Current Trends in Sport Nutrition Research and Practice

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Serve as scientific consultant to Nutrabolt Inc. (Bryan, TX)
Overview

- Performance Enhancement Nutritional Strategies
  - Strength / Power Athletes
  - Endurance Athletes
- Recovery Nutrition
- Trends
**Strength / Power Athletes**

**Nutrition Strategies**

*Strength/Power Athletes*

**Nutritional Considerations**

- CHO & PRO
- Maintain Hydration
- Increase power and recovery from high intensity exercise
- Improve high intensity exercise performance
- Increase muscle mass
Nutrition Strategies
Strength/Power Athletes

• Diet focused on goals (maintenance, weight gain, weight 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

www.jissn.com/content/7/1/7

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Nutrition Strategies
Strength / Power Athletes

• **Nutritional Strategies**
  ▪ Energy Drinks/PWS’s
  ▪ Water/GES
  ▪ Post-Exercise CHO & PRO/EAA

• **Ergogenic Aids**
  ▪ Creatine
  ▪ β-HMB
  ▪ β-alanine
  ▪ Sodium Bicarbonate
  ▪ Nitrates
Effect of EAA on Protein Turnover

6 grams oral EAA + 35 grams oral CHO

Role of Exercise & Nutrition on Protein Synthesis Pathways

CHO
Insulin
Resistance Exercise

Insulin
IGF-1

EAA
Leucine

BCAA

Extracellular space

AMPK

PKB/Akt

mTOR

p70S6K

4E-BP1
eIF4G

↑ muscle protein synthesis

The 28th International
Sport Science Congress
In conjunction with the
The 13th International
Exhibition of Sports
Technology

Sport Science Goes
beyond the Horizon
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.

One of first studies to examine effects of intensity and volume on myogenic regulatory responses to RE.

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**Table 1. Resistance exercise repetitions.**

<table>
<thead>
<tr>
<th>Repetitions</th>
<th>Bars</th>
<th>Logs</th>
<th>Bars</th>
<th>Logs</th>
</tr>
</thead>
<tbody>
<tr>
<td>60–65%</td>
<td>17.4 ± 0.4</td>
<td>1771 ± 43</td>
<td>931 ± 77</td>
<td></td>
</tr>
<tr>
<td>80–85%</td>
<td>87.9 ± 0.9</td>
<td>793 ± 77</td>
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</tbody>
</table>

Data are mean ± SD.
Effects of different intensities of resistance exercise on regulators of myogenesis

- 30 males were randomly assigned to ingest 30-min before, 0-min before, and post- RE (4 sets x 80% to failure of LP & LE)
  - LEU (60 mg/kg)
  - BCAA (120 mg/kg)
  - Placebo
- Muscle biopsies taken at 0, 30, 2, & 6-hr post
- **BCAA and LEU increased the phosphorylation status of 4E-BP1 at 2-hr while BCAA increased the phosphorylation of 4E-BP1 greater than LEU at 6-hr.**
- **BCAA increased the ERK1/2 at 2 and 6 hrs**
- Leucine supplementation did not have any effect on ERK1/2 activation.
- **No effect on insulin**
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. JISSN: 4:18, 2007

- 40 resistance-trained males participated in 90-min of heavy resistance training
- Immediately after exercise, subjects were randomly assigned to ingest 40g 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
- **CHO ingestion with whey following exercise increased insulin levels with no differences among types of CHO in insulin response**

Periexercise coingestion of branched-chain amino acids and carbohydrate in men does not preferentially augment resistance exercise-induced increases in phosphatidylinositol 3 kinase/protein kinase B-mammalian target of rapamycin pathway markers indicative of muscle protein synthesis.

