Nutrient Timing

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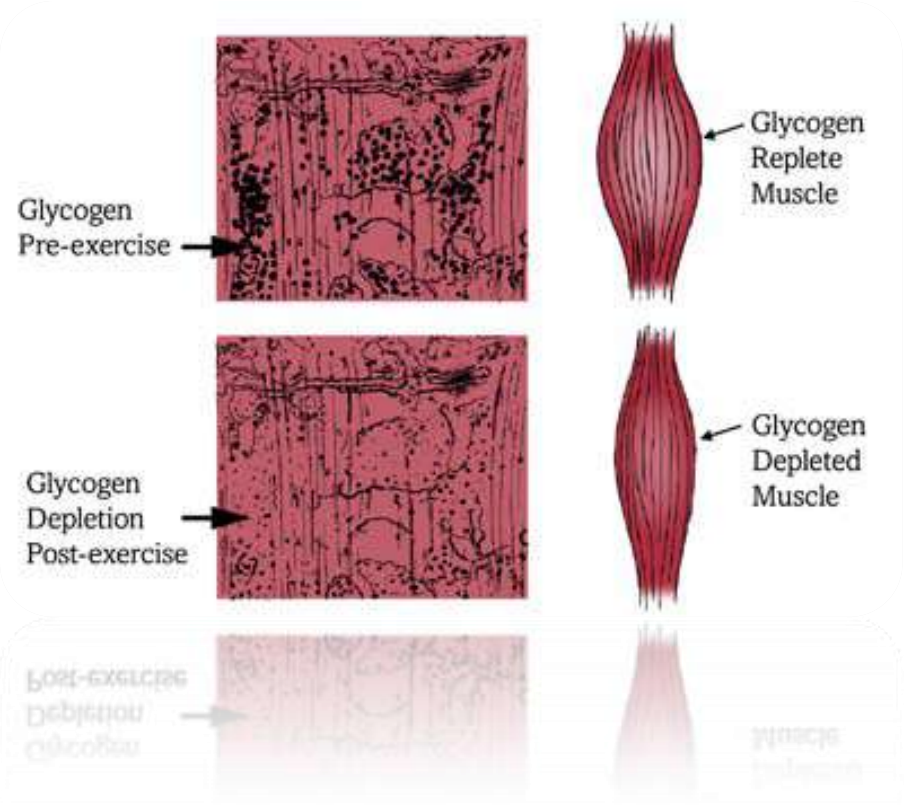
international society of sports nutrition

Overview

- Fatigue and glycogen depletion
- “Staleness” and overtraining
- Nutrient timing
- Glycemic Index
- Optimum recovery foods

Fatigue and Glycogen Depletion

- Glycogen depletion causes fatigue
- Fatigue causes failure
- All strenuous activity, exercise or games, will deplete glycogen
- Muscle glycogen can be replenished through proper diet and nutrient timing



"Staleness" and Overtraining

- Unexplained and persistent poor performance
- Moodiness, fatigue, depression, and irritability
- Painful muscles
- Insomnia
- ↑ heart rate
- Weight loss
- ↑ susceptibility to overuse injuries, colds an GI problems

Training Distress Scale

Staleness Scoring

Please respond to the following items as to how you have been feeling the last week, including today. Insert the number for each item that best describes you in the "Score Column". If you score over 14 for at least 3 days, you should consider taking a break from heavy training for two days and get a few good nights of sleep, IF POSSIBLE. Courtesy of Dr. Jack Raglin

	Not at all	A little	Moderately	Quite a bit	Extremely
Friendly	0	1	2	3	4
Worthless	0	1	2	3	4
Miserable	0	1	2	3	4
Helpful	0	1	2	3	4
Bad-tempered	0	1	2	3	4
Guilty	0	1	2	3	4
Unworthy	0	1	2	3	4
Peeved	0	1	2	3	4
Cheerful	0	1	2	3	4
Sad	0	1	2	3	4

The Remedy

- Rest
- Balanced meals
- Adequate fueling before, during and after exercise
- Stable body weight

Fig 1: The major problems resulting from overtraining

Nutrient Timing: Pre-, During, and Post-training Nutrition

The timing of "when" nutrients are consumed is AS important as "what" nutrients are consumed

Timing is a 'Supplement' or 'Training Tool.'

Nutrient Timing - Window of Opportunity

3 Major Nutrient Timing Windows

- **Pre-exercise***
- **During***
- **0-1 hr***

Pre-training nutrition – the 1st Nutrient Timing Window

- Protein/Amino Acids
- High Glycemic Carbs
  (foods which increase blood glucose levels very rapidly, i.e. simple and highly processed carbohydrates)
- Caffeine

Caffeine

- Enhance performance via effect on the central nervous system (i.e. increased alertness)
- Enhance free fatty acid utilization (more important during endurance exercise)
- Increases pain tolerance

Caffeine Study

- 14 subjects ingested 250 mg of caffeine or placebo (in random order and double blind fashion)
- Caffeine increased maximal anaerobic power (7% greater) in comparison to the placebo.
  - Eur J Appl Physiol Occup Physiol. 1992;65(2):188-91. Caffeine increases maximal anaerobic power and blood lactate concentration. Anselme F et al.

Amino Acids

- Hyperaminoacidemia (high blood levels of amino acids) at rest can increase net synthesis of muscle protein.
  - Is the old anecdotal concept about increased protein intake substantiated?

