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Effects of Prior Fasting on Fat Oxidation during Resistance Exercise

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ABSTRACT

International Journal of Exercise Science 11(2): 827-833, 2018. Prior research has demonstrated that the percentage of fuel utilization contributed by CHO compared to fat rises with an increase in exercise intensity. The role of food intake prior to exercise has been well studied and fasting prior to exercise generally increases reliance on fat as fuel. However, data on the role of fasting prior to resistance exercise is limited. Therefore, the purpose of this study was to assess the effects of one bout of resistance training in a fasted state compared to ingestion of standardized meal on fat and carbohydrate utilization. Twelve female (n = 12, age = 20.1 ± 0.79 yrs, height = 67.0 ± 2.63 in, weight = 143 ± 21.8 lbs) NCAA Division 1 athletes participated in the study. Each participant completed one 10 hour fasted resistance training session and one postprandial resistance training session. The respiratory exchange ratio (RER) and METs were measured using a Cosmed $K4b^2$ portable metabolic cart (Cosmed, Rome, Italy) and heart rate was measured by a Polar H1 heart rate monitor. Participants consumed the prescribed food, waited 15 minutes, and then completed three sets of five repetitions of bench press, back squat, and military press at 60% of their 1-repetition maximum. The mean fasted RER was significantly lower than postprandial for back squat (p=0.01) and military press (p=0.02), but not bench press (p=0.19). There was no difference in METs, RPE, or HR between fasted and postprandial trials for any exercise. Results suggest that fasted resistance exercise relies more heavily on fat metabolism than carbohydrate.

KEY WORDS: Breakfast; metabolism; weight training

INTRODUCTION

It is well recognized that during exercise, both dietary carbohydrate (CHO) and fat operate as substrates used for energy (3, 4). Previous literature has clearly demonstrated that the contribution of CHO utilization increases with a rise in exercise intensity and, inversely, the energy obtained through fat oxidation decreases (1, 2, 15). In addition to intensity, the balance of CHO and fat substrate utilization during exercise is influenced by pre-exercise diet (14, 17).

Evidence collected on substrate utilization through respiratory exchange ratio (RER) during aerobic exercise demonstrates that fat oxidation peaks around a moderate intensity of 45-65% VO_{2max} and then the fat contribution to energy expenditure declines (3, 15). Most literature agrees that during moderate exercise around ~45% VO_{2max}, or an RER of 0.85, is the point at which energy derived from CHO and fat are about equal (7). Romijn, Coyle, Sidossis, Gastaldelli, Horowitz, Endert and Wolfe (15) analyzed CHO and fat metabolism during cycling bouts at 25%, 65% and 85% VO_{2max} and revealed a higher oxidation of fat at 25% and 65% VO_{2max} and a greater metabolism of CHO at 85% VO_{2max}. It should be noted that data on CHO and fat utilization in these studies were measured in aerobic exercise and not resistance training.

Research investigating the effect of resistance exercises on RER during the resistance training bout is lacking. Most studies analyzing CHO and fat use with resistance training have focused on measuring energy metabolism over a period of time post-exercise (9, 13, 16). Melby, Scholl, Edwards and Bullough (11) found that resistance exercises increased fat oxidation as measured through post-exercise metabolic rate for 24-hours after training. These findings are similar to Osterberg and Melby (13) who observed a lower average RER, and therefore greater lipid metabolism, after one strenuous weight training session compared to a non-training day. It is important to note that substrate utilization was not reported or analyzed during the resistance training session and the contribution of CHO and fat throughout the exercise bout is unknown. Further research is necessary to elucidate the specific percentages of energy derived from CHO and fat while performing resistance exercise.

The effects of food intake on the substrate utilization during an aerobic training session have been widely documented, with most data indicating an increase in lipid oxidation when training in a fasted state and a reduction in lipid oxidation with ingestion of a CHO meal before exercise (5, 6, 14, 19). One study examined the impact of a traditional Ramadan fast, where no food or beverage is consumed between sunrise and sunset, on submaximal cycle ergometer exercise and both reported an increase in fat utilization during fasted exercise compared to a controlled breakfast (5). Furthermore, Sherman, Peden and Wright (17) found that ingestion of a carbohydrate-only beverage before the start of exercise led to a significantly higher RER and CHO contribution during a time-trial cycle performance in contrast to the fasted performance. However, there have been no reports on the impact of meal intake and substrate contribution during resistance training.

RER is known to increase with increasing exercise intensity, indicating a greater reliance on CHO for energy. It is also understood that performing aerobic training fasted can result in a reduction of CHO oxidation and increase of fat usage as seen through a decrease in RER. However, few studies have examined the influence of fed or fasted resistance training on substrate utilization. Therefore, the purpose of this study was to assess the effects of one bout of resistance training in a fasted condition compared to ingestion of a standardized meal on fat and carbohydrate utilization measured via respiratory exchange ratio.