- 27 recreationally trained males (20.9 y; 81.8 kg) were randomly assigned to:
  - BCAA (30 g) + CHO (350 g)
  - CHO (350 g)
  - CON
- Participants performed 4 sets of leg press and extensions at 80% 1RM to failure.
- Supplements were ingested 30-min prior to RE, and immediately pre-, and post.
- Glucose & insulin measured at 0, 30-min, 2-hr, and 6-hr post RE
- Muscle biopsies were obtained at baseline and at 30-min, 2-hr, and 6-hr post RE and assayed for ERK1/2, IRS, Akt/PKB, GSK, mTOR, 4E-BP1, and P70S6K.
- Insulin and glucose increase 3-fold with no differences between CHO and BCAA + CHO
Significant time main effects were observed for IRS-1 ($P = .001$), protein kinase B ($P = .031$), mammalian target of rapamycin ($P = .003$), and phosphorylated 70S6 kinase ($P = .001$).

Carbohydrate and CHO + BCAA supplementation significantly increased IRS-1 compared with PLC ($P = .002$).

Coingestion of CHO and BCAA did not augment RE-induced increases in skeletal muscle signaling markers indicative of muscle protein synthesis when compared with CHO.

Activation of mTORC1 by leucine is potentiated by branched-chain amino acids and even more so by essential amino acids following resistance exercise

8 trained volunteers completed 4 RE sessions while ingesting either PLA, leucine, BCAA, or EAA.

Muscle biopsies were taken at rest, immediately after exercise, and following 90 and 180 min of recovery.

Following 90 min of recovery the activity of S6 kinase 1 (S6K1) was greater than at rest in all four trials with a ninefold increase with EAA.

Thr46 alone exhibited a pattern similar to that of S6K1, being 18% higher with EAA than BCAA.

After 180 min of recovery, there was no difference between EAA and BCAA although with both these supplements the increases were still higher than with leucine (40%) and placebo (100%).

EAA ingestion appears to stimulate translation initiation more effectively than PLA, leucine, or BCAA although the results also suggest that this effect is primarily attributable to the BCAA.
• 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.

Effects of Whey Protein Alone or as Part of a Multi-ingredient Formulation on Strength, Fat-Free Mass, or Lean Body Mass in Resistance-Trained Individuals: A Meta-analysis

• Whey protein alone or as a part of a multi-ingredient appears to maximize lean body mass or fat-free mass gain, as well as upper and lower body strength improvement with respect to the ingestion of an iso-energetic equivalent carbohydrate or non-whey protein supplement in resistance-training individuals.
• This enhancement effect seems to be more evident when whey proteins are consumed within a multi-ingredient containing creatine.
Creatine

- Creatine is a naturally occurring non-essential amino acid discovered in 1832.
- Creatine supplementation studies began in early 1900s with interest rekindled by Ingwall and Hultman in 1970s.
- Athletes reported to be using creatine as an ergogenic aid since 1960's.
- Potential therapeutic role investigated since 1970's.
- Emphasis on ergogenic value in athletes since early 1990s as synthetic creatine became available.
- Current research on potential medical uses

Modeling CK transfer for systems bioenergetics


Adapted with permission (uwe.schlattner@ujf-grenoble.fr)
Creatine

Supplementation Protocols

- **High Dose Protocol**
  - Ingest 15-25 g/d (0.3 g/kg/d) during training

- **Loading/Maintenance Protocol**
  - Ingest 0.3 g/kg/d (15-25 g/d) for 5-7 d
  - Ingest 0.03 g/kg/d (3-5 g/d) to maintain

- **Low Dose Protocol**
  - Ingest 0.03 g/kg/d (3-5 g/d)

- **Cycling Protocol**
  - Load/maintain during training and reduce/abstain between training periods

- Takes about 4-6 weeks for muscle creatine levels to return to baseline after loading

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**Bioavailability**

Muscle Total Creatine Stores

![Approximate muscle total creatine levels in mmol/kg dry weight muscle reported in the literature for vegetarians, individuals following a normal diet, and in response to creatine loading with or without carbohydrate (CHO) or CHO and protein (PRO). From Kreider & Juhn, JENB, 2011.](image-url)
Creatine

Short-Term Supplementation

- Short-term creatine supplementation improves:
  - body mass by 1-2 kg in first week of loading;
  - maximal power/strength (5-15%);
  - work performed during sets of maximal effort muscle contractions (5-15%);
  - single-effort sprint performance (1-5%); and,
  - work performed during repetitive sprint performance (5-15%).

