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The Impact of Intermittent Fasting and Exercise on Resting Metabolic Rate and Respiratory Quotient

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ABSTRACT

Smith M, Edwards A, Gateless K, Aab B, Sherrard K, Bolyard C, Stover S. The Impact of Intermittent Fasting and Exercise on Resting Metabolic Rate and Respiratory Quotient. **JEPonline** 2019; 22(7):22-29. Obesity is associated with serious health risks, including cardiovascular disease, diabetes mellitus, and certain cancers. However, evidence suggests that long-term dieting might actually slow down metabolic rate, making it difficult to maintain a healthy body weight. Intermittent fasting (IF) is a method of caloric restriction that involves alternating periods of fasting and non-fasting. The present study investigated the hypothesis that a combination of IF and exercise will allow resting metabolic rate (RMR) to be maintained long-term. Furthermore, it was hypothesized that a combination of IF and exercise will significantly decrease the respiratory quotient (RQ), an estimate of macronutrient utilization. For 3 months, subjects practicing IF ate only during an 8-hr window each day and fasted for the next 16 hrs. A standard diet control group maintained a normal diet spread out over the course of 14 to 18 hrs each day. Based on the data obtained from fitness-tracking devices, the subjects were placed into 1 of 3 activity level groups: minimum exercise, moderate exercise, and maximum exercise. Indirect calorimetry was employed to determine RMR and RQ. No significant differences were found between the 2 groups of subjects at any activity level, suggesting that IF does not slow RMR and does not affect macronutrient utilization.

Key Words: Adaptive Thermogenesis, Resting Energy Expenditure

INTRODUCTION

Obesity in adults is defined as a body mass index (BMI) greater than or equal to 30. Rates of obesity in the United States have been increasing steadily since 2003 (13). This is a serious health problem, given that obesity is associated with an increase in cardiovascular disease, diabetes mellitus, and certain cancers (12,19). As a result, for decades specific diets have been developed to help promote weight loss. However, the evidence suggests that long-term dieting may adversely affect an individual's metabolic rate by hindering efforts to control body weight (9,18).

Resting metabolic rate (RMR) is the energy required by the body to perform basic functions when the body is at rest. Thus, it is distinct from metabolism during exercise and metabolism after eating. As the primary contributor to total energy expenditure, RMR is responsible for up to 75% of the daily expenditure. During periods of energy deficit, perhaps due to weight loss, energy expenditure may be reduced by slowing RMR. This metabolic adaptation, referred to as adaptive thermogenesis, may lead to a chronic reduction in RMR that promotes weight gain over time (3,5).

Respiratory quotient (RQ) is the ratio of CO_2 exhaled to the amount of O_2 consumed. RQ reflects the relative contributions of fat and carbohydrate (CHO) to the oxidative fuel mixture (11). A value of 0.7, for example, indicates that fats are the primary fuel source, while a value of 1.0 would indicate that CHO is the favored fuel.

Intermittent fasting (IF) is a method of caloric restriction that involves alternating periods of fasting and non-fasting (14). Previous studies have reported health benefits associated with IF that include a decrease in fat mass, an increase in fat oxidation, and maintenance of RMR (8,10). Activity level can also have an influence on RMR and RQ. Regular physical activity results in an increase in RMR, while promoting the utilization of more fat-based metabolic fuel (6).

It has been suggested that IF might be an effective means of long-term weight reduction. Hence, the present study investigated the hypothesis that a combination of IF and exercise allows for RMR to be maintained longer, which would help to avoid adaptive thermogenesis. In addition, it was hypothesized that a combination of intermittent fasting and exercise would significantly reduce RQ due to the increase in the rate of fat utilization at rest.

METHODS

Subjects

This research was approved by the Institutional Review Board (IRB) of Davis & Elkins College. A total of 8 males (age 21 to 57) and 8 females (age 21 to 58) signed consent forms to participate in the study. For 3 months, the subjects practicing IF (n = 5) ate only during an 8-hr window each day (from 11:00 a.m. to 7:00 p.m., for example) and fasted for the next 16 hrs. A standard diet control group (n = 11) maintained a normal diet spread out over the course of 14 to 18 hrs each day. The IRB guidelines prohibited the prescription of specific diets for the research subjects. The small sample of subjects in the IF group initiated the diet on their own. Also, they had been fasting regularly for at least 1 yr prior to the study.

