Effect of Food Intake on RER Values During Submaximal Treadmill Exercise

Emily Dyment, Luke Beamer, Caitie Mayo, Alin Richards
Exercise Science, Gardner-Webb University, Boiling Springs, NC 28017

GARDNER-WEBB UNIVERSITY

This project does not attempt to produce generalizable knowledge. It is dedicated to the practice of developing skills and demonstrating understanding of the research process.

Introduction

According to McArdle et al. (2016), fuel contributions to energy expenditure will differ depending on the physiological environment that is present. Various internal environments and expectations will cause individuals to oxidize different fuel sources to yield energy. The ratio of fuel sources being used is often expressed in humans using the RER. According to McArdle et al. (2016), RER stands for respiratory exchange ratio, which is the ratio of carbon dioxide expelled to oxygen inhaled. Due to the varying chemical nature among the macronutrients, different amounts of gas exchange are required to oxidize each fuel source. The RER provides data that can aid in our understanding of what macronutrient is being used for fuel at a given time during exercise (McArdle et al., 2016). During submaximal exercise, individuals typically utilize a combination of both fats and carbohydrates for fuel. The ratio of the relative contribution of macronutrients is dependant on the fuel sources which are readily available to the individual. Typically, an RER of 0.85 denotes the "lipid crossover," which is when equal amounts of fats and carbohydrates are being oxidized to provide energy.

Research Question, Purpose and Hypothesis

- The research question which guided our experiment is as follows:

Does food consumption prior to exercise affect fuel oxidation as reflected by differences in RER values during submaximal exercise?

- The purpose of this experiment was to observe the extent to which food consumption prior to exercise affects fuel oxidation during submaximal exercise.
- It was hypothesized that individuals in the fasted state will utilize fat oxidation as the primary fuel source longer than individuals fed prior to exercise. This will be reflected by lower RER values throughout the graded exercise protocol.

Methods

Subjects

Subjects include 4 young and athletic individuals. Two males and two female subjects between 20 and 23 years of age. Essentially the subjects will be paired up with a partner of similar stature and sex. One partner within the pair will be advised to not eat before the protocol, and be in an overnight fasted state. The other partner will be instructed to eat as they normally would prior to the protocol administration. All subjects will be instructed to wear athletic clothing to perform the required protocol.

Preliminary Testing

Set up the VO_2mask and obtain heart rate monitor for client. Write the chaos prevention on white board and assign roles. Write proper speeds and inclines for all stages on the whiteboard as well. Create a heart rate road map to ensure proper documentation. Calibrate the metabolic cart, gas calibration first and then flow calibration.

Before testing the subjects' height, weight, and resting heart rate data will be collected. Resting heart rate data will be used to determine 85% of predicted heart rate max. The clients will be informed of the risks associated with the exercise protocol. All subjects, more importantly the fasted clients, will be reminded to stop exercising immediately if they feel any abnormal symptoms such as dizziness, or lightheadedness. The non-fasted clients will additionally be asked to state what they ingested prior to the protocol, so this information can be documented by the test administrators. Ensure the subject information is included correctly within the database.

Subject Prep and Resting Data

Ensure the treadmill is on and properly functioning. The subject will be asked if they are ready to perform the protocol, and if they have any questions. The subject will subsequently be set up with the VO_2 mask and heart rate monitor. The data collected will consist of heart rate, RER, VO_2 and VE values. Heart rate will serve at the termination criteria, as the test will be terminated once the client reaches 85% of their maximal heart rate value. The subject will then be asked to sit in a chair to collect resting data for 3 minutes. During this 3 minutes, the proper Bruce Treadmill Protocol will be explained to the client. See *Exercise Protocol* below for an explanation of the testing protocol. Once 3 minutes has passed, the subject will get onto the treadmill to begin the 1- minute warm up at 1.7 mph and zero grade prior to the test.

