FITNESS 2.0

CONGRESO INTERNACIONAL
ACADEMIA & FITNESS

presented by: EXPOFITNESS

Role of Protein in Exercise, Training, and Health

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Overview

EXERCISE & SPORT NUTRITION LABORATORY
TEXAS A&M UNIVERSITY

- New ISSN guidelines for protein and exercise
- Examples of impact of protein and amino acids on training and health
- Nutraceutical and functional food opportunities

ISSN Position Stand

Protein and Exercise *(JISSN 14(20), 2017)*

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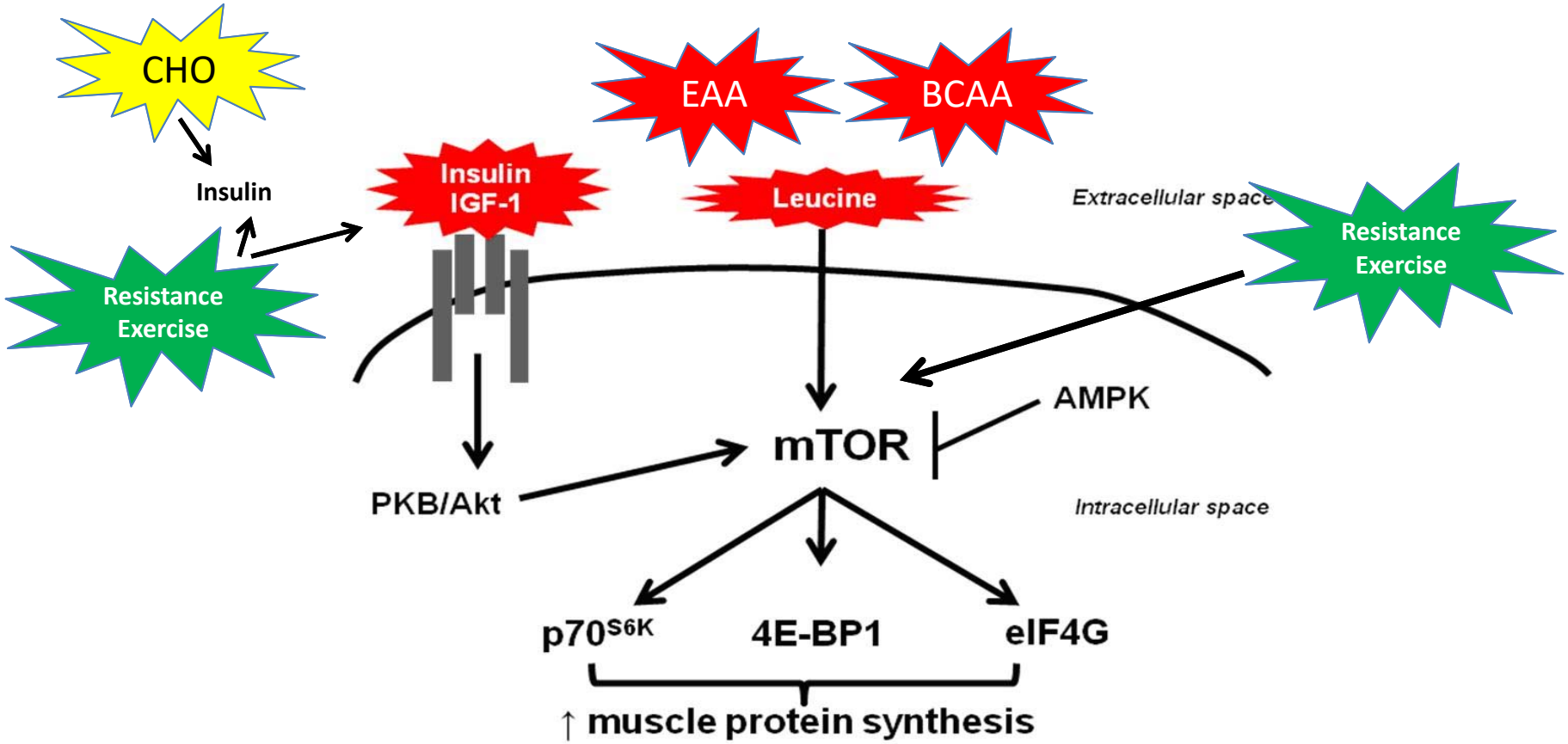
1. An acute exercise stimulus, particularly ***resistance exercise, and protein ingestion both stimulate muscle protein synthesis (MPS)*** and are synergistic when protein consumption occurs before or after resistance exercise.

Role of Exercise & Nutrition on Protein Synthesis Pathways



Effects of different intensities on resistance exercise and regulators of myogenesis

Wilborn et al. J Strength Cond Res 23(8): 2179–2187, 2009

Table 1. Resistance exercise repetitions.

Bout	Leg press repetitions	Leg extension repetition
60–65%	17.94 ± 0.96	17.71 ± 0.83
80–85%	8.79 ± 0.82	9.27 ± 0.77

Data are mean ± *SD*.

- 13 male participants (21.5±2.9 years, 86.1±19.5 kg, 69.7±2.7 in) completed bouts of RE involving ***4 sets of 18–20 repetitions with 60–65% 1RM and 4 sets of 8–10 repetitions with 80–85% 1RM***.
- Vastus lateralis *biopsies were obtained immediately before and at 30-minutes, 2-hrs, and 6-hrs after exercise*.
- The levels of mRNA expression were determined using real-time polymerase chain reaction.

Effects of different intensities on resistance exercise and regulators of myogenesis

Wilborn et al. J Strength Cond Res 23(8): 2179–2187, 2009

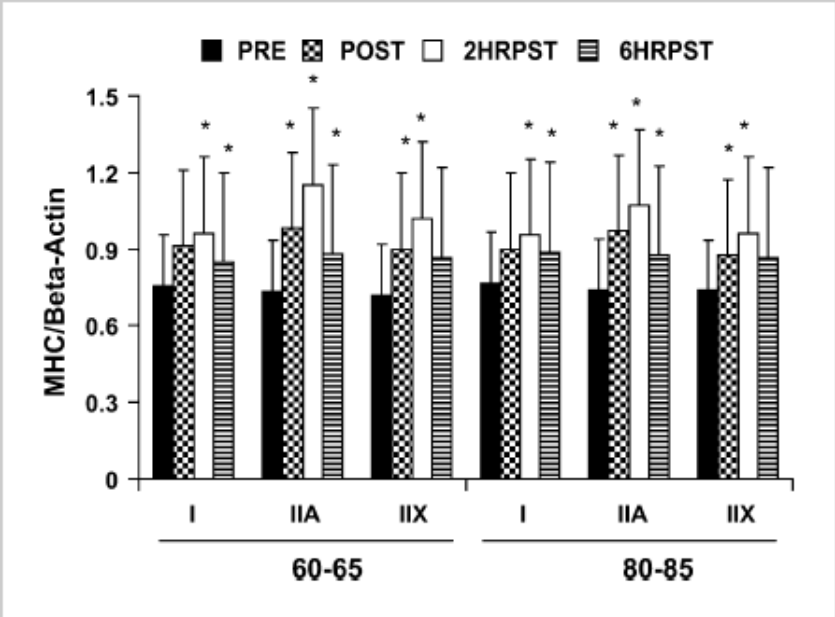


Figure 1. Myosin heavy chain (MHC) isoform mRNA expression in response to resistance exercise bouts with 60–65% and 80–85% 1 repetition maximum. Compared to immediately before exercise, MHC expression was significantly greater at 2 hours (2HRPST). MHC IIA was significantly greater at 30 minutes (PST), 2HRPST, and 6 hours (6HRPST) after exercise. MHC IIX was significantly greater at PST and 2HPST. *Significant main effect for time ($p < 0.05$).

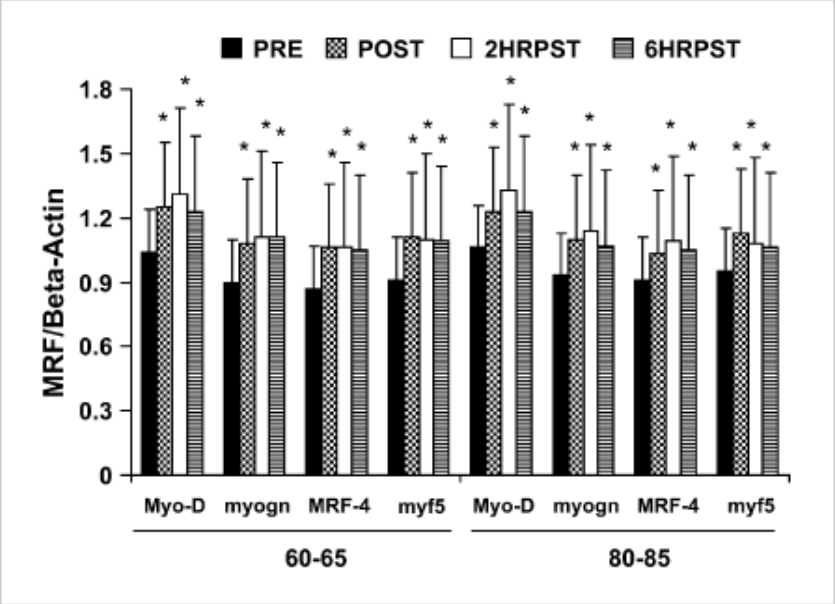


Figure 2. Myogenic regulatory factors (MRF) mRNA expression in response to resistance exercise bouts with 60–65% and 80–85% 1 repetition maximum. Compared to immediately before exercise, Myo-D expression was significantly greater at 30 minutes (PST), 2 hours (2HRPST), and 6 hours (6HRPST) after exercise. Myogenin, MRF-4, and myf5 were significantly greater at PST, 2HPST, and 6HPST. *Significant main effect for time ($p < 0.05$).

Effects of different intensities on resistance exercise and regulators of myogenesis

Wilborn et al. J Strength Cond Res 23(8): 2179–2187, 2009

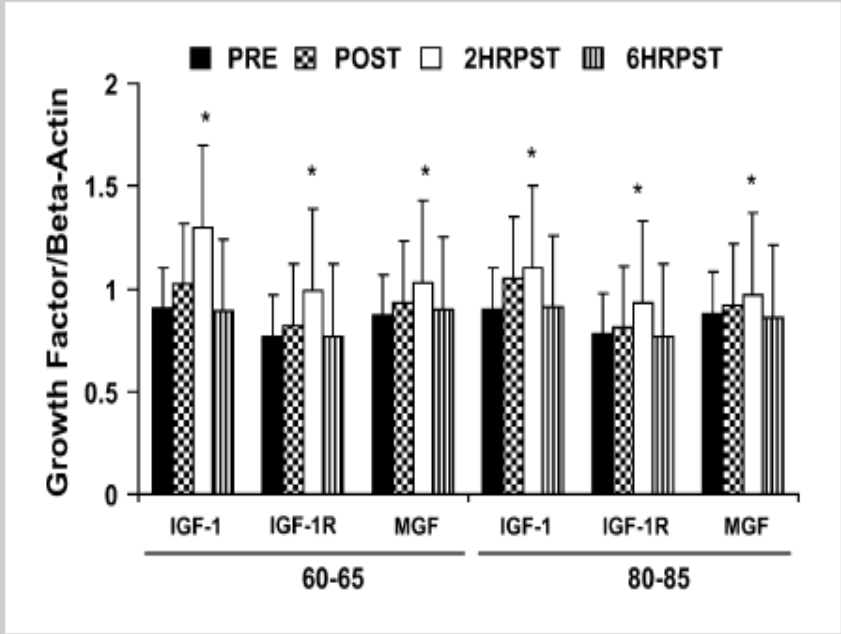


Figure 3. Growth factor mRNA expression in response to resistance exercise bouts with 60–65% and 80–85% 1 repetition maximum. Compared to immediately before exercise, IGF-1, IGF-R1, and MGF were all significantly increased at 2 hours after exercise. *Significant main effects for time ($p < 0.05$).

