7COM1079-0901-2024 - Team Research and Development Project

Final report title: Health care: Heart attack possibility

Group ID: A12

Dataset number: DS148

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### 1. Introduction

### Problem statement and research motivation:

Biological differences, such as hormonal influences, lead to notable disparities in how men and women respond to physical stress, including exercise. A key area of difference lies in their maximum heart rate during exercise. Understanding these gender-specific differences is crucial for individuals experiencing exercise-induced angina, as it provides insights into tailored diagnostic and therapeutic strategies.

This study aims to analyse these differences, contributing to a more nuanced understanding of gender-specific cardiovascular health. Previous research highlights the importance of considering gender in cardiac performance studies (Smith, 2023). Moreover, Taylor (2022) emphasized that personalized approaches based on biological sex can significantly enhance the efficacy of cardiovascular treatments. These findings strongly motivate current investigation.

### The data set:

The dataset used in this research examines the relationship between sex and the maximum heart rate achieved during exercise:

Gender (sex): Encoded as 1 for males and 0 for females.

Maximum heart rate (thalach): The highest heart rate reached during physical exertion.

Filtered individuals who got angina during exercise (exang): select rows where value of exang equals to 1.

### Research question**:**

This study addresses the following question:

“Is there a difference in the means of maximum heart rate between males and females who experience exercise-induced angina?”.

To answer this, statistical analyses will identify meaningful difference between the means maximum heart rates, supported by visualizations.

### Null hypothesis and alternative hypothesis (H0/H1):

Null Hypothesis (H₀): There is no difference in the means of the maximum heart rate between males and females who experience exercise-induced angina.

Alternative Hypothesis (H₁): There is a difference in the means of the maximum heart rate between males and females who experience exercise-induced angina.

## Background research

### Research papers:

The following research papers are relevant to the topic of gender differences in cardiovascular health and their implications for maximum heart rate analysis:

**Bruce (1984)**: This foundational study examined exercise tolerance and heart rate responses in men and women. While outdated, it established early benchmarks for gender-specific cardiovascular responses, particularly during stress testing.

**Kokkinos (2021**): This more recent paper investigated the role of gender in cardiovascular risk factors and outcomes. It found significant differences in heart rate recovery and maximum heart rates, reinforcing the importance of sex-specific considerations in diagnosis and treatment.

**Tanaka (2001)**: This widely cited study proposed gender-specific equations for predicting maximum heart rate, showcasing the impact of biological sex on cardiovascular performance during exercise.

While these studies address general gender differences in cardiovascular health, they lack direct focus on exercise-induced angina. Their findings underscore the need for further research into this specific condition using datasets that capture such nuances.

### Why RQ is of interest:

Existing literature highlights significant gender-based differences in cardiovascular responses, yet few studies directly examine exercise-induced angina and its impact on maximum heart rate. This research gap limits the development of tailored diagnostic and therapeutic strategies. Exploring this question allows for a deeper understanding of sex-specific cardiovascular mechanisms and addresses the gap in existing studies. Future directions could involve using larger, diverse datasets to generalize findings and investigating hormonal influences that contribute to these disparities. This research could ultimately inform more personalized approaches to treating and diagnosing exercise-induced angina.

## Visualisation

### Appropriate plot for the RQ:

The boxplot has been chosen for visually comparing the maximum heart rate (thalach) between genders in individuals with exercise-induced angina (exang = 1). The X-axis represents gender (0 = Female, 1 = Male), while the Y-axis shows the maximum heart rate in beats per minute (bpm). Distinct colours (pink for females, light blue for males) differentiate the groups.

The histogram with a normal curve shows the distribution of maximum heart rate (thalach) among individuals with exercise-induced angina. The X-axis represents heart rate (bpm), and the Y-axis shows frequency. The histogram reveals data spread, while the normal curve allows comparison to a normal distribution.

R-Code:

# Filter data for exercise-induced angina

filtered\_data <- subset(heart\_data, exang == 1)

# Box plot for Maximum Heart Rate by Gender

boxplot(

thalach ~ sex,

data = filtered\_data,

main = "Boxplot of Maximum Heart Rate by Gender",

xlab = "Gender (1 = Male, 0 = Female)",

ylab = "Maximum Heart Rate (thalach)",

col = c("pink", "lightblue"),

names = c("Female", "Male")

)

attach(filtered\_data)

# Histogram with Normal Curve for Maximum Heart Rate

hist(

thalach,

breaks = 10,

probability = FALSE,

main = "Histogram of Maximum Heart Rate with Normal Curve",

xlab = "Maximum Heart Rate (thalach)",

col = "cornsilk2",

border = "cornsilk4"

)

curve(

dnorm(x, mean = mean(thalach), sd = sd(thalach)) \* length(thalach) \* diff(hist(thalach, breaks = 10, plot = FALSE)$breaks)[1],

col = "darkgrey",

lwd = 2,

add = TRUE

)

detach(filtered\_data)

### Additional information relating to understanding the data:

The mean markers indicate that females generally have a higher heart rate than a male counterpart, which agrees with the t-test. This represents the differences in variability between the groups and further confirms the hypothesis of gender differences within the cardiovascular response.