Based on 3 months of data collected from wristband-embedded fitness tracking devices (Fitbit Flex, Fitbit Inc., San Francisco, CA), subjects were placed into 1 of 3 activity level groups: (a) minimum exercise (MIN; fewer than 8,000 $steps \cdot day^{-1}$); (b) moderate exercise (MOD; between 8,000 and 12,000 $steps \cdot day^{-1}$); and (c) maximum exercise (MAX; more than 12,000 $steps \cdot day^{-1}$). Since the American Heart Association recommends 10,000 $steps \cdot day^{-1}$ for a heart-healthy lifestyle (2), 10,000 $steps \cdot day^{-1}$ was designated as the midpoint of the moderate exercise range.

Procedures

Once per month the subjects fasted overnight (8 to 12 hrs) and reported for data collection between 7:30 a.m. and 8:30 a.m. They were encouraged to drink enough water to limit dehydration. Body weight and body fat percentage data were collected using a digital scale capable of measuring electrical impedance (Fitbit Aria, Fitbit Inc., San Francisco, CA). Resting heart rate (HR) and blood pressure were determined via fingertip pulse oximeter and sphygmomanometer, respectively.

RMR was measured by indirect calorimetry. A metabolic cart and canopy system (Cardiopulmonary Exercise Testing System, COSMED, Rome, Italy) was used to analyze gas exchange, allowing measurement of actual RMR and calculation of predicted RMR via the Harris-Benedict equation: RMR for males = 66.473 + 5.003 × height + 13.75 × weight − 6.75 × age; RMR for females = 655.1 + 1.85 × height + 9.563 × weight − 4.676 × age. Measured gas exchange data were used to calculate RQ and estimate the use of fat and CHO as fuel sources. Each subject rested quietly in a supine position under the canopy for 20 min. The first 5 min served as an acclimation to steady state, a period when the average minute VO_2 and VCO_2 changes by less than 10% and the average RQ changes by less than 5%. Only data from the final 15 min of the test were used to determine RMR and RQ.

Statistical Analysis

ProStat version 5.5 (Poly Software International, Pearl River, NY) was used for statistical analysis. The RMR and RQ data were subjected to a multiple comparison analysis of variance (ANOVA). The Fisher's least significant difference test was employed to compare specific groups in the ANOVA. An alpha level of $P<0.05$ was regarded as statistically significant. The data are expressed as mean ± standard error.

RESULTS

While the average age of the IF subjects was significantly greater than that of the standard diet subjects, all other anthropometric and cardiovascular variables were comparable (Table 1). There were no age or gender related differences associated with any demographic variable. In terms of RQ and percent change from the predicted RMR, there were no significant differences between the standard diet group and the IF group (Table 2).

Exercise level significantly affected resting metabolism (Figure 1). In the standard diet group, minimum exercise produced a mean RMR that was lower than predicted, and significantly lower than moderate to maximum exercise. There were no significant differences between the metabolic rates of the IF and standard diet subjects in MOD and MAX exercise groups. However, it should be noted that there were no IF subjects in the MIN group. Outcomes were similar for the RQ values. There were no significant differences between the diets at the MOD and MAX exercise levels, and there were no IF subjects in the MIN group (Figure 2).

Table 1. Anthropometric and Cardiovascular Variables.

	Standard Diet	Intermittent Fasting
Age	27.6 ± 3.6	42.0 ± 6.4*
Steps·Day^{-1}	10,013 ± 1,575.5	11,907 ± 1,959.9
BMI	25.0 ± 1.1	25.9 ± 2.4
Body Fat (%)	24.5 ± 2.0	24.6 ± 2.8
HR (beats·min^{-1})	64.5 ± 2.6	58.7 ± 3.6
SBP (mmHg)	113.9 ± 1.2	116.0 ± 2.5
DBP (mmHg)	79.3 ± 0.8	80.4 ± 1.8

BMI = Body Mass Index; **HR** = Heart Rate; **SBP** = Systolic Blood Pressure; **DBP** = Diastolic Blood Pressure; Data are presented as mean ± standard error. *Significantly different from standard diet ($P<0.05$).