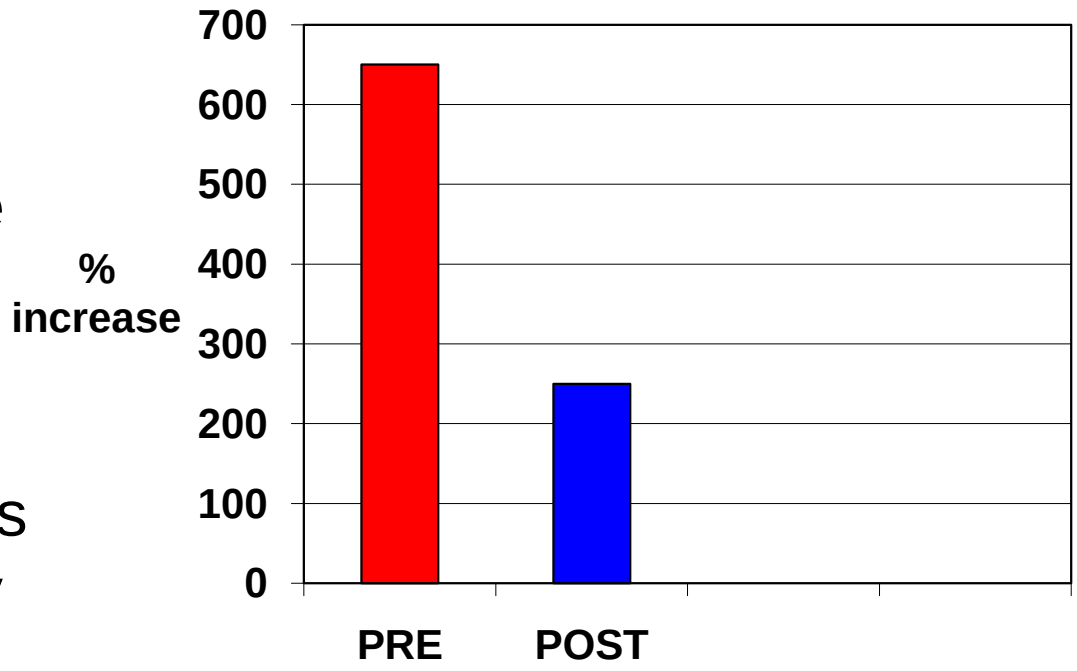
University of Texas Study

- Six healthy subjects consumed a 35 g sucrose + 6 g EAA (essential amino acid) cocktail immediately before or after exercise.
  - EAAs- phenylalanine, tryptophan, valine, leucine, isoleucine, lysine, methionine, threonine
    - Tipton, K. (2001). Timing of amino acid-carbohydrate ingestion alters anabolic response of muscle to resistance exercise. *American Journal of Physiology Endocrinology and Metabolism*, 281, E197-E206.

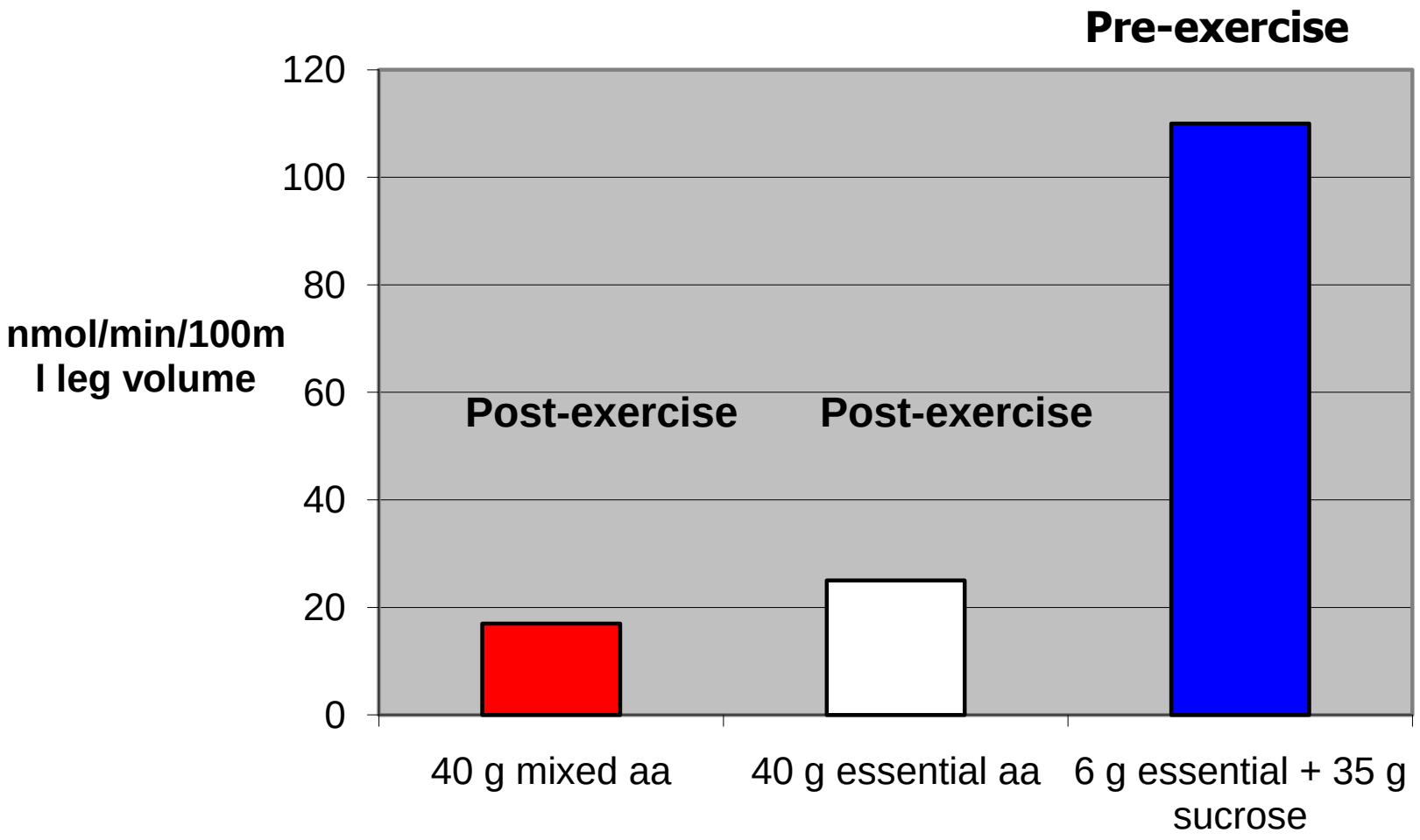
University of Texas Study- Tipton et al. (cont.)

- EAAs provided Pre-exercise yielded a greater delivery to leg muscle
- A measure of muscle protein gain also demonstrated that EAAs provided PRE-exercise are TWICE as effective as when they are given POST-exercise

Amino acid delivery to the leg

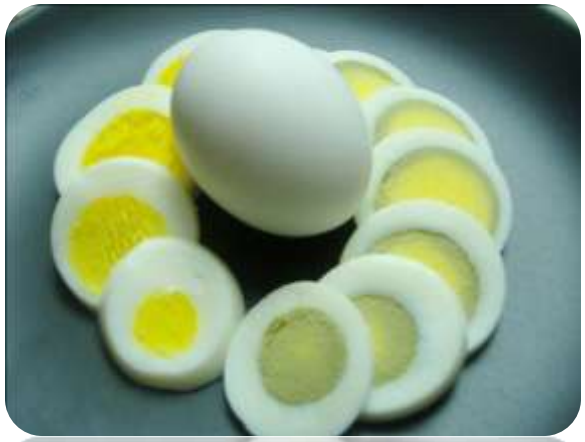


Net Muscle Protein Balance post exercise



Moral of the story

- Consuming a EAA plus sucrose cocktail **BEFORE** training can promote muscle protein gain.