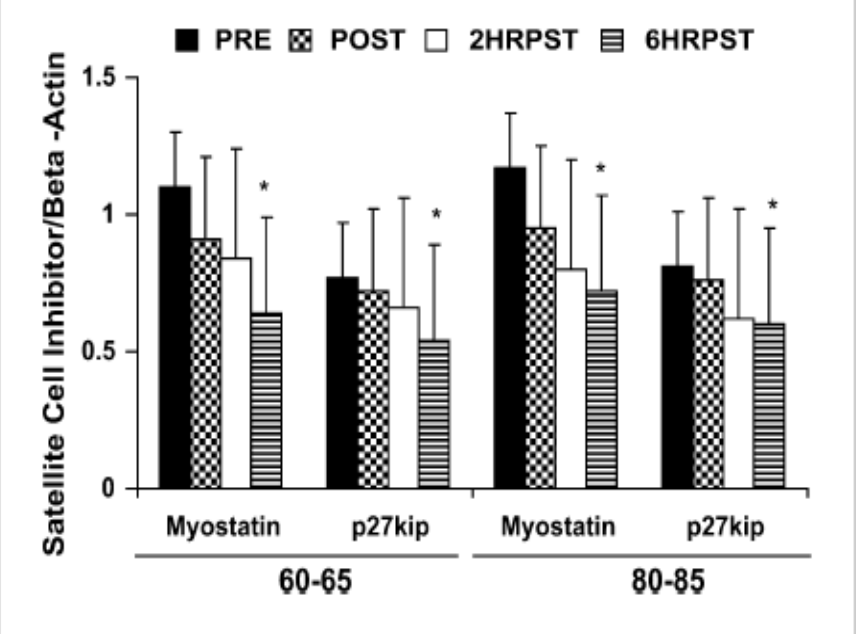
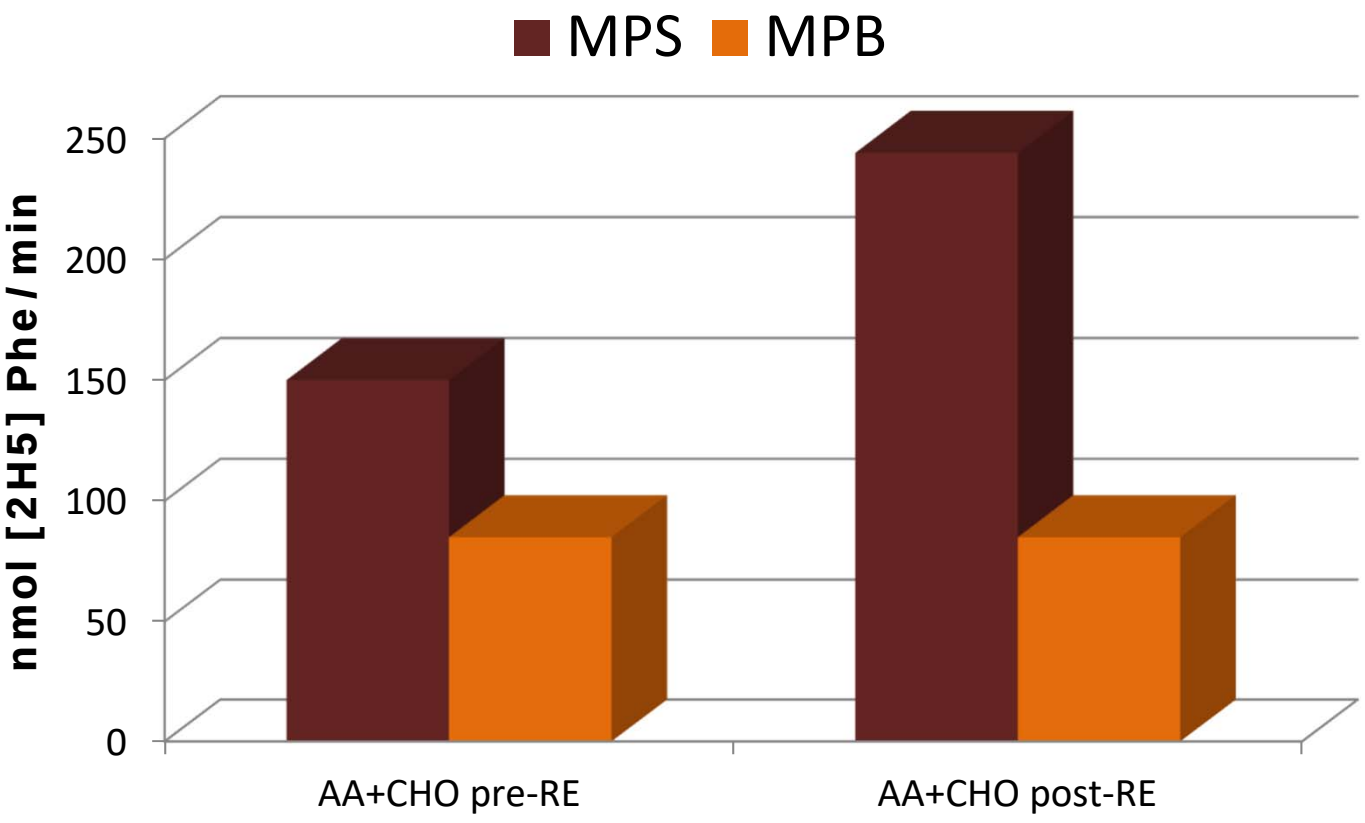


Figure 4. Satellite cell activation inhibitor mRNA expression in response to resistance exercise bouts with 60–65% and 80–85% 1 repetition maximum. Compared to immediately before exercise, myostatin and $p27^{kip}$ were significantly decreased at 6 hours after exercise. *Significant main effects for time ($p < 0.05$).

Contractile and nutritional regulation of human muscle growth

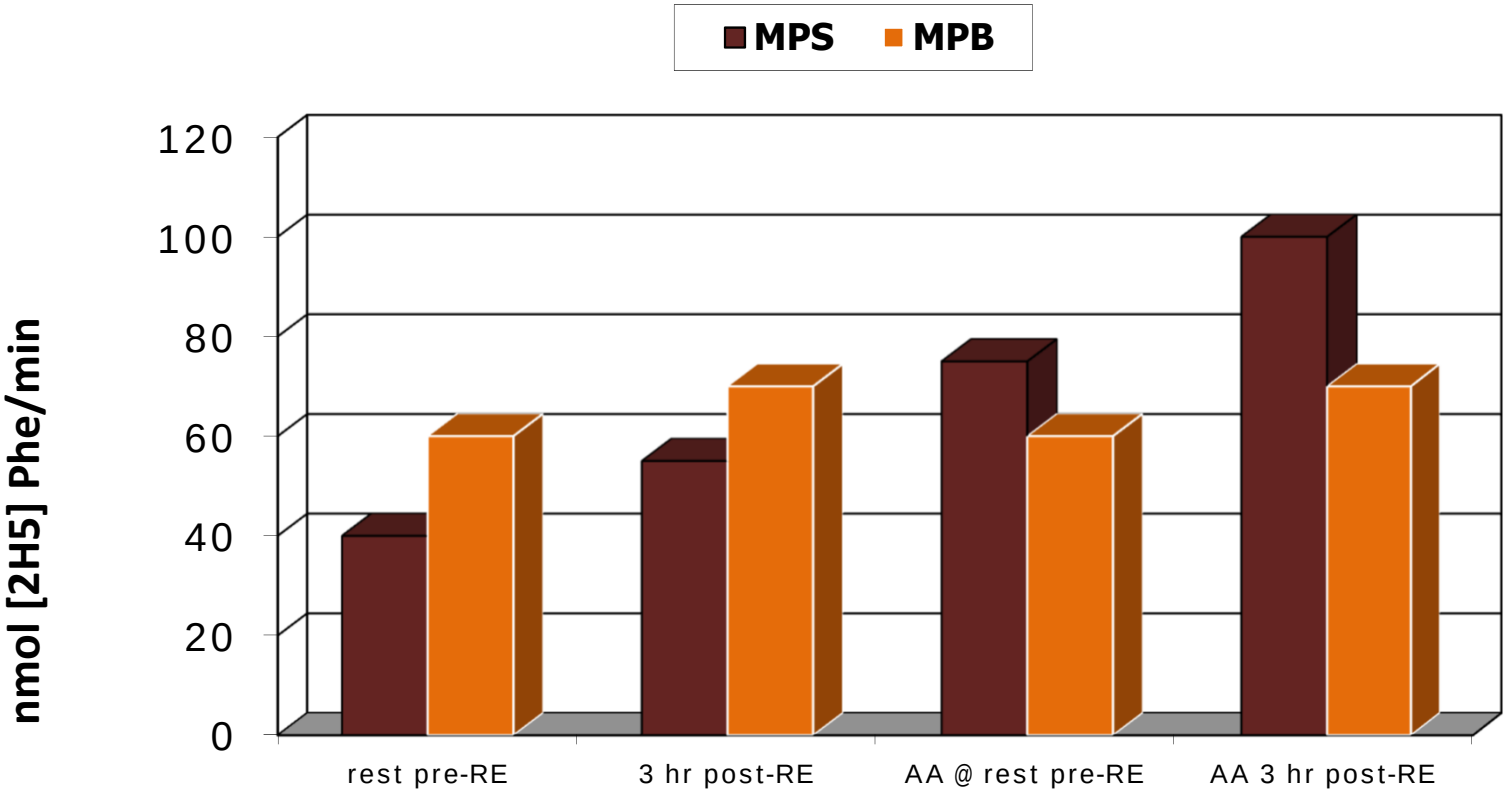
Rasmussen & Phillips. Ex Sport Sci Rev. 31(3): 127-31, 2003



40 grams infused mixed AA + 40 grams infused CHO

Contractile and nutritional regulation of human muscle growth

Rasmussen & Phillips. Ex Sport Sci Rev. 31(3): 127-31, 2003



6 grams oral EAA + 35 grams oral CHO

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2. For building muscle mass and for maintaining muscle mass through a positive muscle protein balance, an overall daily protein intake in the range of ***1.4–2.0 g protein/kg body weight/day (g/kg/d)*** is sufficient for most exercising individuals, a value that falls in line within the Acceptable Macronutrient Distribution Range published by the Institute of Medicine for protein.

Influence of protein intake and training status on nitrogen balance and lean body mass

Tarnopolsky et al. J Appl Physiol (1985). 1988 Jan;64(1):187-93.