METHODS

Participants

Twelve female National Collegiate Athletic Association (NCAA) Division 1 athletes from Samford University participated in this study. Participants were recruited through word of mouth and email. Ability to participate was evaluated via medical history questionnaire, which excluded those who reported smoking, pregnancy, cardiovascular disease, musculoskeletal disease, diabetes or other health problems. Athletes were active members of either the volleyball, track, tennis or the crew team. As a collegiate athlete, all participants engaged in resistance training as part of their strength and conditioning routine and were familiar with the exercises in this study and their one-repetition maximum (1-RM) values. All participants provided informed consent and the experimental protocol was approved by the Samford University Institutional Review Board.

Protocol

Data were collected on two non-consecutive days with a minimum of 48 hours separation between sessions, using a within-group study design. Height and weight of each participant were measured without shoes using a stadiometer and scale. The 1-RM for the military press, back squat and bench press were self-reported by the participants from values obtained during their strength and conditioning training. All participants completed 1-RM testing within a month prior to the study.

The study consisted of two randomized trials: one fasted resistance training session and one postprandial resistance training session. For both trials, participants arrived to the laboratory after an overnight fasting period of 10 hours and all trials began before 12:00pm. For the postprandial trial, participants were provided a standardized breakfast, modified from de Lima et al. (8), consisting of a cereal bar and 120 grams of a banana. With both food items combined, this standardized meal contained 3.3 g protein, 50.9 carbohydrates and 3.4 g fat for a total of 225 kcals and provided a carbohydrate-rich meal. During the fasted session, participants completed the same 15 minutes of rest but without the provided meal (8).

RER and METs were measured using a Cosmed K4b² portable metabolic cart (Cosmed, Rome, Italy) and heart rate was measured by a Polar H1 heart rate monitor (Polar, Kempele, Finland). The K4b² unit uses a breath-by-breath measurement of gas exchange through a rubber facemask (Hans Rudolph V Mask™; Hans Rudolph Inc., Shawnee, KS, USA) sealed around the participant's mouth and nose and a turbine for gas collection. The K4b² unit was worn by the participant using a harness to allow for portability of the system. The weight of the K4b² system is approximately three pounds. The participant wore the K4b² and heart rate monitor for all three exercises and all rest periods. Data from the Cosmed was stored in the memory and downloaded to a computer at the completion of each trial for analysis.

The three resistance training exercises investigated were the bench press, back squat and military press (16), selected for their commonality in resistance training programs, emphasis of different muscle groups, and inclusion of both upper and lower body lifts. The resistance exercise session was a single bout of low-volume resistance exercise, adapted from the protocol previously described by Wallace et al. (23). Each exercise was performed for one set of five repetitions at 60% of 1-RM. Both the bench press and back squat used a barbell and the military press was performed with dumbbells. The barbell was an Olympic bar weighing 22 kg (44 lbs).

Weight was adjusted to 60% of 1-RM by adding plates to both sides. The participants rested for five minutes between the bench press and back squat and 1.5 minutes between the back squat and military press exercises.

During the bench press, participants lay supine on a flat weight bench with their feet flat on the ground for the entire movement and barbell held with a shoulder-width grip. The top of the repetition was considered to be when the participant's elbows were at full extension and the bottom of the repetition was an approximate 75 degree angle of the elbows. For the back squat, the barbell was placed behind the neck and on the upper part of the shoulders and the participant's feet were shoulder-width apart. The top of the repetition was defined as full knee extension and the bottom of the repetition was an approximate 90-degree knee flexion. The military press was performed with dumbbells in each hand. The top of the repetition was defined as full extension of the elbows with dumbbells overhead and the bottom of the repetition when the elbows were bent approximately 90-degrees.

Statistical Analysis
Paired t-tests (Microsoft Excel) were used to compare mean RER, METs, RPE, and HR between the fasted and postprandial trials. Alpha value was set a priori to 0.05.

RESULTS

The mean age of the female participants was 20.08 ± 0.79 years, height was 67.04 ± 2.63 inches, and weight was 143.68 ± 21.76 pounds. The mean fasted RER was significantly lower than postprandial for back squat (p=0.01) and military press (p=0.02), but not bench press (p=0.19). There was no difference in METs, RPE, or HR between fasted and postprandial trials for any of the three exercises (see Table 1). Back squat elicited a higher RER, HR and MET intensity than bench press or military press while there was no difference in RPE (Table 1).