During Training…the 2nd Nutrient Timing Window

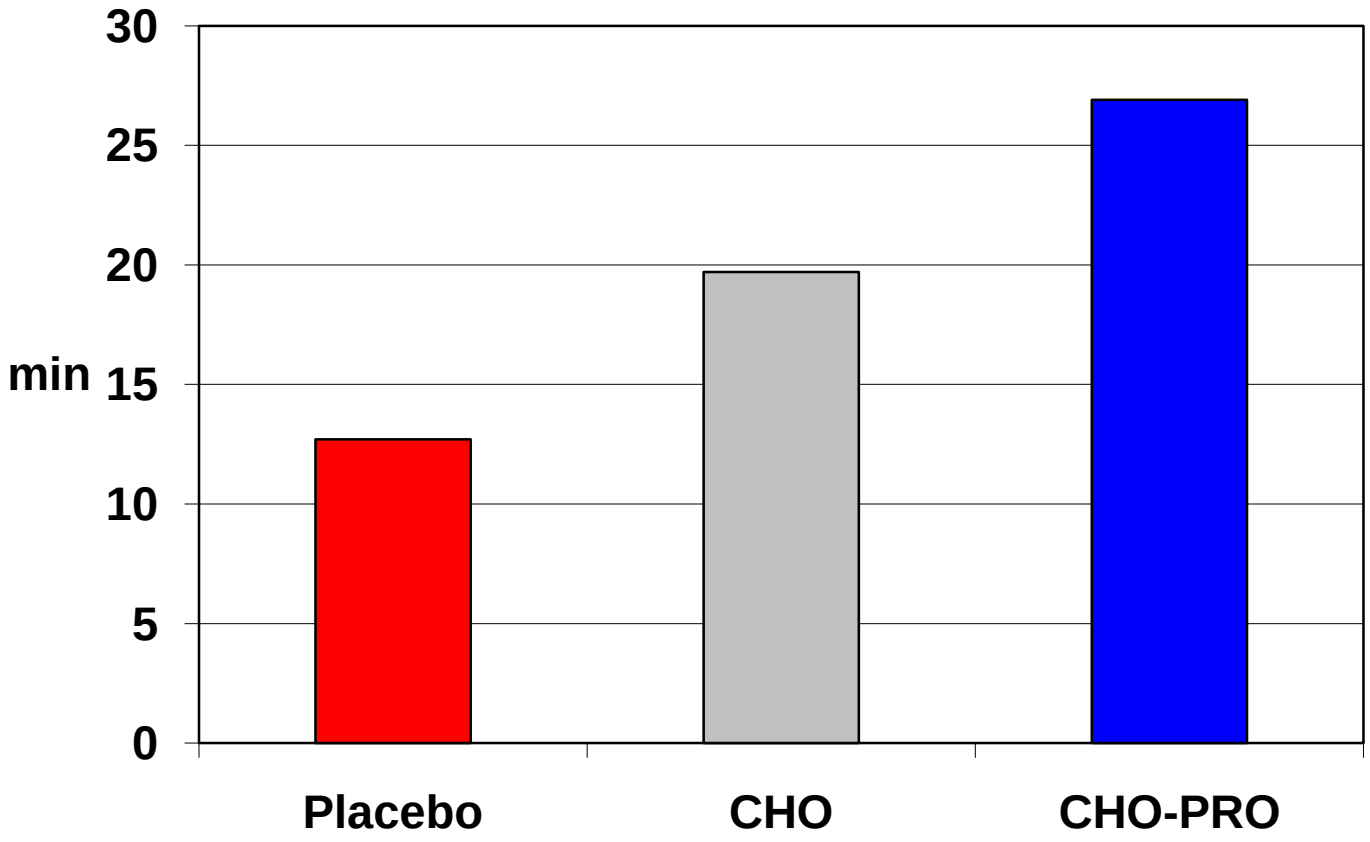
CHO versus CHO-PRO During Endurance Exercise

- Here is some evidence showing that CHO ingestion is important for endurance exercise performance, but CHO + PROTEIN may have even MORE benefits

Nine trained cyclists exercised on 3 separate occasions at intensities that varied between 45% and 75% VO2max for 3 h and then at 85% VO2max until fatigued.

- Supplements (200 ml) were provided every 20 min and consisted of:
  - **Placebo**
  - **7.75% carbohydrate solution**
  - **7.75% carbohydrate/1.94% protein solution**
    - **Ivy, J. L., Res, P. T., Sprague, R. C., Widzer, M. O. (2003). Effect of a carbohydrate-protein supplement on endurance performance during exercise of varying intensity.** *Int J Sport Nutr Exerc Metab*, Sep;13(3), 382-95.

Time to Exhaustion Improves with CHO-PRO



EAA (Protein) + Carbs and Strength Training

- Thirty-two untrained young men
- 12 wk of resistance training twice a week
- Consuming ~675 ml of either:
  - 6% CHO solution
  - 6 g EAA mixture
  - combined CHO + EAA supplement
  - placebo (PLA).
    - Bird SP et al. Independent and combined effects of liquid carbohydrate/essential amino acid ingestion on hormonal and muscular adaptations following resistance training in untrained men. Eur J Appl Physiol. 2006 May;97(2):225-38. Epub 2006 Mar 24. Erratum in: Eur J Appl Physiol. 2006 May;97(2):239.

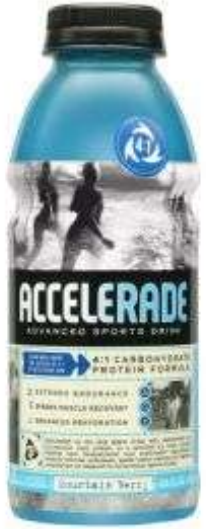
Supplements Used

- CHO solution = Gatorade
- EAA = histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, valine.
- Subjects drank one of the 4 solutions DURING training (between each set).
  - Sipping roughly 22-30 ml (total ml = 675)

- Muscle fiber size increased most with CHO + EAA.
- These data indicate that CHO + EAA ingestion enhances muscle anabolism following resistance training to a greater extent than either CHO or EAA consumed independently.
- The synergistic effect of CHO + EAA ingestion maximizes the anabolic response presumably by attenuating the post-exercise rise in protein degradation.

So what should you do during training?

- Consume a sports drink that has some protein (~5-10 g whey).