- 6 elite bodybuilders, 6 elite endurance athletes, and 6 sedentary controls during a 10-day period of normal protein intake followed by a ***10-day period of altered protein intake.***
- ***The nitrogen balance data revealed that bodybuilders required 1.12 times and endurance athletes required 1.67 times more daily protein than sedentary controls***.
- Lean body mass (density) was maintained in bodybuilders consuming 1.05 g protein/kg/d.
- Endurance athletes excreted more total daily urea than either bodybuilders or controls.
- ***Bodybuilders require a daily protein intake only slightly greater than that for sedentary individuals*** in the maintenance of lean body mass.
- ***Endurance athletes require daily protein intakes greater than either bodybuilders or sedentary individuals*** to meet the needs of protein catabolism during exercise.

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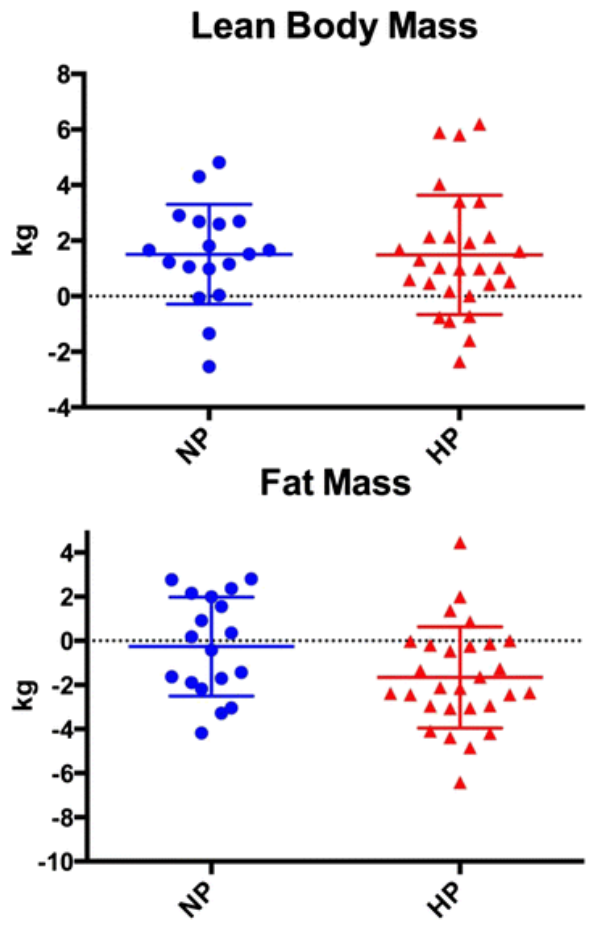
3. There is novel evidence that suggests higher ***protein intakes (>3.0 g/kg/d) may have positive effects on body composition in resistance-trained individuals*** (i.e., promote loss of fat mass).

Antonio et al. JISSN 2014, 11:19

A high protein diet (3.4 g/kg/d) combined with a heavy resistance training program improves body composition in healthy trained men and women--a follow-up investigation

Antonio et al. J Int Soc Sports Nutr. 2016 Jan 16;13:3

- 48 RT men and women were instructed to consume ***2.3 (NP) and 3.4 g/kg/day (HP)*** of dietary protein during heavy RT.
- The ***NP group gained significantly more body weight*** than the HP group; however, the ***HP group experienced a greater decrease in fat mass and % body fat***.
- There was a significant time effect for FFM; however, there was a ***non-significant time by group effect for FFM (change: +1.5 +/- 1.8 NP, +1.5 +/- 2.2 HP***).
- A significant time effect was seen in both groups in maximal strength (i.e., 1-RM squat and bench) vertical jump and pull-ups; however, there were no significant time by group effects.
- There were ***no changes in any of the blood parameters*** (i.e., basic metabolic panel).
- ***Consuming a high protein diet (3.4 g/kg/d) in conjunction with a heavy RT may confer benefits with regards to body composition without deleterious effects***.



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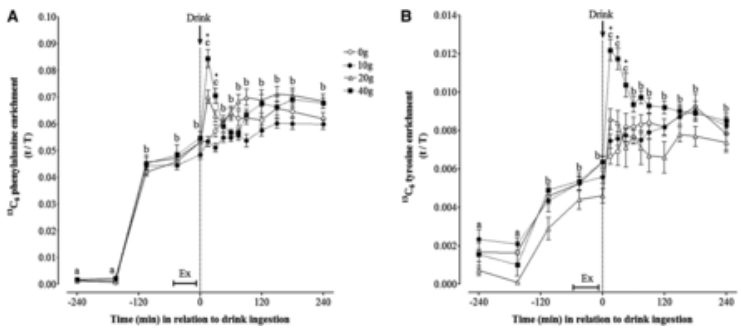
4. Recommendations regarding the optimal protein intake per serving for athletes to maximize MPS are mixed and are dependent upon age and recent resistance exercise stimuli.

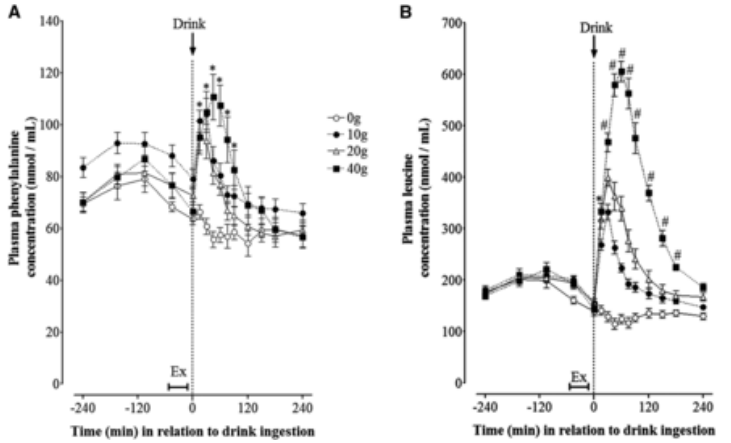
   General recommendations are ***0.25 g/kg*** of a high-quality protein, or an absolute dose of ***20–40 g***.

Myofibrillar muscle protein synthesis rates subsequent to a meal in response to increasing doses of whey protein at rest and after resistance exercise

Witard et al. Am J Clin Nutri. 99, 2014

- 48 RT individuals consumed a ***high-protein (0.54 g/kg body mass) breakfast***.
- Three hours later, a bout of unilateral exercise ***(8 x 10 leg presses and leg extensions; 80% one-repetition maximum)*** was performed.
- Volunteers ingested ***0, 10, 20, or 40 g whey protein isolate immediately (~10 min) after exercise***.
- Myofibrillar ***MPS increased*** above 0 g whey protein (0.041 +/- 0.015%/h) by ***49% and 56% with the ingestion of 20 and 40 g whey protein***, respectively.
- No additional stimulation was observed with 10 g whey protein (P > 0.05).
- Rates of phenylalanine oxidation and urea production increased with the ingestion of 40 g whey protein.
- ***A 20-g dose of whey protein is sufficient for the maximal stimulation of postabsorptive rates of myofibrillar MPS in rested and exercised muscle of ~80-kg resistance-trained, young men.***

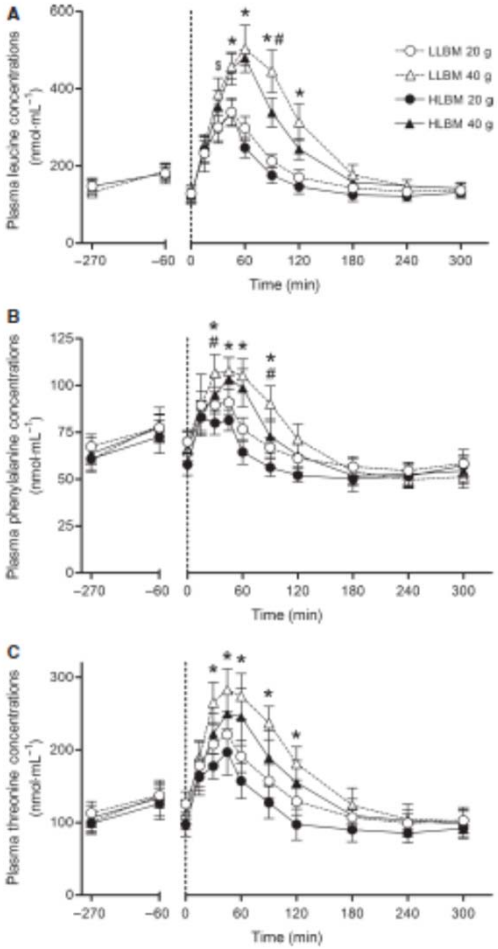




The response of muscle protein synthesis following whole-body resistance exercise is greater following 40 g than 20 g of ingested whey protein

Macnaughton et al. Physiol Rep. 2016 Aug;4(15)

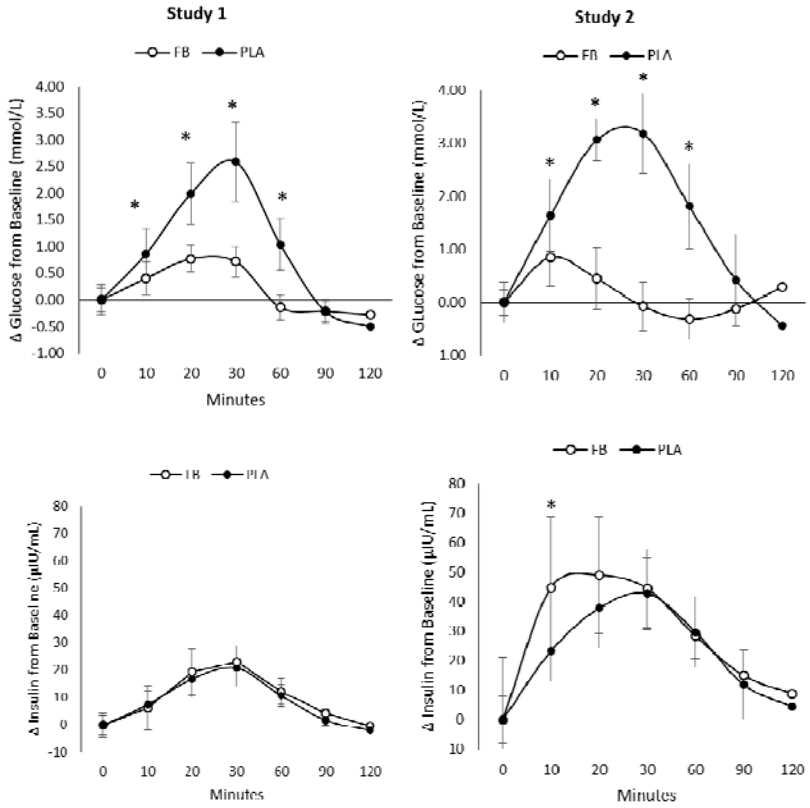
- RT males were assigned to a group with lower LBM (<=65 kg; LLBM n = 15) or higher LBM (>/=70 kg; HLBM n = 15) and participated in two trials in random order.
- MPS was measured with the infusion of (13)C6-phenylalanine tracer and collection of muscle biopsies following ingestion of either ***20 or 40 g protein during recovery from a single bout of whole-body resistance exercise***.
- ***A similar response of MPS during exercise recovery was observed between LBM groups following protein ingestion***.
- ***Overall, MPS was stimulated to a greater extent following ingestion of 40 g*** (0.059 +/- 0.020%.h(-1)) ***compared with 20 g*** (0.049 +/- 0.020%.h(-1); P = 0.005) of protein.
- ***Results indicate that ingestion of 40 g whey protein following whole-body resistance exercise stimulates a greater MPS response than 20 g in young resistance-trained men.***



Glycemic and Insulinemic Response to Ingestion of a Novel Food Bar Containing Whey Protein and Isomalto-Oligosaccharides

Grubic et al. J Nutri Food Sci. 2017 – In press, 2018

- IMO is a prebiotic high fiber, low calorie source of CHO
- This study examined the glycemic and insulinemic responses of ingesting a whey protein food bar with IMO
- In two studies, 20 or 10 men & women ingested 25g or 50g of a dextrose control or a food bar (FB) containing ***25g IMO + 20g whey or 50g IMO with 40g whey*** prior to an OGTT
- Blood samples were collected at 0, 10, 20, 30, 60, 90 and 120 min and assayed for blood glucose and insulin
- ***The glycemic response to FB was significantly lower during the first 60 min following ingestion in comparison to the dextrose PLA in both trials.***
- ***Some evidence that insulin was increased in study 2***
- ***The glucose integrated AUC (iAUC) change from baseline was significantly lower with FB ingestion*** (Study 1 FB 60 [CI 48, 71], PLA 160 [134, 186], p<0.001; Study 2 FB 65 [49, 82], PLA 209 [170, 244] mmol-h/L, p<0.001) while ***no differences were observed between treatments in insulin iAUC responses.***
- This FB may serve as a low glycemic food option.



