Role of Amino Acids in Reducing Fatigue and Overtraining

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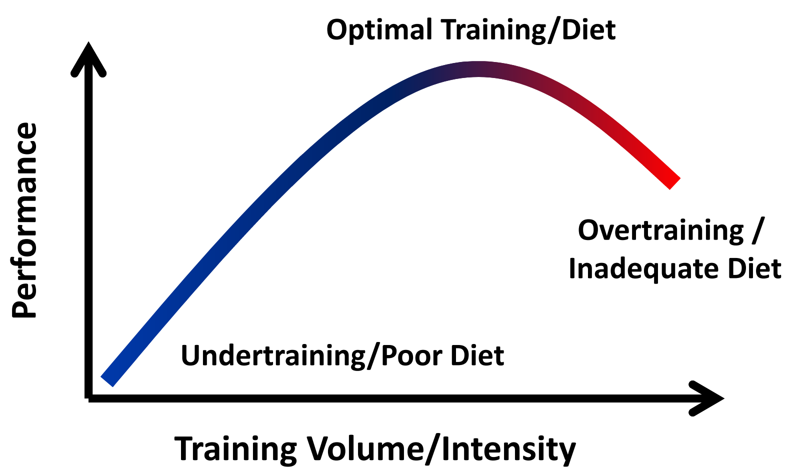
Training Stimulus



Kreider, R.B., A.C. Fry, and M.L. O'Toole (Eds.) Overtraining in Sport. Human Kinetics Publishers, Champaign, IL, 1998, 403 p.

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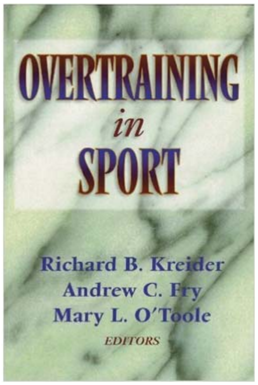
Overreaching

- An accumulation of training and/or non-training stress resulting in a short-term decrement in performance capacity with or without related physiological and psychological signs and symptoms of overtraining in which restoration of performance capacity may take from several days to several weeks.



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Overtraining

- An accumulation of training and/or non-training stress resulting in a long-term decrement in performance capacity with or without related physiological and psychological signs and symptoms of overtraining in which restoration of performance capacity may take from several weeks to several months.

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Parasympathetic Markers

Endurance Overtraining

- Decreased performance
- Decreased body fat
- Decreased maximal oxygen uptake
- Altered blood pressure
- Increased muscle soreness
- Decreased muscle glycogen
- Altered resting heart rate
- Heart rate variability
- Increased submaximal exercise heart rate
- Decreased maximal lactate
- Increased creatine kinase
- Altered cortisol concentration
- Decreased total testosterone concentration
- Decreased ratio of total testosterone to cortisol
- Decreased ratio of free testosterone to cortisol
- Decreased ratio of total testosterone to sex hormone-binding globulin
- Decreased sympathetic tone (decreased nocturnal and resting catecholamines)
- Increased sympathetic stress response

Kraemer, W.J. Physiological Adaptations to Anaerobic and Aerobic Endurance Training Programs. In T.R. Baechle and R.W. Earle. (Eds.). Essentials of Strength Training and Conditioning (2nd ed.) Champaign, IL: Human Kinetics. 2000.

Sympathetic Markers

Anaerobic Overtraining

- Psychological
  - decreased desire and joy to train
- Hormonal
  - Epinephrine and norepinephrine increases beyond normal exercise-induced levels (sympathetic overtraining system)
- Performance Decrements
  - May be too late to be a good predictor to avoid overtraining
- Because conflicting markers, markers of aerobic overtraining are often used to monitor OT status in anaerobic power athletes which is not a completely suitable

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Overtraining Theories

Overtraining

Energy Deficit Theory

Increased Infections ↔ Decreased Hunger

Decreased Hunger ↔ Suppressed Appetite

Suppressed Appetite ↔ Decreased Energy Intake

Decreased Energy Intake ↔ Weight Loss / Muscle Wasting

Weight Loss / Muscle Wasting ↔ Fatigue / Poor Performance

Fatigue / Poor Performance ↔ Increased Risk to Injury

Increased Risk to Injury ↔ Increased Infections

Kreider, R.B., A.C. Fry, and M.L. O'Toole (Eds.) Overtraining in Sport. Human Kinetics Publishers, Champaign, IL, 1998.

Overtraining

Central Fatigue Theory

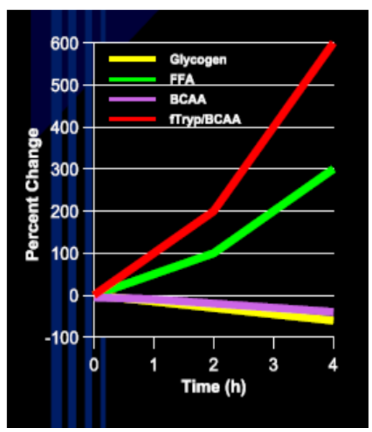
A subset of fatigue that is associated with alterations in CNS function that cannot be reasonably explained by peripheral markers of muscle fatigue