Table 2. Effects of Intermittent Fasting on RMR and RQ.

	Standard Diet	Intermittent Fasting
Change from Predicted RMR (%)	5.5 ± 2.5	10.8 ± 4.6
RQ	0.86 ± 0.01	0.83 ± 0.03

RMR = Resting Metabolic Rate; **RQ** = Respiratory Quotient; Data are presented as mean ± standard error.

DISCUSSION

Results of the current study indicate that IF did not slow RMR. No significant difference was observed between the IF and the standard diet groups (Table 2). In fact, the fasting subjects exhibited metabolic rates that were more than 10% higher than predicted. Furthermore, each IF subject had been fasting for at least 1 yr prior to the study, which is sufficient time for them to have experienced adaptive thermogenesis. Moro and colleagues (10) also reported that IF did not slow RMR. In addition, they demonstrated no changes in thyroid stimulating hormone between the IF group and the standard diet group. Their findings further support the notion that IF did not promote adaptive thermogenesis. These results are very encouraging. Other diets often stimulate an initial increase in fat oxidation and weight loss, followed by a decrease in RMR and eventual weight gain (3).

Exercise level had a major impact on RMR (Figure 1). In the standard diet group, minimum exercise resulted in a mean RMR that was almost 5% lower than predicted. Conversely, moderate to maximum exercise resulted in a mean RMR roughly 9% higher than predicted, and significantly higher than the MIN group mean. Previous studies have demonstrated a similar relationship between exercise level and RMR, primarily due to the increased lean body mass associated with long-term exercise training (6,16).

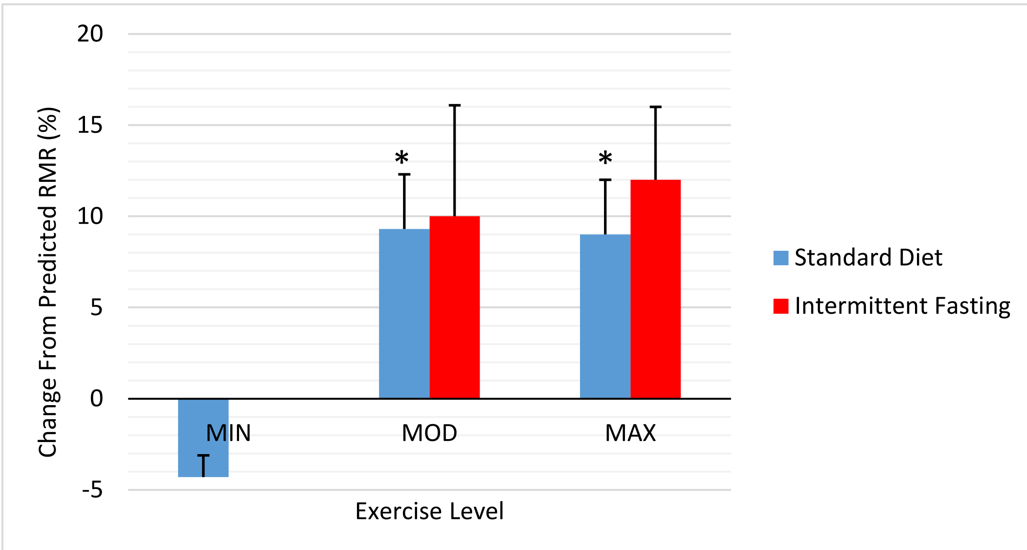

Figure 1. Exercise Effect on RMR. *Significantly different from minimum exercise ($P<0.05$).