### Useful information for the data understanding:

From the boxplot, it can be observed that females generally have a greater mean maximum heart rate compared to males with exercise-induced angina. There are no noticeable outliers in either group. The histogram confirms the data follows a normal distribution, with most heart rate values centered around the mean and fewer extreme values.

## Analysis

### Statistical test used to test the hypotheses and output:

Independent **t-test** was used to confirm differences in the means of maximum heart rate (thalach) in terms of sex, wherein males (sex = 1) and females (sex = 0) were compared against each other after experiencing exercise-induced angina (exang = 1). Levene's Test showed equal variances **(p = 0.089),** meaning the standard t-test is used properly. The test is appropriate because it tests differences in means of two independent groups which fits the research question. The t-test (p = 0.01832) indicates a statistically significant difference.

### The null hypothesis is rejected /not rejected based on the p-value:

The null hypothesis (H₀) states that there is no difference in the means of maximum heart rate (thalach) between males and females experiencing exercise-induced angina. The p-value based on the two-sample t-test is **0.01832**, which is less than the significance level of **0.05**. We thus **reject the null hypothesis**. This means that there is a statistically significant difference between the two groups with respect to their means of maximum heart rates. The observed difference indicates that females have a higher mean maximum heart rate as compared to males. These findings support the hypothesis that physiological differences due to gender influence heart rate under stress.

## Evaluation – group’s experience at 7COM1079

### What went well:

The group worked effectively through clear communication and regular offline and online meetings, allowing members to support each other and resolve issues promptly. Moreover, all members completed their tasks before deadlines, thus ensuring steady progress throughout the project. Besides, GitHub was used efficiently for version control and to show each member's contribution. Finally, the group used Slack frequently to seek clarifications from instructors.

### Points for improvement:

We started with a lack of knowledge about process in general, which led to improper division and performance of tasks. Plus, questioning skills are necessary to be clearer when doubting something and hence establish smoother communication with instructors. More advanced features, like branching and pull requests of GitHub need to be used to facilitate collaboration and improve version control. Proper planning and training on using GitHub will enhance task allocation in future.

### Group’s time management:

The group managed time well, completing all tasks before the deadline. The regular offline meetings every Wednesday and additional online sessions using Microsoft Teams were held to answer questions and ensure clarity. This continuous communication and planning allowed the group to maintain a steady progress and meet deadlines without delays.

### Project’s overall judgement:

The project was successful, where all objectives were achieved with a well-implemented solution and proper documentation. Strong teamwork and time management ensured the quality of deliverables. While task allocation and usage of tools could be improved, the overall outcome reflected effective collaboration and technical skills.

### Group members and GitHub Ids:

Leslie Nelson Fernandes – leslie628

Lipi Chandrakar – lipichandrakar

Thi Nhu Lai Vo – tv24aac and jvl-13

Syed Khurram Ali – Khurram-ak

Hafiza Ayesha Saddiqa – Ba455

### Comment on the GitHub log output:

* + - 1. ***Commit Message 1:*** *Added boxplot and histogram.*

This commit introduced data visualizations, providing clear insights into the dataset and aiding in the analysis process*.*

* + - 1. ***Commit Message 2:*** *Added T-Test*

The inclusion of the T-test enabled statistical analysis, helping to evaluate the significance of differences between groups*.*

* + - 1. ***Commit Message 3:*** *Final report, done format and checked contents*

This final commit completed the project report, summarizing the findings and ensuring that all objectives were clearly communicated.

## Conclusions

### Results explained:

According to the t-test results, the mean maximum heart rate for males (group 1) is 134.56 bpm, whereas the mean maximum heart rate for females (group 0) is 146.50 bpm. When exercising, women's heart rates are greater than men's, as observed by the 11.94 bpm difference, which is unlikely to be the result of chance. It can also show how gender-related physiological or hormonal factors affect variations in heart rate.

### Interpretation of the results:

The findings support our research topic by showing that physiological gender differences can impact exercise-induced angina individuals' maximal heart rates. For example, estrogen in women can cause their heart rates to be higher than those of men. Therefore, a customized treatment plan will be required for each gender. This study emphasizes the need to take gender into account while doing research in exercise physiology and clinical practice in a broader sense.