Davis, J.M. Int. J. Sports Nutri. 5:S29-38, 1995

Overtraining

Central Fatigue Theory

- As FFA increase during exercise (> 1mmol/L), tryptophan which is bound to albumin is released into the blood
- Plasma BCAA levels decline due to increase oxidation as fuel
- Ratio of free tryptophan to BCAA increases promoting entry of tryptophan into the brain
- 5-HT (serotonin) levels increase in the brain and CNS



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Overtraining

Central Fatigue Theory

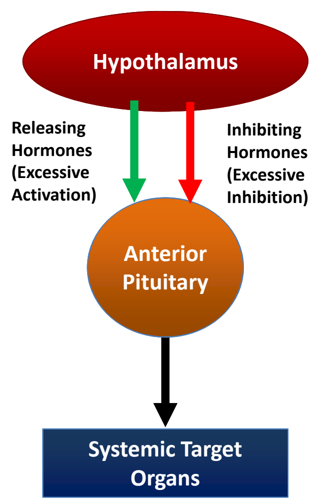
- 5-HT induces sleep, depresses motor neuron excitability and muscle power output, influences autonomic and endocrine function, suppresses appetite, affects psychological perception of fatigue, alters hormone regulation
- Chronic elevations in 5-HT have been reported in overtrained athletes and may explain some signs and symptoms of overtraining.

Kreider, R. *Central fatigue and overtraining.* In Kreider, R.B., A.C. Fry, and M.L. O'Toole (Eds.) Overtraining in Sport. Human Kinetics Publishers, Champaign, IL, 1998.

Overtraining

Hormone Dysregulation Theory

- Excessive exercise and/or inadequate energy intake down-regulates the hypothalamic-pituitary axis (HTPA)
- Leads to inadequate production of anterior and/or posterior pituitary hormones
- Altered hormonal status slows recovery from exercise
- Associated with overreaching, overtraining, and female athlete triad



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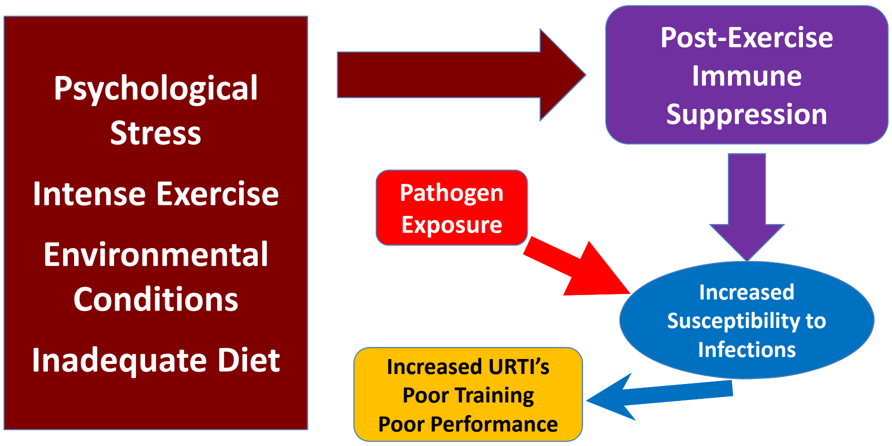
Overtraining
Immunosuppression Theory



Overtraining
Recovery Theory

- Overtraining may be due to a lack of planned rest and recovery during intense training and/or stressful periods of training or competition.
- Need to plan for adequate sleep and recovery from intense training
- Need to plan tapering from training prior to competition

Nutritional Strategies to Prevent Overtraining

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Preventing Overtraining

Nutritional Strategies

- Proper Diet
  - Energy Balanced Diet
  - Adequate Macronutrients
  - Nutrient Dense
  - Nutrient Timing

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Nutritional Guidelines

General Fitness / Active Populations

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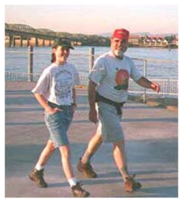

- Goal focused diet (maintenance, weight gain/loss)
- **Carbohydrate** (45%-55% of calories)
  - 3 – 5 g/kg/d
- **Protein** (10-15% of calories)
  - 0.8 – 1.0 g/kg/d (younger)
  - 1.0 – 1.2 g/kg/d (older)
- **Fat** (25-35% of calories)
  - 0.5 – 1.5 g/kg/d
- Make Good Food Choices
- Meal timing can optimize training response

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Nutritional Guidelines

Athletes

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- Goal focused diet (maintenance, weight/loss)
- **Carbohydrate** (55%-65% of calories)
  - 5 – 8 g/kg/d – moderate training
  - 8 – 10 g/kg/d – heavy training
- **Protein** (15-20% of calories)
  - 1.0 – 1.5 g/kg/d moderate training
  - 1.5 - 2.0 g/kg/d during heavy training
- **Fat** (25-30% of calories)
  - 0.5 – 1.5 g/kg/d
- Meal Timing Important
- Use of energy supplements helpful

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Nutritional Guidelines

Strength / Power Athletes

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- Goal focused diet (maintenance, weight gain/ loss)
- **Carbohydrate** (40-55% of calories)
  - 3 – 5 grams/kg/day typically sufficient
- **Protein** (15-30% of calories)
  - 1.5 – 2.0 grams/kg/day general
  - 2.0 – 2.25 grams/kg/day during heavy training and/or at altitude
- **Fat** (20-30% of calories)
  - 1 – 1.5 grams/kg/day
- Greater emphasis on meal timing
- May need more education about nutritional ergogenic aids