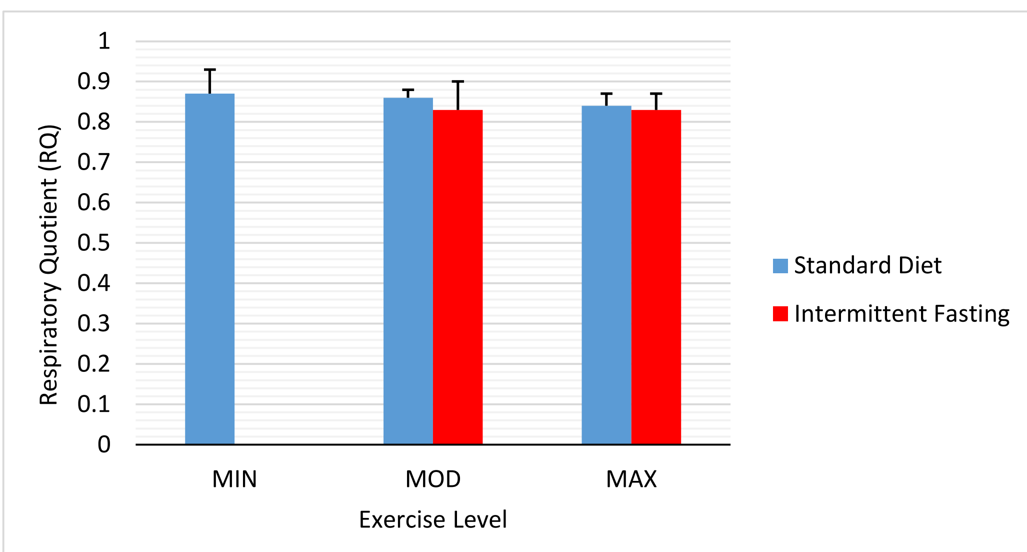

Figure 2. Exercise Effect on RQ.

Previous data reported by Roberts and Dallal (15) indicated that RMR decreases by 150 $kcal \cdot decade^{-1}$ in normal weight individuals (BMI 18.5 to 25.0). The current study indicated no age-related differences in RMR, perhaps due to the fact that the oldest participating subjects (age 47 to 58) exercised at the MOD or MAX levels.

Males tend to have higher basal metabolic rates than females. However, when adjusted for lean body mass, those differences may not be significant (4). The current study demonstrated no gender-related differences in body fat percentage or RMR.

No significant RMR differences were observed between the IF and standard diet groups at MOD or MAX exercise levels (Figure 1), although the IF subjects in the MAX group generated metabolic rates that were 12% higher than predicted. Unfortunately, we were unable to assess the combination of IF and minimum exercise in the current study, as no IF subjects exercised at the MIN level.

There were no significant differences between the RQ values, regardless of the diet or exercise level (Figure 2). Previous research comparing active and sedentary females generated similar results (6). The ketogenic diet, which is characterized by high fat, moderate protein, and very low CHO intake, can produce a dramatic decline in RQ (7,17). However, the ketogenic diet can be extremely difficult to maintain for long periods of time (1). In the current study, neither fasting nor exercise affected the utilization of macronutrients. The RQ values were consistently between 0.83 and 0.87, regardless of the diet or exercise level. Again, we were unable to assess the combination of IF and minimum exercise since no IF subjects exercised at the MIN level.

It should be noted that sample sizes in the current study were reduced considerably when the subjects were placed into separate groups based on activity level. The IF group was small at the onset (n = 5) due to the IRB restrictions. There were only 2 subjects in the IF MAX group, and no subjects in the IF MIN group. While the results of this preliminary study are encouraging, follow-up studies with larger sample sizes are necessary to confirm the metabolism-enhancing potential of intermittent fasting.

CONCLUSIONS

Although IF did not significantly affect either RMR or RQ, it is important to note that it did not decrease RMR or increase RQ. If IF can be maintained, it may offer a solution to the weight loss plateau, or even weight gain, that many dieters encounter as they attempt to control body weight over time. If resting metabolism and macronutrient utilization remain stable, the maintenance of a health body weight may be more likely.

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