Postexercise Glycogen Recovery and Exercise Performance is Not Significantly Different Between Fast Food and Sport Supplements

Michael J. Cramer, Charles L. Dumke, Walter S. Hailes, John S. Cuddy, and Brent C. Ruby

A variety of dietary choices are marketed to enhance glycogen recovery after physical activity. Past research informs recommendations regarding the timing, dose, and nutrient compositions to facilitate glycogen recovery. This study examined the effects of isoenergetic sport supplements (SS) vs. fast food (FF) on glycogen recovery and exercise performance. Eleven males completed two experimental trials in a randomized, counterbalanced order. Each trial included a 90-min glycogen depletion ride followed by a 4-hr recovery period. Absolute amounts of macronutrients (1.54 ± 0.27 g·kg⁻¹ carbohydrate, 0.24 ± 0.04 g·kg⁻¹ fat, and 0.18 ± 0.03 g·kg⁻¹ protein) as either SS or FF were provided at 0 and 2 hr. Muscle biopsies were collected from the vastus lateralis at 0 and 4 hr post exercise. Blood samples were analyzed at 0, 30, 60, 120, 150, 180, and 240 min post exercise for insulin and glucose, with blood lipids analyzed at 0 and 240 min. A 20k time-trial (TT) was completed following the final muscle biopsy. There were no differences in the blood glucose and insulin responses. Similarly, rates of glycogen recovery were not different across the diets (6.9 ± 1.7 and 7.9 ± 2.4 mmol·kg wet weight⁻¹·hr⁻¹ for SS and FF, respectively). There was also no difference across the diets for TT performance (34.1 ± 1.8 and 34.3 ± 1.7 min for SS and FF, respectively). These data indicate that short-term food options to initiate glycogen resynthesis can include dietary options not typically marketed as sports nutrition products such as fast food menu items.

It is common knowledge that muscle glycogen stores can be significantly replenished when dietary carbohydrate (CHO) sources are ingested following a glycogen depleting bout of exercise (Bergstrom & Hultman, 1966). The positive relationship between initial muscle glycogen stores and work time to exhaustion (Ahlborg et al., 1967) has led to the present dogma that exercise performance necessitates an emphasis on muscle glycogen. Research has continued to demonstrate that regular CHO feedings after glycogen depletion enhance muscle glycogen resynthesis (Ivy et al., 2002). Additional emphasis has been placed on macronutrient composition/ratios (Blom et al., 1987; Burke, Collier, & Hargreaves, 1993;; Zawadzki, Yaspelkis, & Ivy, 1992), the amount of macronutrient (Ivy, Lee, et al., 1988), and timing of ingestion (Ivy et al., 2002;) to assist athletes, clinicians, and coaches in exercise recovery and performance efforts.

Carbohydrate composition (glucose, fructose, and sucrose) and varying levels of glycemic index (GI) have demonstrated subtle impact on overall rates of muscle glycogen resynthesis (Beavers & Leutholtz, 2008; Blom et al., 1987; Burke, Collier, & Hargreaves, 1993; R. Jentjens & Jeukendrup, 2003). Collectively, these data have emphasized the concept of sports supplements as the preferred nutritional approach to facilitate glycogen recovery. In contrast, the use of chocolate milk has gained recognition as an alternative to traditional sport supplement products for glycogen recovery (Karp et al., 2006; Roy, 2008; Shirreffs, Watson, & Maughan, 2007; Thomas, Morris, & Stevenson, 2009).

While fast food is often viewed as a barrier to the prevention and treatment of obesity in children (Bonnet et al., 2014), sensible menu items may offer a more economical approach to glycogen recovery compared with costly sports supplements. Moreover, there appears to be two major stigmas associated with fast food. The first links fast food to unhealthy eating, childhood obesity, and poor nutritional choices while the second categorizes fast food ingredients as low quality. In contrast, the nutritional value and ingredient quality of sports supplemental food items goes mostly unchallenged because of marketing perceptions and a link to regular physical activity/exercise training.