Post Exercise Nutrition
The 3rd Nutrient Timing Window

Post Exercise Nutrition Should:

1. Restore Electrolytes and Water
2. Replenish Skeletal Muscle Glycogen Stores
3. Rebuild/Repair Skeletal Muscle Fibers

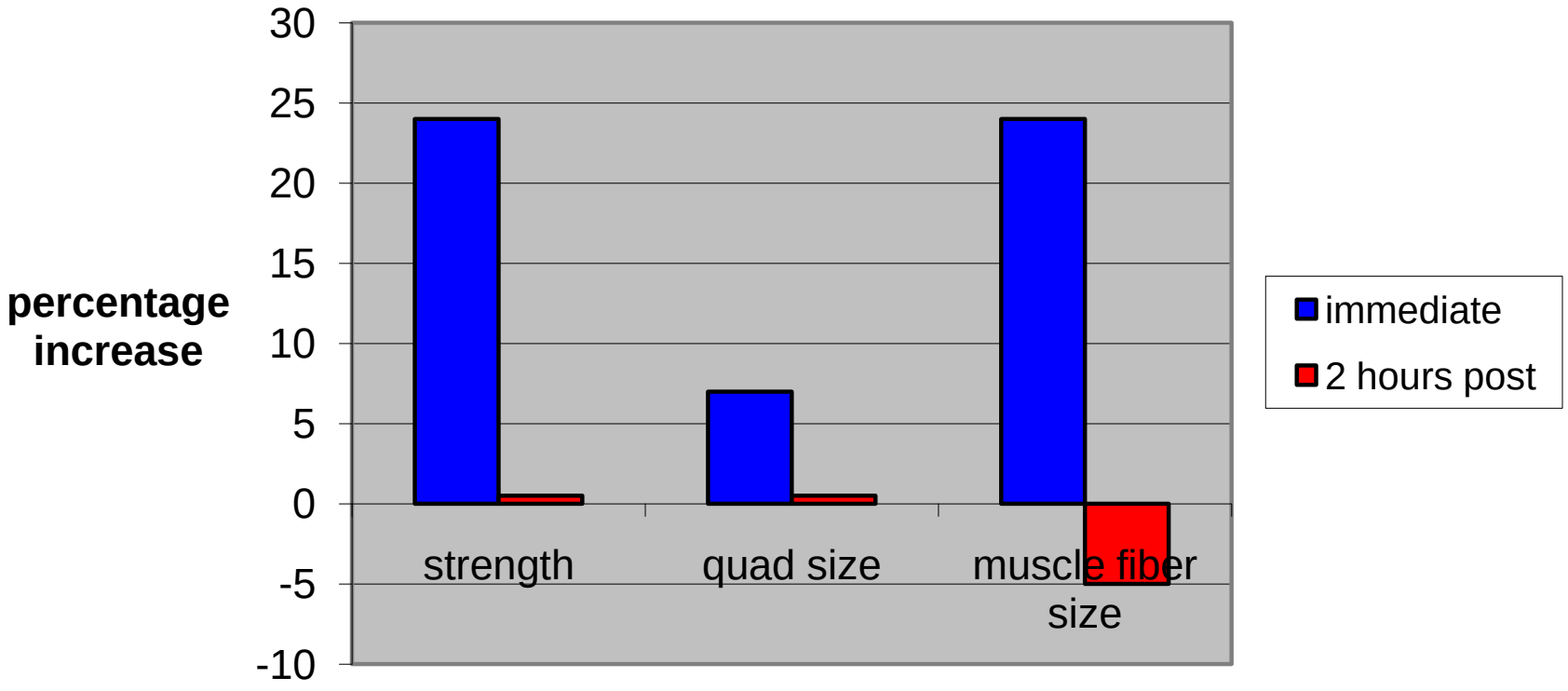
Post-exercise Nutrition

- The Major Players
  - Timing is important!
  - Protein / amino acids
  - Carbohydrate

Study 1 - Timing, Timing, Timing

- 13 men (74 yr of age); Trained 3 x per week for 12 wk with weights
- Took a liquid meal
  - **(10 g protein, 7 g carbohydrate, 3 g fat)** either:
- IMMEDIATELY AFTER TRAINING
- 2 HOURS AFTER TRAINING
  - Esmarck B et al. Timing of postexercise protein intake is important for muscle hypertrophy with resistance training in elderly humans. J Physiol. 2001 Aug 15;535(Pt 1):301-11

Changes in strength, muscle size, and muscle fiber size



Study 2: Milk versus CHO-electrolyte drink

- Nineteen, untrained men (18–25 yr) consumed either a milk (MILK) or a carbohydrate-electrolyte (CHO) drink immediately following each workout during a 10 wk resistance training program.
  - Rankin, J. W., et al. (2004). Effect of Post-Exercise Supplement Consumption on Adaptations to Resistance Training. *Journal of the American College of Nutrition*, 23(4), 322-330.

- **Results:**
  - **MILK tended to increase body weight and fat-free mass compared to CHO.**

- **Summary:**
  - It is possible that a more prolonged training with supplementation period would expand the trend for greater Fat-Free Tissue gains in MILK.

Study 3: CHO better than no calories

- Two groups of eight subjects performed a resistance exercise bout (10 sets of 8 repetitions of leg presses at 80% of 1-RM) before they rested in bed for 4 h.
- One group (CHO) received a drink consisting of 100 g of carbohydrates 1 h postexercise.
- The other group (Pla) received a noncaloric placebo drink.
- Although carbohydrate improved net leg protein balance after resistance exercise, the effect was minor and delayed compared with the previously reported effect of ingestion of amino acids.

- Borsheim, E., Cree, M. G., Tipton, K. D., Elliott, T. A., Aarsland, A., Wolfe, R. R. (2004). Effect of carbohydrate intake on net muscle protein synthesis during recovery from resistance exercise. *J Appl Physiol,* Feb;96(2), 674-8.

Study 4: Whey-Amino Acids-Carbs versus Carbs alone

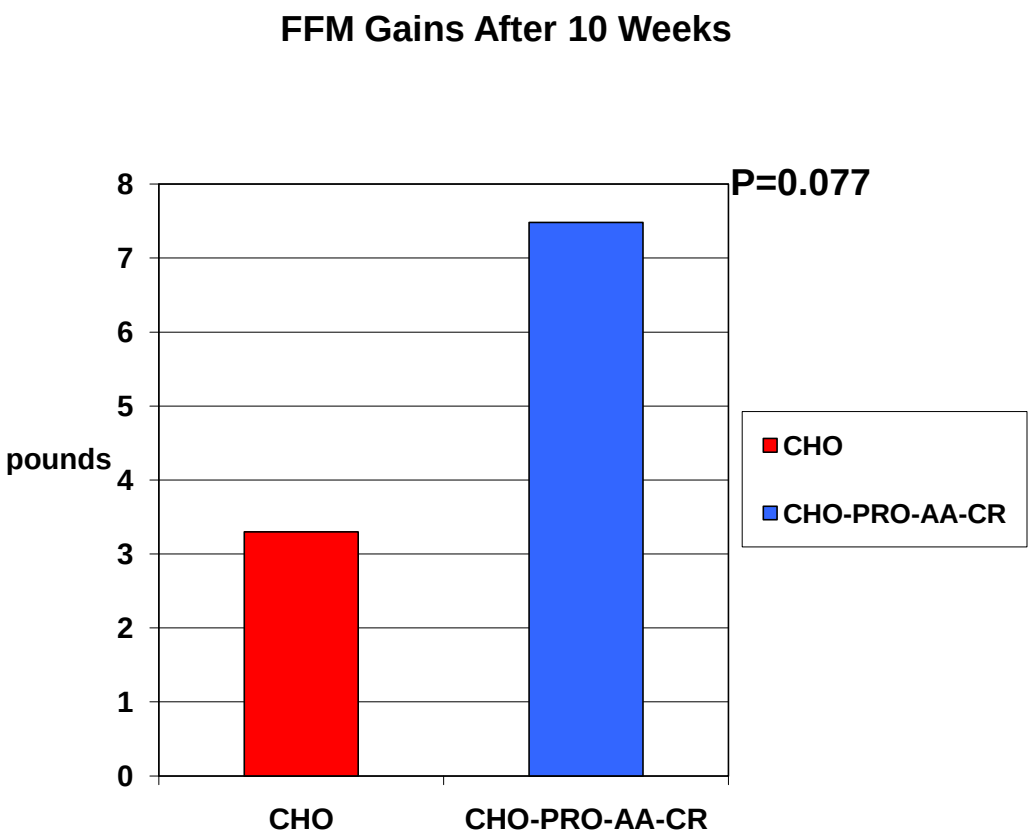
- Eight subjects participated in 2 trials.
  - In one (PAAC), they ingested 1 hr after resistance exercises:
    - 77.4 g CHO
    - 17.5 g whey protein
    - 4.9 g AA 1 hr after resistance exercise
  - In the other (CON),
    - 100 g CHO
- A mixture of whey protein, AA, and CHO stimulated muscle protein synthesis to a greater extent than isoenergetic CHO alone.
  - Borsheim, E., Aarsland, A., Wolfe, R. R. (2004). Effect of an amino acid, protein, and carbohydrate mixture on net muscle protein balance after resistance exercise. *Int J Sport Nutr Exerc Metab*, Jun;14(3), 255-71.

