The Effects of Food Intake & Physical Activity on Resting Metabolic Rate

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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.

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INTRODUCTION

Resting metabolic rate (RMR) measures the energy a person requires to sustain vital body function while at rest. RMR is the most considerable element of total daily energy expenditure (McArdle et al., 2015). RMR varies depending on gender, age, weight, fat-free body mass (FFM), and physical fitness level (McMurray et al., 2014). During this study, RMR was measured indirectly by measuring the volume of oxygen consumption (VO2), the volume of carbon dioxide production (VCO2) (McMurray et al., 2014). The proper protocol for measuring RMR was to have the subject complete an overnight fast and refrain from working 12-18 hours before the test (McArdle et al., 2015). This protocol ensures an accurate RMR measurement because recent food intake and recently active skeletal muscle can cause an increase in RMR (Speakman & Selman, 2003). However, this study deviated from this protocol to examine the impact of eating and exercising on the measured RMR value compared to the value from an estimation equation, for each subject. The Cunningham equation and the Harris-Benedict equation were used for the prediction values. The drive to understand the physiological changes that occur when one has recently eaten and participated in physically activity, inspired the idea to see how big an impact those aspects had on RMR. Often known as the "rest and digest" stage, the parasympathetic nervous system would normally be in a total resting stage for the RMR test. However, in this lab, the subjects were currently "digesting", and their skeletal muscle is recovering, causing the subjects to not truly be in a resting state to test RMR. The purpose of this study was to compare subjects measured resting metabolic rate (RMR) results, after breaking standard preparation protocol, to the equation based estimated kcal/day values. The hypothesis of this lab is that the measured RMR level of each subject, both male and female, would have a significant increase of the RMR value when compared to the predicted RMR. Between both the Cunningham prediction equation and the Harris-Benedict equation, it was expected that during the test subjects measured RMR would show a significant increase from the estimation equation.

METHODS

Six volunteers, three females and three males, were used as the subjects for the study. All subjects were thoroughly informed of the test they were participating in and made aware of the proper preparation. In preparation for this study, the subjects ate according to their normal intake for the day within 12-18 hours of the test, had eaten a meal within 1 hour of the test, and participated in some type of physical exercise within 2 hours of the test. Two prediction equations were used to calculate each subject's estimated resting kcal/day: the Harris-benedict equation and the Cunningham equation. The independent variables for the test were determined to be the subject's characteristics such as stature, body mass, fat free body mass, age, and activity level. The dependent variables for the test were determined to be the subject's preparation for the test such as eating and exercising before the test. The following materials and equipment were used: a metabolic cart with proper equipment, the hood, a heart rate monitor, a table for the subject to lie on, and a blanket. In preparation for the test, the metabolic cart was gas calibrated by ensuring the cart's gas umber corresponded to the connected RMR gas tank and a flowmeter calibration was completed. Each subject was clearly informed of the procedure and the required proper preparation of the test. A date was scheduled for each subject to participate in the RMR test to allow them to prepare properly within the 12-18 hours before the test. On the scheduled date, information for the estimation equations was gathered from each subject to estimate their average kcal/day using the two prediction equations. Two prediction equations were completed for each subject using the individual's characteristics of body mass, stature, fat free body mass (FFM), age, and gender. The subject was instructed to lie on the table for 15 minutes before the test began to attempt to reach a resting state. Once the subject reaches a resting state, the dilution pump is turned on and the hood can then be placed over the subject's head. The RMR test was then completed on each of the subjects according to the following timeline.

RESULTS

The total number of subjects was 6 with 3 females and 3 males. All subjects are between the age of 20 and 21 years. The mean weight and height were higher in males than in females which is to be expected. Also, the percent body fat was higher in males than females. The absolute difference for each subject was measured and the mean of the measurements was calculated. The absolute difference was expected to be a positive difference due to the alterations in the preparation of this test. The mean absolute difference was higher for males than females. The relative difference included each subject's body weight in kilograms (kg). The relative difference was expected to a positive difference also. The relative difference was higher for males than females. Also, the absolute and relative differences were higher for the Harris Benedict prediction equations compared to the Cunningham prediction equation.

Table 1

Demographics of Subjects

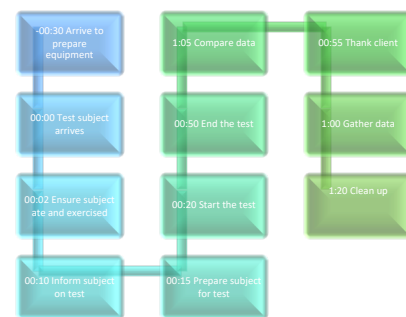|	Number	Mean Age	Mean Weight	Mean Height	Mean % Body Fat
Total	6	20.33	79.47	68.00	23.64
Males	3	20.33	92.42	71.00	22.02
Females	3	20.33	66.51	65.00	25.27

Note. Age in years, Weight in kilograms, Height in inches.

