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Carbohydrates and Resistance Training Performance

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Outline

• Quick Review of the Roles of Protein and Fat
• Case studies – Who is the Smartest Person in the Weight Room?
• CHO and Skeletal Muscle Glycogen Resynthesis
• CHO and Resistance Training Performance
• CHO and Net Muscle Protein Balance
• CHO and its Appropriate Role in a Resistance Training Program
• Questions?
Role of Protein

- Need to ingest high quality protein
- How much?
  - 0.7 to 0.9 grams/pound of body mass per day
  - Must consider leucine content of the protein
- Protein timing
  - Need to consider the refractory response
Role of Fat

- No need to avoid fat in the post-exercise period
Who is the Smartest Person in the Weight Room?
Who is the Smartest Person in the Weight Room?

• Person #1 (a Californian)
  – Ingests the right amount and type of carbohydrate immediately following each resistance exercise session in order to resynthesize skeletal muscle glycogen.
Who is the Smartest Person in the Weight Room?

- Person #2 (a New Yorker)
  - Ingests the right amount and type of carbohydrate prior to each resistance exercise session in order to maximize the performance of the upcoming workout.
Who is the Smartest Person in the Weight Room?

• Person #3 (a Texan)
  – Ingests the right amount and type of carbohydrate immediately following each resistance exercise session in order to stimulate insulin secretion and improve net muscle protein balance.
Who is the Smartest Person in the Weight Room?

• Person #1 (a Californian)
  – Ingests the right amount and type of carbohydrate immediately following each resistance exercise session in order to resynthesize skeletal muscle glycogen.
What Fuels a Resistance Exercise Session?
Phosphagen System

Metabolism

ADP + Pi → ATP

At Rest

Creatine-P → Creatine + Pi

During Exercise

ADP + Pi → ATP

For muscle contraction
Fat Also Fuels Resistance Exercise

- Adipose Tissue Lipolysis
- IMTG stores
- Post-workout fat burning?
Skeletal Muscle Glycogen Resynthesis

• Are carbohydrates depleted during a resistance exercise bout?
  – If so, to what extent?
% of Skeletal Muscle Content

Pre-Exercise  After 1 Set Biceps Curl  After 3 Sets Biceps Curls

MacDougall, et al. (1999)
<table>
<thead>
<tr>
<th>Reference</th>
<th>Population</th>
<th>Intervention</th>
<th>% Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koopman (2006)</td>
<td>8 untrained males</td>
<td>8 sets of 10 reps of leg press and 8 sets of 10 reps of leg extension @ 75% 1RM. 2 min rest btw sets. 45-min total time.</td>
<td>~36%</td>
</tr>
<tr>
<td>MacDougal (1999)</td>
<td>8 trained bodybuilders</td>
<td>3 sets of arm curls @ 80% 1RM to failure. 3 min rest between sets.</td>
<td>24%</td>
</tr>
<tr>
<td>Pascoe (1993)</td>
<td>8 recreationally trained males</td>
<td>~9 sets of 6 reps of unilateral leg ext. @70%1RM to failure. 30 sec rest between sets.</td>
<td>28%</td>
</tr>
<tr>
<td>Robergs (1991)</td>
<td>8 resistance trained males</td>
<td>Trial 1 = Leg extensions at 70% 1RM for 6 sets of 6 reps. Trial 2 = 6 sets at 35% 1RM with the other leg.</td>
<td>38%</td>
</tr>
<tr>
<td>Essan-Gustavsson (1990)</td>
<td>9 trained bodybuilders</td>
<td>5 sets of &lt; 12 reps of 4 exercises: front squats, back squats, leg press, leg extension.</td>
<td>28%</td>
</tr>
<tr>
<td>Tesch (1986)</td>
<td>9 RT males</td>
<td>5 sets of 5-10 reps of 4 exercises: front squats, back squats, leg press, leg extension.</td>
<td>26%</td>
</tr>
<tr>
<td>Lesmes (1983)</td>
<td>4 active non-RT males</td>
<td>20 unilateral maximal 30-sec leg flexion and extension. 1 leg @ 600/sec and the other leg @ 3000/sec.</td>
<td>~45%</td>
</tr>
</tbody>
</table>
Pre-Resistance Exercise Muscle Glycogen Levels

Post-Resistance Exercise Muscle Glycogen Levels

% of Skeletal Muscle Glycogen Content

100%

75%

50%

25%

0%

~33% Reduction
Who is the Smartest Person in the Weight Room?