Since glucose was only increased by up to 15% with FB, the higher protein intake may have increased insulin to a greater degree.

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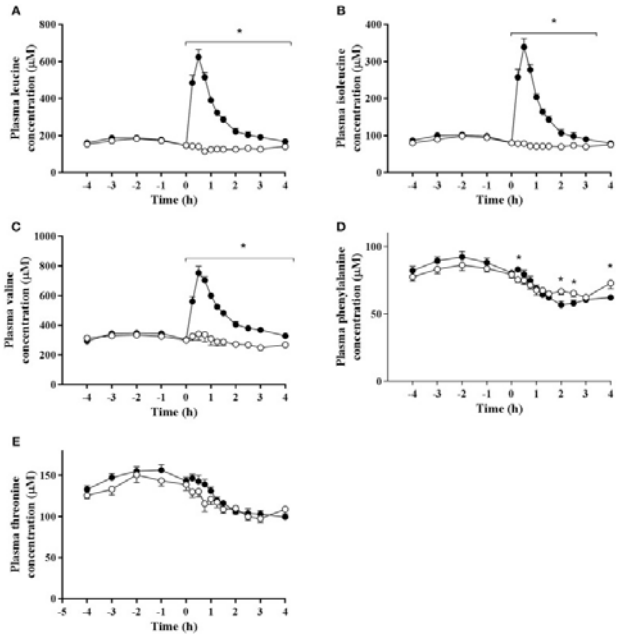
5. Acute protein doses should strive to contain ***0.7–3.0 g of leucine*** and/or a higher relative leucine content, in addition to a balanced array of the essential amino acids (EAAs).

Trommelen & van Loon. Nutrients **2016**, 8, 763

Branched-chain amino acid ingestion stimulates muscle myofibrillar protein synthesis following resistance exercise in humans

Jackman et al. Front Physiol. 8:390, 2017

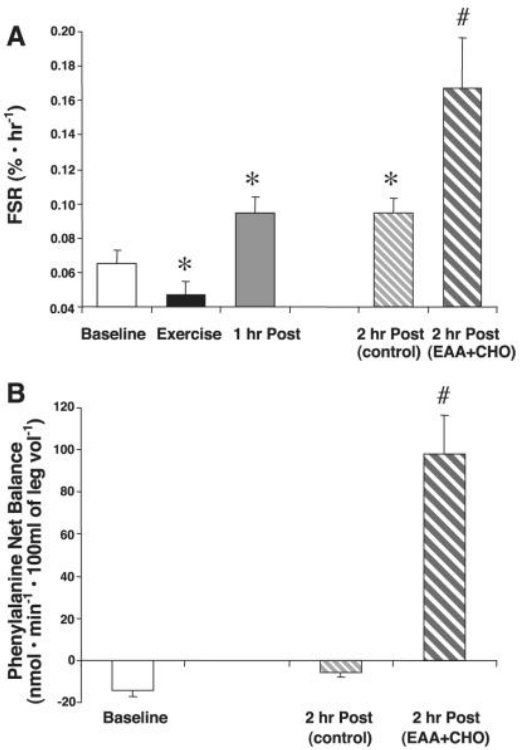
- 10 young RT men completed two trials, ingesting either ***5.6 g BCAA*** or a ***placebo*** (PLA) drink ***immediately after resistance exercise***.
- Myofibrillar-MPS was measured during exercise recovery with a primed, constant infusion of L-[ring13C6] phenylalanine and collection of ***muscle biopsies pre and 4 h-post drink ingestion***.
- The percentage increase from baseline in plasma leucine (300 +/- 96%), isoleucine (300 +/- 88%), and valine (144 +/- 59%) concentrations ***peaked 0.5 h-post drink in BCAA***.
- ***A greater phosphorylation status of S6K1Thr389 and PRAS40*** was observed ***in BCAA*** than PLA at 1 h-post drink ingestion.
- ***Myofibrillar-MPS was 22% higher in BCAA (0.110 +/- 0.009%/h) than PLA (0.090 +/- 0.006%/h).***
- Phenylalanine Ra was ~6% lower in BCAA (18.00 +/- 4.31 mumol.kgBM-1) than PLA (21.75 +/- 4.89 mumol.kgBM-1; P = 0.028) after drink ingestion.
- ***Ingesting BCAAs alone increases the post-exercise stimulation of myofibrillar-MPS and phosphorylation status mTORC1 signaling.***



Leucine-enriched essential amino acid and carbohydrate ingestion following resistance exercise enhances mTOR signaling and protein synthesis in human muscle

Dreyer et al. Am J Physiol Endocrinol Metab. 2008 Feb;294(2):E392-400

- 16 male subjects were randomized to ingest a ***control or EAA+CHO*** supplement solution 1 h after resistance exercise.
- ***MPS and 4E-BP1 phosphorylation during exercise were reduced***.
- ***Postexercise FSR was elevated above baseline in both groups at 1 h but was further elevated in the EAA+CHO group at 2 h postexercise***.
- Increased FSR was associated with enhanced phosphorylation of mTOR and S6K1 ($P < 0.05$).
- Akt phosphorylation was elevated at 1 h and returned to baseline by 2 h in the control group, but it remained elevated in the EAA+CHO group.
- 4E-BP1 phosphorylation returned to baseline during recovery in control but became elevated when EAA+CHO was ingested.
- eEF2 phosphorylation decreased at 1 and 2 h postexercise to a similar extent in both groups ($P < 0.05$).
- ***Results suggest that enhanced activation of the mTOR signaling pathway is playing a role in the greater synthesis of muscle proteins when resistance exercise is followed by EAA+CHO ingestion***.



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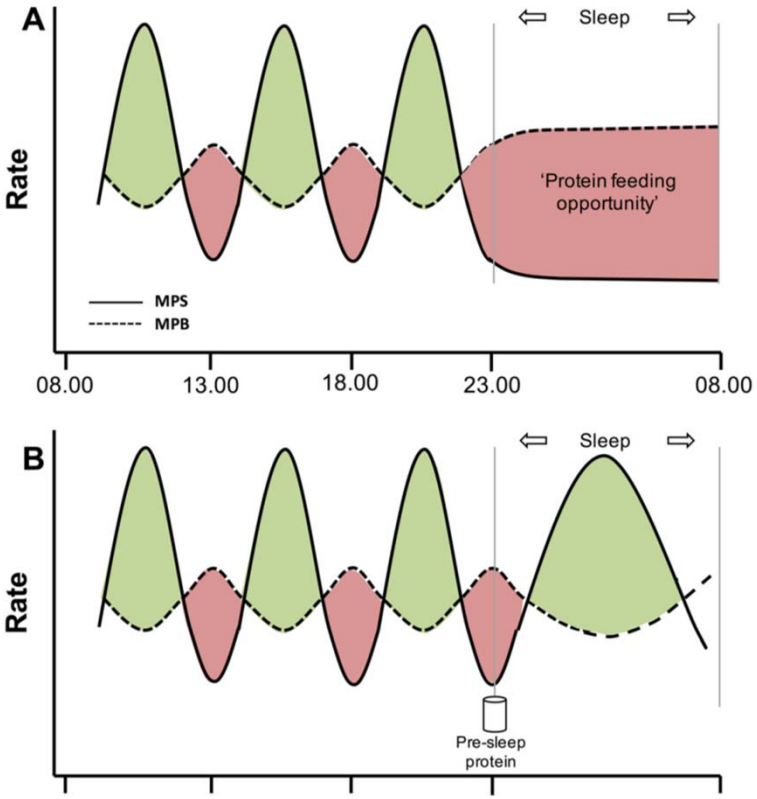
6. ***Protein doses should ideally be evenly distributed, every 3–4 h, across the day.***

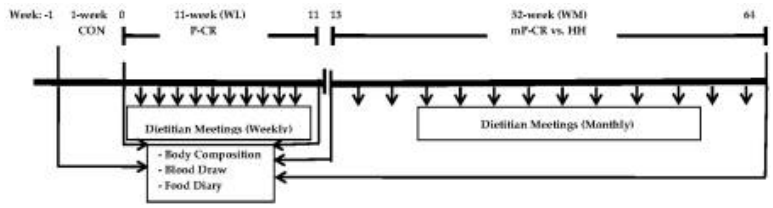


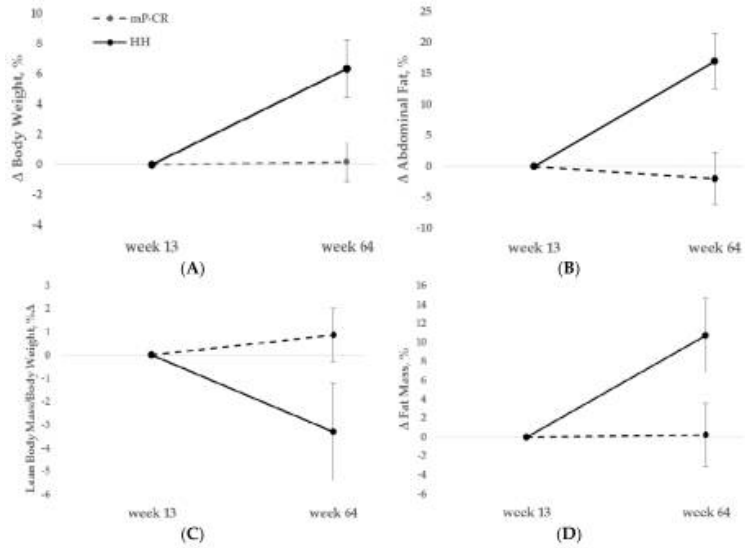
Trommelen & van Loon. Nutrients **2016**, 8, 763

