Instructor Notes

Title: "Easy fitness"

Discipline and courses: Upper division physiology, exercise physiology

Degree of difficulty: I-M (Introductory-Intermediate)

Goal: Emphasize importance of cardiovascular function with focus on factors of cardiac output

Resources needed: This project requires introduction to cardiovascular physiology in a upper level physiology course. Students are expected to perform basic calculations and interpret results. Additionally, students will be required to perform basic statistical analysis using Microsoft excel, or any other spreadsheet application. Students will need to have a basic background in how to perform basic functions; Descriptive statistics and basic inferential statistics.

The data analysis tool included in Microsoft excel will not work for this project. The data was not set up in the proper format. Students will need to input formulas to calculate descriptive and inferential statistics, for instructions on how to complete this see the following link: https://silo.tips/download/an-introduction-to-using-microsoft-excel-for-quantitative-data-analysis

Deliverables:

The project will analyze a data set regarding a drug that is claiming to increase cardiovascular performance during exercise simply by taking a pill. Groups of two students will return a "lab report" over a data set. The report will contain an introduction and results/discussion pertaining to the data. Students will perform some basic physiological calculations and descriptive and inferential statistics, and results will be summarized in figures and presented in the lab report.

Duration: The project should require 2 weeks to complete and require 1-2 50-minute classroom periods. Students will be required to turn in their assignments three weeks after the assigned date.

Timeline of events

- **Project as designed: 2 weeks**
  - Go through the case study together as a class
  - Introduce students to the spreadsheet in class: 50-minute class period
    - Explain important variables
    - General layout of spreadsheet
    - Introduce calculations that will need to be carried out
    - Go over lab report requirements
    - Lab reports are due 3 weeks after assigned date
- **Reduce project: (1 week)**
  - Alteration suggested:
    - Reduce the number of exercise groups
  - Project carried out as designed.

        - Students will perform less analysis and be required less response towards discussion
- **In class (2 50-minute periods)**
    - Alteration suggested:
        - Write up is omitted
    - Go through the case study together as a class
    - Break into small groups:
        - Day 1: Students generate hypothesis:5-10 minutes
            - Discuss as group
        - Day 1: Students calculate cardiac output and averages for heart rate, stroke volume, and cardiac output: 30-40 minutes.
            - If students do not finish, remainder of work assigned as homework.
        - Day 2: Data discussion and result presentation
            - Conclude with discussion of the significance of the: data. 30 minutes

Group project: 2 people per group will work collaboratively to complete the project. This will alleviate gaps in knowledge and the work demand of the project. The instructor should go over the spreadsheet with students as a whole and meet with students as needed if they have question over performing the analysis.

Project instructions for the instructor:

In this study, students will be presented with a project in case-study format. The case study is focused on cardiovascular performance during exercise testing the claims of a new miracle pill. Students are provided with a fictitious research project and delivered unique data sets containing cardiovascular measurements, heart rate, and stroke volume. Students will be required to calculate and interpret cardiac output. Additionally, students will perform descriptive (average and standard deviation) and inferential statistics (t-tests) that will be used to draw conclusions about the meaning of the data. Students will compare data between different levels of exercise and analyze the impact on cardiovascular variables, heart rate, stroke volume, and cardiac output. If desired, an instructor can include gender as a variable, other data supplied on the spreadsheet are included to provide a more realistic data set but should not be used for additional analysis given they are not fit a normal distribution. The worksheet has been designed to generate random values for heart rate and stroke volume that reflect realistic values for sedentary and active individuals that fall within a normal distribution. This worksheet is referred to as "Instructor data generator" in the workbook. Unique worksheets have been produced for instructor and student versions such that the students do not see how the data was generated. If the instructor desires to alter the data or include other variables, the formulas should be removed prior to disseminating to students. (An easy way to do this is to copy/paste by value.) The instructor worksheets contain the calculated cardiac output and descriptive and basic inferential statistics in addition to the figures for the unique data sets but. The student version has this

information removed. The only instructor worksheet that is modifiable is the "Instructor data generator" worksheet. All other instructor worksheets are pictures of the worksheet used to generate student values.

Students are expected to write up results in the format of a lab report and should address the following questions in their write up:

Text in bold is provided in the student version. Example responses are provided here and should not be shared with students.