Table 2

Absolute Difference between Predicted and Measured RMR

	Mean Absolute Difference (Cunningham)	Mean Absolute Difference (Harris Benedict)
All	252.75	332.03
Males	377.65	455.30
Females	127.85	208.77

Table 3

Relative Difference between Predicted and Measured RMR

	Mean Relative Difference (Cunningham)	Mean Relative Difference (Harris Benedict)
All	2.93	4.21
Males	4.30	6.00
Females	1.56	2.85

Timeline:
- -00:30 Arrive to prepare equipment
- 00:00 Test subject arrives
- 00:02 Ensure subject ate and exercised
- 00:10 Inform subject on test
- 00:15 Prepare subject for test
- 00:20 Start the test
- 00:50 End the test
- 00:55 Thank client
- 1:00 Gather data
- 1:05 Compare data
- 1:20 Clean up

DISCUSSION

The average value of RMR for females is 0.839 kcal/kg/h, respectively; the average value of RMR for males is 0.892 kcal/kg/h, respectively (McMurray et al., 2014). During this test, all subjects' measured RMR exceeded the estimated values from the prediction equations. This result was hypothesized to be the consequence of food intake and physical activity within two hours of the RMR test. This result is consistent with the literature. According to Compher et al. (2006), a subject's food intake and physical activity levels before the conduction of the RMR test can significantly affect the results. According to Mole (1990), excessive food consumption increases RMR while fasting, and a low-calorie diet causes RMR values to decrease.

The increased RMR from food intake and physical activity is believed to be due to the needed increase of metabolic rate to digest food and recover from physical exertion (Compher et al.,2006). According to Berke et al. (1992), physical activity within two hours before the RMR test increases the test's estimated kcal/day. If the skeletal muscle is recently active, it can cause a temporary increase in RMR due to its continuous use of energy to produce work and recover from work production (Speakman & Selman, 2003). However, the long-term effect of regular physical activity can cause a lasting increase in an individual's baseline RMR due to an increase in fat-free body mass (FFM). Table 1 displays the mean weight and height of the subjects. As expected, the males were higher in both categories. This implies that male subjects would have a higher average kcal/d than the female subjects. Figure 1 displays that the measured and estimated kcal/day of the males was higher than that of the females. Table 2 and 3 depict the difference between the differences between the estimation equations and the measured RMR. The measured value was higher than both equations, as expected due to the preparation of the subjects. The absolute and relative differences of the male subject was significantly higher than the female subjects. This was expected due the males having higher body mass and higher kcal/day value than the females. The tables also depict the Harris Benedict equation's estimated values averaged higher than the Cunningham equation's values. The Cunningham equation's estimations may be more accurate due to the inclusion of subject's FFM.

RQ is the ratio of carbon dioxide production to oxygen consumption. It was measured that all subjects stayed within a respiratory quotient (RQ) value of 0.85-1.0. When RQ surpasses 1.0, a subject's carbon dioxide production (VCO2) increases past oxygen consumption (VO2). The subjects' RQ range depicts that all subjects were primarily using carbohydrates as their primary energy substrate. The usage of carbohydrates implies that the subjects could not reach a true resting metabolic rate due to an increased need for energy production (McArdle et al., 2015). When the need for energy increases, adenosine triphosphate (ATP) is produced to fuel the completion of metabolic work (such as digesting macronutrients and replenishing muscle nutrients) (McArdle et al., 2015). A balance between energy intake and energy expenditure is vital to reaching performance and health goals. Many athletes and dieticians rely on accurate RMR measurements to calculate the necessary caloric intake for an individual's health and fitness goals. To have accurate RMR data, it is essential to follow the preparation protocol for the subject. For example, if an RMR was miscalculated, the RMR test could overestimate by 300 kcal/day. While that number may seem small, an increase of 300 kcal/day can cause an immense effect on an individual's weight and health over a long period. The study supported the concept that increasing FFM will increase baseline RMR discussed above. This concept is helpful from the position of a dietitian or exercise physiologist in determining how to reach the goal weight/body composition of a client. For accuracy of measured RMR, the first five minutes of the test were thrown out to ensure the subject was in a proper resting state. The results revealed slight differences in the absolute and relative values of measured RMR, Harris-benedict equation, and Cunningham equation. There were no significant errors during this study. However, suppose the study were to be repeated; In that case, it may be beneficial to regulate the subjects' food consumption and the mode/intensity of physical activity the subjects completed for added knowledge and understanding of the effect of food intake and physical activity on RMR. If food intake was regulated, it may be possible to measure the effect that higher consumption of certain macronutrients has on measured RMR, and the effect that high-intensity training could have versus endurance training on RMR. This study aimed to determine if, and the extent, to which eating and exercising before an RMR test could affect the results. The thermic effect of digesting food and the energy requirement to recover from high physical exertion were hypothesized to increase the RMR results considerably. The results of the study supported the original hypothesis.

Figure 1

A Comparison of Subjects' Measured and Estimated RMR Values by Gender

Legend: Mean Cunningham, Mean Harris Benedict, Mean Measured
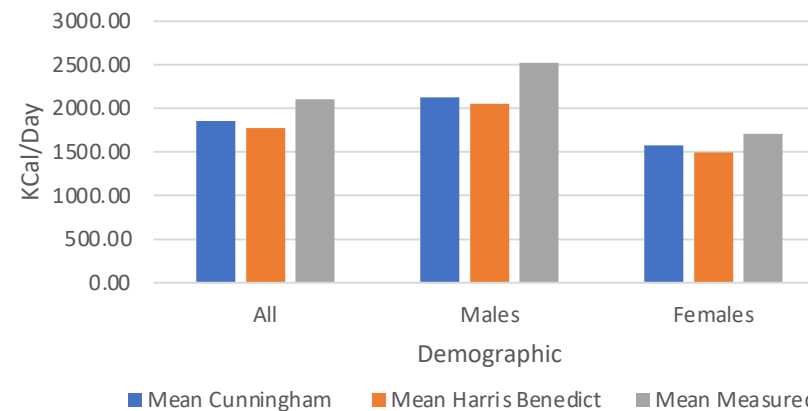
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