The purpose of this study was to investigate the efficacy of fast food dietary sources for glycogen recovery compared with common sport supplement foods/beverages. We hypothesized that commonplace fast food options can provide adequate macronutrient needs to restore muscle glycogen and that the potential benefits will not be different from an approach using sport supplement products.
Methods

Participants

Eleven recreationally active male participants (n = 11) completed this randomized cross-over study design. Participants were healthy, injury-free and familiar with moderate to high intensity exercise (27.7 ± 6.3 years, 180 ± 8 cm, 76.8 ± 10.2 kg, 10 ± 5% fat, 4.2 ± 0.4 LO2·min⁻¹, 309 ± 32 Wmax). Before data collection, each participant completed a Physical Activity Readiness Questionnaire (PAR-Q) and provided informed consent. All procedures were approved by the University Institutional Review Board.

Preliminary Testing

All preliminary testing was completed during the same initial visit after a minimum 4-hr fast. Body composition was estimated using hydrodensitometry. Underwater weight was measured using an electronic strain-gauge scale (Exertech, Dreshbach, MN) with estimated residual lung volume (Goldman & Becklake, 1959). Body density was calculated using underwater weight and transposed to body composition using the Siri equation (Siri, 1993). Peak oxygen uptake (VO2peak) and maximal power output (Wmax) were determined in the laboratory on a cycle ergometer (Velotron, RacerMate Inc., Seattle, WA). Participants completed a graded exercise protocol starting at 95 W, increasing 35 W every 3 min until volitional fatigue. Expired gases were analyzed using a calibrated metabolic cart (ParvoMedics, Inc., Salt Lake City, UT). VO2peak was determined as the highest fifteen second average oxygen uptake during the test. Maximum power output was calculated by adding the power output (watt) of the last completed stage to the time in the stage volitional fatigue was achieved multiplied by 35 W. For example, each minute of each stage was assumed to be equivalent to 11.67 W (35·0.334 = 11.67).

In addition to the measure of VO2peak, participants completed two practice (PTT) 20km time trials (TT) on the same cycle ergometer on 2 separate days to ensure TT competency before the completion of the experimental trials. Participants were verbally instructed to complete the distance as quickly as possible and were allowed the flexibility of shifting gears electronically. Distance and time were measured using the RacerMate Inc. software. (RacerMate, Inc., Seattle, WA).

Experimental Design

Participants completed two trials with 7 days between each trial in a randomized crossover design. Trials included the consumption of sport supplement products (SS) or fast food menu items (FF) during a 4-hr recovery period after a glycogen depletion ride. A 20km TT followed the recovery period to evaluate exercise performance. Participants were instructed to abstain from exercise and keep a dietary record of all food and drink consumed 24-hr before each trial. Participants were instructed to duplicate this diet for the second trial to minimize differences in resting muscle glycogen levels. The morning of each trial, participants arrived at the laboratory following a 12-hr fast. Each participant completed the 90-min glycogen depleting exercise using the above mentioned cycle ergometer. The protocol included a 10-min warm up at 55% Wmax followed by a series of 10 intervals (2-min at 80% Wmax followed by 4-min at 50% Wmax). After the interval series, participants completed 8-min at 60% Wmax followed by a final 12-min at 50% Wmax. Water consumption was ad libitum. Following the 90-min cycling trial, participants rested in a reclined/ seated position during a 4-hr recovery period and adhered to a prescribed feeding schedule. Following the 4-hr recovery period, participants completed the 20km TT on the same cycle ergometer as described above.

Feeding Strategy

Participants consumed absolute amounts of macronutrients as either SS or FF at 0 and 2-hr of recovery. All food items were weighed for accuracy in conjunction with nutrition label serving sizes. Participants consumed the same food items, which amounted to 1.54 ± 0.27, 0.24 ± 0.04, and 0.18 ± 0.03 g·kg⁻¹ for carbohydrate, fat, and protein, respectively. Table 1 and 2 illustrate the detailed menu items.