Exercise Protocol:: Bruce Submaximal Treadmill Test

The exercise protocol consists of three minute stages, with increases in speed and/or incline every subsequent stage. A one-minute warm up at beginning speed with no incline has been implemented. The first stage consists of 0% incline and 1.7mph. After three minutes, the incline increases by 5%, this is considered to be stage 0.5. These first two "stages" are to be omitted for healthy subjects. All subjects included in this study are healthy young adults, therefore the first two stages of the protocol will be omitted. The preliminary stage will begin at 1.7mph and 10% grade. The second stage will increase the speed and grade to 2.5mph and 12% respectively. The third stage increases to 3.4mph and 14% grade. The fourth stage further increases to 4.2mph and 16% incline. Ensure you obtain RPE data throughout the test to monitor the client. Continue to monitor and talk to client during the protocol. Manually enter RPE data and heart rate data if not being recorded automatically.

Test Termination and Data Recording

Testing will be terminated when the individual reaches 85% of their heart rate max, or if they display any signs for termination test criteria. This includes excessive sweating or redness, excessive rises in blood pressure and heart rate, signs of dizziness or the client requesting to stop testing. Clients will be monitored throughout the entire test using the RPE scale to ensure they do not overexert themselves and remain safe. Once the test has been terminated, required data will be recorded and the client will immediately be disconnected from the VO_2 mask.

Results

The main variables which were monitored throughout the exercise protocol were heart rate and RER. Heart rate was monitored as it as used as the termination criteria of the test. This was to ensure the test remained submaximal in nature. RER was the variable which was significant to the data collection. RER values were closely monitored in all subjects in order to make comparisons between those who were fasted and those who were unfasted. According to Table 1, the lowest RER values throughout the protocol were reached by both the fasted subjects. The male fasted subject had the lowest RER value of 0.67. Each of the subjects displayed their lowest RER value at the same speed and incline, which was during the second stage of the protocol. Figure 1 displays the differences between the fasted and non fasted male RER values throughout the protocol. Figure 2 displays the differences between all fasted and non fasted subjects during the third stage of the protocol. Figure 3 displays the average RER values for both male and female fasted versus unfasted subjects over time. All three figures work to display that fasted subjects portrayed lower overall RER values throughout exercise.

Table 1: *Comparison Between Fasted and Unfasted Subjects Lowest RER Value During Bruce Submaximal Treadmill Protocol*

Subject	Speed (mph)	Incline (%)	Lowest RER Value
Male Fasted	2.5	12	0.67
Male Unfasted	2.5	12	0.78
Female Unfasted	2.5	12	0.73
Female Fasted	2.5	12	0.72