Items to be addressed in the introduction:

1. **Why are you measuring the impact of exercise and the effectiveness of the drug?**

   Exercise directly impacts cardiovascular function, increasing cardiac output. The advertisement did not include any of this information in their claim, and it should have been included.

2. **Why are you (the researcher) measuring heart rate and stroke volume to test the claims of the drug presented in the advertisement?**

   The drug claims to increase cardiovascular performance, which can be measured by blood pressure and cardiac output. Blood pressure is not very informative on its own. Cardiac output is more informative about cardiovascular function given it is a measurement of the capacity of the heart to support activity.

3. **What is the role of cardiac output? How do you expect cardiac output to be affected when measured immediately following exercise? How would exercising regularly affect cardiac output when measured at rest?**

   Cardiac output is a measure of how much blood the heart is pumping per minute. When measured immediately following exercise, cardiac output is expected to be elevated due to an increase in heart rate and stroke volume. When an individual exercises regularly the heart undergoes remodeling and the myocytes increase in size, increase their ability to increase contraction. Heart rate will be reduced in individuals who exercise regularly. The increasing stroke volume and decreasing heart rate maintain cardiac output at rest in exercising individuals.

Items to addressed in the discussion:

1. **Present your data succinctly, summarizing the data. Make sure you reference the figures.**

   Students should summarize data. Briefly, the data should demonstrate that exercise can alter cardiovascular parameters, specifically heart rate, stroke volume, and cardiac output. The data is investigating the effect of a miracle pill on cardiovascular performance. It is found from the data that cardiovascular performance is only affected in individuals who don't exercise; specifically, stroke volume is increased in simulated data. In individuals who

exercise, the drug reduces cardiovascular performance by substantially reducing stroke volume.

2. **Was cardiac performance affected by the drug compared to the control measurement? Discuss factors that affect cardiac output (Preload, afterload, contractility) and speculate how this pill may have impacted these factors**.

In non-exercising individuals, stroke volume is increased. This could occur if the drug increased contractility or preload or reduced afterload.

If the drug increased contractility, it is likely acting directly on the heart acting as a positive inotropic agent.

If the drug increases preload, it is likely inducing venoconstriction, increasing venous flow returning to the heart, given that heart rate is not increasing.

If the drug reduces afterload, it is likely reducing vascular resistance through vasodilation. Without further measurements, one cannot predict where vasodilation is occurring, but if it enhances exercise performance, the vasodilation is likely occurring in skeletal muscle.

3. **Did the level of activity affect efficacy of the pill? Explain.**

The drug is less effective as exercise routine increases. Stroke volume is substantially reduced in high exercise individuals.

4. **How were the resting cardiovascular values affected by level of activity? How were the cardiovascular values affected by exercise when immediately measured after activity? Is this what you expected? Why or why not?**

Students should provide a response that compares resting data between the different exercise groups based on observation of trends. An ANOVA would be used normally to compare values between exercise groups; however, statistics is not a prerequisite for this course. Therefore, students in the course will look at the trends to draw conclusions across exercise groups.

Resting values and exercise:

Values reflect heart rate, stroke volume, and cardiac output prior to exercise when at rest. For resting values, heart rate and stroke volume will be affected by exercise level. Resting cardiac output should have a similar value regardless of exercise level.

- Zero exercise individuals: Heart rate is elevated; stroke volume is reduced compared to higher levels of exercise.
- 1-2 days of exercise per week: Heart rate should be similar to individuals who do not exercise but will be higher than individuals who exercise more frequently. Stroke volume is increased compared to individuals who do not exercise but is less than individuals who exercise more frequently.

- 3-4 days of exercise per week: Heart rate is less than individuals who exercise 1-2 days a week or not at all, and stroke volume increases compared to individuals who exercise 1-2 days a week or not at all.
- 5 or more days of exercise per week: Heart rate is less than all groups. Stroke volume increases compared to all groups.

Control measurement and exercise routine:

Values reflect heart rate, stroke volume, and cardiac output immediately following exercise. The impact of exercise training can be observed on cardiac output during exercise. Exercising cardiac output is elevated in trained individuals.