Muscle Biopsies

Muscle biopsies of the vastus lateralis muscle were performed at 0 and 4-hr of recovery using the percutaneous biopsy needle technique with the aid of suction (Evans, Phinney, & Young, 1982). One milliliter of 1% lidocaine was injected directly beneath the skin to anesthetize an area approximately 2 cm², then an additional 2–3 ml of 1% lidocaine preparation was injected near the location of the fascia. Adrenaline was not used in combination with the lidocaine. Following the lidocaine injection a small (approximately 0.5 cm) incision was made through the skin and muscle fascia. The Bergstrom biopsy needle was then inserted through the incisions into the belly of the vastus lateralis muscle, removing approximately 30mg of tissue. Excess blood, fat, and connective tissue were immediately removed. Tissue samples were frozen in liquid nitrogen and stored in a freezer at -80 °C for later muscle glycogen analyses. The 4-hr biopsy was taken from a site approximately 2 cm proximal to the initial 0-hr biopsy location. Second trial biopsies were taken from the opposite leg and leg order was randomized across trials.

Blood Sampling

Blood samples were obtained from an antecubital arm vein using a venipuncture technique at scheduled intervals of 0, 30, 60, 120, 150, 180, and 240 min of recovery (n = 10). Samples were allowed to clot then spun at 4000 rpm for 15 min in a refrigerated centrifuge (4 °C) (Jouan Inc., MR22i). Serum was aliquoted into tubes and stored at -30 °C for later glucose and insulin analyses. Whole
blood samples were collected at 0 and 4 hr of recovery and sent to Providence St. Patrick Hospital in Missoula, MT for lipid analyses.

**Questionnaire**

Participants completed gastrointestinal discomfort questionnaires assessing feelings of hunger, fullness, sickness, and stomach discomfort at 0, 1, 2, 3, and 4 hr of recovery. A second postmeal questionnaire was administered at 0 and 2 hr of recovery assessing meal satisfaction, taste, and acceptability. Questionnaires were designed on a 150 mm visual analog scale (VAS) with “Not at all” on the left and “Extremely” on the right end points. Participants placed an “X” along the continuum in response to each question. Scores were reported as the distance from “Not at all” in mm divided by 150 mm. This technique has been previously used to evaluate dietary impacts (Kissileff et al., 2003).

**20 km Time Trial**

After recovery, participants performed a 20 km TT on the same cycle ergometer as described above (Velotron, RacerMate Inc., Seattle, WA). Participants were instructed to complete the distance as quickly as possible and were allowed to shift gears electronically. Verbal encouragement was not provided during any of the TT testing segments.

**Tissue and Blood Analysis**

Two separate muscle samples (12.7 ± 3.0 mg, obtained at the same time point) were each analyzed in duplicate to determine muscle glycogen concentrations using an enzymatic spectrophotometric method (Ruby et al., 2005). Samples were weighed and placed in 0.5 ml of 2N HCl solution. Sample solutions were weighed, incubated in an oven for two hours at 100 °C, then reweighed and

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**Table 1  Fast Food Feeding**

<table>
<thead>
<tr>
<th>Fast Food</th>
<th>Energy (kJ)</th>
<th>Fat (g)</th>
<th>Cho (g)</th>
<th>Pro (g)</th>
<th>Qty</th>
<th>Sodium (mg)</th>
</tr>
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<tbody>
<tr>
<td>0 hr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Hotcakes</td>
<td>1464</td>
<td>9</td>
<td>60</td>
<td>8</td>
<td>1</td>
<td>590</td>
</tr>
<tr>
<td>Hashbrown</td>
<td>628</td>
<td>9</td>
<td>15</td>
<td>1</td>
<td>1</td>
<td>310</td>
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<tr>
<td>Orange Juice (small)</td>
<td>628</td>
<td>0</td>
<td>34</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>2720</td>
<td>18</td>
<td>109</td>
<td>11</td>
<td>11</td>
<td>900</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Hamburger</td>
<td>1046</td>
<td>9</td>
<td>31</td>
<td>12</td>
<td>1</td>
<td>480</td>
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<tr>
<td>Coke (medium)</td>
<td>837</td>
<td>0</td>
<td>54</td>
<td>0</td>
<td>1</td>
<td>45</td>
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<tr>
<td>Fries (small)</td>
<td>962</td>
<td>11</td>
<td>29</td>
<td>3</td>
<td>1</td>
<td>160</td>
</tr>
<tr>
<td>Total</td>
<td>2845</td>
<td>20</td>
<td>114</td>
<td>15</td>
<td>15</td>
<td>685</td>
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<td>4 hr total</td>
<td>5565</td>
<td>38</td>
<td>223</td>
<td>26</td>
<td>26</td>
<td>1585</td>
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**Table 2  Sport Supplement Feeding**