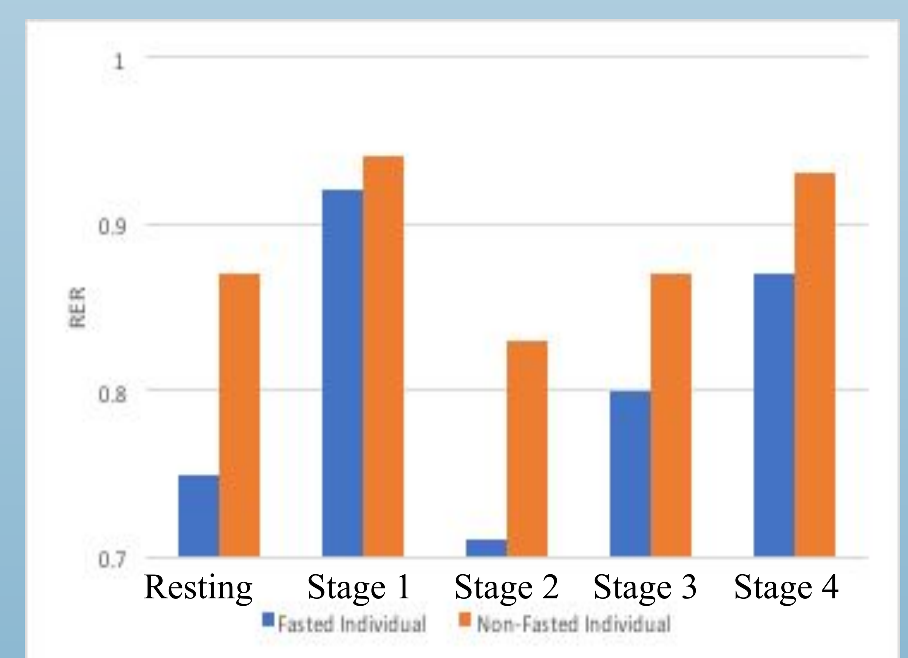

Figure 1: *Comparison Between Fasted and Non-fasted Male Subject's RER Values During Submaximal Treadmill Protocol*

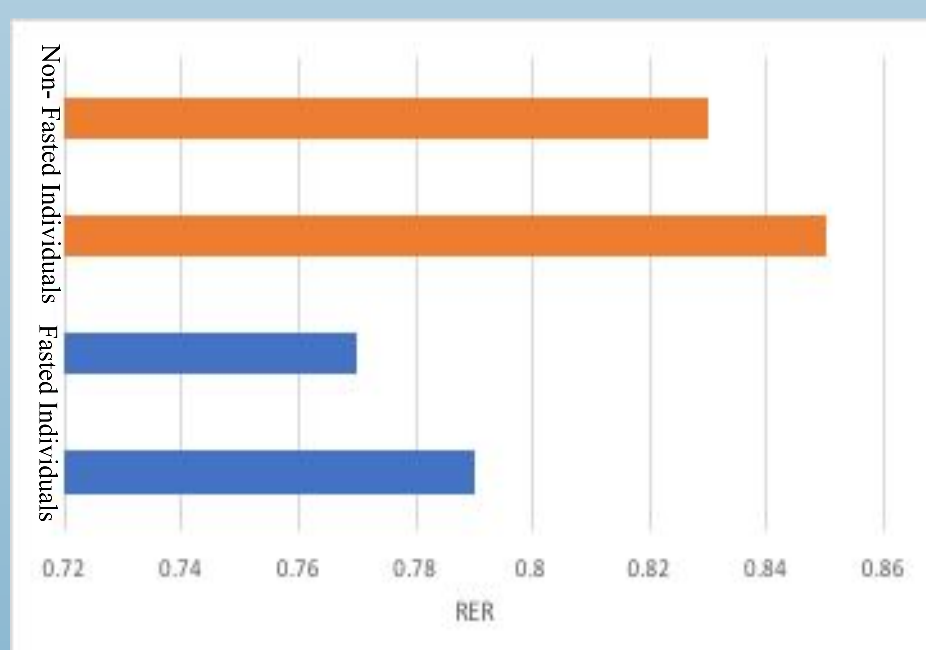

Figure 2: *Comparison Between Fasted and Non-fasted Subject's RER Values During Third Stage of Submaximal Treadmill Protocol*