Kreider & Jung, JENB, 2011

Effects of Creatine on Exercise Performance

<table>
<thead>
<tr>
<th>Reference</th>
<th>Methods</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volek et al.</td>
<td>25 g/d for 7 days</td>
<td>The amount of work performed ↑ during 5 sets of bench press and jump squats</td>
</tr>
<tr>
<td>Wiroth et al.</td>
<td>15 g/d for 5 days</td>
<td>Maximal power and work performed ↑ during 5 X 10 s cycling sprints with 60 s rest recovery</td>
</tr>
<tr>
<td>Mujika et al.</td>
<td>20 g/d for 6 days</td>
<td>Repeated sprint performance ↑ (6 X 15 m sprints with 30 s recovery)</td>
</tr>
<tr>
<td>Mero et al.</td>
<td>20 g/d + sodium bicarbonate 0.3 g/kg for 6 days</td>
<td>2 X 100 m swim performance ↑</td>
</tr>
<tr>
<td>Preen et al.,</td>
<td>20 g/d for 5 days</td>
<td>Resting and post-exercise creatine and PCR content ↑</td>
</tr>
<tr>
<td>MSSE, 2001</td>
<td></td>
<td>Mean work performed and total work performed ↑</td>
</tr>
</tbody>
</table>

Sport Science Goes beyond the Horizon
**Creatine**

*Long-Term Supplementation*

- Studies show long-term creatine supplementation enhances quality of training generally leading to 5-15% greater gains in strength and performance.
- Creatine supplementation during resistance-training typically promotes a 1-3 kg greater gain in FFM in 4 – 12 weeks
- Muscle biopsy studies show gains are due to greater protein content in muscle.

Kreider & Jung, JENB, 2011

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### Effects of Creatine Supplementation on Training Adaptations

<table>
<thead>
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<th>Author</th>
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<th>Results</th>
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</thead>
<tbody>
<tr>
<td>Vandenberghe et al., JAP, 1997</td>
<td>20 g/d X 4 days; 5 g/d X 65 days</td>
<td>Total creatine &amp; PCR content, maximal strength (20-25%), maximal intermittent exercise capacity of the arm flexors (10-25%), and FFM by 60 % ↑ during 10 wks training in women</td>
</tr>
<tr>
<td>Stone et al., IJSN, 1999</td>
<td>~10 or 20 g/d with and without pyruvate for 5 wks</td>
<td>Body mass, FFM, 1 RM bench press, combined 1 RM squat and bench press, vertical jump power output, and peak rate of force development ↑ in 42 division college football player</td>
</tr>
<tr>
<td>Volek et al., MSSE, 1999</td>
<td>25 g/d X 7 days; 5 g/d X 77 days</td>
<td>Muscle total creatine and PC, FFM, type I, IIa, &amp; IIb muscle fiber diameter, bench press, squat 1RM, and lifting volume ↑ in 19 resistance trained athletes</td>
</tr>
<tr>
<td>Willougby et al., MSSE, 2001</td>
<td>6 g/d X 12 wks</td>
<td>Total body mass, FFM, and thigh volume, 1 RM strength, myofibrillar protein content, Type I, IIa, &amp; IIx MHC mRNA expression, and MHC protein expression ↑</td>
</tr>
</tbody>
</table>
Effects of plyometric training and creatine supplementation on maximal-intensity exercise and endurance in female soccer players

- Female soccer players with similar training load and competitive background were assigned to ingest a PLA or CRE during plyometric training or a non-training/supplementation CON group.
- Athletes were evaluated for jumping, maximal and repeated sprinting, endurance and change-of-direction speed performance before and after 6-wks of training.
- After intervention, the CON group did not change.
- Both plyometric training groups improved jumps, sprint, repeated sprinting, endurance, and change-of-direction speed performance.
- The CRE group improved more in the jumps and repeated sprinting performance tests than the CON and PLA groups.
- Adaptations to plyometric training may be enhanced with creatine supplementation.