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Nutritional Guidelines

Nutrient Timing

- Pre-exercise meals (4-6 h)
- Pre-exercise snack (30-60 min)
  - 40-50 g CHO, 10 g PRO
- Sports drinks during exercise (> 60 min)
  - 6%-8% glucose-electrolyte solution
  - Sports gels/bars at half-time
- Post-exercise snack (within 30 min)
  - 1 g/kg CHO, 0.5 g/kg PRO
- Post-exercise meal (within 2 hrs)
- CHO loading (2-3 days prior to competition)
  - Taper training by 30%-50%
  - Ingest 200-300 extra grams of CHO

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Role of Amino Acids

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BCAA

- Blunts increases in the free tryptophan/ BCAA and may reduce central fatigue.
- May decrease protein degradation possibly by promoting an anticatabolic hormonal profile.
- Theoretically, BCAA supplementation during intense training may help reduce fatigue and minimize protein degradation.
- Blomstrand reported a 3-4% enhancement in marathon performance following consumption of a sports drink (PRIPPS Energy-2) containing BCAAs versus placebo (Stewart, Sportscience. 3(2), 1999).
- Other studies report some physiological and/or psychological effects with adding BCAA to sports drinks
- The potential ergogenic effect on acute exercise is equivocal
- May have greater influence during training to reduce catabolism, maintain immunity, and/or promote greater training adaptations

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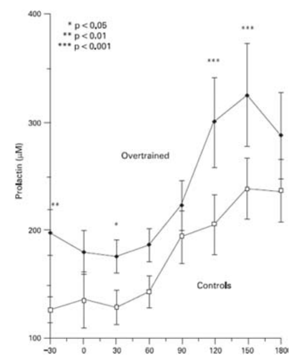
BCAA

The effects of the 5-HT2C agonist m-chlorophenylpiperazine on elite athletes with unexplained underperformance syndrome (overtraining)
Budget a et al. Br J Sports Med. 44:280-3, 2010.

- A possible link between the neurotransmitter, 5-hydroxytryptamine (5-HT), plasma tryptophan, and branched chain amino acids concentration and exercise-induced fatigue is described by the central fatigue hypothesis.
- 5-HT receptors and neuroendocrine "challenge" tests, using prolactin release as a measure of 5-HT activity have been used to assess 5-HT sensitivity.
- This study examined whether 5-HT sensitivity may be related to elite athletes diagnosed with unexplained, underperformance syndrome (UUPS).
- There was an apparent increased sensitivity of 5-HT receptors in athletes with UUPS compared with fit, well-trained controls, as measured via increased prolactin release following a bolus dose of *m*-chlorophenylpiperazine , a 5-HT agonist.
- No changes were observed in plasma amino acid concentrations in either group.
- Results suggest that ***5-HT sensitivity may be increased in athletes with underperformance syndrome***.
- ***BCAA supplementation may therefore help compensate for an increased 5-HRT sensitivity***.



Glutamine

- About 60 percent of the AA pool in a cell is comprised of glutamine.
- Glutamine plays a number of important physiological roles:
  - Affecting protein and glycogen synthesis through cell hydration / volume (*Low, 1996*)
  - Glutamine serves as one of the most readily used amino acids for protein synthesis.
  - The nitrogen from glutamine can be used to form ATP; making DNA which are involved in programming the structure of chromosomes and genes; and, forming RNA which are involved in the replication and transcription of DNA and protein synthesis.
  - Glutamine can also serve as an important fuel source during exercise.
  - Glutamine is the primary fuel for lymphocytes

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Glutamine

- Studies indicate that intense exercise decreases plasma glutamine levels.
- Parry-Billings et al. (1992) reported that overtrained athletes had significantly lower (-8.5 percent) plasma glutamine levels than non-overtrained athlete controls.
- Schena et al. (1993) reported that plasma glutamine levels decreased by 10 percent following 90 minutes of running at 75 percent of VO2 max.
- Kargotich et al. (2005) reported that plasma glutamine levels decrease by 16 percent in male swimmers who performed 15 x 100 meter free-style swims at 95 percent of maximal capacity compared to non-exercising, non-trained controls.
- The exercise-induced reductions in glutamine concentrations appear to occur in spite of carbohydrate feedings during exercise (*van Hall, 1998*).

Glutamine

- BCAA (4-6 g) and/or glutamine (4 -12 g) prior to and/or following exercise can increase plasma glutamine concentrations and that oral glutamine supplementation prior to and following a marathon race decreases the incidence of infections reported in runners after a marathon (*Castell, 1997; 1998).*
- Other studies have reported that glutamine supplementation did not enhance muscle tissue in rats (*Olde Damink, 1999*) or improve immune system function (*Castell, 1997; Rohde, 1998*).