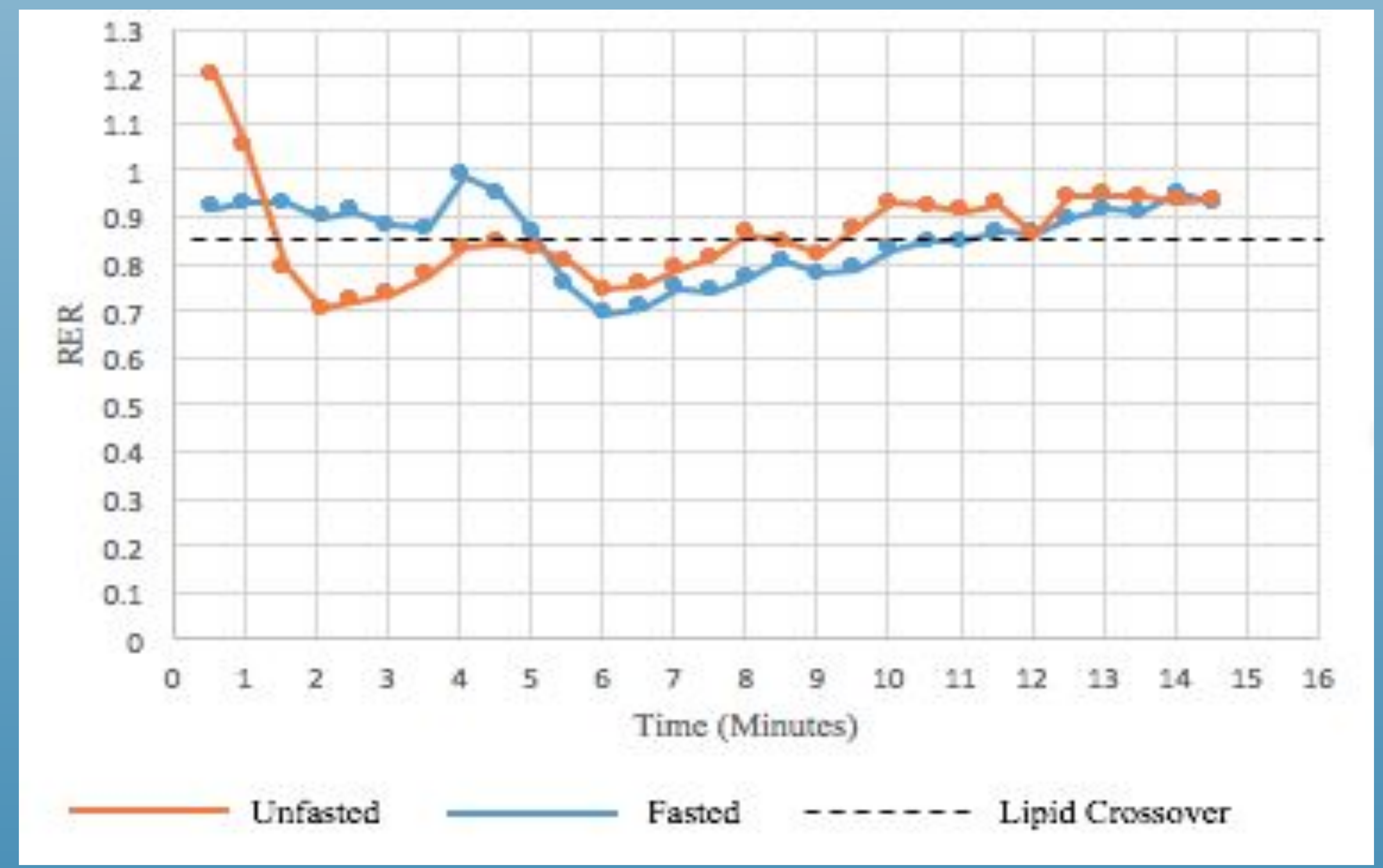

Figure 3: *Comparison Between Fasted and Unfasted Subject's RER Values Over Time in Relation to Lipid Crossover During Submaximal Treadmill Protocol*

Discussion

The results of this experiment support the stated hypothesis. Additionally, there are several conclusions which can be made from the data collected in this experimental study. It appears that overall, fasting prior to exercise *will* cause fat oxidation to be utilized as the primary fuel source at higher percentages compared to non-fasted individuals throughout a submaximal exercise test. However, the data did not display this conclusively throughout the entire protocol for all of the included subjects.

