum rate.

Pulse vs Duration



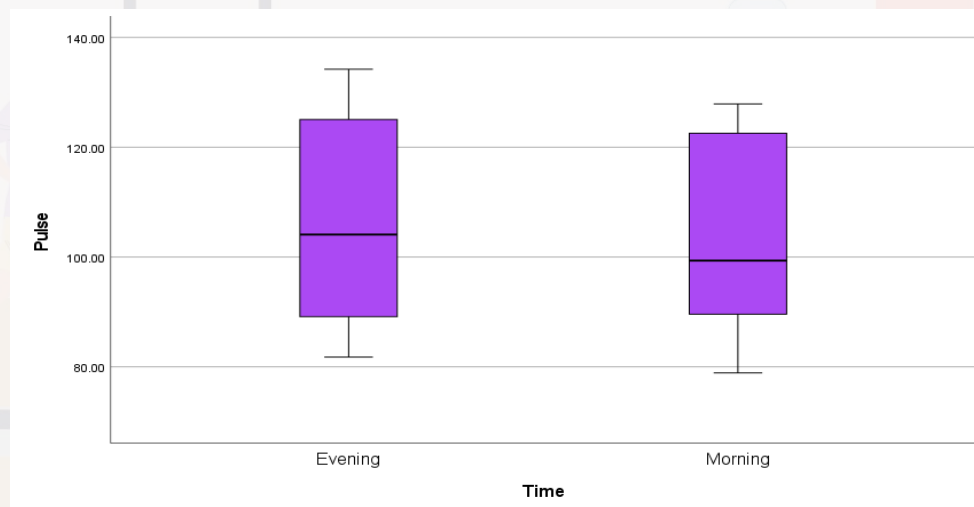
From this plot, we infer that the pulse rate will be slightly higher at the starting time of the workout and in the middle of the workout, the pulse rate will slightly go down as compared to pulse rate during the starting time.

Pulse Vs Caffeine



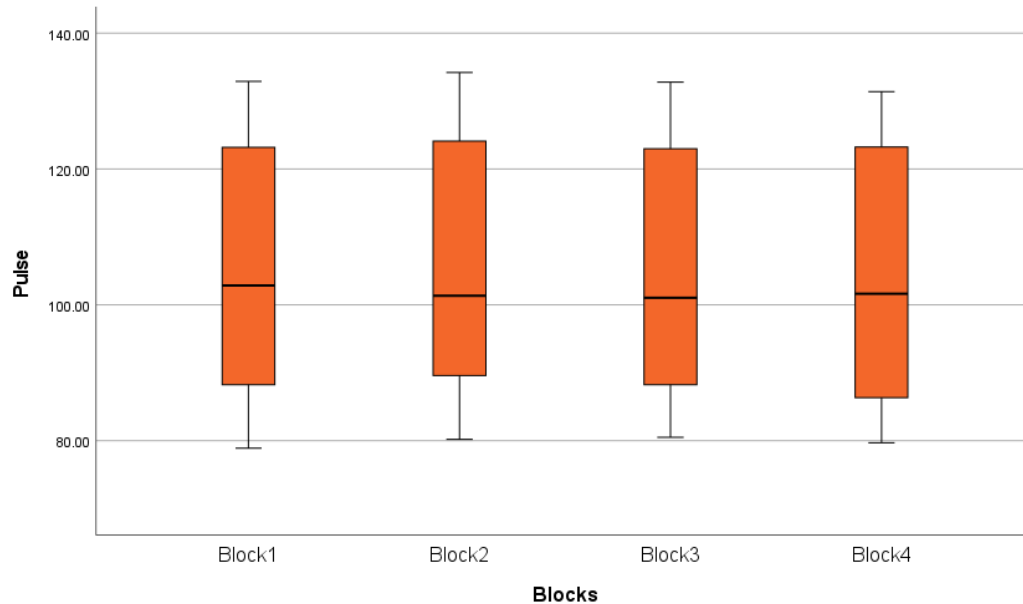
From this graph we infer that caffeine intake during the exercise tends to increase the heart rate. Caffeine is effective for enhancing the performance and considered as one of the best supplements for high intensity exercises. But it is always advised to use low doses of caffeine during the exercises.