Effects of ingesting Supplements Designed to Promote Lean Tissue Accretion on Body Composition During Resistance-Training
Kreider et al. JISN 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 Creatine Supplementation on Body Composition, Strength, and Sprint Performance
Kreider et al. MSSE 30:73-82, 1998

- 28 DI football players
- In a DB-R-P controlled manner, assigned to supplement diet with:
  - CHO containing placebo
  - CHO plus 15.75 g/d CM
- Greater gains in FFM, strength, and sprint performance
- Comprehensive safety analysis revealed no adverse effects during intense training

*Cited over 500 times

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 American football players
- In a DB-R-P manner, assigned to supplement diet 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
The effects of creatine ethyl ester supplementation combined with heavy resistance training on body composition, muscle performance, and serum and muscle creatine levels.

Spillane et al., JISSN, 6:6, 2009

- In a double blind manner, 30 participants were randomly assigned to ingest 0.30 g/kg FFM for 5-days and 0.075 g/kg FFM for 42 days of a PLA, CRT, or CEE.
- Serum creatine concentrations in PLA (p = 0.007) and CRT (p = 0.005) compared to CEE.
- Serum creatinine was greater in CEE compared to the PLA (p = 0.001) and CRT (p = 0.001) and increased at days 6, 27, and 48.
- Total muscle creatine content was significantly higher in CRT (p = 0.026) and CEE (p = 0.041) compared to PLA, with no differences between CRT and CEE.
- Significant changes over time were observed for body composition, body water, muscle strength and power variables, but no significant differences were observed between groups.
A buffered form of creatine does not promote greater changes in muscle creatine content, body composition, or training adaptations than creatine monohydrate.

Jagim et al. JISSN 9:43. 2012

- 36 resistance-trained participants (20.2 ± 2 years, 181 ± 7 cm, 82.1 ± 12 kg, and 14.7 ± 5% body fat) were randomly assigned to supplement their diet with:
  - CrM at normal loading (4 x 5 g/d for 7-days) and maintenance (5 g/d for 21-days) doses;
  - KA at manufacturer’s recommended doses (KA-L, 1.5 g/d for 28-days); or,
  - KA with equivalent loading (4 x 5 g/d for 7-days) and maintenance (5 g/d) doses of CrM (KA-H).
- Neither manufacturers recommended doses or equivalent loading and maintenance doses of CrM promoted greater changes in muscle creatine content, body composition, strength, or anaerobic capacity than CrM.
- There was no evidence that supplementing the diet with a buffered form of creatine resulted in fewer side effects than CrM.

Acute and chronic safety and efficacy of dose dependent creatine nitrate supplementation and exercise performance.

Galvan et al. JISSN 13:12, 2016

- Day 0 – 7: Loading Phase (4 doses/d)
  - PL: 26 g dextrose/d
  - CrM: 12 g CrM + 2 g flavoring + 8 g dextrose/d
  - CrN-L: 6 g CrN + 2 g flavoring + 8 g dextrose/d
  - CrN-H: 12 g CrN + 2 g flavoring + 8 g dextrose/d
- Day 8 – 28: Maintenance Phase (1 dose/d)
  - PL: 6.5 g dextrose/d
  - CrM: 3 g CrM + 0.5 g flavoring + 2 g dextrose/d
  - CrN-L: 1.5 g CrN + 0.5 g flavoring + 2 g dextrose/d
  - CrN-H: 3.0 g CrN + 0.5 g flavoring + 2 g dextrose/d
- Muscle creatine increased significantly by d-7 in the CrM and CrN-High groups, but then decreased by d-28 for CrN-High.
- Some ergogenic benefits were observed among groups most likely due to influence of nitrate.
- CrN delivered at 3 g was well-tolerated, demonstrated similar performance benefits to 3 g CrM, and within the confines of this study, there were no safety concerns.
- There was no evidence that CrN at recommended or twice recommended doses is more efficacious than CrM at the doses studied.
Creatine Supplementation and Upper Limb Strength Performance: A Systematic Review and Meta-Analysis