Protein-pacing caloric-restriction enhances body composition similarly in obese men and women during weight loss and sustains efficacy during long-term weight maintenance

Arciero et al. J Nutrients. 2016 Jul 30;8(8)

- During weight loss (WL), men (n = 21) and women (n = 19) were assessed for changes in body composition, RMR, and biomarkers at weeks 0 (pre) and 12 (post).
- Men and women had similar reductions ($p < 0.01$) in weight (10%), total BF (19%), abdominal BF (25%), VAT (33%), glucose (7%-12%), insulin (40%), leptin (>50%) and increase in % lean body mass (9%). RMR (kcals/kg bodyweight) was unchanged and respiratory quotient decreased 9%.
- ***Twenty-four subjects (mP-CR, n = 10; HH, n = 14) completed weight maintenance***.
- ***Modified protein-caloric restriction (mP-CR) regained significantly less body weight (6%), TBF (12%), and ABF (17%) compared to those following a heart health higher CHO diet***.
- ***Results demonstrate mP-CR enhances weight loss, body composition and biomarkers, and maintains these changes for 52-weeks compared to a traditional HH diet.***





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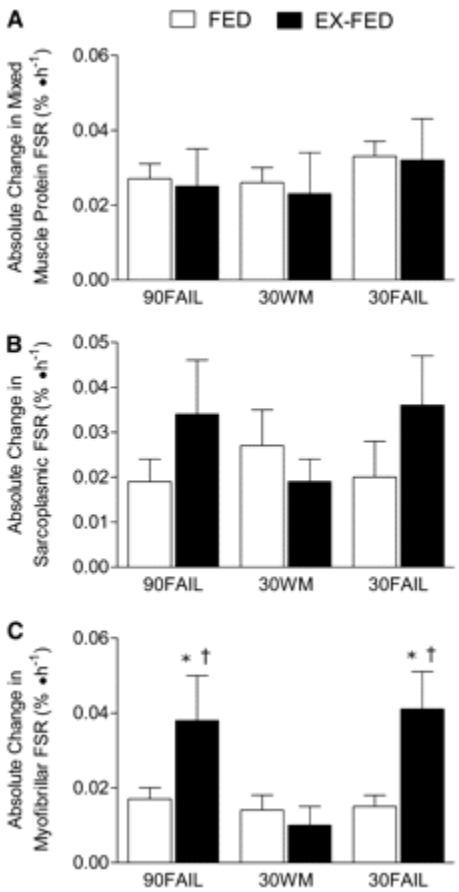
7. The optimal time period during which to ingest protein is likely a matter of individual tolerance, since benefits are derived from pre- or post-workout ingestion; however, ***the anabolic effect of exercise is long-lasting (at least 24 h), but likely diminishes with increasing time post-exercise.***

Enhanced amino acid sensitivity of myofibrillar protein synthesis persists for up to 24 h after resistance exercise in young men

Burd et al. J Nutr. 2011 Apr 1;141(4):568-73

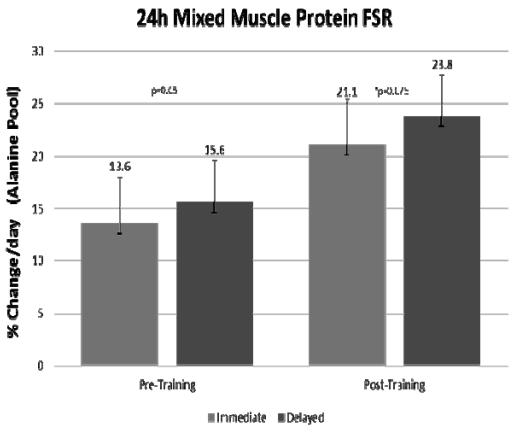
- 15 men received a primed, constant infusion of l-[ring-(13)C(6)] phenylalanine to ***measure muscle protein synthesis after protein feeding at rest (FED; 15 g whey protein) and 24 h after RE (EX-FED).***
- Participants performed unilateral leg exercises: 1) ***4 sets at 90% of maximal strength to failure (90FAIL); 2) 30% work-matched to 90FAIL (30WM); or 3) 30% to failure (30FAIL).***
- Regardless of condition, ***rates of mixed muscle protein and sarcoplasmic protein synthesis were similarly stimulated at FED and EX-FED***.
- ***Protein ingestion stimulated rates of myofibrillar protein synthesis above fasting rates by 0.016 +/- 0.002%/h and the response was enhanced 24 h after resistance exercise, but only in the 90FAIL and 30FAIL conditions, by 0.038 +/- 0.012 and 0.041 +/- 0.010, respectively.***
- Phosphorylation of protein kinase B on Ser473 was greater than FED at EX-FED only in 90FAIL, whereas phosphorylation of mammalian target of rapamycin on Ser2448 was significantly increased at EX-FED above FED only in the 30FAIL condition.
- ***Results suggest that resistance exercise performed until failure confers a sensitizing effect on human skeletal muscle for at least 24 h*** that is specific to the myofibrillar protein fraction.

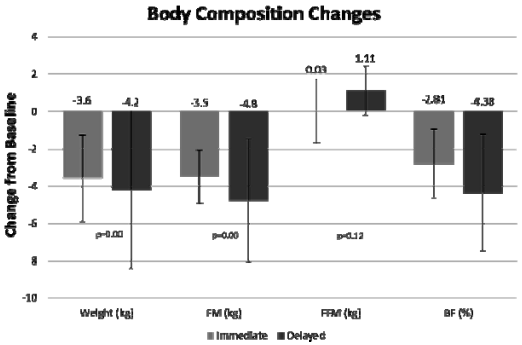


Effects of immediate and delayed nutrient timing following resistance exercise on changes in mixed muscle fractional synthesis rate (FSR) in post-menopausal women participating in a weight loss program

Byrd et al. JISSN 10(Suppl 1): p. P3. 2013

- ***21 sedentary women participated in a 12 week weight loss program*** (1,500 kcal/d; 30% C, 45% P, and 25% F) while participating in circuit resistance exercise (RE) (30min; 3d/wk) and walking (10k steps, 4/d wk)].
- Each ingested ***15 g of*** protein immediately post (I) or 2 hours post (D) RE.
- ***The D group generally experienced more favorable body mass, fat mass, and % body changes***.
- No significant interactions were observed in muscle FSR expressed as percent/day of the alanine pool (I-Pre 13.6±4.3, I-Post 21.1±4.3; D-Pre 15.6±4.0, D-Post 23.8±4.0 %/d, p=0.93).
- ***FSR was upregulated (p<0.05) in response to a pre-training bout of RE (14.6±2.9 %/d), and trended 54% higher (p=0.075) in response to post-training values (22.5±2.9 %/d).***
- Results indicate that the program was effective in promoting weight and fat loss, while maintaining FFM.
- ***Post exercise FSR increased pre-training, and trended higher at 12-wks***





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8. While it is possible for physically active individuals to obtain their daily protein requirements through the consumption of whole foods, ***supplementation is a practical way of ensuring intake of adequate protein quality and quantity, while minimizing caloric intake, particularly for athletes who typically complete high volumes of training***.

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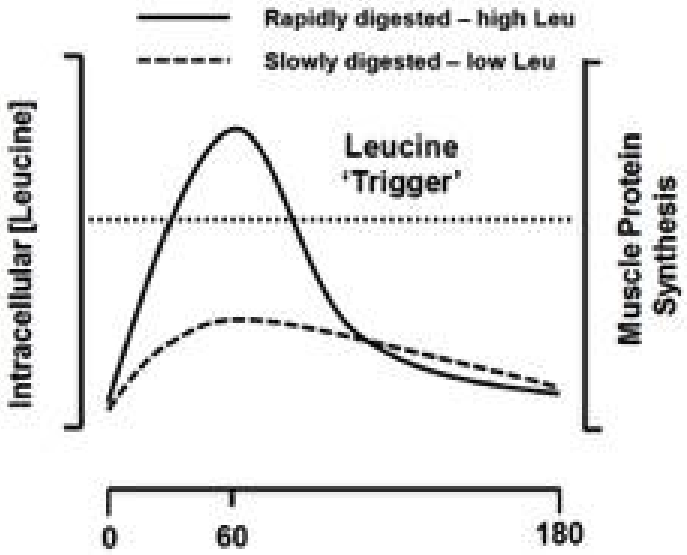
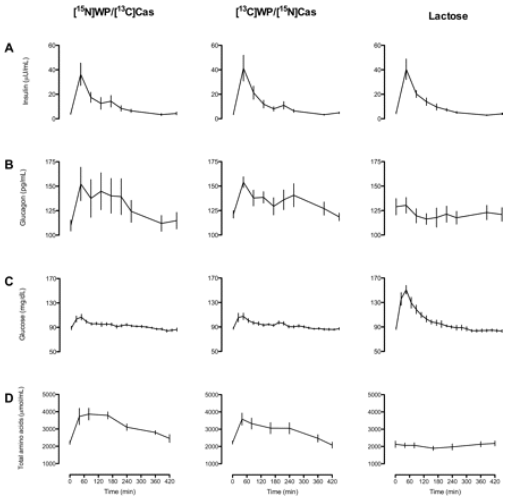
9. ***Rapidly digested proteins that contain high proportions of essential amino acids (EAAs) and adequate leucine, are most effective in stimulating MPS.***

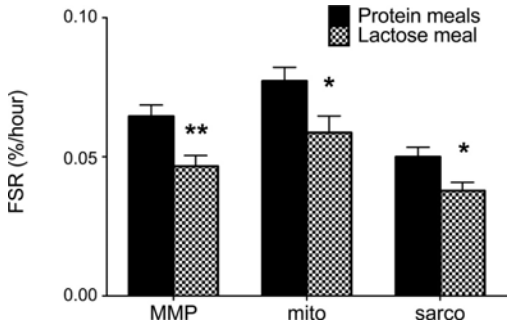


Coingestion of whey protein and casein in a mixed meal: demonstration of a more sustained anabolic effect of casein

Soop et al. Am J Physiol Endocrinol Metab. 2012 Jul 1;303(1):E152-62.