Pulse vs Time of Workout

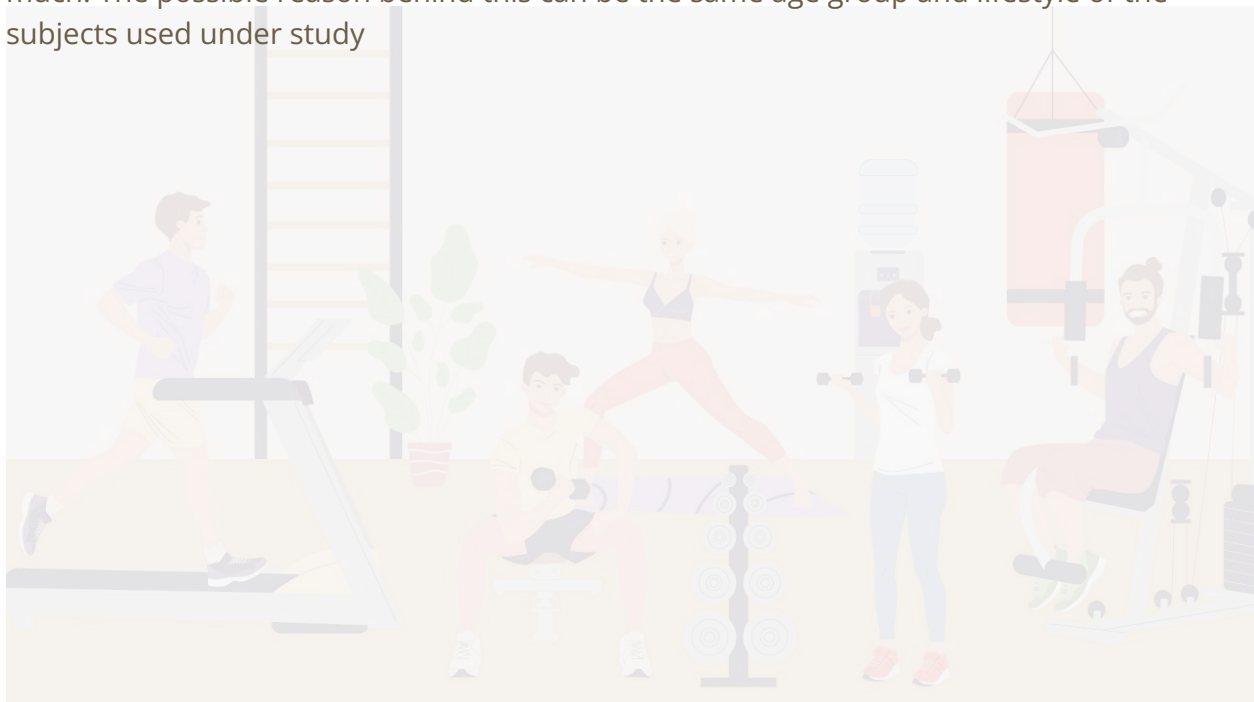


From this graph we infer that there is a slight increase in the pulse rate during evening workout in comparison to morning workouts. Since, the Evening workouts are the longer workouts and also it helps in lifting more weights which ultimately increases the pulse rate of an individual.