Study 5: Whey-AA-Cr-CHO versus CHO

- Placebo
  - 92 g maltodextrin
- Treatment
  - 76 g carbs (55 maltodextrin, 21 dextrose and fructose)
  - 13 g whey protein
  - 3 g creatine and ~5 g EAAs
- 370 kcals for both

Chromiak JA et al. Effect of a 10-week strength training program and recovery drink on body composition, muscular strength and endurance, and anaerobic power and capacity.
Nutrition. 2004 May;20(5):420-7.

- 41 young males, in either control(CHO) or treatment (CHO-Pro-AA-Cr) group + strength training;
- Participated in a 4 d/wk, 10-wk periodized strength training program.
- A substantial benefit in fat-free mass (MUSCLE) for the treatment group



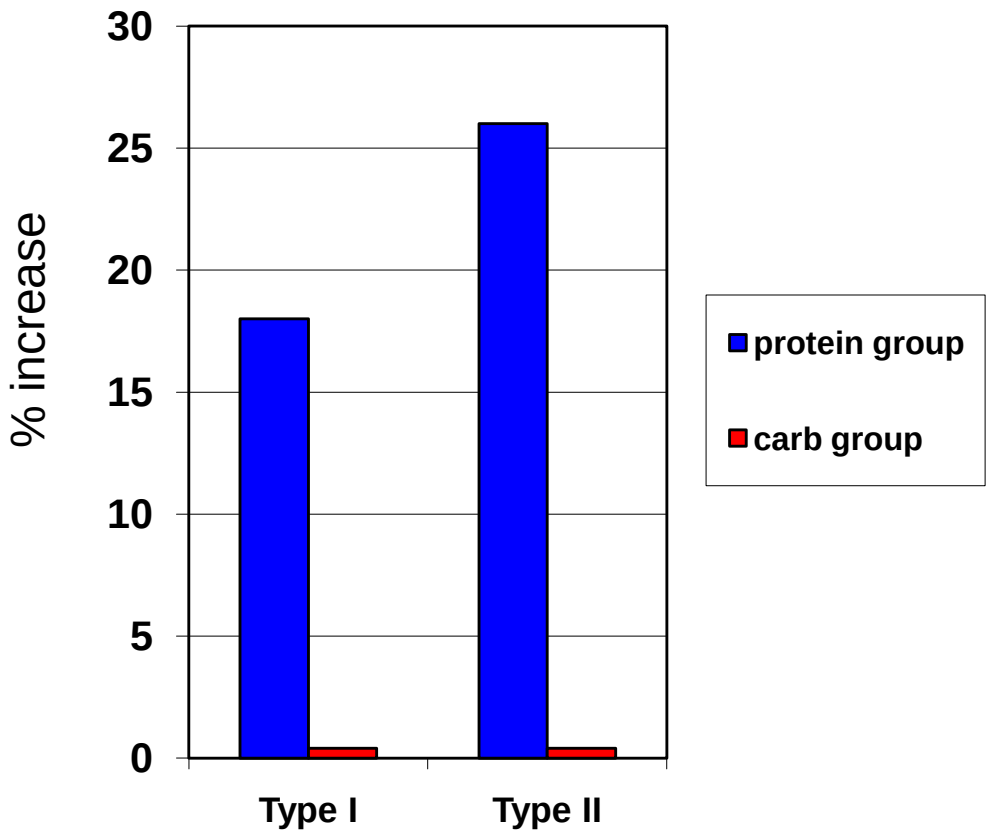
Study 6: Protein pre- and post-training good

- 14 wk of resistance training combined with timed ingestion of
  - isoenergetic protein versus carbohydrate supplementation *(*Anderson, L. L., et al. (2005). The effect of resistance training combined with timed ingestion of protein on muscle fiber size and muscle strength. Metabolism, 54(2), 151-156. *)*
- Supplementation was administered before and immediately after each training bout and, in addition, in the morning on non-training days.

Muscle Fiber Hypertrophy & Squat Jump Performance

- Type I and II muscle fiber hypertrophy

- Squat jump height increased only in the protein group



Study 7: Pre-Post timing vs. Morning-Evening timing

- Study to examine effects of supplement timing compared with supplementation in the hours not close to the workout on muscle-fiber hypertrophy, strength, and body composition during a 10-wk RE program.
  - Cribb, P. J., and Hayes, A. (2006). Effects of supplement timing and resistance exercise on skeletal muscle hypertrophy. *Med Sci Sports Exerc*, Nov;38(11), 1918-25.

Results

- PRE-POST demonstrated better gains in:
- ↑ LBM
- ↑ 1-RM (squat, bench)
- ↑ Type II muscle fibers x-sectional area
- ↑ Muscle glycogen concentrations
- ↑ Muscle creatine concentrations

Study 8: Protein/Amino Acids

- This study examined 10 wks of resistance training and the ingestion of supplemental protein and amino acids on muscle performance and markers of muscle anabolism.

  - Willoughby DS, Stout JR, Wilborn CD. Effects of resistance training and protein plus amino acid supplementation on muscle anabolism, mass, and strength. Amino Acids. 2007 May;32(4):467-77. Epub 2006 Sep 20.

Results

- The protein supplement resulted in greater increases in:
- ↑ total body mass
- ↑ fat-free mass
- ↑ thigh mass
- ↑ muscle strength
- ↑ serum IGF-1
- ↑ IGF-1 mRNA
- ↑ MHC I and IIa expression
- ↑ myofibrillar protein.