<table>
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<tr>
<th>Sport Supplement</th>
<th>Energy (kJ)</th>
<th>Fat (g)</th>
<th>Cho (g)</th>
<th>Pro (g)</th>
<th>Qty</th>
<th>Sodium (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 hr</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Gatorade (20 oz)</td>
<td>544</td>
<td>0</td>
<td>34</td>
<td>0</td>
<td>1</td>
<td>270</td>
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<tr>
<td>Kit’s Organic PB</td>
<td>837</td>
<td>11</td>
<td>25</td>
<td>6</td>
<td>2</td>
<td>95</td>
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<tr>
<td>Cliff Shot Bloks (1 blok)</td>
<td>139</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>4</td>
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<td>Total</td>
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<td>22</td>
<td>116</td>
<td>12</td>
<td>12</td>
<td>527</td>
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<tr>
<td>2 hr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cytomax (1 scoop, 10 oz)</td>
<td>377</td>
<td>0</td>
<td>22</td>
<td>0</td>
<td>2</td>
<td>120</td>
</tr>
<tr>
<td>Power Bar Recovery PBCC</td>
<td>1088</td>
<td>10</td>
<td>30</td>
<td>12</td>
<td>1</td>
<td>180</td>
</tr>
<tr>
<td>Power Bar Energy Chews</td>
<td>837</td>
<td>0</td>
<td>46</td>
<td>3</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>2678</td>
<td>10</td>
<td>120</td>
<td>15</td>
<td>15</td>
<td>450</td>
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<tr>
<td>4 hr total</td>
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<td>32</td>
<td>236</td>
<td>27</td>
<td>27</td>
<td>977</td>
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</table>
reconstituted to their original weight using distilled water. To normalize pH, 1.5 ml of 0.67 M NaOH was added. Then 100 ml of the muscle extract solution was added to 1 ml of infinity glucose (HK) liquid stable reagent (ThermoTrace Ltd.) and read on a spectrophotometer at 340 nm. Muscle glycogen concentration was calculated using the extinction coefficient of NADH. Muscle glycogen concentrations are expressed in mmol•kg⁻¹ wet weight of muscle.

Blood samples were analyzed for glucose in triplicate using Infinity glucose (HK) liquid stable reagent (ThermoTrace Ltd.) and read on a spectrophotometer at 340 nm. Blood glucose concentration was calculated using the extinction coefficient of NADH. Samples were analyzed for insulin in duplicate using an enzymatic spectrophotometric ELISA method (EIA-2935, DRG International). Serum lipid analyses were performed by the laboratory at Providence St. Patrick Hospital (Missoula, MT). Samples were allowed to clot for 30 min in serum separating tubes then spun at 2500G in a refrigerated centrifuge (Beckman Coulter INC). Samples were then placed in a chemistry analyzer for reading (Dimension Vista 500, Siemens). Mean intra-assay coefficient of variation for muscle samples, glucose, and insulin was less than 5%.

Statistical Analysis

A two-tailed, paired t test was used to compare rates of muscle glycogen recovery (Microsoft Excel, Microsoft Corp., Redmond, WA). PTT and TT performance times were analyzed using a one-way ANOVA with repeated measures (SPSS Inc., Chicago, IL). Muscle glycogen, blood glucose, serum insulin, blood lipids, and questionnaire data were analyzed using a two-way ANOVA (trial × time) with repeated measures (SPSS Inc., Chicago, IL). A probability of type I errors less than 5% was considered significant ($p < .05$). All data are reported as mean ± SD.

Results

Muscle Glycogen

We were unable to detect a statistically significant difference in muscle glycogen concentration postexercise when comparing SS and FF trials at 0 and 4-hr of recovery ($p > .05$). There was a main effect for time, demonstrating an overall increase in muscle glycogen concentrations following the 4-hr recovery period ($p < .05$, $n = 11$) (Figure 1). Similarly, the calculated rate of muscle glycogen

![Figure 1](image-url) — Muscle glycogen concentration during recovery. Solid square = SS, Open square = FF $^*p < .05$ ($n = 11$) main effect for time vs 0 hr. Values are mean ± SEM.
recovery was not different between diets (6.9 ± 1.7 and 7.9 ± 2.4 mmol·kg wet weight⁻¹·hr⁻¹ for the SS and FF trials, respectively (p > .05, n = 11).