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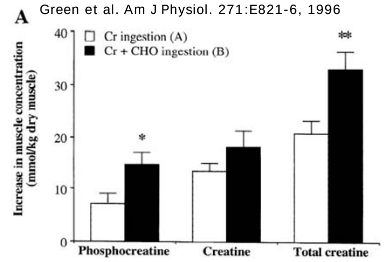
Creatine

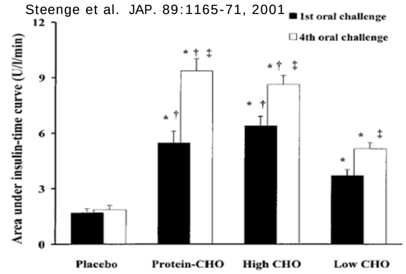
Glycogen Synthesis

- *Green et al (1996a; 1996b)* demonstrated that co-ingesting creatine (5 g) with large amounts of glucose (e.g., 95 g) enhanced creatine and carbohydrate storage in muscle.
- *Steenge et al. (2000)* found ingesting creatine (5 g) with 47–97 g of carbohydrate and 50 g of protein also enhanced creatine retention.
- The researchers suggested that creatine transport was mediated in part by glucose and insulin.

Green et al. Am J Physiol. 271:E821-6, 1996



Steenge et al. JAP. 89:1165-71, 2001

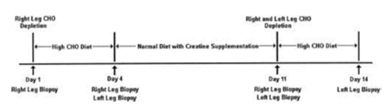


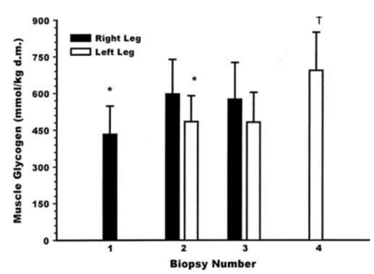
Creatine

Glycogen Synthesis

Muscle glycogen supercompensation is enhanced by prior creatine supplementation
Nelson et al. Med Sci Sports Exerc. 33(7):1,096-1,100, 2001.

- 12 men performed two standard glycogen loading protocols interspersed with a standard creatine load of 20 g/d for 5 d.
- The initial glycogen loading protocol increased muscle glycogen by 4% with no change in total muscle creatine.
- Creatine loading showed significant increases in total muscle creatine levels in both the left leg (+ 41.1±31.1 mmol/kg DM) and the right leg (+36.6±19.8 mmol/kg DM with no change in either leg's muscle glycogen content.
- After the final glycogen loading, a significant 53% increase in muscle glycogen (+241±150 mmol/kg DM) was detected.
- The postcreatine load total glycogen content (694±156 mmol/kg DM) was significantly greater than the precreatine load total glycogen content (597±142 mmol/kg DM).
- Results reveal that a ***muscle's glycogen loading capacity is influenced by its initial levels of creatine*** and the accompanying alterations in cell volume.





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Creatine
Reduces Catabolism

The effect of creatine supplementation upon inflammatory and muscle soreness markers after a 30km race
Santos et al. Life Sci. 75(16):1917-24, 2004.

- 34 experienced marathon runners were supplemented for 5 days prior to the 30km race with 4 x 5g of creatine and 15g/d of maltodextrin while the control group received the same amount of maltodextrin.
- Pre-race and 24-hour post blood samples were collected
- Athletes from the control group presented an increase in plasma CK (4.4-fold), LDH (43%), PGE2 6.6-fold) and TNF-alpha (2.34-fold) concentrations
- ***Creatine attenuated the changes observed for CK (by 19%), PGE2 and TNF-alpha (by 60.9% and 33.7%, respectively) and abolished the increase in LDH*** plasma concentration observed after running 30km.
- The athletes did not present any side effects such as cramping, dehydration or diarrhea, neither during the period of supplementation, nor during the 30km race.

Table 2
Creatine kinase (CK), lactate dehydrogenase (LDH), prostaglandin E_2 (PGE_2), tumour necrosis factor-alpha (TNFα) and creatinine plasma concentrations measured immediately before and 24h after a 30km running, in the plasma obtained from athletes subjected to a placebo (Con, n = 16) or a creatine supplementation protocol (CR, n = 18)

	Con Before	Con After	Cr Before	Cr After
CK (U/l)	48.26 ± 27.28	213.19 ± 113.60*	32.17 ± 16.42	170.95 ± 61.82*
LDH (U/l)	208.9 ± 17.6	298.7 ± 23.6*	198.7 ± 13.5	185.3 ± 21.5#
PGE2 (pg/ml)	42.76 ± 4.95	329.35 ± 17.96*	47.12 ± 8.76	110.42 ± 12.38*#
TNFα (pg/ml)	91.18 ± 7.55	213.76 ± 15.05*	97.77 ± 9.24	141.6 ± 3.32*#
Creatinine (mg/dl)	0.22 ± 0.03	0.34 ± 0.09	0.31 ± 0.05	0.41 ± 0.07

The results are expressed as mean ± SEM of 23 samples.
* $p<0.05$ for comparison with the values obtained before the exercise bout.
\# $p<0.05$ for comparison with the values obtained for the control group. The observed power was 1,00 for LDH, PGE_2 and TNFα.