Conclusion

- Protein consumed 30 to 40 min. before and immediately after strength training accelerated the gains in strength and muscle mass over the 10 wk period versus taking isocaloric carbohydrate placebo before and after training.

Study 8: Whey protein Pre vs. Post

- Amino acid uptake was not different (Pre vs Post [20 g of whey intact protein]) when calculated:
- This is in contrast with free-form EAA (which has greater AA uptake PRE than POST).
  - Tipton KD, Elliott TA, Cree MG, Aarsland AA, Sanford AP, Wolfe RR. Stimulation of net muscle protein synthesis by whey protein ingestion before and after exercise. Am J Physiol Endocrinol Metab. 2007 Jan;292(1):E71-6. Epub 2006 Aug 8.

Post-Exercise (Endurance)

Study 1 – Improved Time to Exhaustion in Women

- "It was concluded that post-exercise macronutrient intake following endurance exercise can attenuate reductions in body weight and improve nitrogen balance during 7 days of increased energy expenditure. Importantly, post-exercise supplementation improved time to exhaustion during a subsequent bout of endurance exercise."
  - Int J Sport Nutr Exerc Metab. 2002 Jun;12(2):172-88. **The influence of post-exercise macronutrient intake on energy balance and protein metabolism in active females participating in endurance training.** Roy BD, Luttmer K, Bosman MJ, Tarnopolsky MA.

Study 2 - CHO-PRO versus CHO only for muscle glycogen recovery

- 2.5 hr of cycling to deplete muscle glycogen
- Consumed immediately and 2 hr post exercise
- A. CHO-PRO-Fat (80g, 28g, 6g)
- B. CHO-Fat (108g, 6g)
- C. CHO-Fat (80g, 6g)
  - Note: A and B have same number of calories
- The A group resulted in 20-30% greater muscle glycogen 4 hours post-exercise
  - Ivy, et al. (2002). Early Post-exercise muscle glycogen recovery is enhanced with a carbohydrate-protein supplement. *Journal of Applied Physiology*, 93, 1337-1344.

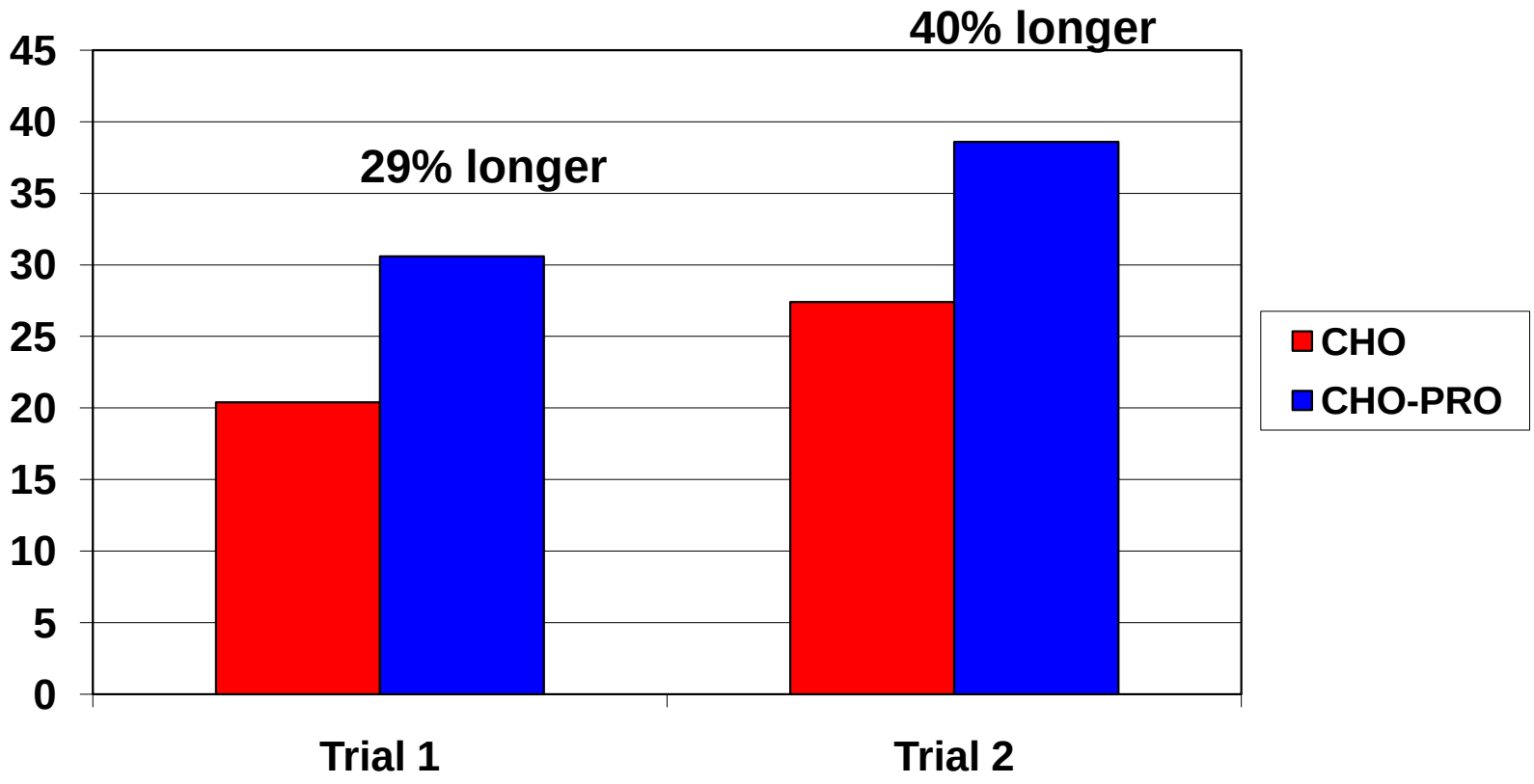
Study 3: CHO-PRO versus CHO drink

- Fifteen male cyclists (mean VO_2peak = 52.6 ± 10.3 ml·kg·min^{-1}) rode a cycle ergometer at 75% VO_2peak to volitional exhaustion, followed 12 - 15 h later by a second ride to exhaustion at 85% VO_2peak.
- Subjects consumed 1.8 ml·kg·BW^{-1} of randomly assigned CHO or CHO-PRO beverage every 15 min of exercise, and 10 ml·kg·BW^{-1} immediately after exercise.
- "Gatorade vs. Accelerade"
  - Saunders MJ, Kane MD, Todd MK. Effects of a carbohydrate-protein beverage on cycling endurance and muscle damage.Med Sci Sports Exerc. 2004 Jul;36(7):1233-8. ***JMU STUDY***