- Conducted a meta-analysis on 53 studies (563 individuals in the creatine supplementation group and 575 controls).
- Results did not differ at T0, while, at T1, the effect size (ES) for bench press and chest press were 0.265 (95 % CI 0.132-0.398; p < 0.001) and 0.677 (95 % CI 0.149-1.206; p = 0.012), respectively.
- Overall, pectoral ES was 0.289 (95 % CI 0.160-0.419; p = 0.000), and global upper limb ES was 0.317 (95 % CI 0.185-0.449; p < 0.001).
- Meta-analysis of changes between T0 and T1 gave similar results.
- The meta-regression showed no link with characteristics of population or supplementation, demonstrating the efficacy of creatine independently of all listed conditions.
- Creatine supplementation is effective in upper limb strength performance for exercise with a duration of less than 3 min, independent of population characteristics, training protocols, and supplementary doses or duration.

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 antitabatic nutrient during intense training and in elderly to reduce muscle mass loss
- Recent promising effects with FA-HMB
Effects of Calcium β-Hydroxy-β-methylbutyrate (HMB) Supplementation During Resistance-Training on Markers of Catabolism, Body Composition and Strength

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

- 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.

- 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.

Effects of 4 Weeks of High-Intensity Interval Training and beta-Hydroxy-beta-Methylbutyric Free Acid Supplementation on the Onset of Neuromuscular Fatigue

- 37 participants completed PWC at the onset of neuromuscular fatigue threshold (PWC(FT)) tests while EMG’s were recorded.
- Participants ingested a PLA or HMB or were assigned to a CON group during 4-wks of HIIT.
- HIIT training increased PWC(FT).
- The HMB group experienced greater changes in PWC(FT) compared to PLA and CON.
- Adding HMB supplementation with HIIT in untrained men and women may further improve endurance performance measures.
β-Alanine

• Muscle carnosine has been reported to serve as a physiological buffer, possess antioxidant properties, influence enzyme regulation, and affect sarcoplasmic reticulum calcium regulation.

• Beta-alanine (β-ALA) is a non-essential amino acid. β-ALA supplementation (e.g., 2–6 grams/day) has been shown to increase carnosine concentrations in skeletal muscle by 20–80% (Culbertson et al, Nutrients, 2010).

β-Alanine

• Stout et al. (JISSN, 2008) reported that 28-d of β-ALA supplementation (3-6 g/d) delayed the onset of neuromuscular fatigue.

• Hoffman et al. (IJSNM, 2008) reported that creatine / β-ALA supplementation (10/3 g/d) increased FFM in college football players participating in a 10-wk resistance training program.

• Kendrick et al. (AA, 2008) reported that 3.6 g/d of β-ALA for 4-wks increased training adaptations.
β-Alanine supplementation slightly enhances repeated plyometric performance after high-intensity training in humans

- 27 trained participants were allocated to ingest a PL or BA for 8 weeks (4.0-5.6 g/d).
- Participants performed plyometric high-intensity training (two sessions per week during the 8 weeks).
- Before and after training, maximal jump heights were recorded during squat jump (SJ) and counter-movement jump (CMJ) and an index of fatigue was recorded as a mean height of 45 consecutive CMJ.
- SJ and CMJ were increased by 8.8 and 6.4 % in PL group and 9.9 and 11.0 % in BA group with no differences between groups.
- The BA group observed better performance in the fatigue test (+8.6 %) compared to PL group.
- **BA supplementation resulted in a slight improvement of explosive force after 45 maximal consecutive jumps in young athletes.**