- 18 healthy participants were studied after ingestion of *1*) ***0.625 g/kg FFM*** each of [^{15}N]WP and [^{13}C]Cas and 0.9 g/kg FFM lactose ([***^{15}N]WP/[^{13}C]Cas group***), *2*) ***0.625 g/kg FFM*** each of [^{13}C]WP and [^{15}N]Cas and 0.9 g/kg FFM lactose (***[^{13}C]WP/[^{15}N]Cas group***), and *3*) 1.85 g/kg FFM of lactose only (***lactose group***).
- ***At 80-120 min***, the ***rates of appearance*** (R(a)) across the splanchnic bed of Phe ***from WP and Cas were similar*** [0.068 +/- 0.010 vs. 0.070 +/- 0.009%/min].
- ***At time 220-260 min***, ***Phe appearance from WP had slowed*** (0.039 +/- 0.008%/min, P < 0.05) whereas ***Phe appearance from Cas was sustained*** (0.068 +/- 0.013%/min).
- Similarly, ***accretion rates*** across the leg of Phe absorbed from WP and Cas ***were not different at 80-120 min*** (0.011 +/- 0.002 vs. 0.012 +/- 0.003%/min; ns), but they were ***significantly lower for WP*** (0.007 +/- 0.002%/min) ***at 220-260 min than for Cas*** (0.013 +/- 0.002%/min) at 220-260 min.
- ***Early after meal ingestion, AA absorption and retention were similar for WP and Cas, but as rates for WP waned, absorption and assimilation into skeletal muscle were better retained for Cas.***





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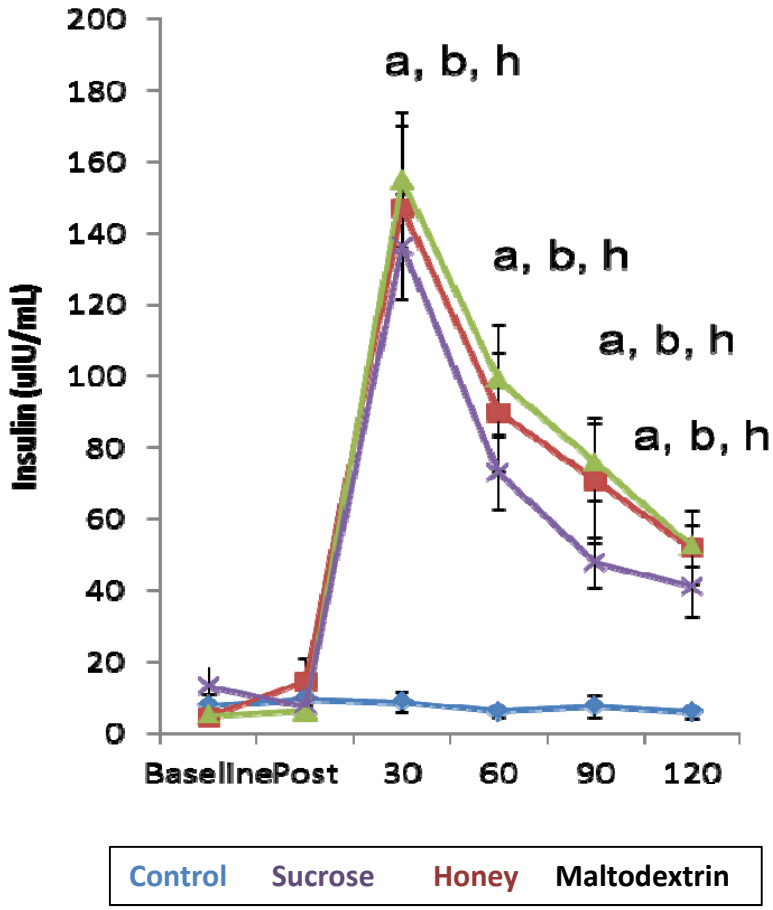
10. Different types and quality of protein can affect amino acid bioavailability following protein supplementation.

Additive benefits may be seen when combining protein with other nutrients.

Effects of ingesting protein with various forms of carbohydrate following resistance-exercise on substrate availability and markers of anabolism, catabolism, and immunity

Kreider et al. IJSN 4:18, 2007

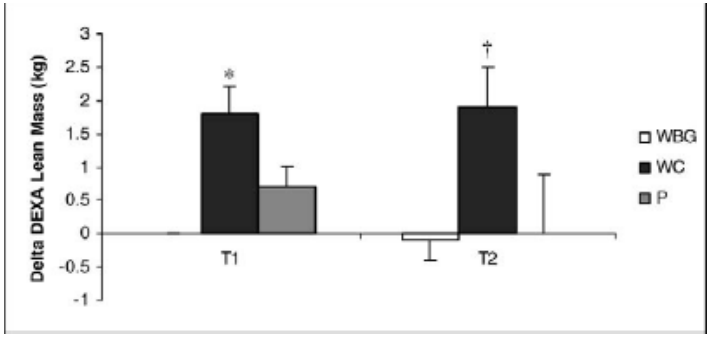
- 40 resistance-trained males participated in 90-min of heavy resistance training
- Immediately after exercise, subjects were randomly assigned to ingest **40 g of whey protein with 120 g of:**
  - Sucrose
  - Honey powder
  - Maltodextrin
- Glucose, insulin, and markers of catabolism (testosterone, cortisol, muscle and liver enzymes, general markers of immunity were monitored for 120 minutes following exercise.
- ***Insulin levels increased differentially depending on type of CHO consumed with PRO***

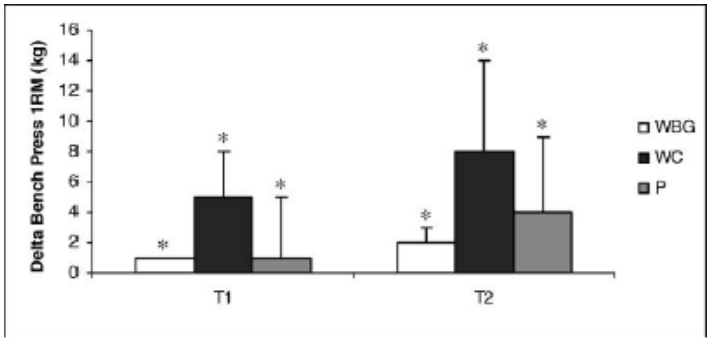


Effects of protein and amino acid supplementation on resistance training adaptations

Kerksick et al. JSCR. 20(3):643-653, 2006

- 36 resistance trained males participated in a 4 d/wk resistance training program for 10-wks
- In a DB-PC-R manner, assigned to supplement diet with:
  - 48 g/d CHO Placebo
  - 40 g/d Whey + 8 g/d Casein
  - 40 g/d Whey + 3 g/d BCAA + 5 g/d glutamine
- ***Greater change in FFM in WC group***
- Similar gains strength, muscular endurance, and anaerobic sprint capacity
- ***Combining fast and slow digesting protein may provide greater benefits than all fast digesting proteins.***



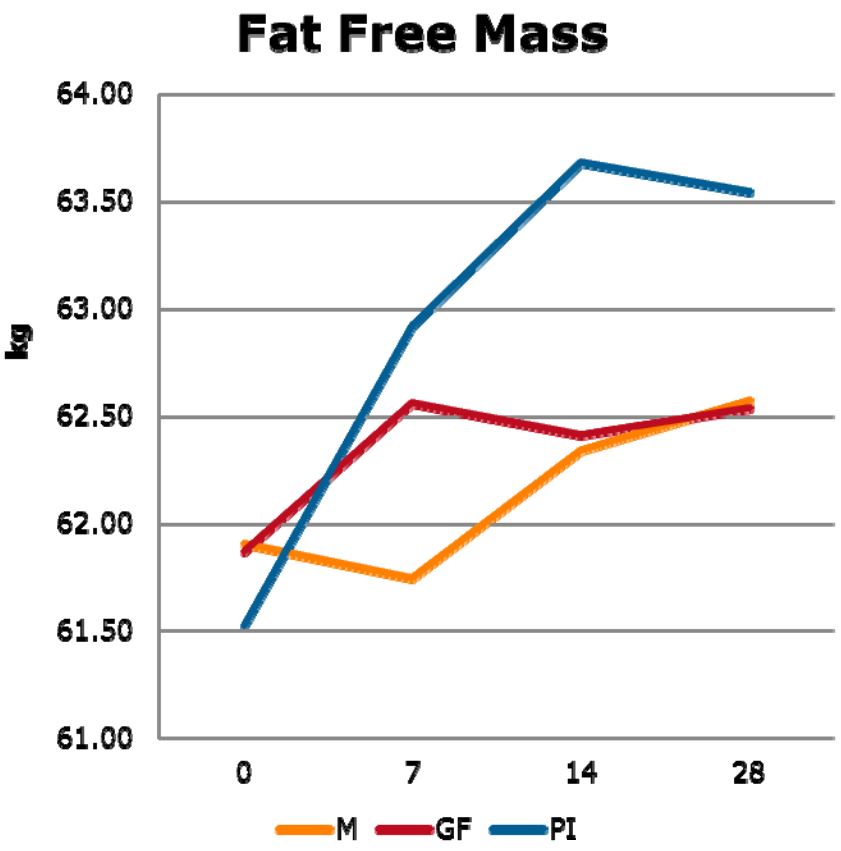


Kerksick et al. ***JSCR.*** *20(3):643-653, 2006.*

Effects of ingesting Effects of Ingesting Supplements Designed to Promote Lean Tissue Accretion on Body Composition During Resistance-Training

Kreider et al. IJSN 6:234-46, 1996

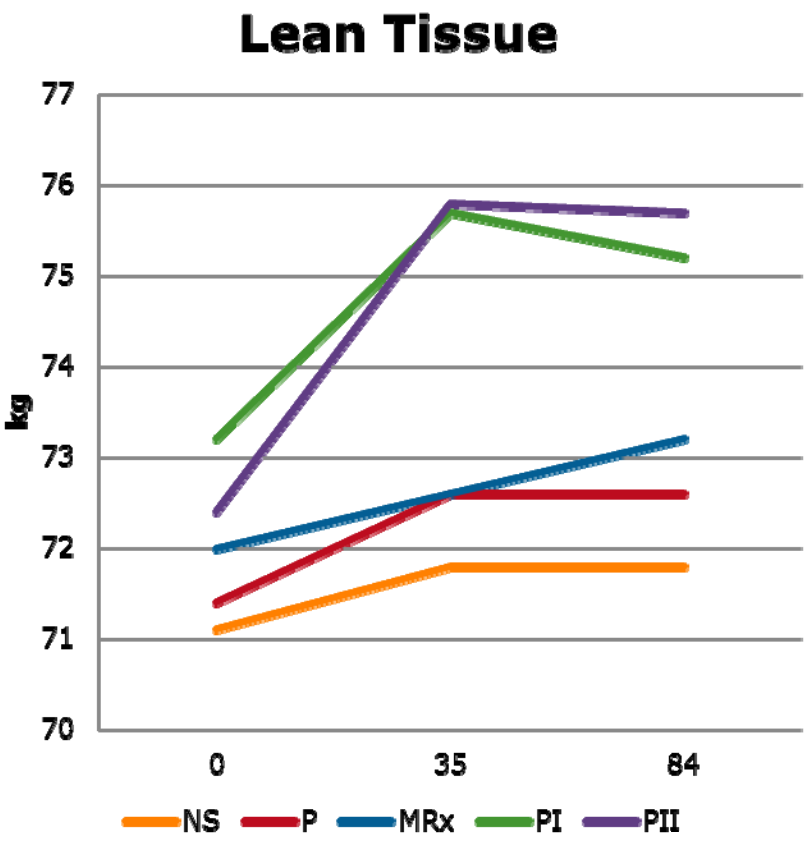
- 28 resistance trained males
- In a DB-R-P manner, assigned to supplement diet with:
  - Maltodextrin (190 g/d)
  - Gainers Fuel 1000 (290 g/d)
  - Phosphagain (64 g/d CHO, 67 g/d PRO, 20 g/d CM)
- Greater gain in FFM and body mass in CM group
- Improved strength & muscle endurance in CM group



Effects of Nutritional Supplementation During Off-Season College Football Training on Body Composition & Strength