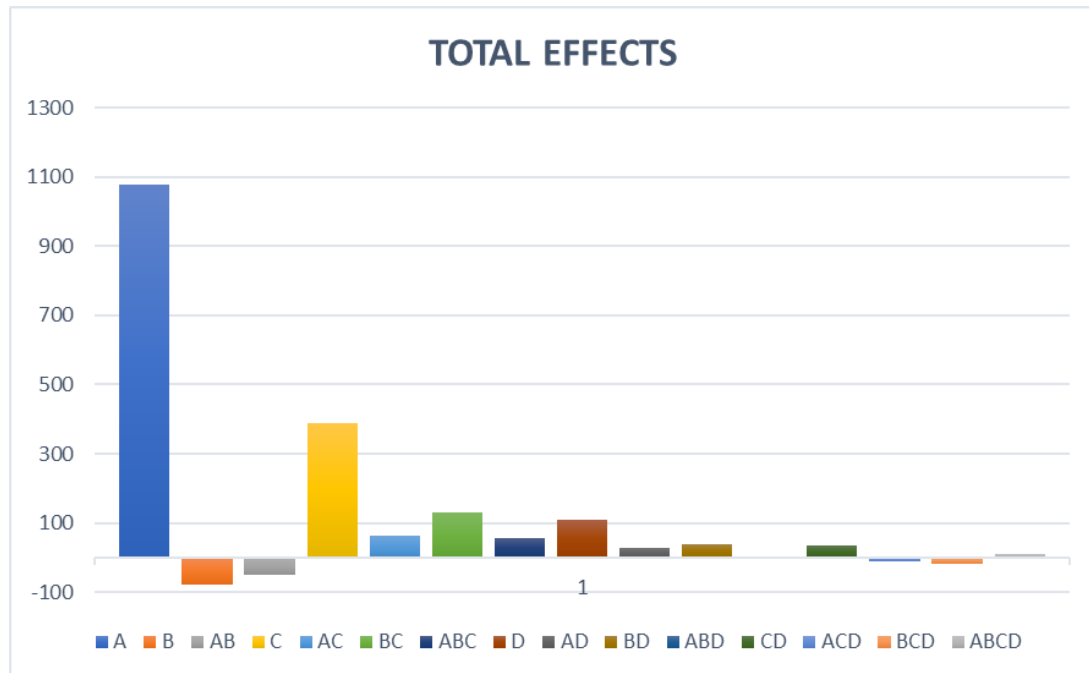
Pulse vs Blocks



From this graph we can infer that the pulse rate among different subjects does not vary much. The possible reason behind this can be the same age group and lifestyle of the subjects used under study



Estimated Total Effects



From the above estimated effects we can see that by inspection various main effects and 2 factor interaction are only significant ones.