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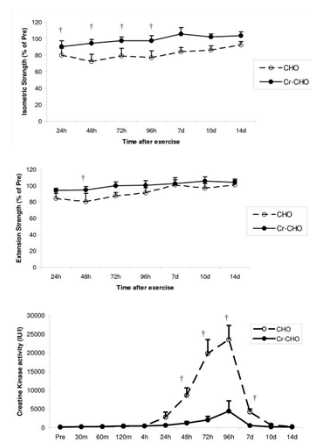
Creatine
Enhanced Recovery

Creatine supplementation enhances muscle force recovery after eccentrically-induced muscle damage in healthy individuals
Cooke et al. J Int Soc Sports Nutri. 6:13, 2008.

- 14 untrained males were randomly assigned to ingest 0.3 g/kg/d of CM with CHO for 5-d and 0.1 g/kg/d of CM with CHO for 14 days or a CHO placebo.
- After 5-d of supplementation, performed ***4 x 10 eccentric-only repetitions at 120% of their 1-RM*** max on the leg press, leg extension and leg flexion exercise machine.
- Plasma CK and LDH activity were assessed as relevant blood markers of muscle damage.
- The Cr-supplemented group had ***significantly greater isokinetic (10% higher) and isometric (21% higher) knee extension strength during recovery*** from exercise-induced muscle damage.
- ***Plasma CK activity was significantly lower (by an average of 84%) after 48 hrs, 72 hrs, 96 hrs, and 7 days recovery*** in the Cr group.
- ***Creatine improved the rate of recovery of knee extensor muscle function after injury***.



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Creatine

Enhanced Recovery

The effects of creatine supplementation on muscular performance and body composition responses to short-term resistance training overreaching
Volek et al. Eur J Appl Physiol. 91(5-6):628-37, 2004.

- 17 men were randomly assigned to supplement with 0.3 g/kg per day of CM (n=9) or placebo (n=8) while performing ***resistance exercise (5 days/week for 4 weeks) followed by a 2-week taper phase***.
- 1RM squat and BP and explosive power in the BP were reduced during training in P but not CM.
- Explosive power in the BP, body mass, and LBM in the legs were augmented to a greater extent in CM by the end of the 6-week period.
- A tendency for greater 1-RM squat improvement (P=0.09) was also observed in CM.
- Changes were not related to changes in circulating hormone concentrations obtained in the resting, postabsorptive state.
- ***CM was effective for maintaining muscular performance during the initial phase of high-volume resistance training overreaching*** that otherwise results in small performance decrements.

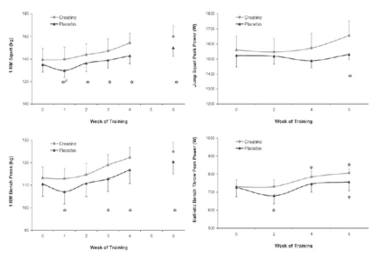

Table 5 Blood metabolite responses in subjects supplemented with creatine monohydrate (*CrM*) or placebo (*P*). Values are mean (SD). *CK* Creatine kinase, *TC* total cholesterol, *TG* triglycerides, *Hb* hemoglobin, *Hct* hematocrit

		Week 0	Week 1	Week 2	Week 3	Week 4	Main time effect	Group×time
Uric acid (mg/dl)	CrM	6.1 (1.3)	5.4 (1.5)**	5.3 (1.6)**	5.1 (1.4)**	5.0 (1.4)**	0.000	0.002
	P	6.1 (1.6)	7.2 (2.4)**	6.6 (1.7)	6.1 (1.7)	5.6 (1.8)		
Ammonia (μmol/l)	CrM	42.8 (19.1)	24.1 (21.3)*	23.8 (18.0)*	34.5 (17.4)	27.0 (19.0)	0.000	0.424
	P	38.2 (18.4)	20.5 (13.3)	17.1 (5.0)	35.5 (18.7)	37.2 (13.2)		
CK (IU/l)	CrM	91 (69)	836 (920)*	242 (124)	228 (146)	142 (74)	0.000	0.617
	P	72 (38)	1297 (1630)	177 (79)	162 (106)	88 (47)		
Glucose (mg/dl)	CrM	95.4 (10.5)	87.1 (7.2)*	92.8 (7.2)*	88.5 (6.3)*	90.4 (7.0)*	0.000	0.472
	P	97.9 (8.9)	90.0 (10.0)	92.8 (9.3)	89.0 (8.6)	88.2 (4.5)		
TC (mg/dl)	CrM	190 (38)	181 (38)	187 (45)	189 (41)	193 (30)	0.406	0.430
	P	189 (46)	181 (38)	191 (36)	180 (35)	180 (51)		
TG (mg/dl)	CrM	81 (31)	69 (32)	82 (40)	89 (42)	92 (44)	0.292	0.127
	P	126 (91)	99 (74)	126 (94)	102 (59)	90 (63)		
Hb (g/dl)	CrM	15.2 (1.0)	15.1 (1.2)*	14.9 (1.0)*	14.7 (0.9)*	14.9 (0.8)*	0.005	0.192
	P	15.7 (1.1)	14.6 (1.0)	15.0 (0.6)	14.8 (1.0)	14.8 (0.6)		
Hct (%)	CrM	44.9 (2.4)	42.2 (1.9)*	42.3 (1.9)*	43.1 (1.9)*	43.2 (1.5)*	0.000	0.957
	P	44.4 (2.0)	41.3 (2.4)	42.0 (1.6)	42.4 (2.0)	42.8 (1.3)		
Creatinine (mg/dl)	CrM	1.65 (0.09)	1.74 (0.09)**	1.76 (0.13)**, ***	1.77 (0.09)**, ***	1.79 (0.13)**, ***	0.005	0.000
	P	1.60 (0.07)	1.60 (0.07)	1.54 (0.04)	1.57 (0.03)	1.61 (0.06)		