Kreider et al. JEP 2(2):24-39, 1999

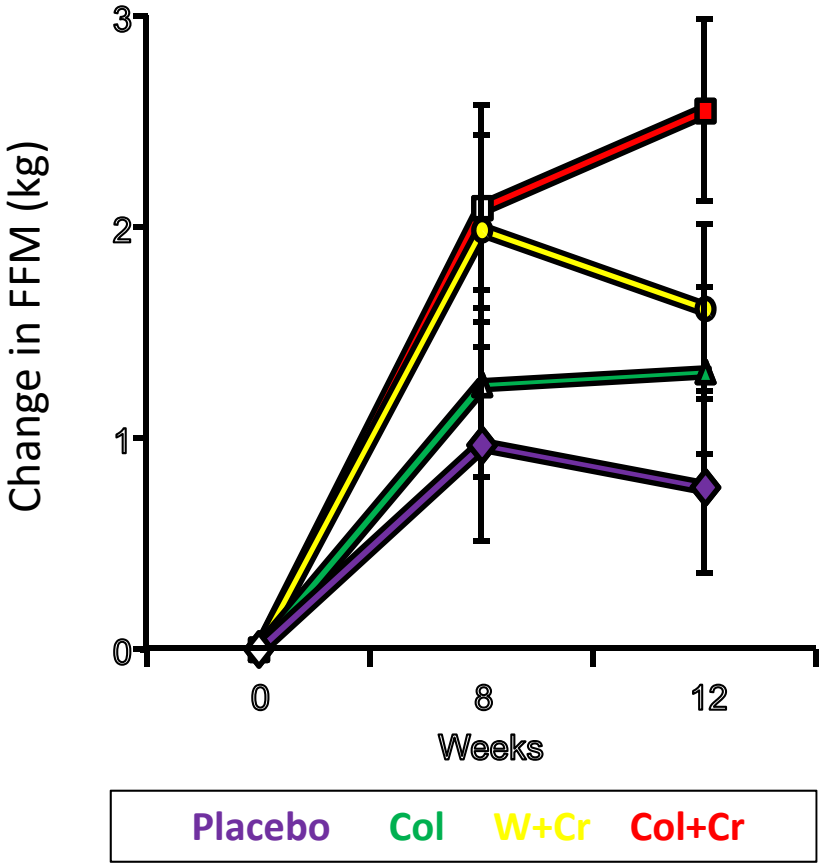
- 62 DI football players
- In a DB-R-P manner, assigned to supplement diet for 84-days with:
  - Non-Supplemented Control
  - Maltodextrin Placebo
  - MetRx
  - Phosphagain I (20 g/d CM)
  - Phosphagain II (25 g/d CM)
- ***Greater gains in FFM & strength in CM groups***



Impact of differing protein sources and a creatine containing nutritional formula after 12 weeks of resistance training.

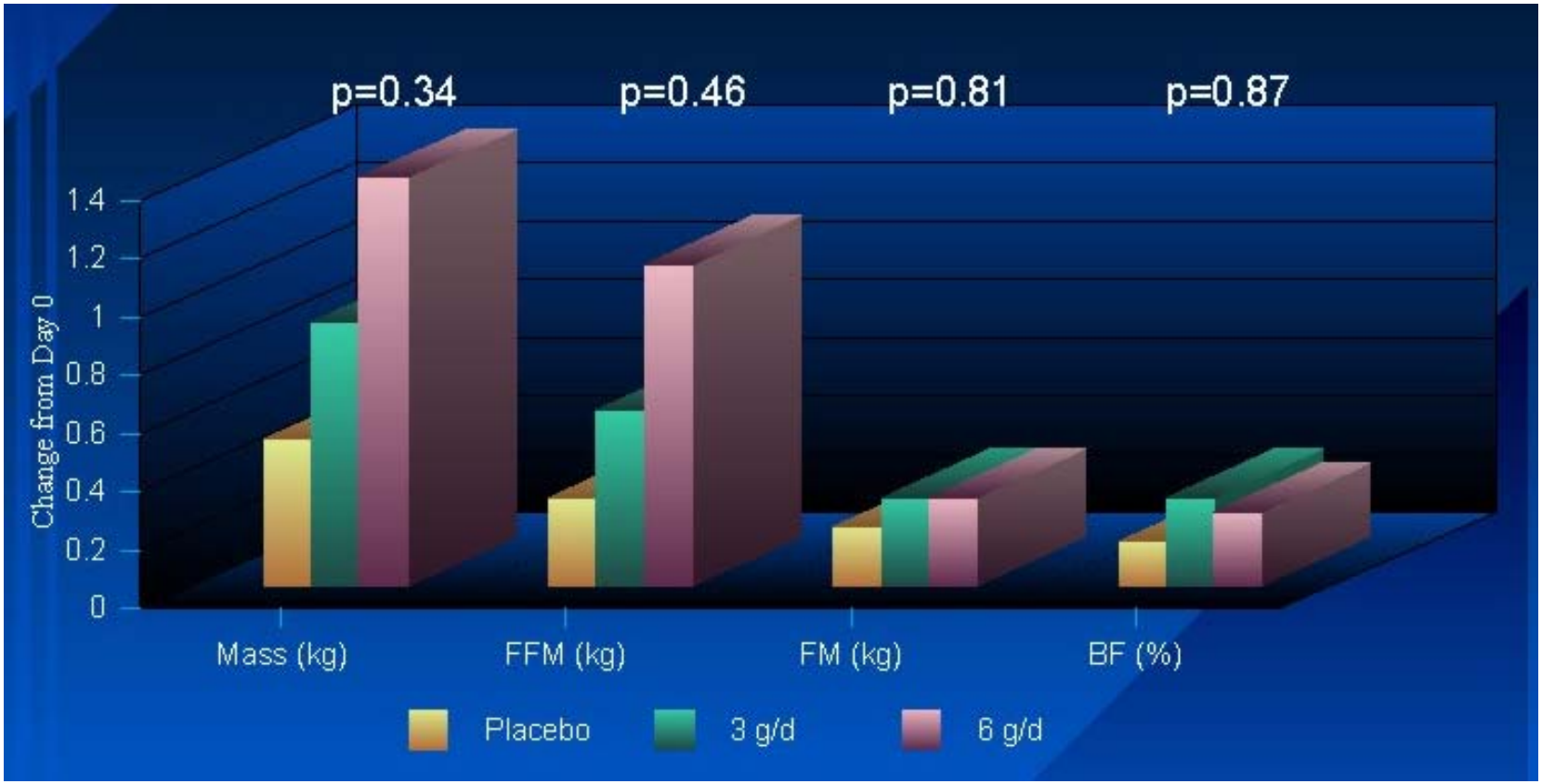
Kerksick et al. Nutri. 23(9):647-656, 2007

- 49 resistance trained males
- In a DB-R manner, assigned to supplement diet during resistance-training with:
  - 63 g/d of CHO
  - 60 g/d of Colostrum
  - 60 g/d of Whey + 3 g of CM
  - 60 g/d of Colostrum + 3 g of CM
- Colostrum > gain than whey
- ***Adding CM to whey and colostrum increased weight & FFM gain***
- No differences among groups in muscle fiber adaptations.
- ***First study to show combining different types of protein with creatine may affect changes.***



Effects of Calcium β-Hydroxy-β-methylbutyrate (HMB) Supplementation During Resistance-Training on Markers of Catabolism, Body Composition and Strength

Kreider et al. Int J Sports Med. 20(8):503-9, 1999



CHO/Protein supplement fortified with 0, 3 or 6 g/d of calcium β-HMB for 28 d in resistance-trained men.

ISSN Position Stand

Protein and Exercise *(JISSN 14(20), 2017)*

11. Athletes should consider focusing on ***whole food sources of protein that contain all of the EAAs*** (i.e., it is the EAAs that are required to stimulate MPS).

Amino Acid	Main Food Sources
Histidine	soy protein, eggs, parmesan, sesame, peanuts
Isoleucine	eggs, soy protein & tofu, whitefish, pork, parmesan
Leucine	eggs, soy protein, whitefish, parmesan, sesame
Lysine	eggs, soy protein, whitefish, parmesan, smelts
Methionine	eggs, whitefish, sesame, smelts, soy protein
Cysteine	eggs, soy protein, sesame, mustard seeds, peanuts
Phenylalanine	eggs, soy protein, peanuts, sesame, whitefish
Tyrosine	soy protein, eggs, parmesan, peanuts, sesame
Threonine	eggs, soy protein, whitefish, smelts, sesame
Tryptophan	soy protein, sesame, eggs, winged beans, chia seeds
Valine	eggs, soy protein, parmesan, sesame, beef

ISSN Position Stand

Protein and Exercise *(JISSN 14(20), 2017)*

11. Endurance athletes should focus on achieving ***adequate carbohydrate intake*** to promote optimal performance; ***the addition of protein may help to offset muscle damage and promote recovery.***

Effects of amino acid supplementation on ultraendurance triathlon performance

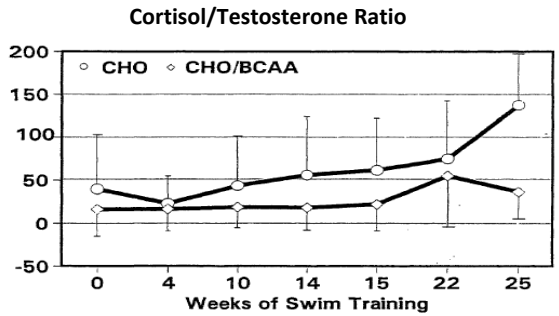
Kreider et al. In ***Proceed. First World Cong. Sports Nutri.*** *: Enero, 1992, pp. 488-536, 1992.*

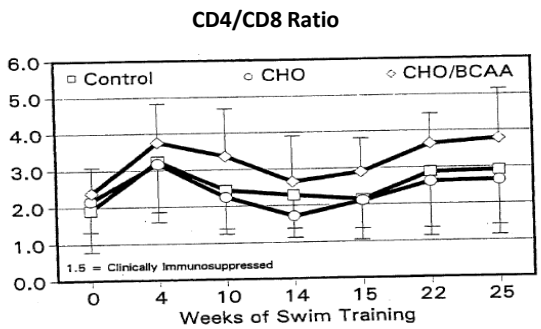
- Examined effects of BCAA (2 g/hr) supplementation with CHO drinks prior to, during, and following ultraendurance triathlon performance (1.2-S, 56-B, 13-R miles) compared to CHO drinks with placebo
- ***BCAA supplementation reduced markers of catabolism during 3-d of recovery but did not significantly affect exercise performance***

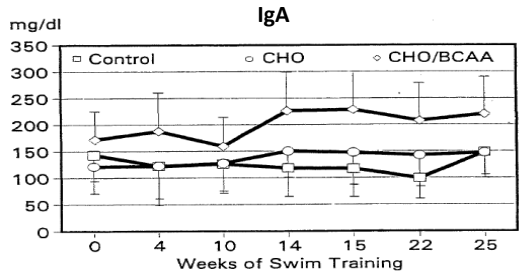
Central fatigue hypothesis and overtraining

Kreider. In: Overtraining in Sport. Kreider, Fry, O'Toole, Eds., 1998.

- Examined effects of BCAA supplementation (2.2 g) prior to and following workouts during 25-weeks of college swim training in 20 swimmers and 10 environmental controls.
- ***Cortisol, the ratio of cortisol to testosterone, Neu/Lymph ratio, and symptoms of overtraining were lower while IgA and the CD4/CD8 ratio was higher in the BCAA group***
- BCAA supplementation during intense training lessened markers of overtraining.