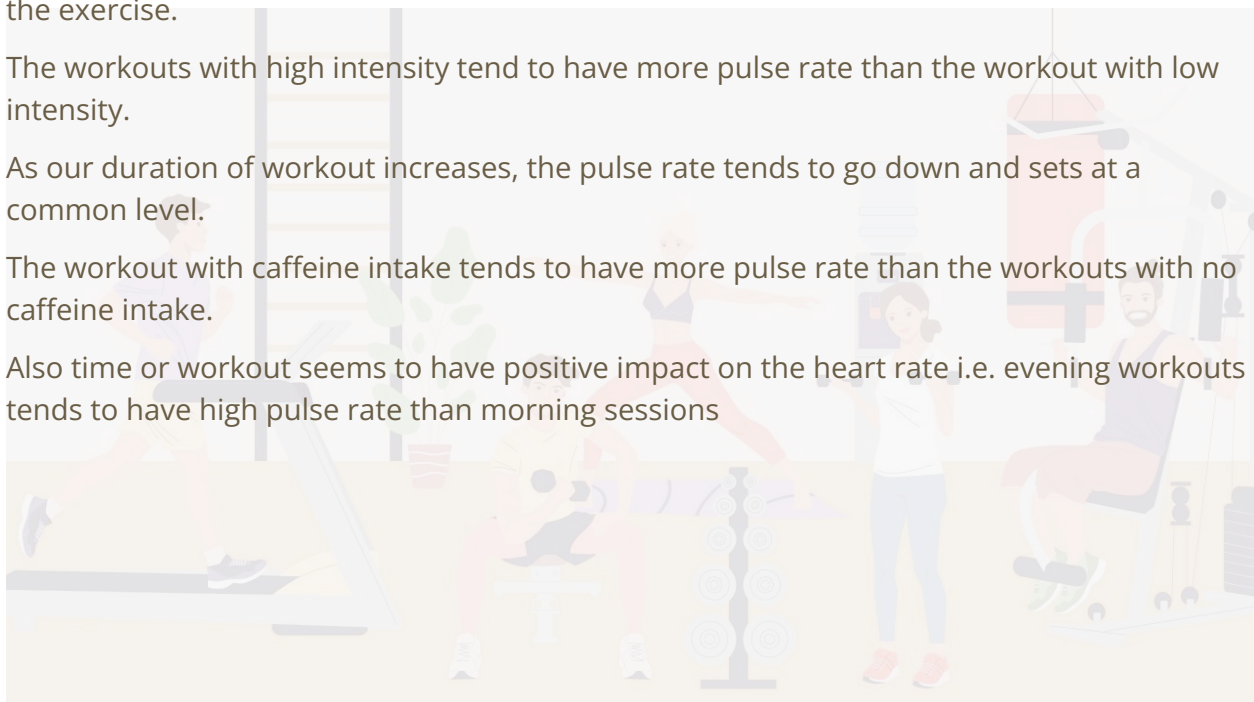
The intensity and caffeine are the most significant effect in deciding the pulse rate after the exercise.

The workouts with high intensity tend to have more pulse rate than the workout with low intensity.

As our duration of workout increases, the pulse rate tends to go down and sets at a common level.

The workout with caffeine intake tends to have more pulse rate than the workouts with no caffeine intake.

Also time or workout seems to have positive impact on the heart rate i.e. evening workouts tends to have high pulse rate than morning sessions