Table 1. Mean ± standard deviations for respiratory exchange ratio (RER), metabolic equivalents (METs), rating of perceived exertion (RPE), and heart rate (HR) in beats per minute for bench press, back squat, and military press in the fasted and postprandial state. * indicates statistically significantly different from postprandial value for the specified exercise (alpha < 0.05). † indicates statistically significantly different from bench press and military press (alpha < 0.05).

	Bench Press		*Back Squat*		*Military Press*	
	Fasted	**Postprandial**	**Fasted**	**Postprandial**	**Fasted**	**Postprandial**
RER	0.88 ± 0.16	0.94 ± 0.16	0.74 ± 0.08*†	0.80 ± 0.07	0.86 ± 0.09*	0.94 ± 0.09
METs	3.14 ± 0.59	3.30 ± 0.50	5.58 ± 0.97†	5.56 ± 1.00	4.02 ± 0.73	3.94 ± 0.53
RPE	13.0 ± 1.6	12.8 ± 1.8	12.3 ± 0.9	11.9 ± 0.9	12.6 ± 1.5	12.6 ± 1.5
HR	86.8 ± 20.8	80.8 ± 10.1	116.6 ± 11.16†	111.8 ± 11.8	107.0 ± 16.0	97.5 ± 11.0

DISCUSSION

These data suggest that fasted resistance exercise relies more heavily on fat metabolism than carbohydrate. Others have found similar reliance on fat as a fuel source during fasted aerobic exercise (5, 6, 14, 18). However, we are unaware of other studies that have examined the role of fasting compared to feeding on resistance exercise fuel utilization. Our data suggest that fasted resistance training has a similar effect on fuel usage, at least during the exercise bout itself, as does aerobic exercise. We found that during two of the three exercises performed (back squat and military press), the fasted state resulted in lower RER and therefore higher reliance on fat as fuel compared to the postprandial state.

All participants performed the exercises in the same order (bench press, back squat, military press) after consuming the standardized meal and waiting 15 minutes. We found no difference in fasted versus postprandial RER in bench press, the exercise performed closest in time to the food consumption, but did find greater fat reliance in the later-performed exercises. Thus, it may be that 15 minutes is an inadequate rest time from food consumption to exercise, as the effect of the feeding may not be evidence at that time. We opted not to counterbalance the order of exercises because the location of the Cosmed device was difficult to change during the session, and because HR, RPE, and VO2 were unlikely to be influenced by performing the tasks in varying orders. Previous literature suggests plasma glucose concentrations peak approximately 30 - 60 minutes after consumption of carbohydrates (10, 20). This further implies the lack of change in substrate utilization during the first resistance exercise between the fasted and fed trials can be attributed to an insufficient rest duration to allow for an increased uptake and oxidation of blood glucose from the high-carbohydrate meal. However, it is important to point out that the total exercise time, while variable between participants, did not take longer than 15 minutes, suggesting that digestion and absorption of the food did impact fuel utilization within 30 minutes (the total time participants were present in lab, from food consumption to performance of the final exercise).

Data from studies of aerobic exercise indicate that 24-hour fuel utilization is altered by exercising in the postprandial state compared to fasted (18), and other research has shown the time course is estimated to be 6 hours, meaning that the fuel use changes post-exercise persist until that time (12). However, our study did not address the role of resistance training on fuel utilization changes beyond the exercise bout itself. Because our data indicate that fuel utilization during fasted resistance training changes in the same fashion as fasted aerobic exercise, we speculate that fasting during resistance exercise impacts post-exercise fat oxidation similarly to aerobic exercise. Therefore, increased reliance on fat for fuel over the course of hours or even days could potentially impact body composition and lead to lower percent fat in body composition analysis. However, this is speculative.

There could be beneficial effects of fasted resistance training on body composition, similar to those found with fasted aerobic exercise, which has been shown to decrease percent body fat in active men who fast during Ramadan (21). However, bodybuilders who resistance trained during a fasted state did not have different body composition changes compared to bodybuilders who trained in a postprandial state (22). It is unclear whether the reason the active men responded favorably to fasting is because they did aerobic as opposed to resistance training or because they were only recreationally active, whereas the bodybuilders were leaner (14-15% body fat compared to 19.3-19.4% body fat in the recreationally active males). Though there is reason to believe body composition might be affected long-term, the potential impacts on athletic performance are unknown. Future work should investigate the time-course of fuel utilization changes with fasted resistance exercise, and whether these changes impact body composition in the long term. Potential drawbacks, such as hypoglycemia, have been poorly studied and should also be investigated. Overall, our data indicate that fasting prior to resistance training does indeed result in increased reliance on fat as fuel, the impacts on fuel use throughout the subsequent day, as well as the long-term effects, are unknown.

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