- Zero exercise individuals: Heart rate is comparable to other groups; stroke volume is reduced compared to higher levels of exercise; cardiac output is less than other groups.
- 1-2 days of exercise per week: Heart rate is comparable to other groups; stroke volume is reduced compared to higher levels of exercise; cardiac output is less than groups that exercise more but more than individuals who do not exercise.
- 3-4 days of exercise per week: Heart rate is comparable to other groups; stroke volume is increased compared to lower levels of exercise; cardiac output is higher than groups that exercise less, but less than individuals who have higher exercise routines.
- 5 or more days of exercise per week: Heart rate is comparable to other groups; stroke volume is increased compared to all other groups.

Overall exercise has a strong impact on the resting and control measurement of heart rate and stroke volume. Cardiac output while at rest is consistent across groups or slightly lower in groups that exercise regularly, whereas when measured immediately after exercise, it is substantially increased in exercising groups.

Students should expect this result, when under an exercise regimen, individuals undergo cardiovascular remodeling. The heart becomes more efficient, pumping more blood per beat and reducing the number of beats per minute.

5. **Explain the significance of cardiac output, heart rate, and stroke volume during exercise in relation to the data. Explain the impact of the pill on groups with different activity levels.**

Impact of the pill on cardiovascular performance:

- Zero exercise individuals: The drug improved cardiac output by increasing stroke volume. Cardiac output should be higher than control measurements.
- 1-2 days of exercise per week: The drug has a minimal effect. Stroke volume may be slightly elevated, and heart rate may be slightly decreased; overall cardiac output should present a value similar to control measurements.
- 3-4 days of exercise per week: The drug begins to have a negative impact on cardiovascular performance. Stroke volume is substantially reduced, and heart rate will be slightly lower. Cardiac output should reflect these changes and is reduced.

- 5 or more days of exercise per week: The drug has a clear negative impact on cardiac performance. Stroke volume is significantly reduced, and heart rate will be reduced. Therefore, cardiac output will be reduced.

6. **You are calculating cardiac output to gauge cardiac performance. How else could Oxygen delivery to tissues be improved? Are there any tradeoffs associated?**

Erythropoiesis would increase the number of circulating erythrocytes. This has the benefit of increasing oxygen delivery; however, it has negative implications as well. Increasing erythrocytes increases the viscosity of the blood, increasing the resistance to blood flow and increasing afterload. This would increase the pressure the ventricles must generate to overcome resistance to blood flow in order to eject blood from ventricles.

7. **What is your conclusion on the miracle drug? Would you recommend people take it to improve physical performance?**

   The drug was effective in sedentary individuals primarily by increasing stroke volume. However, in exercising individuals the drug has a negative impact on exercise performance, reducing stroke volume and in turn cardiac output.

8. **Regardless of the drug's efficacy, what is required to increase exercise performance in endurance athletes?**

   Increasing exercise performance is much more complex than simply increasing cardiac output. In order to increase exercise performance, an individual needs to increase oxygen delivery to tissues. This requires an alteration in pulmonary, cardiovascular and muscle properties.

   Pulmonary adjustments: Total ventilation needs to be enhanced to increase delivery to blood and CO_2 removal from the body.

   Cardiovascular adjustments: Cardiac output increases the amount of blood that is delivered to tissues. Exercising individuals may experience a short-term increase in circulating erythrocytes in order to deliver oxygen at a higher rate to tissues.

   Tissue adjustment: Skeletal muscle in this case needs to increase blood flow delivery and accommodates through increasing vasculature.

9. **Did you support the initial hypothesis? Provide enough detail in your response to justify your answer.**

   The data partially support the drug's claims. In people who do exercise or exercise infrequently, the drug appears to increase cardiac output by increasing stroke volume. In individuals who exercise frequently, the drug has the opposite effect decreasing cardiac output by reducing stroke volume. The mechanism by which the drug acts was not identified in the current study and would be a future area of research.

Guidance for faculty regarding project:

Carrying out as a group project:

For students to gain an appreciation for cardiac output and the factors that impact cardiac output it is imperative students equally share roles in the preparation of the analysis, and interpretation of data. Instructor may want to verify that students are both contributing to this project.

Revision and continuation: Instructors can modify the data under the "instructor data generator" if they desire. Other variables can be incorporated as well. In order to do this instructor can modify variables may want to take care that the data fall under a normal distribution. Other variables the worksheet is ready to use would be gender but contains other variables such as age, weight, education status, and income level. Instructors are encouraged to have fun with this and design projects that will enhance student learning.

Guidelines on evaluation:

A sample rubric is provided in the student version, and the instructor should adjust this document accordingly to suit their needs.