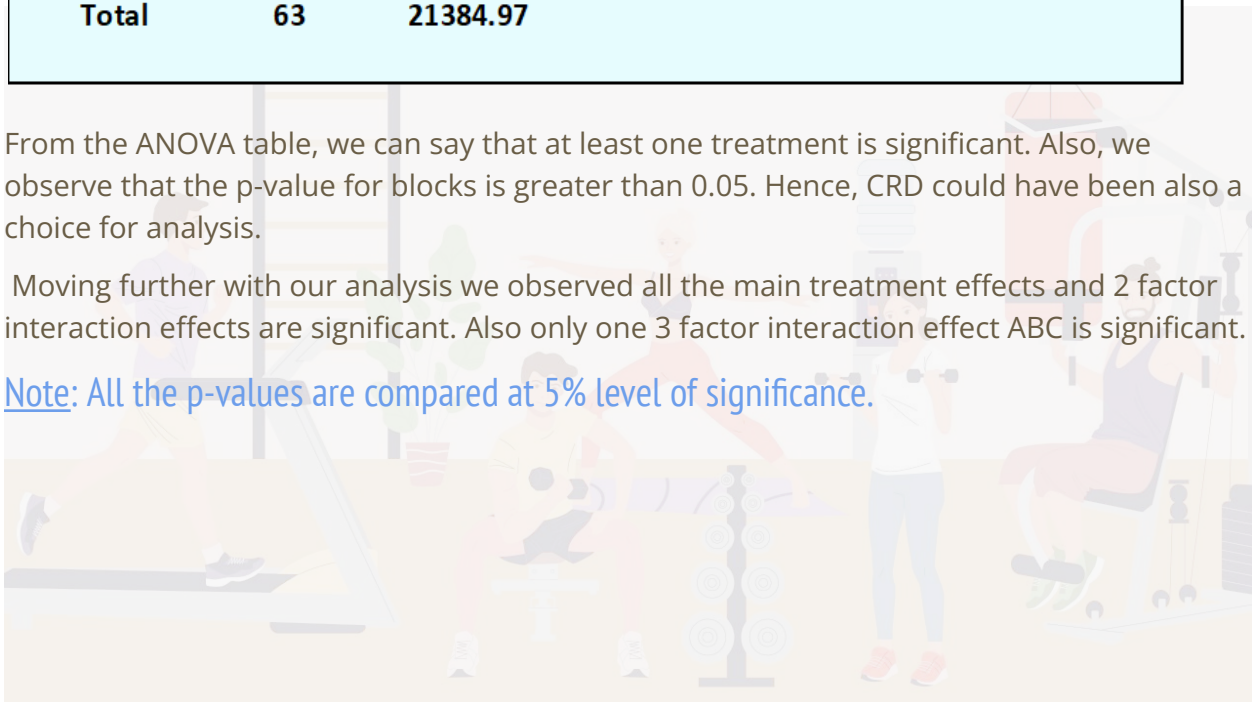
ANOVA Table

ANOVA TABLE					
S.V	D.F	S.S	M.S	F	P-Val
Blocks	3	2.32	0.773	0.357	0.784
Treatments	15	21285.38	1419.026	656.471	0.000
A	1	18164.30	18164.301	8403.185	0.000
B	1	97.02	97.022	44.885	0.000
AB	1	36.00	36.000	16.654	0.000
C	1	2347.40	2347.403	1085.957	0.000
AC	1	63.20	63.203	29.239	0.000
BC	1	266.51	266.506	123.291	0.000
ABC	1	52.93	52.926	24.484	0.000
D	1	189.75	189.751	87.783	0.000
AD	1	13.88	13.876	6.419	0.015
BD	1	24.50	24.502	11.335	0.002
ABD	1	0.30	0.302	0.140	0.710
CD	1	21.16	21.160	9.789	0.003
ACD	1	2.10	2.103	0.973	0.329
BCD	1	4.95	4.951	2.290	0.137
ABCD	1	1.38	1.381	0.639	0.428
Error	45	97.27	2.162		
Total	63	21384.97			

From the ANOVA table, we can say that at least one treatment is significant. Also, we observe that the p-value for blocks is greater than 0.05. Hence, CRD could have been also a choice for analysis.

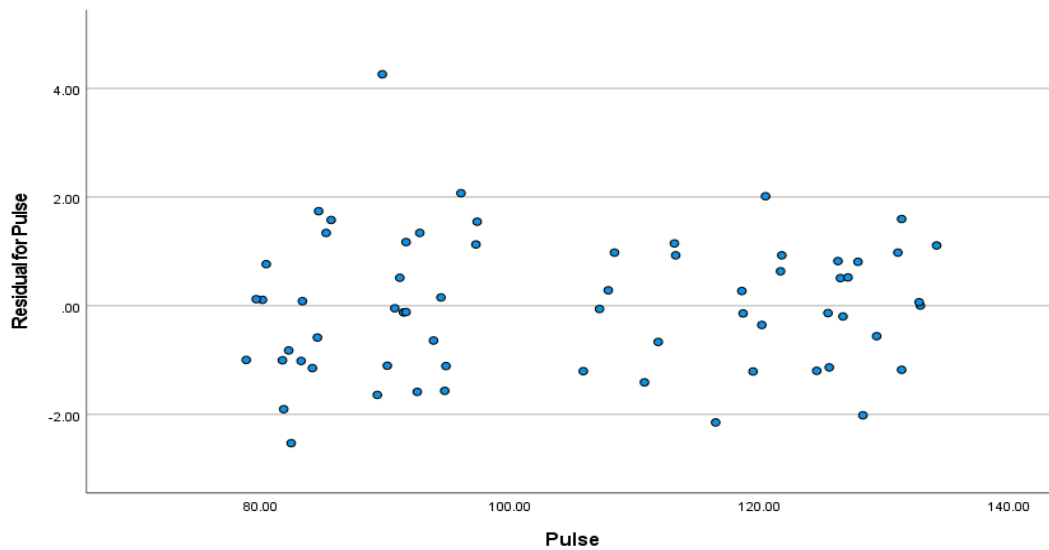
Moving further with our analysis we observed all the main treatment effects and 2 factor interaction effects are significant. Also only one 3 factor interaction effect ABC is significant.