β-Alanine supplementation slightly enhances repeated plyometric performance after high-intensity training in humans

- 14 cyclists performed a supramaximal cycling test, 4- and 10-km TT’s, and 4 x 1-km sprints prior to and following 28 d of loading (6.4 g/d) with BA or a PLA and after a 5-wk of HIT (repeated 1-km sprints – 2 x/ wk) while taking (1.2 g/d) of BA or a PLA.
- BA loading improved sprint 3 and 4 of the 4 x 1-km sprints (4.5 +/- 3.4% and 7.0 +/- 4.0%).
- After HIT, training intensity increased to a greater degree with BA (9.9 +/- 5.0% vs. 4.9 +/- 5.0).
- BA improved maximal cycling time to exhaustion (14.9 +/- 9.2% vs. 9.0 +/- 6.9%) and anaerobic capacity (5.5 +/- 4.2%)
- **BA enhances training intensity during HIT and provides benefits to exhaustive supramaximal cycling compared to HIT alone.**
Metabolic consequences of beta-alanine supplementation during exhaustive supramaximal cycling and 4000-m time-trial performance

- 17 cyclists were administered 6.4 g/d of BA or PLA for 4-wks
- Participants performed a supramaximal cycling tests to exhaustion and a 4k TT before and after supplementation
- BA increased time to exhaustion (+12.8 +/- 8.2 s) and anaerobic capacity (+1.1 +/- 0.7 kJ)
- 4000-m TT performance was improved with BA (-6.3 +/- 4.6 s) and the mean anaerobic power output was greater (+6.2 +/- 4.5 W).
- **BA supplementation increased time to exhaustion concomitant with an augmented anaerobic capacity during supramaximal intensity cycling**, which was also mirrored by a meaningful increase in the anaerobic contribution to power output during a 4000-m cycling TT, resulting in an enhanced overall performance.

β-Alanine ingestion increases muscle carnosine content and combat specific performance in soldiers

- 18 elite combat soldiers were randomly assigned to either a BA or placebo (PL) group.
- Carnosine content of the gastrocnemius and brain was determined by proton MRS.
- Participants performed military relevant tasks that included a 2.5 km run, a 1-min sprint, 50-m casualty carry, repeated 30-m sprints with target shooting, and a 2-min serial subtraction test (SST) to assess cognitive function under stressful conditions.
- BA significantly increased muscle carnosine content with no changes seen in brain carnosine content.
- No differences were seen in 2.5 km run, 1-min sprint, repeated sprints, or shooting performance, but BA significantly (p = 0.044) improved time for the 50-m casualty carry and SST performance.
- **30-days of BA ingestion can increase muscle carnosine content and improve aspects of military specific performance.**
Effects of 28 days of beta-alanine and creatine supplementation on muscle carnosine, body composition, and exercise performance in recreationally active females
Kresta et al. JISSN. 11:55, 2014

- 32 females were randomized in a double-blind, placebo-controlled manner into one of four supplementation groups:
  - β-ALA only (BA, n=8)
  - creatine only (CRE, n=8)
  - β-ALA and creatine combined (BAC, n=9)
  - Placebo (PLA, n=7).
- Participants supplemented for 4-wks and had were assessed at 0, 7 and 28 days.
- Muscle carnosine levels non-significantly increased (BA 35.3±4; BAC 42.5±99; CRE 0.72±27; PLA 13.9±44 %, p=0.59).
- Participants in the BAC group showed a trend towards improvement during the second Wingate after one week.
- There were some trends for anaerobic exercise indicating groups supplementing with creatine may have greater improvements.