### Reasons and/or implications for future work, limitations of your study:

The consistency of these results with a larger sample size should be confirmed by future research. A deeper analysis might be possible if more variables, including age, were considered, as the existing variables that were employed were limited.

## Reference list

Bak, M.-J. et al. (2022) Clinical significance of ventricular premature contraction provoked by the Treadmill Test, MDPI. Available at: <https://www.mdpi.com/1648-9144/58/4/556> (Accessed: 04 January 2025).

Charles Faselis et al. (2014) Exercise Capacity and All-Cause Mortality in Male Veterans With Hypertension Aged ≥70 Years. Available at: <https://www.ahajournals.org/doi/10.1161/HYPERTENSIONAHA.114.03510> (Accessed: 04 January 2025).

DR;, T.H.K. (2001) Age-predicted maximal heart rate revisited, Journal of the American College of Cardiology. Available at: <https://pubmed.ncbi.nlm.nih.gov/11153730/> (Accessed: 04 January 2025).

Emily M. Rogers et al. (2023) Progressive exercise training improves cardiovascular psychophysiological outcomes in young adult women with a history of adverse childhood experiences. Available at: <https://journals.physiology.org/doi/pdf/10.1152/japplphysiol.00248.2022> (Accessed: 04 January 2025).

Smith, D.L. (2023) Advanced cardiovascular exercise physiology, Google Books. Available at: <https://books.google.com/books/about/Advanced_Cardiovascular_Exercise_Physiol.html?id=gBExM6v-XPcC> (Accessed: 04 January 2025).

## Appendices

### R code used for analysis and visualisation:

Analysis.R code with the appropriate statistics to test the hypotheses.

install.packages("car")

install.packages("car", repos = "https://cran.rstudio.com/")

library(readxl)

library(car)

options(repos = c(CRAN = "https://cran.rstudio.com"))

heart\_data <- read\_excel("heart.xls")

#Cleaning of Dataset

#Shows the number of missing values in each column

colSums(is.na(heart\_data))

#removing missing values

heart\_data <- na.omit(heart\_data)

#Filling missing values with a default or mean

heart\_data$thalach[is.na(heart\_data$thalach)] <- mean(heart\_data$thalach, na.rm = TRUE)

#Checking for duplicates

duplicates <- duplicated(heart\_data)

print(duplicates)

# Checking the structure of the dataset

str(heart\_data)

# Ensuring numeric type

heart\_data$age <- as.numeric(heart\_data$age)

#Saving the Cleaned data set

write.csv(heart\_data, "cleaned\_heart\_data.csv", row.names = FALSE)

# Filter data for exercise-induced angina

filtered\_data <- subset(heart\_data, exang == 1)

# Box plot for Maximum Heart Rate by Gender

boxplot(

thalach ~ sex,

data = filtered\_data,

main = "Boxplot of Maximum Heart Rate by Gender",

xlab = "Gender (1 = Male, 0 = Female)",

ylab = "Maximum Heart Rate (thalach)",

col = c("pink", "lightblue"),

names = c("Female", "Male")

)

attach(filtered\_data)

# Histogram with Normal Curve for Maximum Heart Rate

hist(

thalach,

breaks = 10,

probability = FALSE,

main = "Histogram of Maximum Heart Rate with Normal Curve",

xlab = "Maximum Heart Rate (thalach)",

col = "cornsilk2",

border = "cornsilk4"

)

curve(

dnorm(x, mean = mean(thalach), sd = sd(thalach)) \* length(thalach) \* diff(hist(thalach, breaks = 10, plot = FALSE)$breaks)[1],

col = "darkgrey",

lwd = 2,

add = TRUE

)

detach(filtered\_data)

# Shapiro-Wilk test for normality (female)

shapiro\_test\_females <- shapiro.test(filtered\_data$thalach[filtered\_data$sex == 0])

# Shapiro-Wilk test for normality (male)

shapiro\_test\_males <- shapiro.test(filtered\_data$thalach[filtered\_data$sex == 1])

# Print results of Shapiro-Wilk test and Log the results

sink("Rscript.log", append=TRUE)

# Result: p < 0.05 (indicating non-normal distribution)

# Result: p > 0.05 (indicating normal distribution)

print(shapiro\_test\_females)

print(shapiro\_test\_males)

sink()

str(filtered\_data)

filtered\_data$sex <- as.factor(filtered\_data$sex)

# Perform Levene's Test for equality of variances

# Result: p < 0.05 (indicating significant difference in variances)

levene\_result <- leveneTest(thalach ~ sex, data = filtered\_data)

# Log the Levene's test result

sink("Rscript.log", append=TRUE)

print(levene\_result)

sink()

# Perform t-test for difference in means between males and females

# Result: p < 0.05 (indicating significant difference in means)

t\_test\_result <- t.test(thalach ~ sex, data = filtered\_data, var.equal = TRUE)

# Log the t-test result

sink("Rscript.log", append=TRUE)

print(t\_test\_result)

sink()

### GitHub log output:

b1f60d7 | lipichandrakar | 2025-01-04 | References added, alignment adjusted.