*Significantly different ($P \leq 0.05$) from week 0 value for collapsed group means
**Significantly different ($P \leq 0.05$) from week 0 value for corresponding CrM or P group
***Significantly different ($P \leq 0.05$) from corresponding value for P group

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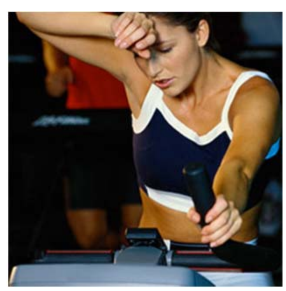
HEALTH SPORT MEDICINE 2015 creatine CONFERENCE

The consensus was that creatine supplementation can help athletes enhance glycogen loading; experience less inflammation and/or muscle enzyme efflux following intense exercise; and, tolerate high volumes of training and/or overreaching to a greater degree thereby promoting recovery.



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Amino Acids

Essential Amino Acids (EAA)

- Ingestion of 3-6 g of EAA or 18 g or whey protein following exercise stimulates protein synthesis
- Post-exercise ingestion of CHO and protein promotes a more anabolic hormonal environment.
- Ingesting EAA, protein, and CHO following exercise should promote greater recovery and training adaptations

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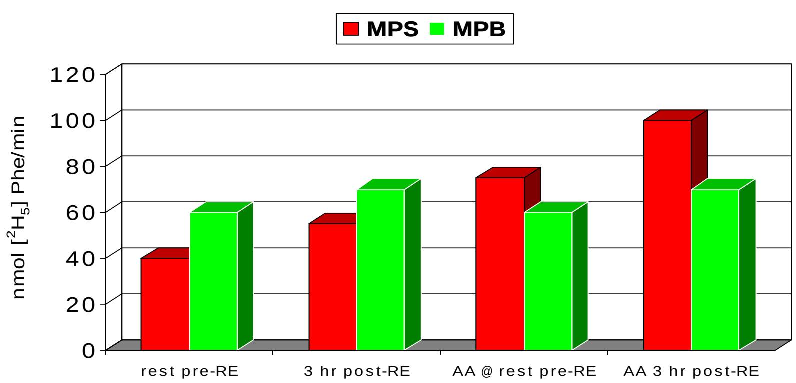
Effect of Mixed AA & CHO n Protein Turnover

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



6 grams oral EAA + 35 grams oral CHO

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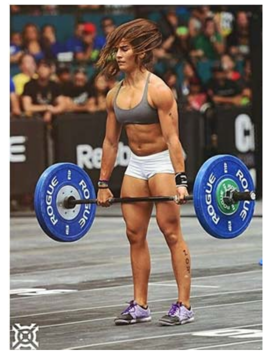
How much EAA is needed to enhance muscle protein synthesis?

- As little at 3 grams of EAA's is enough to significantly increase protein synthesis (*Miller et al. 2003*)
- 6 grams of EAA's appears to be an optimal dose (*Borsheim et al. Am J Physiol. 283:E648-57, 2002*).
- 100 grams of CHO can increase protein synthesis by 35% while 6 grams of EAA's increases protein synthesis by 250% (*Biolo et al. 1997, Borsheim et al. 2003*)
- ***20 g of whey protein contains about 9 g of EAA's***



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Amino Acids

(β-HMB)

- Leucine, α-ketoisocaproate (KIC) and β-HMB have been reported to inhibit protein degradation
- Ingestion of 1.5 to 3 g/d of HMB reported to increase FFM and strength in untrained subjects initiating training
- Gains in muscle mass typically 0.5 – 1 kg greater than controls during 3 – 6 weeks of training
- Consistent results observed in untrained and older subjects initiating training.
- ***Greater effects as an anticatabolic nutrient during intense training*** and in elderly to reduce muscle mass loss

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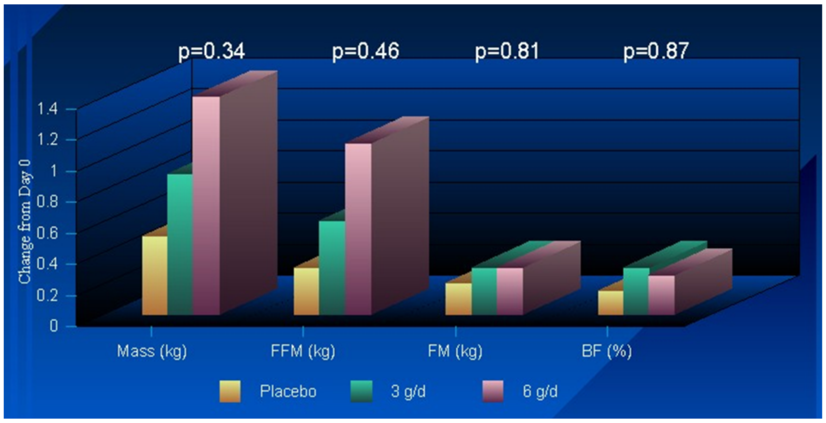
Amino Acids
(β-HMB)