The effects of beta alanine plus creatine administration on performance during repeated bouts of supramaximal exercise in sedentary men

- 44 untrained men were assigned to one of four treatment groups randomly:
  - P (10 g maltodextrose)
  - Cr (5 g creatine plus 5 g maltodextrose);
  - BA (1.6 g BA plus 8.4 g maltodextrose); or,
  - BA + Cr (.6 g BA + 5 g creatine plus 3.4 g maltodextrose).
- Supplements were taken twice a day for 22 days, then four times a day for the following 6 days.
- Prior to and following 28 days, peak power (PP), mean power (MP), and fatigue index (FI) was determined.
- PP increased in the Cr (from 642.7+/−148.6 to 825.1+/−205.2 in PP2 and from 522.9+/−117.5 to 683.0+/−148.0 in PP3, respectively).
- MP was increased in BA+Cr
- BA and BA+Cr have strong performance enhancing effect by increasing mean power and delaying fatigue Index during the repeated WAnT.
Sodium Bicarbonate

• Supplementation Protocols:
  – 0.3 g/kg of baking soda 1 to 2 hours before competition
  – 10 g/d for 5-d
• Reported to buffer acidity and improve high intensity exercise performance (1 - 3 min)
• Possible GI distress
• Start out with a small amount during training to build up tolerance

Effects of chronic bicarbonate ingestion on performance of high intensity work
McNaughton et al. EJAP, 80:333-6. 1999

• 8 subjects performed a 60-s sprint on a CE prior to and following 5-d of supplementation of SB (0.5 g/kg/d) and following 1 month cessation
• SB significantly increased blood bicarbonate levels and pH levels
• SB increased work by 14% and peak power
Ergogenic effects of caffeine and sodium bicarbonate supplementation on intermittent exercise performance preceded by intense arm cranking
Marriott et al. JISSN, 12:13, 2015

- 12 male team-sports athletes (n = 12) ingested sodium bicarbonate (NaHCO3; 0.4 g/kg), caffeine (CAF; 6 mg/kg) or placebo (PLA) on three different occasions.
- Participants engaged in intense arm exercise prior to the Yo-Yo intermittent recovery test level-2 (Yo-Yo IR2).
- CAF and NaHCO3 elicited a 14 and 23% improvement (P < 0.05), respectively, in Yo-Yo IR2 performance, post arm exercise compared to PLA.
- RPE was lower (P < 0.05) during the Yo-Yo IR2 test in the NaHCO3 trial in comparison to CAF and PLA, while no difference in heart rate was observed between trials.
- **Caffeine and sodium bicarbonate administration improved Yo-Yo IR2 performance and lowered perceived exertion after intense arm cranking exercise, with greater overall effects of sodium bicarbonate intake.**

Separate and Combined Effects of Caffeine and Sodium-Bicarbonate Intake on Judo Performance

- 10 judokas performed 4 supplementation protocols- NaHCO3, CAF, NaHCO3 + CAF, and placebo (PLA) followed by 3 Special Judo Fitness Tests (SJFTs) interspaced with 5 min rest.
- The combined supplement (NaHCO3 + CAF) resulted in a higher number of throws than with PLA (24.4 +/- 0.9 and 23.2 +/- 1.5 throws, respectively, P = .02) during the first SJFT.
- In the 3rd SJFT, NaHCO3 and NaHCO3 + CAF resulted in more throws than with PLA (23.7 +/- 1.6, 24.4 +/- 1.0, and 22.0 +/- 1.6 throws, P = .001 and P = .03, respectively).
- Sum of throws performed in the 3 SJFTs were higher than PLA only for NaHCO3 + CAF (68.8 +/- 4.4 and 72.7 +/- 3.1 throws, respectively, P = .003).
- **Combined supplementation of NaHCO3 + CAF increased judo performance compared with PLA.**
Nitrates

- Dietary intake of food or juices with high nitrate levels has been reported to promote healthy blood pressure due to a vasodilatory effect
- Studies show consuming BRJ prior to exercise (e.g., 300-500 ml) improves aerobic endurance efficiency
- Some studies suggest nitrate supplementation can also enhance intermittent exercise performance and/or recovery

The Effects of Nitrate-Rich Supplementation on Neuromuscular Efficiency during Heavy Resistance Exercise