**Blood Glucose**

There was no difference for blood glucose concentrations between SS and FF trials at 0, 30, 60, 120, 150, 180, and 240 min of recovery (p > .05, n = 10) (Figure 2). There was a main effect for time, as blood glucose was elevated at 30 and 150 min compared with time 0 (p < .05, n = 10).

**Serum Insulin**

There was no difference for serum insulin concentrations between SS and FF trials at 0, 30, 60, 120, 150, 180, and 240 min of recovery (p > .05, n = 10) (Figure 3). There was a main effect for time, with serum insulin elevated at 30, 60, 150, and 180 min compared with time 0 (p < .05, n = 10).

**Blood Lipids**

There was no difference between SS and FF trials for total cholesterol, high-density, low-density lipoproteins, and triglycerides at 0 hr and 4 hr postexercise (Table 3). There was a main effect for time, which demonstrated that CHOL, HDL, and LDL were lower 4 hr postexercise compared with time 0 (p < .05, n = 10)

**20k Time Trial**

There was no difference in TT performance between PTT and the experimental trials (34.3 ± 2.1, 34.5 ± 1.9, 34.1 ± 1.8, and 34.3 ± 1.7 min for PTT1, PTT2, SS, and FF trials, respectively, p > .05, n = 11).

**Questionnaire**

There was no difference for feelings of sickness and discomfort between the trials observed at 0, 1, 2, 3, and 4 hr of recovery (p > .05, n = 11). Hunger displayed a main effect for time with scores of 42 ± 8, 64 ± 6, 28 ± 6, 53 ± 7, and 72 ± 6 mm at 0, 1, 2, 3, and 4 hr of recovery, respectively (p < .05, n = 11). Hunger was higher at 4 hr compared with time 0 hr of recovery. Participants reported being more full during the SS compared with FF immediately after the 2-hr feeding (108 ± 33 vs. 75 ± 42 mm, respectively, interaction effect, p < .05, n = 11). No difference was observed for perceived meal taste and acceptability after 0 and 2-hr feedings (p > .05, n = 11). There was no difference between the diets for feelings of satiety after 0 and 2 hr feedings, but the FF meal was more satisfying at 2 hr compared with the initial 0 hr FF meal (78 ± 32 vs. 52 ± 27 mm, respectively, interaction effect, p < .05, n = 11).

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**Figure 2** — Blood glucose concentration during recovery. —FF, —SS *p < .05 (n = 10) main effect for time vs 0 hr. Values are mean ± SEM.
**Discussion**

This protocol was designed to evaluate the impacts of nontraditional sport nutritional choices on recovery, specifically glycogen recovery, and subsequent exercise performance. This was accomplished by matching macronutrient composition from fast food menu items with commercially available sport nutrition products used for the 0 and 2 hr postexercise feedings. Primary findings demonstrate that muscle glycogen recovery and exercise performance were not different when comparing products created specifically for sport recovery and traditional fast food. These data are novel in demonstrating effective glycogen recovery benefits from fast food menu items comparable to products most often advertised as a practical option to optimize glycogen recovery.

A wide range of feeding strategies have been implemented (macronutrient composition, amount, and timing of ingestion) so as to develop specific suggested guidelines to enhance immediate glycogen resynthesis (Ivy, 1998; Ivy et al., 2002; Ivy, Katz, et al., 1988; R. Jentjens & Jeukendrup, 2003; Reed et al., 1989). Optimal glycogen recovery recommendations are 1.2 g·kg⁻¹ CHO every hour, ingested in regular intervals of 30 min or less (R. Jentjens & Jeukendrup, 2003; van Loon et al., 2000). This study chose to use a 2-hr interval feeding strategy as suboptimal, real-world application of recovery strategies where environment, nutrient source availability, and total amount of nutrient source ingestion may hinder adherence to optimal recovery recommendations. Administration of CHO immediately after exercise has been shown to improve glycogen recovery by 45% versus delayed feed-

![Figure 3](image-url)  
*Figure 3* — Serum insulin concentration during recovery.—FF, —SS *p < .05 (n = 10) main effect for time vs 0 hr. Values are mean ± SEM.