Effects of Calcium â-Hydroxy-â-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



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Amino Acids
(β-HMB)

The effects of 12 weeks of beta-hydroxy-beta-methylbutyrate free acid supplementation on muscle mass, strength, and power in resistance-trained individuals: a randomized, double-blind, placebo-controlled study
Wilson et al. Eur J Appl Physiol. 114(6):1217-27, 2014

- A three-phase DBPCR intervention study was conducted.
- Phase 1 was an 8-week-periodized resistance-training program;
- Phase 2 was a 2-week overreaching cycle; and Phase 3 was a 2-week taper.
- Muscle mass, strength, and power were examined at weeks 0, 4, 8, and 12 to assess the chronic effects of HMB-FA; and assessment of these, as well as cortisol, testosterone, and creatine kinase (CK) was performed at weeks 9 and 10 of the overreaching cycle.
- ***HMB-FA enhances hypertrophy, strength, and power following chronic resistance training, and prevents decrements in performance following the overreaching*.**

Table 1 Effect of beta-hydroxy-beta-methylbutyrate free acid (HMB-FA) supplementation on muscle strength and power in participants performing a 12-week resistance-training regimen

	Week of study				*p* value[a]
	0	4	8	12	
Total strength[b] (kg)					
Placebo	426.7 ± 14.5	444.6 ± 14.5	457.8 ± 14.5	452.0 ± 14.5	
HMB-FA	426.7 ± 14.5	458.7 ± 14.5	477.6 ± 14.5	503.8 ± 14.5	0.0001
Squat (kg)					
Placebo	143.8 ± 5.2	150.4 ± 5.2	155.4 ± 5.2	151.1 ± 5.2	
HMB-FA	143.7 ± 5.2	154.9 ± 5.2	162.4 ± 5.2[#]	179.9 ± 5.2[#]	0.0001
Bench press (kg)					
Placebo	112.9 ± 6.6	116.4 ± 6.6	118.5 ± 6.6	116.7 ± 6.6	
HMB-FA	112.4 ± 6.6	120.8 ± 6.6	123.7 ± 6.6	125.2 ± 6.6[#]	0.02
Deadlift (kg)					
Placebo	170.4 ± 9.2	178.2 ± 9.2	184.3 ± 9.2	184.5 ± 9.2	
HMB-FA	170.3 ± 9.2	182.7 ± 9.2	191.2 ± 9.2	198.4 ± 9.2[#]	0.009
Wingate peak power (W)					
Placebo	879.1 ± 38.3	927.0 ± 38.3	987.2 ± 38.3	982.5 ± 38.3	
HMB-FA	879.7 ± 38.3	936.0 ± 38.3	980.7 ± 38.3	1,038.6 ± 38.3[#]	0.01
Vertical jump power (W)					
Placebo	5,224 ± 73	5,636 ± 73	5,839 ± 73	5,854 ± 73	
HMB-FA	5,219 ± 73	5,835 ± 73[#]	6,039 ± 73[#]	6,211 ± 73[#]	0.001

Table 2 Effect of beta-hydroxy-beta-methylbutyrate free acid (HMB-FA) supplementation on muscle strength and power during the overreaching phase, weeks 8, 9, and 10, of a 12-week resistance-training regimen

	Week of study			*p* value[a]
	8	9	10	
Total strength[b] (kg)				
Placebo	467.8 ± 11.9	443.6 ± 11.9	447.6 ± 11.9	
HMB-FA	469.4 ± 11.9	464.5 ± 11.9[#]	467.3 ± 11.9[#]	0.01
Squat (kg)				
Placebo	159.2 ± 4.8	152.6 ± 4.8	150.6 ± 4.8	
HMB-FA	159.3 ± 4.8	158.3 ± 4.8[#]	162.6 ± 4.8[#]	0.0001
Bench press (kg)				
Placebo	121.4 ± 4.7	113.5 ± 4.7	115.6 ± 4.7	
HMB-FA	121.4 ± 4.7	120.3 ± 4.7[#]	120.1 ± 4.7[#]	0.05
Deadlift (kg)				
Placebo	187.2 ± 6.9	177.3 ± 6.9	181.4 ± 6.9	
HMB-FA	188.8 ± 6.9	185.9 ± 6.9	184.7 ± 6.9	0.26
Wingate peak power (W)				
Placebo	983.9 ± 38.8	917.5 ± 38.8	939.5 ± 38.8	
HMB-FA	977.6 ± 38.8	965.4 ± 38.8[#]	972.7 ± 38.8[#]	0.04
Vertical jump power (W)				
Placebo	5,949 ± 57.5	5,723 ± 57.5	5,656 ± 57.5	
HMB-FA	5,949 ± 57.5	5,867 ± 57.5[#]	5,870 ± 57.5[#]	0.0001