029b16a | leslie628 | 2025-01-02 | modified report file

fdf40c9 | Ba455a | 2024-12-29 | introduction added

56be8cf | leslie628 | 2024-12-28 | added conclusion and appendices

7510fb3 | tv24aac | 2024-12-27 | added my name and id

ac0304b | tv24aac | 2024-12-27 | add evaluation draft to report and delete unnecessary file

ef0e2de | Khurram-ak | 2024-12-27 | background draft added

8a491cb | leslie628 | 2024-12-26 | renamed file generated log file of test results

0afb5ec | leslie628 | 2024-12-26 | added comments reordered code

8bfd1ca | leslie628 | 2024-12-23 | after cleaning original data set, filtering with exang=1. Modified code accordingly

e29c80f | Thi Nhu Lai Vo | 2024-12-20 | Update boxplot conclusion in README.md

a867835 | LaiVoJM | 2024-12-20 | change boxplot gender color

0f9027d | leslie628 | 2024-12-15 | switched labels

dd1b0a0 | leslie628 | 2024-12-15 | Merge branch 'main' of https://github.com/tv24aac/team-research-project

f012440 | lipichandrakar | 2024-12-11 | Added my draft

f42c6c2 | lipichandrakar | 2024-12-10 | Added draft

8ff3a61 | Khurram-ak | 2024-12-10 | feat: datatype validation and rewritting dataset

7a79528 | Khurram-ak | 2024-12-10 | feat: name added

bd7d0b6 | lipichandrakar | 2024-12-08 | Added report title and my name

7300008 | leslie628 | 2024-12-06 | Added dataset, group ID and my name

e26e003 | Lipi Chandrakar | 2024-12-06 | Reorganized code

be5a315 | Khurram-ak | 2024-12-05 | feat: removing missing values from dataset and checking for duplicates

5f2459b | LaiVoJM | 2024-12-05 | report tasks distribution

140c77c | lipichandrakar | 2024-12-05 | Report

f166747 | lipichandrakar | 2024-12-05 | Report

9693e39 | leslie628 | 2024-12-05 | draft report

ecf713c | tv24aac | 2024-12-04 | Update README.md boxplot explanation

044b299 | Lipi Chandrakar | 2024-12-04 | Enhanced result

b901ff9 | Lipi Chandrakar | 2024-12-04 | Enhanced result

a5719ac | Ba455a | 2024-12-03 | Changes

61f9030 | Ba455a | 2024-12-03 | add ppt visualization

03bc61a | lipichandrakar | 2024-12-03 | Added Result

c9cc47d | Khurram-ak | 2024-11-30 | feat: readMe more points and code updation

1b97c37 | Khurram-ak | 2024-11-30 | feat readme more points

d412c37 | tv24aac | 2024-11-29 | Update README.md

d52bfb8 | tv24aac | 2024-11-29 | Update README.md visualization part

33b92b9 | LaiVoJM | 2024-11-29 | change density to frequency

7746c22 | LaiVoJM | 2024-11-29 | Merge branch 'main' of https://github.com/tv24aac/team-research-project

8717f7d | LaiVoJM | 2024-11-29 | change density to frequency

dba7822 | Khurram-ak | 2024-11-29 | feat: ReadMe file updated

1d5392d | leslie628 | 2024-11-27 | removed local path

95965be | leslie628 | 2024-11-25 | Added project related content to readme file.

d1d1934 | leslie628 | 2024-11-25 | Merge branch 'main' of https://github.com/tv24aac/team-research-project

11b6a55 | leslie628 | 2024-11-25 | added research question presentation file

9fea397 | Khurram-ak | 2024-11-20 | testing

f36658b | lipichandrakar | 2024-11-17 | Added T-Test

7973140 | leslie628 | 2024-11-17 | removed local path

301d939 | lipichandrakar | 2024-11-17 | Team R&D

d8fd3e3 | lipichandrakar | 2024-11-17 | boxplot\_histogram.R

ab3c47b | lipichandrakar | 2024-11-17 | Added boxplot and histogram

0ce0777 | lipichandrakar | 2024-11-17 | I'm Tired

523ecdb | lipichandrakar | 2024-11-14 | Added README.md

c02ae33 | tv24aac | 2024-10-29 | Update README.md

a9ee087 | laivo-uh | 2024-10-16 | Create README.md

3aaa655 | LaiVoJM | 2024-10-16 | first commit