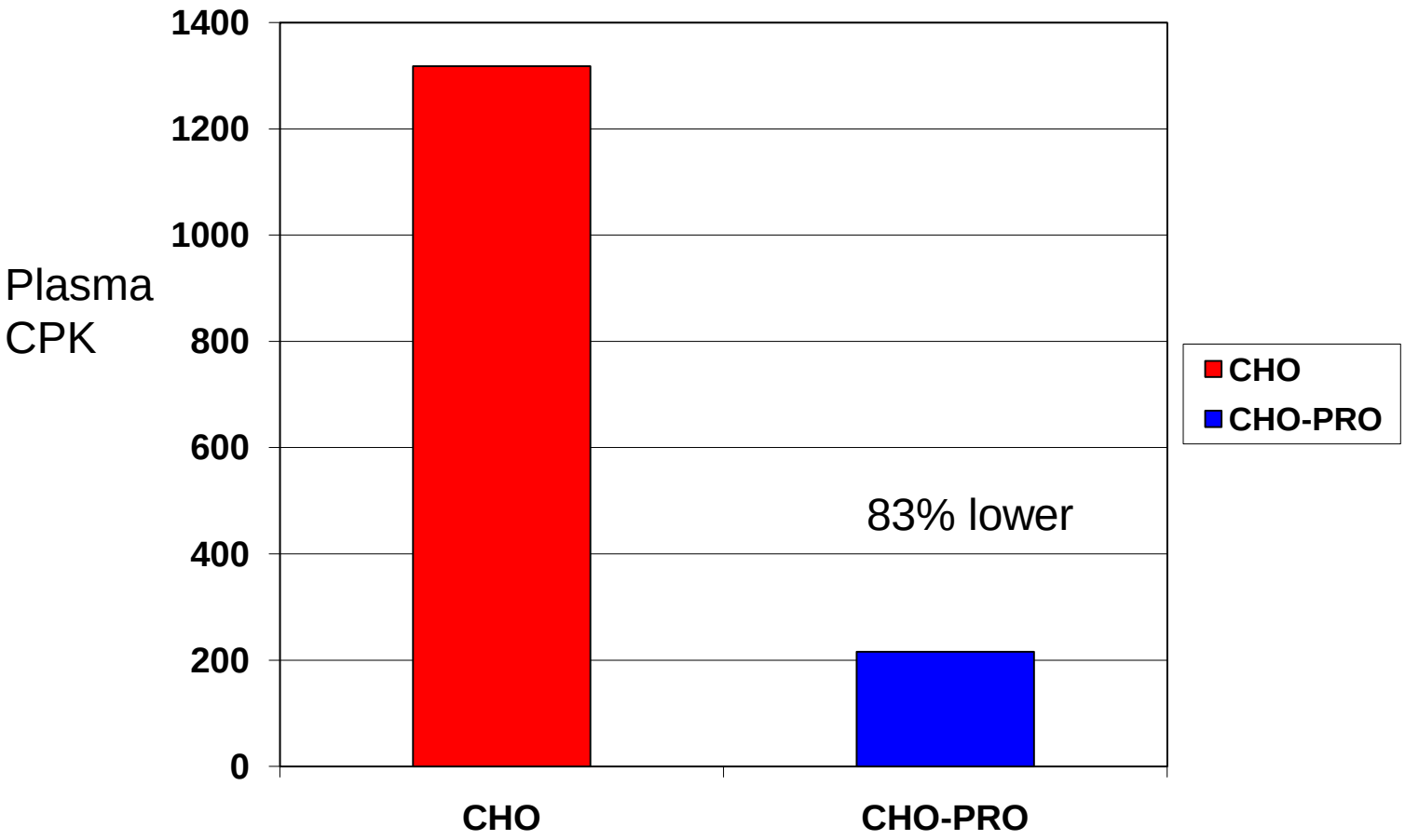
CHO-PRO last longer

1st trial at 75% VO2peak

2nd trial at 85% Vo2peak



Less muscle fiber damage with CHO-PRO



Conclusion

- A carbohydrate beverage with additional protein calories produced significant improvements in time to fatigue and reductions in muscle damage in endurance athletes.

Post-exercise protein supplementation

- Healthy US male Marine recruits; N=387; One of three treatments – supplements taken immediately post-exercise during the 54-d basic training period.
  1. Placebo (zero grams CHO, PRO, or Fat)
  2. Control (8 g CHO, 0 g PRO, 3 g Fat)
  3. Protein supplement (8 g CHO, 10 g PRO, 3 g Fat)
     - Flakoll PJ et al. Postexercise protein supplementation improves health and muscle soreness during basic military training in Marine recruits. J Appl Physiol. 2004 Mar;96(3):951-6. Epub 2003 Dec 2.

Compared to the placebo and control groups…

- The protein supplemented group had:
- 33% ↓ medical visits
- 28% ↓ visits due to viral/bacterial infections.
- 37% ↓ visits due to muscle/joint problems
- 83% ↓ visits due to heat exhaustion
- Less muscle soreness at day 34 and 54

What to take post-training…general rules of thumb

- Even 100 Calories will help.
- Manipulate CHO:PRO ratio for strength-power athletes vs endurance athletes
- Some essential fatty-acids for restoration of intra-muscular triglycerides
- More dietary energy for larger individuals

Post Exercise Meal Should:

I. Liquid – ease of consumption and rapid replenishment of fluids.

II. Contain electrolytes which may accelerate rehydration by speeding intestinal reabsorption of fluids and improve fluid retention.

III. Contain rapidly digesting, high glycemic carbs.

IV. Contain rapidly digesting protein with a complete essential amino acid profile (i.e. whey protein concentrates, essential amino acids)

V. As little as 100 Calories might help!

What about Meal Frequency?

- Twelve boxers were divided between:
  - **2 meals day-1 group** (the **2M** group)
  - **6 meals day-1 group** (the **6M** group).
  - Both groups ingested the same total energy (1200 kcal) per day for 2 weeks.

- Although there was no difference in change of body weight by food restriction between the two groups, the decrease in lean body mass (LBM) was significantly greater in the 2M group than in the 6M group.
  - **Iwao, S., Mori, K., and Sato, Y. (1996). Effects of meal frequency on body composition during weight control in boxers.** *Scand J Med Sci Sports,* Oct;6(5), 265-72.

After an endurance workout!

1. Consume ~ 500 Calories. If you're a small individual (decrease the serving size). *May tailor for lean body mass/ size and total duration & intensity of activity*
2. 2 to 4 times as much Carbs as Protein (example, whey protein). Add some healthy fat (example, flax oil, peanut/almond butter); about 6 g (a teaspoon)
3. Consume your 'normal' meal an hour afterwards.

After resistance-training?