• Person #1 (a Californian)
  – Ingests the right amount and type of carbohydrate immediately following each resistance exercise session in order to resynthesize skeletal muscle glycogen.

I do not believe that this strategy should be the guiding principle for ingesting carbohydrate in the post-workout time period.
Interesting Glycogen Depletion Facts

• Training status does not affect glycogen depletion (1989 Bell).

• The faster the contraction, the greater the glycogen depletion (1983 Lesmes).

• Lower intensities (20-30% MVC or %1RM) deplete glycogen of slow twitch muscle fibers, and higher intensities preferentially deplete glycogen of fast twitch fibers (1998 Tesch; 1974 Gollnick).
Interesting Glycogen Depletion Facts

- At the same relatively higher intensities, fast twitch fibers experience greater depletion than slow twitch fibers (with IIX experiencing greater depletion than type IIA) (1983 Lesmes)

- Males deplete more glycogen than females (1989 Bell)
Carbohydrate for Acute Performance Enhancement

• Can carbohydrate ingestion prior to and/or during a resistance exercise bout result in an enhancement of performance?
Who is the Smartest Person in the Weight Room?

• Person #2 (a New Yorker)
  – Ingests the right amount and type of carbohydrate prior to each resistance exercise session in order to maximize the performance of the upcoming workout.
CHO Ingestion Prior to/During RE

• Due to the fact that resistance training relies upon carbohydrates as an energy source, it has been hypothesized that ingesting carbohydrates prior to a resistance training bout will increase the total amount of work that may be performed during the workout.
Despite the fact that skeletal muscle glycogen is depleted during resistance exercise, the majority of studies investigating carbohydrate ingestion prior to and during an acute bout of resistance exercise do not report improvements in resistance training performance.
<table>
<thead>
<tr>
<th>Reference</th>
<th>Population</th>
<th>Intervention</th>
<th>Performance Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kulik (2008)</td>
<td>8 Resistance Trained Males</td>
<td>Sets of back squats at 85%1RM to exhaustion</td>
<td>No</td>
</tr>
<tr>
<td>Haff (2001)</td>
<td>8 Resistance Trained Males</td>
<td>16 sets of 10 reps at 120°/sec on an isokinetic dynamometer</td>
<td>Yes</td>
</tr>
<tr>
<td>Haff (2000)</td>
<td>8 Resistance Trained Males</td>
<td>3 sets of isokinetic leg flexion/ext prior to and following free weight protocol which involved 3 sets of 10 reps of squats (65% 1RM), speed squats (45% 1RM) and 1-legged squats (10% 1RM).</td>
<td>No</td>
</tr>
<tr>
<td>Dalton (1999)</td>
<td>22 RT Subjects (energy restricted)</td>
<td>5 sets of squat, bench &amp; leg press, &amp; leg ext. @ 80% 10RM to 60% 10RM. Bench press &amp; leg ext completed to failure at 80% of 10RM on final set.</td>
<td>No</td>
</tr>
<tr>
<td>Lambert (1991)</td>
<td>7 Resistance Trained Males</td>
<td>As many sets of 10 repetitions as possible at 80% of 10RM on the leg extension machine.</td>
<td>No*</td>
</tr>
<tr>
<td>2 Others in Abstract Form*</td>
<td></td>
<td></td>
<td>No</td>
</tr>
</tbody>
</table>
CHO Ingestion Prior to/During RE

- In the studies that have reported an enhancement or near enhancement of performance, the resistance exercise workout was not of a practical nature (i.e., 16 sets of lower body resistance exercise conducted on an isokinetic dynamometer or 17 sets of a leg extension exercise) and do not resemble workouts that are typically conducted by resistance training athletes.
Who is the Smartest Person in the Weight Room?

- Person #2 (a New Yorker)
  - Ingests the right amount and type of carbohydrate prior to each resistance exercise session in order to maximize the performance of the upcoming workout.

I do not believe that this strategy should be the guiding principle for ingesting carbohydrate prior to or during a resistance exercise workout.
Carbohydrate & Net Muscle Protein Balance

Is there a role for post-exercise carbohydrate ingestion to improve net muscle protein balance?
Who is the Smartest Person in the Weight Room?

• Person #3 (a Texan)
  – Ingests the right amount and type of carbohydrate immediately following each resistance exercise session in order to stimulate insulin secretion and improve net muscle protein balance.
Protein Synthesis

Protein Breakdown
Carbohydrates & Net Muscle Protein Balance

- Carbohydrates do not appear to enhance protein synthesis when ingested alone.
  - When ingested with protein, protein synthesis is increased
  - Elevations in insulin have been shown to significantly increase rates of protein synthesis – but these reports resulted from the infusion of insulin (not that secreted in response to oral carbohydrate ingestion)

(Biolo et al. 1995; Hillier et al. 1998)
# Carbohydrate & Net Muscle Protein Balance

<table>
<thead>
<tr>
<th>Reference</th>
<th>CHO Dose</th>
<th>Intervention</th>
<th>↑ Protein Synthesis?</th>
<th>↓ Protein Breakdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roy, et al. (1997)</td>
<td>1 g/kg BW immediately after and 1 hour later</td>
<td>4 sets each of leg press &amp; leg extension @85% 1RM</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>[RT males]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Borsheim, et al. (2004) [Rec. active]</td>
<td>1.3 g maltodextrin/kg BW one hour post-exercise</td>
<td>10 sets of 8 reps of leg extensions @80% 1RM</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>
Carbohydrate & Net Muscle Protein Balance

• Insulin was responsible for the suppression of skeletal muscle protein breakdown.

(Heslin et al. 1992; Denne et al. 1991; Kettelhut et al. 1988; Gelfand and Barrett 1987)
Carbohydrate & Net Muscle Protein Balance

• To suppress skeletal muscle protein breakdown:
  – Ingest 1 gram of carbohydrate per kilogram of body mass immediately after and again one hour following (or 2 grams/kg body mass over a two-hour post-exercise period).
  – This is the same recommendation for rapidly resynthesizing skeletal muscle glycogen following resistance exercise.
Who is the Smartest Person in the Weight Room – the Texan!

- Person #3 (a Texan)
  - Ingests the right amount and type of carbohydrate immediately following each resistance exercise session in order to stimulate insulin secretion and improve net muscle protein balance.

I believe this is the best strategy for ingesting carbohydrate – to optimize NMPB via the suppression of muscle protein breakdown.
Very Important Question

• Do the benefits of ingesting carbohydrate immediately after/during resistance exercise equate to chronic, favorable adaptations in a resistance training program?
Adding Carbohydrate to Protein Post-Exercise

- 32 non–resistance-trained male subjects completed 2 whole-body resistance exercise sessions per week for 12 weeks.
- As soon as the workouts began, subjects ingested one of the following 4 beverages (after each set):
  - 40 g of carbohydrate (approximately 0.5 g CHO per kilogram of body mass)
  - 6 g of essential amino acids
  - 40 g of carbohydrate + 6 g of essential amino acids (CHO-EAA)
  - Non-caloric placebo.
Adding Carbohydrate to Protein Post-Exercise

• What was measured?
  – Fat free mass
  – 3-methylhistidine excretion
  – Muscle fiber cross-sectional area
What Happened after Adding Carbohydrate to Protein Post-Exercise for 12-weeks?

- Skeletal muscle protein breakdown (as measured via urinary 3-methylhistidine):
  - Measured before and 48 hours after the last training session of the program.
  - EAA and carbohydrate only groups showed no significant change.
  - CHO-EAA group significantly decreased 3-methylhistidine (26% decrease), suggesting an additive effect of carbohydrate and essential amino acids and their ability to suppress skeletal muscle protein breakdown.
What Happened after Adding Carbohydrate to Protein Post-Exercise for 12-weeks?

• Fat free mass
  – Fat-free mass significantly improved for all groups (including the placebo group), but only the CHO-EAA group (9 pounds) demonstrated significantly greater gains in fat-free mass as compared with the placebo (4 pounds).

• Muscle fiber cross-sectional area
  – Only the CHO-EAA group (20% increase) and the essential amino acid group (18% increase) resulted in significant improvements as compared with the placebo group (7% increase).
Does this Work in the Real World?

**January 14, 2013**

- 181 pounds
  - Lean Body Mass = 165 pounds
  - Fat Mass = 16 pounds

**February 15, 2013**

- 180.5 pounds
  - Lean Body Mass = 166.5 pounds
  - Fat Mass = 14 pounds
References

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Questions?