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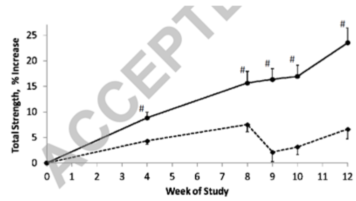
Amino Acids

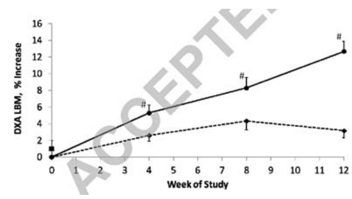
(β-HMB)

Interaction of Beta-Hydroxy-Beta-Methylbutyrate Free Acid (HMB-FA) and Adenosine Triphosphate (ATP) on Muscle Mass, Strength, and Power in Resistance Trained Individuals

Lowery et al. J Strength Cond Res. In press, 2015

- Investigated the effects of 12 weeks of HMB-FA (3g) and ATP (400mg) administration on lean mass (LBM), strength, and power in trained individuals.
- A three-phase DBPCR intervention
- Phases consisted of an 8-week periodized resistance-training program (Phase 1), followed by a 2-week overreaching cycle (Phase 2), and a 2-week taper (Phase 3).
- Participants taking HMB-FA experienced a 12.7% increase in LBM, a 23.5% increase in strength gains, a 21.5% increase in VJ, and a 23.7% increase in Wingate power.
- During the overreaching cycle, strength and power declined in the placebo group (4.3 to 5.7%) while supplementation with HMB-FA/ATP resulted in continued strength gains (1.3%).
- ***HMB-FA and ATP blunted the typical response to overreaching, resulting in a further increase in strength during that period*.**



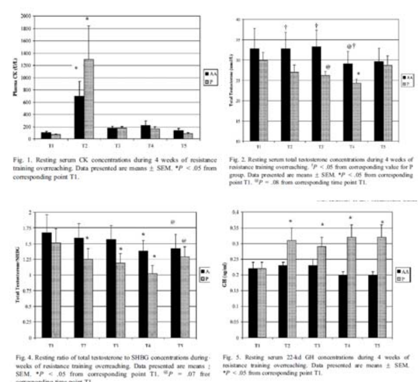


Amino Acids

The effects of amino acid supplementation on hormonal responses to resistance training overreaching

Kraemer et al. Metabolism. 55(3):282-91, 2006

- 17 RT men were randomly assigned to either an amino acid (AA) or a placebo (P) group and underwent 4 weeks of total-body RT designed to induce a state of overreaching.
- The protocol consisted of two 2-week phases (phase 1, 3 sets of 8 exercises performed for 8-12 repetitions; phase 2, 5 sets of 5 exercises performed for 3-5 repetitions).
- Muscle strength and resting blood samples were determined before (T1) and at the end of each training week (T2-T5).
- ***AA supplementation attenuated muscle strength loss during initial high-volume stress, possibly by reducing muscle damage by maintaining an anabolic environment*.**



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Amino Acids

Amino acid supplements and recovery from high-intensity resistance training
Sharp and Pearson. JSCR. 24(4):1125-30, 2010

- 8 RT males were randomly assigned to either a high branched chain amino acids (BCAA) or placebo group.
- Subjects consumed the supplement for 3 weeks before commencing a fourth week of supplementation with concomitant high-intensity total-body resistance training (overreaching) (3 x 6-8 repetitions maximum, 8 exercises).
- Blood was drawn prior to and after supplementation, then again after 2 and 4 days of training.
- Serum testosterone levels were significantly higher, and cortisol and creatine kinase levels were significantly lower in the BCAA group.
- Short-term amino acid supplementation, which is high in BCAA, may produce a net anabolic hormonal profile while attenuating training-induced increases in muscle tissue damage.
- ***Increasing BCAA intake during periods of overreaching, may increase performance while decreasing the risk of injury or by maintaining an anabolic environment.***

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Mitigating Overtraining & Immunosuppression

Summary

- Overtraining is a maladaptation to training typically due to excessive training/stress, inadequate recovery/rest, and/or improper diet.
- Overtraining is often manifested with physiological and/or psychological signs and symptoms including increased prevalence to URTI's and illness.
- Although the etiology is not well-understood, a number of training, recovery, and nutritional factors play a role.

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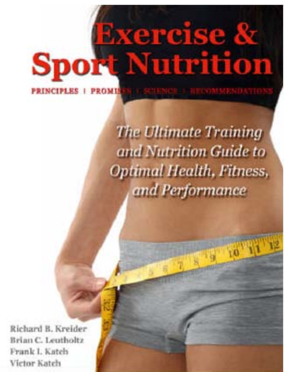
Mitigating Overtraining & Immunosuppression

Recommendations

- Athletes should eat enough calories to offset energy expenditure.
- Athletes should eat 4 – 6 meals per day and ingest CHO/PRO snacks between meals in order to offset energy expenditure.
- Amino Acid (BCAA, glutamine, EAA), creatine, & HMB supplementation can help mitigate the effects of high intensity and high volume training thereby reduce progression of overreaching to overtraining.



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Role of Amino Acids in Reducing Fatigue and Overtraining

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Disclosures: Receive industry sponsored research grants and serve as a scientific and legal consultant. Serve as scientific consultant to Nutrabolt Inc. (Bryan, TX)

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