(goal of increasing muscular body weight)

1. Consume ~ 500 Calories. Decrease serving size for smaller individuals.
2. However, increase the protein to carbohydrate ratio compared to endurance training. (The degree of muscle glycogen depletion is less, yet the demand to provide amino acids for skeletal muscle repair and growth is greater. *The carb:protein ratio is dependent on goals, individual tolerance, and training parameters*)
3. Add some healthy fat (example, flax oil, peanut butter, almond butter); about 6 grams (a teaspoon)
4. Consume your 'normal' meal an hour afterwards.

Glycemic Index (GI)

- Glycemic Index (GI): Ranking of CHO based on blood glucose response to a reference food
  - High GI produce rapid "spike" in glucose
  - Low GI produce slow, sustained increase
- Immediately after mission: HIGH GI
  - Carrots, raisins, corn flakes, breads, rice cakes
- Recovery and maintenance: LOW GI
  - Yogurt, apples, dried fruit, lentils, beans

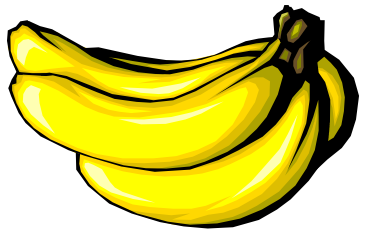
Glycemic Index of Foods

GI > 85

- White Bagel
- English Muffins
- Doughnut
- Raisins
- Corn Chips
- Ice Cream
- Sports Drinks

GI < 60

- Yogurt
- Grapefruit/Oranges
- Beans
- Peanuts
- Apples/Banana/Plums
- Milk
- Brown Rice



http://www.glycemicindex.com/

Recovery Meals

Food/Beverage Products	CHO (g)	Pro (g)
Peanut butter, 2 Tbsp, and jelly, 2 tsp, on wheat bread, 2 slices	43	14
Wendy's Mandarin Chicken Salad and Cranapple juice, 8 oz	88	27
Hard-boiled egg, 1, and bagel	56	12
Hand-Tossed Style Chicken Supreme Pizza (Pizza Hut), 1 slice, and juice, 8 oz	57	13
Subway Breakfast Western Egg with Cheese on Deli Roll with orange juice, 4 oz	47	28

Recovery Meals

Food/Beverage Products	CHO (g)	Pro (g)
Taco Bell Bean Burrito, 1	54	13
Low-fat yogurt with fruit, 8oz	47	11
Soldier Fuel Bar, 1, or other high CHO Sports Bar	40	10
String cheese, 2, and apple or pear, 1 large	23	14
Cereal with low-fat milk, 1 cup	53	13
McDonald English Muffins with Jam, 2	36	5
Arby's Jamocha Shake, regular size	81	11

Key Points

- Nutrient timing is critical to performance
- High GI foods are ideal for recovery
- Protein added to recovery meal helps muscle rebuilding
- Sports bars, gels, and drinks are suitable

Summary

- A need to feed! Use these nutrient timing windows:
  - Breakfast
  - Pre, During, and Post-Workout
- Rest of the day
  - Emphasize unprocessed carbs, unsaturated fats (e.g. from fish, peanuts, almonds, etc), and plenty of protein.

References

- Anderson, L. L., et al. (2005). The effect of resistance training combined with timed ingestion of protein on muscle fiber size and muscle strength. *Metabolism,* 54(2), 151-156.
- Anselme et al. (1992). Benefits of caffeine ingestion on sprint performance in trained and untrained swimmers. *European Journal of Applied Physiology, 64(4), 377-380.*
- Bird, S. P., Tarpenning, K. M., Marino, F. E. (2006). Independent and combined effects of liquid carbohydrate/essential amino acid ingestion on hormonal and muscular adaptations following resistance training in untrained men. *Eur J Appl Physiol*, 97(2), 239.
- Borsheim, E., Cree, M. G., Tipton, K. D., Elliott, T. A., Aarsland, A., Wolfe, R. R. (2004). Effect of carbohydrate intake on net muscle protein synthesis during recovery from resistance exercise. *J Appl Physiol,* Feb 96(2), 674-8.
- Chromiak, J., et al. (2004). Effect of a 10-Week strength training program and recovery drink on body composition, muscular strength and endurance, and anaerobic power and capacity. *Nutrition,* 20, 420-427.
- Cribb, P. J., Hayes, A. (2006). Effects of supplement timing and resistance exercise on skeletal muscle hypertrophy. *Med Sci Sports Exerc,* Nov, 38(11), 1918-25.

References

- Esmarck, B. et al. (2001). Timing of postexercise protein intake is important for muscle hypertrophy with resistance training in elderly humans. J Physiol. Aug 15;535(Pt 1):301-11.
- Flakoll, et al. (2004). Postexercise protein supplementation improves health and muscle soreness during basic military training in marine recruits, *JAP,* 96, 951-956.
- Haff G. et al. (2001). The effects of supplemental carbohydrate ingestion on intermittent isokinetic leg exercise.
  J Sports Med Phys Fitness. 2001 Jun;41(2):216-22.
- Haff G. et al. (2000). Carbohydrate supplementation attenuates muscle glycogen loss during acute bouts of resistance exercise.
  Int J Sport Nutr Exerc Metab. 2000 Sep;10(3):326-39.
- Ivy, J. L., Res, P. T., Sprague, R. C., Widzer, M. O. (2003). Effect of a carbohydrate-protein supplement on endurance performance during exercise of varying intensity. *Int J Sport Nutr Exerc Metab,* Sep,13(3), 382-95.

References

- Ivy, et al. (2002). Early Post-exercise muscle glycogen recovery is enhanced with a carbohydrate-protein supplement. *Journal of Applied Physiology*, 93, 1337-1344.
- Rankin, J. W., et al. (2004). Effect of Post-Exercise Supplement Consumption on Adaptations to Resistance Training *Journal of the American College of Nutrition*, 23(4), 322-330.
- Roy, B. D., et al. (2002). The influence of post-exercise macronutrient intake on energy balance and protein metabolism in active females participating in endurance training. *IJSN*, 12, 172-188.
- Saunders, M. J., Kane, M. D., Todd, M. K. (2004). Effects of a carbohydrate-protein beverage on cycling endurance and muscle damage. *Med Sci Sports Exerc, 36(7), 1233-1238.*
- Iwao, S., Mori, K., Sato Y. (1996). Effects of meal frequency on body composition during weight control in boxers. *Scand J Med Sci Sports*, Oct, 6(5), 265-72.

References

- Tipton, K. (2001). Timing of amino acid-carbohydrate ingestion alters anabolic response of muscle to resistance exercise. *American Journal of Physiology Endocrinology and Metabolism*, 281, E197-E206.

- Tipton, K. et al. (2007). Stimulation of net muscle protein synthesis by whey protein ingestion before and after exercise.Am J Physiol Endocrinol Metab. Jan;292(1):E71-6. Epub 2006 Aug 8.

- Willoughby, et al. (2006). Effects of resistance training and protein plus amino acid supplementation on muscle anabolism, mass, and strength. *Amino Acids*, 32(4), 467-477.