According to Stannard et al. (2010), training in an overnight fasted state enhances storage of muscle glycogen compared to training in the fed state. The study conducted by Stannard et al. (2009) included eight females and six male healthy participants. The subjects were randomly divided into groups, one group being fasted, and called the FAST group and another group was fed, and called the FED group. The study concluded that training in a fasted state enhances storage of muscle glycogen during exercise. This was observed in the laboratory experiment considering overall the fasted individuals spent more time utilizing fat oxidation for fuel, which would increase the amount of muscle glycogen which remains stored. This was much more prevalent in the male subject data. Although the female fasted subject had overall lower RER values throughout testing, the differences throughout the early and middle stages appeared almost negligible. As displayed in Figure 1 the differences between the two male subjects were extremely significant throughout the entire protocol. Resting and all 4 stages of the protocol displayed the fasted subject having significantly lower RER values. This reflects that fat oxidation was the more dominant fuels source for the fasted subject. From this it is assumed that the fasted subjects stored more muscle glycogen compared to the fed subjects.

According to Bergman & Brooks (1999), food intake 3-4 hours before exercise increases carbohydrate oxidation during exercise. Thus the fed nutritional state predisposes subjects to carbohydrate oxidation regardless of training state and exercise intensity. In the laboratory study, it was evident the non-fasted subjects were predisposed to more frequent fat oxidation when compared to the fasted subjects. Figure 2 displays that during stage 3 each of the fasted subjects had lower RER values when compared to the non-fasted subjects. Additionally, Figure 3 displays that overall the fasted subjects had lower RER values at all different intensities and stages of the protocol.

According to Goedecke et al. (2000), it has long been recognized that both dietary fat and carbohydrates both serve as substrates for energy metabolism, and that relative contribution of the two substrates to power production can be influenced by factors such as the pre-exercise diet. This study conducted by Goedecke et al. (200) included 45 males and 16 female endurance trained cyclists. The study worked to display how various individual factors contribute to differences in RER both during rest and throughout a cycle ergometer test. The results of this study proved that both muscle fiber type and relative distribution as well as dietary intake prior to exercise were strongly correlated with RER during the latter stages of the protocol. These stages were all above 25% of the peak watts. This study was very in-depth, and required extremely invasive measurements to determine the ratio of each muscle fibre types found within the individuals being tested. Although the laboratory study did not include as much detail, the findings were similar in the regard to the effect that different levels of accessible fuel had on the RER values throughout the protocol.

Conclusion

In conclusion, the study of fasted versus non-fasted individuals and their fuel sources used during exercise presented results that favored the use of lipids during submaximal exercise specifically for unfasted individuals. The hypothesis presented expected conclusive results for higher lipid consumption among fasted individuals. However, the data collected during the stages 1 and 2 of the protocol for the female subjects presented negligible differences between the fasted and un-fasted individuals. Male data presented the desired results of consistent lipid usage throughout the study for the fasted individual, which supported the hypothesis. Further studies should repeat the experiment with larger sample size to ensure that RER values are conclusive.

References

1. Bergman, B., C., Brooks, G., A. (1999). Respiratory gas-exchange ratios during graded exercise in fed and fasted trained and untrained men. Journal of Applied Physiology, 86(2), 479-487. doi:10.1152/jappl.1999.86.2.479
2. Goedecke, J. H., Gibson, A. S. C., Grobler, L., Collins, M., Noakes, T. D., & Lambert, E. V. (2000). Determinants of the variability in respiratory exchange ratio at rest and during exercise in trained athletes. American Journal of Physiology-Endocrinology and Metabolism, 279(6). doi: 10.1152/ajpendo.2000.279.6.e1325
3. Stannard, S. R., Buckley, A. J., Edge, J. A., & Thompson, M. W. (2010). Adaptations to skeletal muscle with endurance exercise training in the acutely fed versus overnight-fasted state. Journal of Science and Medicine in Sport, 13(4), 465-9. doi: 10.1016/j.jsams.2010.03.002.
4. McArdle, W. D., Katch, F. I., & Katch, V. L. (2016). *Exercise physiology: Nutrition, energy, and human performance*(8th ed.). Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins.