The Influence of Nutrient Timing & Distribution on Body Composition

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Agenda

- Acute effects of meal frequency & protein distribution
- Chronic effects of meal frequency & protein distribution
- Chronic effects of carbohydrate distribution
- Closing notes on individual variation
- Q/A

Hierarchy of Evidence

- Systematic Reviews & Meta-Analyses of RCTs
- Randomized Controlled Trials (RCTs)
- Observational Research
- Anecdote & Tradition
ANABOLIC WINDOW
Hurry up bro, it's closing...

Acute (short-term) effects
Acute (short-term) effects: Meal frequency

24-hour energy expenditure

- Tightly-controlled metabolic chamber studies have failed to detect differences in 24-hour thermogenesis in isocaloric comparisons of a **nibbling pattern** (6-7 meals) and a **gorging pattern** (2 meals) [1,2].

Muscle protein synthesis (MPS)

- 80 g protein consumed over 4 feedings through the day were superior to 2 or 8 feedings for raising MPS over a 12-hr period [3,4]. This has been attributed to meeting the "leucine threshold" necessary to significantly elevate MPS above resting levels.

- Mamerow et al [5] found that a moderate amount of protein at each meal (roughly 30 g in 3 meals) stimulated 24-hr MPS more effectively than skewing the majority of protein intake toward the evening meal (10.7, 16.0, and 63.4 g breakfast, lunch, and dinner, respectively).
“Leucine threshold” as a possible explanation

- The leucine threshold for triggering MPS at rest is thought to be approximately 1 g in younger subjects and about 2 g in older subjects [6].
- Maximizing (as opposed to merely initiating) the acute anabolic response in the trained state may require 2-3 g leucine [7], which in practical terms amounts to roughly 20-40 g protein.

### Acute (short-term) effects: Protein distribution

#### Leucine and BCAA content of foods

<table>
<thead>
<tr>
<th>Source</th>
<th>Leucine</th>
<th>BCAA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whey protein isolate</td>
<td>14%</td>
<td>26%</td>
</tr>
<tr>
<td>Milk protein</td>
<td>10%</td>
<td>21%</td>
</tr>
<tr>
<td>Egg protein</td>
<td>8.5%</td>
<td>20%</td>
</tr>
<tr>
<td>Muscle protein</td>
<td>8%</td>
<td>18%</td>
</tr>
<tr>
<td>Soy protein isolate</td>
<td>8%</td>
<td>18%</td>
</tr>
<tr>
<td>Wheat protein</td>
<td>7%</td>
<td>15%</td>
</tr>
<tr>
<td>Pea protein</td>
<td>6%</td>
<td>14%</td>
</tr>
</tbody>
</table>


“Additionally, it should be noted that the breakpoint observed in the present study would reflect the estimated average requirement to maximize MPS and, as such, the acute protein intake may be as high as ~0.60 g/kg for some older men (depending on the presence of potential contributing factors to the “anabolic resistance” of MPS) and ~0.40 g/kg for some younger men.”


“To account for inter-individual variability we propose the addition of two standard deviations to our estimate, yielding a dose of protein that would optimally stimulate MPS at intake of 0.4 g/kg/meal. In our view, ingestion of protein beyond this dose would result in no further stimulation of MPS.”

Optimizing MPS: Breaking Research Using Whole-Body Exercise


Acute (short-term) effects: Protein distribution

Recent data challenging the “even & capped” protein distribution model

- Kim et al [8] found that net protein balance (PS minus PB) was greater with protein dosed at 1.5 g/kg vs. 0.8 g/kg, regardless of distribution pattern through the day (33/33/33% vs 15/20/65%).

- Kim et al [9] found a greater net protein balance (equal MPS, less PB) with a 70 vs 40 g protein dose: “Stimulation of gut protein synthesis is potentially beneficial, particularly in a situation where MPS has been already maximized.”
Acute (short-term) effects: Protein distribution

Limitations of the acute studies

- Low overall protein intake (80-90 g within a 12-hour period), roughly half of what is typically consumed in the athletic population focused on size/strength gains.
- Absence of other macronutrients, which may influence outcomes (except Mamerow et al [5] and Kim et al who had conflicting findings).
- Most importantly: acute MPS response does not reliably correlate with long-term adaptations such as strength and hypertrophy [10-14].

Chronic (long-term) effects
Purpose of our meta-analysis:

• The purpose (mention general) was to conduct a multi-level meta-regression of randomized controlled trials to determine whether protein timing is a viable strategy for enhancing post-exercise muscular adaptations.

Inclusion criteria:

• At least one treatment group consumed a minimum of 6 g essential amino acids (EAAs) ≤ 1 hour pre- and/or post-resistance exercise and at least one control group did not consume protein < 2 hours pre- and/or post-resistance exercise.

• Minimum 6-week trial duration.
Chronic (long-term) effects: Protein timing meta-analysis with Brad Schoenfeld & James Krieger

Strengths of our meta-analysis:
- A total of 23 studies were analyzed comprising 525 subjects.
- Quality of studies was high (8.7 on PEDro scale).
- Studies were separately coded and recoded by two different investigators.
- Basic analysis carried out to see if there was an effect of protein timing.
- Regression sub-analysis was then performed to assess whether other factors might explain variances.

Results of our meta-analysis:
- Basic analysis showed a small effect (0.2 ES) for protein timing on hypertrophy.
- Regression analysis found that virtually the entire effect was explained by greater total daily protein consumption in treatment group (1.66 vs. 1.33 g/kg).
- A sub-analysis of the protein-matched studies failed to detect a timing effect. Why? It's likely due to the sufficiently high/optimized total daily protein intakes (1.91 g/kg in the treatment groups vs 1.81 g/kg in the control groups).
Chronic (long-term) effects: Protein timing meta-analysis with Brad Schoenfeld & James Krieger

Limitations of our meta-analysis:

- Only 5 studies that were initially considered for analysis matched protein intake between groups. 2 showed an effect, 3 did not.
- Only 2 studies evaluated trained subjects with matched intake. 1 showed an effect, 1 did not.
- Only 1 study assessed the timing effect of an ample dose of carbohydrate as coingested with ample protein.

Meal Frequency Meta-analysis
Chronic (long-term) effects: Meal frequency meta-analysis with Brad Schoenfeld & James Krieger

Purpose of our meta-analysis:
• To quantitatively analyze the available (& relevant) body of controlled studies on meal frequency’s effect on body composition.

Inclusion criteria:
• RCTs directly comparing feeding frequencies of ≤ 3 meals a day with ≥ 3 meals a day in human adults.
• Minimum 2-week trial duration.
• Reported body composition change.
• Excluded post-bariatric surgery patients.

Results (15 studies met inclusion criteria):
• Meal frequency did not significantly affect total body weight change.
• Higher meal frequencies were associated with greater losses of fat mass and greater retention of lean mass.
• Sensitivity analysis revealed that the removal of a single study (Iwao et al) completely eliminated the significant effect of meal frequency on changes in body composition.
Chronic (long-term) effects: Meal frequency meta-analysis with Brad Schoenfeld & James Krieger

Limitations:
- Sedentary subjects (except Iwao et al).
- Low daily protein intakes (except Arciero et al).
- Our findings are specific to body composition. Other health-related outcomes (i.e., glucose control, lipids, appetite, etc) or performance-related outcomes (i.e., muscle strength or endurance) were not analyzed.

The Fasted Cardio Study
Chronic effects: Fasted versus fed cardio with Schoenfeld, Wilborn, & Krieger

Purpose & design:
- To investigate changes in body composition following 4 weeks of fasted versus fed aerobic exercise (50 min @ 70% MHR + 5 min warm-up & 5-min cool-down) in young women (n=20, 22.4 y/o, normal-weight) in hypocaloric conditions.

Dietary intervention:
- BMR was estimated by the Mifflin-St. Jeor equation, activity factor was 1.5, 500 kcal was subtracted.
- Dietary protein intake was set at 1.8 g/kg of body mass, Fat was 25-30% of total kcals, and carbohydrate comprised the remainder.
- Sample meal plans were provided to guide the participants in acceptable food choices.

Dietary intervention (continued):
- Nutritional counseling was provided throughout the study period to help ensure dietary adherence and self-reported food intake was monitored on a regular basis.
- Food records using MyFitnessPal.com were collected and analyzed daily to ensure that intake was not based on recall.
- A meal replacement shake (20g P, 40g C, 0.5g F) was provided either immediately prior to exercise for the FED group or immediately following exercise for the FASTED group, under the supervision of a research assistant.
Chronic effects: Fasted versus fed cardio with Schoenfeld, Wilborn, & Krieger

Results & conclusion:
• Both groups showed a significant loss of weight ($P = 0.0005$) and fat mass ($P = 0.02$) from baseline, but no significant between-group differences were seen in any outcome measure. Lean mass was retained in both groups.
• As long as total daily nutrition is equated, body composition changes from aerobic exercise & chronic hypocaloric conditions are similar regardless of fasted versus fed training.

Limitations:
• Testing period was fairly short (4 weeks).
• Intake was self-reported.
• Subjects were young, normal-weight women.

Chronic (long-term) effects: Protein distribution

No clear advantage to evenly spread protein intake
• Previous research by Arnal et al found no difference in nitrogen retention & FFM between young women consuming a "pulse-feeding" pattern with 79% of the day's protein needs (~54 g) in one meal, versus protein evenly spread across four meals in young subjects [13].
• In elderly women, a “pulse” pattern resulted in more positive nitrogen balance and better FFM retention than an evenly spread feeding pattern [14].
• Adechian et al [15] found no significant between-group differences in body composition change in a 6-week comparison of whey vs casein consumed in a 'pulse' meal pattern (8/80/4/8%) vs a 'spread' pattern (25/25/25/25%).
• Arciero et al [16] found that protein intake spread over 6 meals increased LBM and lost more FM than 3 meals under hypocaloric conditions.
Protein Timing Study (Pre-Publication)

October 20 – 22, 2016

Purpose & design:
• To test the hypothesis of the “anabolic window of opportunity.” by comparing the 10-wk effects of immediate pre- vs post-resistance exercise protein consumption (24 g) on trained young men (RT at least 3 x wk for 1 yr).
• RT was progressive & supervised, 9 exercises per session hitting all major muscle groups, 3 sets per exercise, 8-12 reps (apprx 75% of 1 RM), 90 sec interset rest , 3 sessions per week.
• DXA assessed body composition, ultrasound assessed muscle thickness.
• Upper and lower body strength was assessed by 1RM testing in the bench press the back squat.
• Protein intake was set at 1.8 g/kg, fat 25-30% of total kcals, with the remaining CHO set to create a caloric surplus.
Pre- versus Post-Exercise Protein Intake (Pre-Publication)

Results:

- Both PRE-SUPP and POST-SUPP groups significantly increased maximal squat strength.
- There was a trend toward increased maximal bench press strength for both groups.
- Neither group showed significant gains in lean mass. However, the PRE-SUPP trended toward greater left arm lean mass compared to the POST-SUPP group.
- There was a trend for a greater increase in biceps thickness in the PRE-SUPP than the POST-SUPP group.
- Both groups significantly lost body fat.

Limitations

- Both groups substantially reduced their energy intake from baseline; by ~400 kcal. This is the opposite of what they were supposed to do; hypocaloric conditions were sustained despite hypercaloric conditions being assigned.
- Intake was self-reported, which widens the door for inaccuracy.

Perspective:

- Although conditions were not optimal for size and strength gains, it’s possible that our study served to challenge the common presumption that protein timing in the post-exercise anabolic window is more crucial in an energy deficit.
Carbohydrate Distribution &
Body weight/Body Comp

October 20 – 22, 2016

Chronic effects of carbohydrate distribution: 8-study saga

- 1 study shows a fat oxidation advantage of eating later in the day.
- 1 study shows no significant difference in weight or fat loss.
- 1 study shows a greater preservation of lean mass from eating more calories later in the day.
- 1 study shows a greater weight loss, fat loss, and waist reduction from eating more carbs later in the day.
- 4 studies show essentially the opposite - favorable weight and/or body composition effects of front-loading caloric intake.

Scorecard:
- Carbs earlier in the day is better: 4 studies
- Carbs later in the day is better: 3 studies
- No difference either way: 1 study

(Limitations, Practical application)
Putting It All Together: Practical Application

Meal frequency & nutrient distribution

- Number of meals can be tailored to the individual's goal, personal preference, tolerance, and schedule.
- Acute studies show that higher frequency does not equal greater thermogenesis or increased metabolic rate.
- Chronic studies overall show no meaningful advantage of a higher frequency (> 3 meals/d) on body composition.
- CAUTION, there's still a lack of meal frequency research on athletic subjects undergoing a formal training program, and consuming an optimal level of protein.
**Practical Application**

**Meal frequency & nutrient distribution**
- Fed versus fasted cardio makes no significant difference as long as total macronutrition is matched (at least with our subject profile).
- The research on carb distribution does not lean strongly in favor of any particular direction, so place carbs according personal preference, tolerance, & goal.
- Focus primarily on hitting **total daily macronutrient targets**, but for maximizing muscle gain or muscle retention, make sure at least 3 meals per day contain at least 20-40 g high-quality protein, depending on age [25-28].

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**Protein Rec’s in Recent Reviews & Position Stands**

<table>
<thead>
<tr>
<th>Source</th>
<th>Population</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pencharz et al (2016)</td>
<td>General population</td>
<td>1.5-2.2 g/kg</td>
</tr>
<tr>
<td>Phillips et al (2014)</td>
<td>Athletes in hypocaloric conditions</td>
<td>1.3-1.8 g/kg</td>
</tr>
<tr>
<td>Helms et al (2013)</td>
<td>Lean, resistance-trained athletes in hypocaloric conditions</td>
<td>2.3-3.1 g/kg FFM</td>
</tr>
<tr>
<td>Churchward-Venne (2013)</td>
<td>Resistance trainees in a hypocaloric conditions</td>
<td>1.2-2.3 g/kg</td>
</tr>
<tr>
<td>Phillips &amp; Van Loon (2011)</td>
<td>Athletes in hypocaloric conditions</td>
<td>1.8-2.7 g/kg</td>
</tr>
<tr>
<td>ADA/DC/ACSM Position Stand (2009)</td>
<td>Endurance &amp; strength athletes</td>
<td>1.2-1.7 g/kg</td>
</tr>
<tr>
<td>JISSN Position Stand (2007)</td>
<td>Exercising individuals</td>
<td>1.4-2.0 g/kg</td>
</tr>
<tr>
<td>Wilson &amp; Wilson (2006)</td>
<td>Strength-training athletes</td>
<td>1.2-2.2 g/kg</td>
</tr>
</tbody>
</table>
Studies Challenging the Presumed Maximally Effective Daily Dose of 1.6 g/kg

1. **Candow et al, 2006:**
   3 g/kg outperformed 1.7 g/kg for improving bench & squat strength. PMID:16948480

2. **Willoughby et al, 2007:**
   2.8 g/kg outperformed 2.3 g/kg for increasing lean mass and bench & leg press strength.
   PMID:16988909

3. **Cribb et al, 2007:**
   3.1 g/kg outperformed 1.6 g/kg for increasing contractile protein and bench, squat, & pulldown strength. PMID:17277594
Nitpicking towards optimal protein distribution

- The goal of maximizing muscle gain may require a higher frequency of protein-rich meals than the goal of retaining muscle while dieting (e.g., 4-6 meals versus 2-3 meals).
- Minimal protein feeding distribution for optimizing muscle gain: 4 meals containing protein that meets or exceeds the leucine threshold (at least 20-40 g, depending on age, or just simplify it to a minimum of 0.5 g/kg LBM) at the following time points – at minimum:
  - Waking/early meal
  - Pre-workout
  - Post-workout
  - Pre-bed/late meal
- Minimal carbohydrate feeding distribution for optimizing muscle gain: It depends (individualize to training program & goals).

Postworkout Protein + Carbs
Versus Protein Only – for GAINZ
Carbs Fail to Acutely Increase MPS Given Sufficient Protein

- Staples & colleagues (charts above) [35] found that 50g maltodextrin added to 25g whey protein ingested after resistance training was unable to further increase postexercise net muscle protein balance compared to the protein dose without carbs.
- Hamer et al saw no effect of 40 g CHO + 20 g whey in older men [36].
- Both of these studies echoed earlier work by Koopman et al [37], who found no additional effect of CHO (up to 0.6 g/kg/hr) on MPS when ample protein (0.3 g/kg/hr) was consumed post-exercise. That's 3 strikes, too bad it's all acute data.

First-ever longitudinal study comparing post-exercise PRO-only with PRO + CHO

**Design:** 12-week comparison of post-exercise CHO (34.5 g maltodextrin), PRO (37.5 g whey containing 30 g protein), and CHO-PRO (a combination of the treatments) on untrained subjects.

**Results:**
- Significant and similar increases in lean mass and muscle thickness (CSA) were seen the protein-containing treatments, but not in CHO-only.
- Significant & similar decreases in leg and trunk fat mass were seen the protein-containing treatments, but not in CHO-only.
- Increases in maximal & isometric strength were not differently affected by any of the interventions (possibly due to novice trainee status).

**Limitation:** only a single time point of dietary journal assessment.


- **Protocol:** Cyclists & triathletes did a 2-hr constant load at 70.8% VO2max followed by a 20-km time trial, to be completed as quickly as possible. 12 CHO-electrolyte doses (10-120 g per hour) were tested) A 1:1:1 glucose-fructose-maltodextrin mix per hour during the 2-h constant load ride.

- **Results:** Incremental performance improvements occurred until 78 g/hr, with diminishing performance enhancement seen at CHO levels >78 g/hr.

- **My comment:** This study improves upon previous designs with its wide range of dosages its use of multiple transportable CHO. It’s a good example of how more can be better – only to a point, after which diminishing returns are seen.

On a related note to the previous study…

**RESEARCH GEM:** Colombani et al recently did a systematic review and found that under real-world race conditions (i.e., non-fasted subjects tested via TT instead of TTE), CHO ingested near or during exercise have:

“…an unlikely effect with bouts up to perhaps 70 min and a possible but not compelling ergogenic effect with performance durations longer than about 70 min.”


Recent Meta-analysis of Fed-State Conditions

- **Purpose:** to expand on Colombani’s findings via an updated literature search in to yield an extended number studies to conduct a meta-analysis.
- **Inclusion criteria:** endurance-trained subjects, tested in real-world conditions (between 2 h and 4 h after ingesting last meal), no TTE (only TT or a submaximal exercise followed by a TT).
- **Results:** 16 studies were included in the meta-analysis. A 6-8 % carbohydrate solution just before and/or while exercising longer than 90 minutes benefitted male trained cyclists (there were insufficient data to draw conclusions for women).
- **Limitations:** the results may be limited to trained male cyclists, other populations & conditions had insufficient data.

Practical application

Nitpicking towards optimality: carbohydrate for performance (approaching/exceeding 2 hrs)

• **Intra-workout:** endurance-oriented training sessions that approach or exceed 2 hours of continuous exhaustive work (or training in a fasted state for more than an hour) can typically benefit from intra-workout nutrition, which I’ve boiled down to 10-20 g P, 40-80 g C per hour of training.

• **Post-workout:** endurance-oriented training sessions that approach or exceed 2 hours of continuous exhaustive work - separated by less than ~8 hours: CHO at 1.2g/kg, or 0.5g/lb per hour for up to 5 hours postexercise should restock glycogen at a maximal rate. A practical and equally effective alternative is to consume CHO at 0.8 g/kg in plus 0.4 g/kg protein or essential amino acids per hour of recovery.

The Importance of Individual Variation
Normal/habitual intake of 85 g/d (1.39 g/kg) was compared with a high intake of 166 g/d (2.72 g/kg) in well-trained female cyclists in caloric maintenance. In order to preserve N-balance, subject #5 was estimated to require 2.83 g/kg.


References


19. Keim NL, Van Loan MD, Horn WF, Barbieri TF, Mayclin PL. Weight loss is greater with consumption of large morning meals and fat-free mass is preserved with large evening meals in women on a controlled weight reduction regimen. J Nutr. 1997 Jan;127(1):75-82.


21. Jakubowicz D, Froy O, Wainstein J, Boaz M. Meal timing and composition influence ghrelin levels, appetite scores, and weight loss maintenance in
References
References


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