<table>
<thead>
<tr>
<th></th>
<th>FF</th>
<th>SS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Table 3</strong> Blood Lipid Profile for Both Trials (FF and SS) at the Beginning (0 hr) and End (4 hr) of Recovery</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 hr</td>
<td>4 hr</td>
</tr>
<tr>
<td>CHOL (mg/dL)</td>
<td>173 ± 32</td>
<td>160 ± 34*</td>
</tr>
<tr>
<td>TRIG (mg/dL)</td>
<td>106 ± 31</td>
<td>108 ± 53</td>
</tr>
<tr>
<td>HDL (mg/dL)</td>
<td>62 ± 15</td>
<td>56 ± 16*</td>
</tr>
<tr>
<td>LDLc (mg/dL)</td>
<td>89 ± 27</td>
<td>83 ± 28*</td>
</tr>
</tbody>
</table>

*p < .05 (n = 11) main effect for time vs 0 hr.
ings and is further enhanced with the addition of a 2-hr feeding (Ivy, Katz, et al., 1988). However, if feeding is provided prior and during extended exercise, the inclusion of a carbohydrate/protein recovery product immediately postexercise does not enhance rates of glycogen recovery compared with a 2-hr delayed feeding (Reinert et al., 2009). Carbohydrate amount used in the current study of 1.54 ± 0.27g·kg-1 was in accordance with previous studies suggesting a plateau of glycogen recovery between feedings of 0.7 and 3.0g·kg-1 administered in two hour intervals (Blom et al., 1987; Ivy, Lee, et al., 1988; R. L. Jentjens et al., 2001; Reinert et al., 2009). In addition, muscle glycogen recovery rates of 6.9 ± 1.7 and 7.9 ± 2.4 mmol·kg wet weight-1·hr-1 for SS and FF, respectively, are comparable to previous research of 4.1–10.6 mmol·kg wet weight-1·hr-1 for SS and FF, respectively, are muscle glycogen recovery rates of 6.9 ± 1.7 and 7.9 ± 2.4 mmol·kg wet weight-1·hr-1 for SS and FF, respectively, are comparable to previous research of 4.1–10.6 mmol·kg wet weight-1·hr-1 given a variety of modalities, environments and feeding strategies (Gillum, Dumke, & Ruby, 2006; Naperalsky, Ruby, & Slivka, 2010; Reinert et al., 2009; Ruby et al., 2005).

While the presence of protein in the form of essential amino acids (EAA) enhances muscle glycogen recovery in conjunction with a moderate amount of CHO (approximately 0.8g·kg-1·hr-1), protein added to a high CHO supplement (≥ 1.2 g·kg-1·hr-1) does not further increase glycogen recovery rates (R. L. Jentjens et al., 2001). Although the inclusion of additional protein and/or novel amino acids may alter short-term rates of glycogen recovery (Ivy et al., 2002; Ruby et al., 2005), the present data demonstrate that the sources of carbohydrate and protein (1.54 ± 0.27 and 0.18 ± 0.03 g·kg-1 respectively) from fast food result in comparable rates of glycogen synthesis.

The present blood response data demonstrates a rapid rise in blood glucose and insulin 30 min following each feeding with a concomitant return to baseline by 60-min post feeding. This is comparable to prior research using varied strategies in the carbohydrate dose (Ivy, Lee, et al., 1988), feeding intervals (Ivy, Katz, et al., 1988), and type of feedings (Ivy et al., 2002). The near identical response patterns for glucose and insulin with the two diets highlight the lack of difference between diets in terms of digestion, absorption and ultimately CHO delivery to the muscle.

While it is commonly hypothesized that the chronic consumption of fast food choices have a negative effect on dyslypemia, cardiovascular risk, and obesity (Grundy & Denke, 1990), the acute consumption has received little attention in the literature when applied to young, active individuals. Furthermore, fast food sources matched isoenergetically to sports supplements can provide for basic recovery needs of the muscle and may offer a convenient and economical approach to glycogen recovery under some circumstances.

Acknowledgments

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