Note: All the p-values are compared at 5% level of significance.

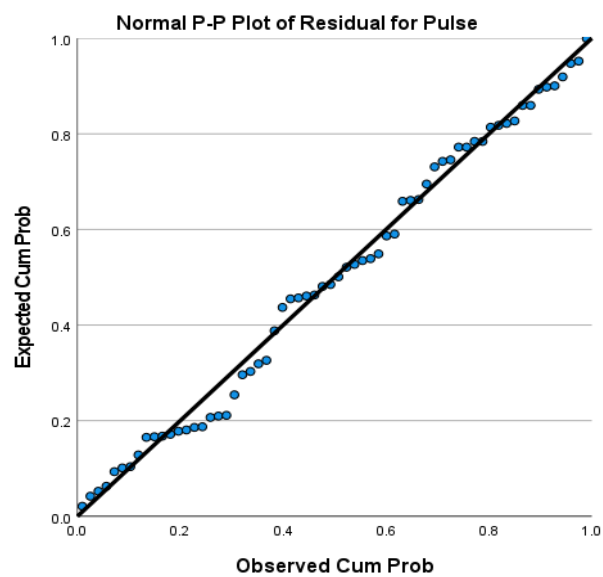


Residual Analysis

Scatter Plot (Residuals)



Normal P-P Plot



From the scatter plot, we observe all the points are random. Hence fulfilling the assumption for the fitted model. We also tried to plot the standard residuals and they were under the three-sigma limits. So, we are allowing the outlier.

From the PP-plot, we observe that almost all the points lie on the or near the line (except points between probability 0.2 and 0.4). Hence, the fitted model is a good fit.

Alternative Design

An alternative design for above experiment is to be constructed in two replicates with two blocks each confounding the highest order interaction i.e. ABCD.

ANOVA TABLE					
S.V	D.F	S.S	M.S	F	P-Val
Blocks	3	5.13	1.708	1.203	0.345
Treatments	14	10812.88	772.348	544.044	0.000
A	1	9248.00	9248.000	6514.314	0.000
B	1	24.50	24.500	17.258	0.001
AB	1	28.13	28.125	19.811	0.001
C	1	1200.50	1200.500	845.635	0.000
AC	1	21.13	21.125	14.881	0.002
BC	1	136.13	136.125	95.887	0.000
ABC	1	40.50	40.500	28.528	0.000
D	1	78.13	78.125	55.031	0.000
AD	1	8.00	8.000	5.635	0.032
BD	1	12.50	12.500	8.805	0.010
ABD	1	0.13	0.125	0.088	0.771
CD	1	8.00	8.000	5.635	0.032
ACD	1	1.13	1.125	0.792	0.388
BCD	1	6.13	6.125	4.314	0.057
Error	14	19.88	1.420		
Total	31	10837.88			

Such a design is Cost as Well as Time efficient as it also provides us with the same conclusions as made above with the less data keeping in mind that effect ABCD is confounded.

We can't partially confound the effect ABCD with other 3 factor interaction effects as it will lead to confounding of the main effect.

Concluding Remarks

From the above experiment we can conclude that the factor under considerations i.e. Intensity, Duration, Time of Workout and Caffeine Intake During Workout has significant effects on the pulse rate.

Due to the time constraint and resource constraint the best possible factors that could have affected the heart rate during the exercise have been studied and there can be various other factors which can be considered.

So, keeping in mind these factors one can design a proper workout plan on the basis of an individual's capabilities and fitness goals with effectiveness while considering his or her safety.