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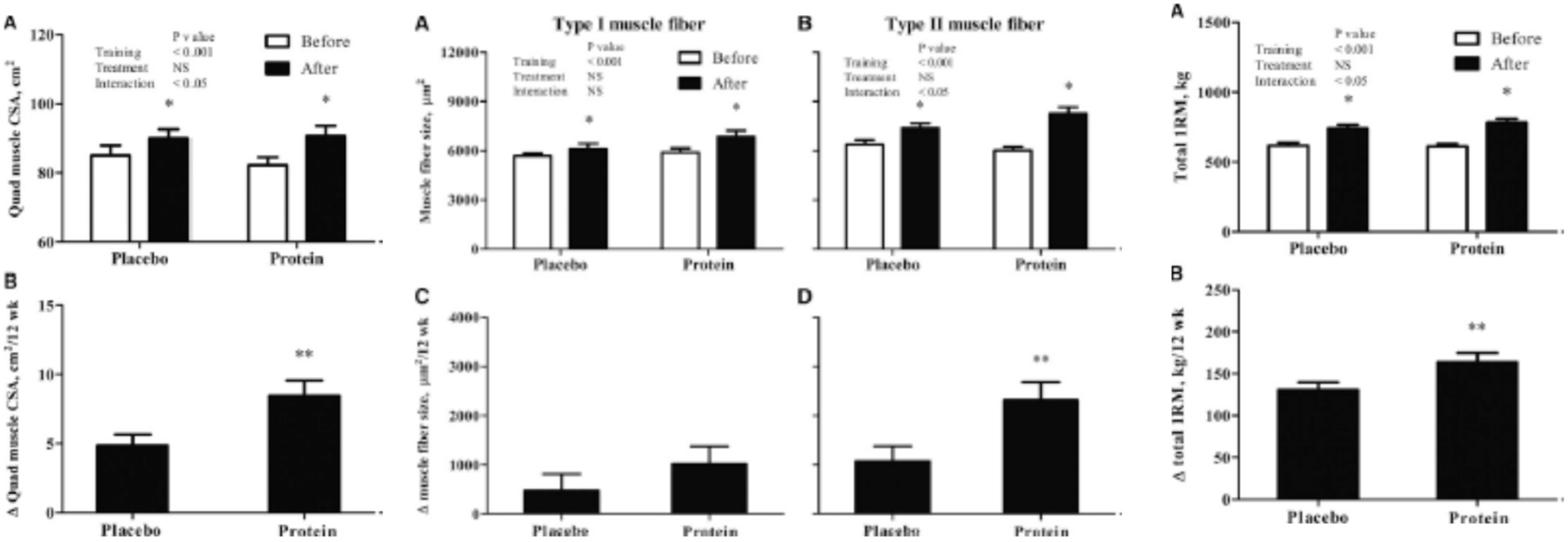
13. Pre-sleep casein protein intake (30–40 g) provides increases in overnight MPS and metabolic rate without influencing lipolysis.

Protein ingestion before sleep increases muscle mass and strength gains during prolonged resistance-type exercise training in healthy young men

Snidjers et al. J Nutr. 2015 Jun;145(6):1178-84

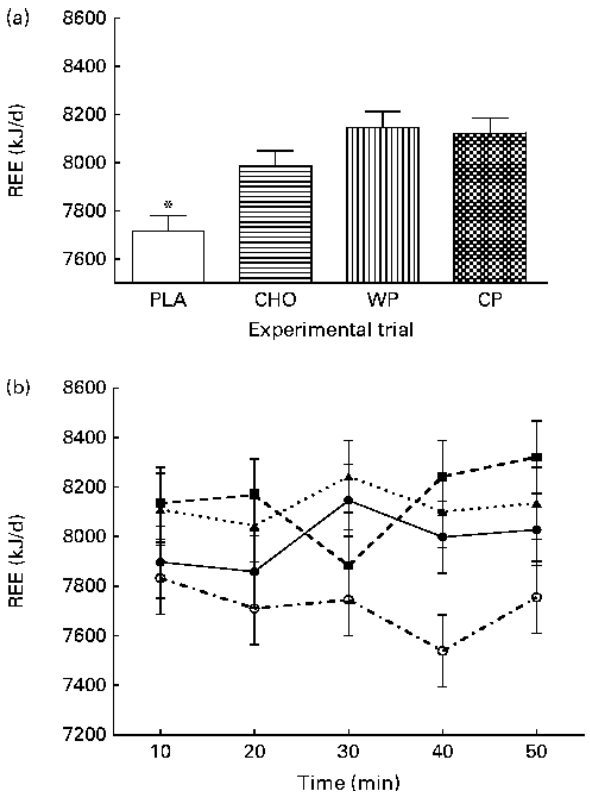
- 44 young men were randomly assigned to a progressive, 12-wk RE training program.
- One group consumed a protein supplement containing ***27.5 g of protein, 15 g of carbohydrate, and 0.1 g of fat every night before sleep***.
- ***Protein ingestion before sleep represents an effective dietary strategy to augment muscle mass and strength gains during resistance exercise training in young men***.



Night-time consumption of protein or carbohydrate results in increased morning resting energy expenditure in active college-aged men

Madzima et al. Br J Nutri. 111:71-77, 2014

- 11 men participated in a randomized, double-blind, cross-over study.
- A single dose ***of WP (30 g), CP (30 g), CHO (33 g) or PLA was consumed 30 min before sleep***, and each trial was separated by 48-72 h.
- The next morning (05.00-08.00 hours), measurements of satiety, hunger and desire to eat and REE were taken.
- There were no significant differences in appetite measures among the groups.
- ***The predicted REE was significantly greater after consumption of the WP (8,151 (sem 67) kJ/d), CP (8,126 (sem 67) kJ/d) and CHO (7,988 (sem 67) kJ/d) than after that of the PLA (7716 (sem 67) kJ/d).***
- No significant differences between the WP and CP groups in any metabolic measurements.
- ***Night-time consumption of WP, CP or CHO, in the hours close to sleep, elicits favorable effects on the next-morning metabolism when compared with that of a PLA in active young men***



Protein and Health Aging

Paddon-Jones et al. Am J Clin Nutr 101(6):, 1339S-1345S, 2015

- Consuming an adequate amount of high-quality protein at each meal, in combination with physical activity, may delay the onset of sarcopenia, slow its progression, and/or reduce the magnitude of its functional consequences.
- Meeting a protein threshold (approximately 25-30 g/meal) represents a promising dietary strategy to help maintain muscle mass and function.
- For many older adults, breakfast is a carbohydrate-dominated lower-protein meal and represents an opportunity to improve daily protein intake.
- Animal proteins generally have a higher proportion of the amino acid leucine.
- Leucine plays a key role in stimulating translation initiation and muscle protein anabolism and is the focus of ongoing research.
- Protein requirements should be assessed in the light of habitual physical activity.
- An evenly distributed protein diet provides a framework that allows older adults to benefit from the synergistic anabolic effect of protein and physical activity.

International Society of Sports Nutrition position stand: safety and efficacy of creatine supplementation in exercise, sport, and medicine

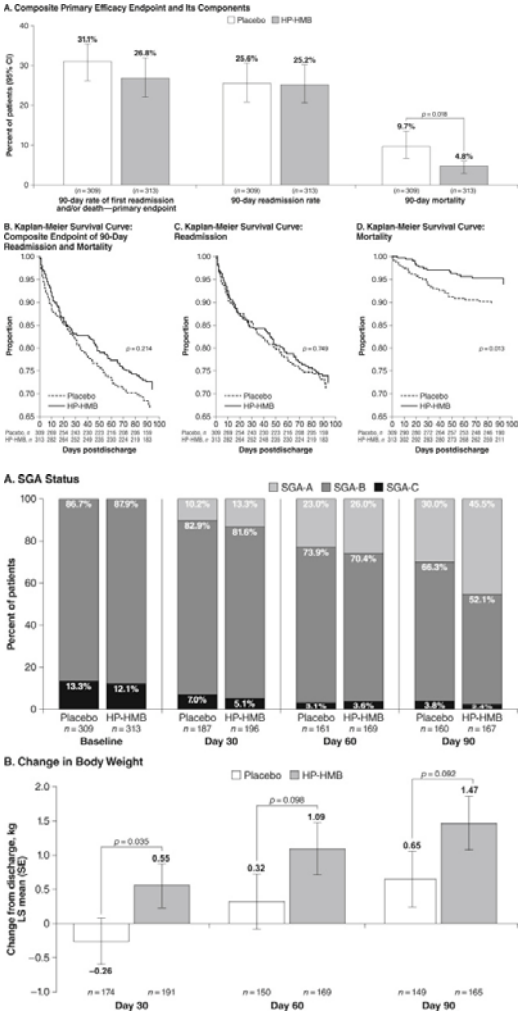
Kreider et al. J Int Soc Sports Nutr. 13;14:18, 2017

- ***Creatine supplementation increases intramuscular creatine concentrations*** which may help explain improvements in high intensity exercise performance and training adaptations.
- Creatine supplementation has been reported to ***enhance post-exercise recovery, injury prevention, thermoregulation, rehabilitation, and concussion and/or spinal cord neuroprotection***.
- Studied clinical applications include:
  - Neurodegenerative diseases (e.g., muscular dystrophy, Parkinson's, Huntington's disease)
  - Diabetes
  - Osteoarthritis
  - Fibromyalgia
  - Aging
  - Brain and heart ischemia
  - Adolescent depression
  - Pregnancy
- ***Maintaining a diet high in creatine (2-3 g/d) throughout the lifespan may provide numerous health benefits***.

Readmission and mortality in malnourished, older, hospitalized adults treated with a specialized oral nutritional supplement: A randomized clinical trial

Deutz et al. Clin Nutr. 2016 Feb;35(1):18-26

- Older (>/=65 years), malnourished adults hospitalized for congestive heart failure, acute myocardial infarction, pneumonia, or chronic obstructive pulmonary disease were provide ***standard-of-care plus HP-HMB (n = 328) or a placebo supplement (n = 324), 2 servings/day.***
- No between-group differences were observed for 90-day readmission rate, but ***90-day mortality was significantly lower with HP-HMB relative to placebo*** (4.8% vs. 9.7%; relative risk 0.49, 95% confidence interval [CI], 0.27 to 0.90; p = 0.018).
- ***HP-HMB resulted in improved odds of better nutritional status*** (SGA class, OR, 2.04, 95% CI: 1.28, 3.25, p = 0.009) at day 90, and an increase in body weight at day 30 (p = 0.035).
- Compared with placebo ***HP-HMB decreased mortality and improved indices of nutritional status during the 90-day observation period.***



Nutraceutical & Functional Food

Opportunities

- Protein is going to continue to serve as a primary supplement in the sport nutrition and health category.
- Identifying sources of protein that contain high levels EAA (particularly leucine) will continue to drive supplement and functional food industry
- Opportunities exist to:
  - Expand use in clinical populations and elderly
  - Identify ways to optimize bioavailability (e.g., protein blends, isolation of AA's/derivatives, consume with probiotics)
  - Add quality protein and/or amino acids to functional food.

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Gracias

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