- 14 resistance-trained consumed an nitrate-rich (NR) or nitrate-poor (NP) supplement for 3 d, performed a bout of heavy resistance exercise, completed a washout, and then repeated the procedures with the remaining supplement.
- Before, during, and after exercise, individual and gross motor unit efficiency was assessed during isometric and dynamic muscle contractions and physical performance, heart rate, lactate, and oxygen consumption (VO2) were determined.
- NR supplementation resulted in lower initial muscle firing rates at rest and lower mean and maximum firing rates over the course of fatiguing exercise.
- NP supplementation was accompanied by increased mean and maximum firing rates by the end of exercise and lower initial firing rates.
- Nitrate supplementation resulted in higher mean peak electromyography (EMG) amplitudes.
- Supplementation with an NR beetroot extract-based supplement provided neuromuscular advantages during metabolically taxing resistance exercise.

- 12 resistance trained males ingested either 70 ml of "BEET It Sport (R)" nitrate shot containing 6.4 millimoles (mmol/L) or 400 mg of nitrate; or a blackcurrant placebo drink.
- Participants completed a resistance exercise session, consisting of bench press exercise at an intensity of 60% of their established 1 repetition maximum (1-RM), for three sets until failure with 2 minute rest interval between sets.
- Results showed a significant difference in repetitions to failure (p < 0.001) and total weight lifted (p < 0.001).
- No significant differences were seen in lactate, local, or general indicators of fatigue.
- **Nitrate supplementation before exercise improved resistance training performance and work output.**

**Nitrate Intake Promotes Shift in Muscle Fiber Type Composition during Sprint Interval Training in Hypoxia**  De Smet et al. Front Physiol. 7: 233, 2016

- 27 moderately-trained participants were allocated to one of three experimental groups: Sprint Interval Training (SIT) in normoxia (20.9% FiO2) + PLA (N), SIT in hypoxia (15% FiO2) + PLA (H), or SIT in hypoxia + nitrate (HN).
- All participated in 5 weeks of SIT on a cycle ergometer (30-s sprints interspersed by 4.5 min recovery-intervals, 3 weekly sessions, 4-6 sprints per session).
- Nitrate (6.45 mmol NaNO3) or placebo capsules were administered 3 h before each session.
- SIT decreased the proportion of type IIX muscle fibers in all groups (P < 0.05).
- The relative number of type IIA fibers increased (P < 0.05) in HN (P < 0.05 vs. H), but not in the other groups.
- Compared with H, SIT tended to enhance 30-s sprint performance more in HN than in H (P = 0.085).
- **SIT in hypoxia combined with nitrate supplementation increases the proportion of type IIA fibers in muscle, which may be associated with enhanced performance in short maximal exercise.**
Nutrition Strategies

Endurance Athletes

- Goals
  - Provide necessary dietary carbohydrate
  - Maintain hydration and blood glucose levels during exercise
  - Spare muscle glycogen utilization during exercise
  - Promote glycogen resynthesis
  - Increase endurance capacity
  - Increase anaerobic threshold
  - Maintain muscle mass
**Nutritional Guidelines**
*Endurance Athletes*

- Diet focused on goals (maintenance, weight gain, 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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**Nutrition Strategies**
*Endurance Athletes*

- Nutritional Strategies
  - High CHO diet
  - Taper & CHO Load
  - Post-Exercise CHO/PRO

- Ergogenic Aids
  - Water/GES/Gels during exercise
  - Caffeine / Energy Drinks / PWS’s
  - Sodium Phosphate
  - Nitrates (Beet Root Juice)
  - Creatine
ISSN Position Stand - Caffeine

- Caffeine is effective for enhancing sport performance in trained athletes when consumed in low-to-moderate dosages (~3-6 mg/kg)
- Caffeine can enhance vigilance during bouts of extended exhaustive exercise, as well as periods of sustained sleep deprivation.
- Caffeine is ergogenic for sustained maximal endurance exercise, and has been shown to be highly effective for time-trial performance.
- Caffeine supplementation is beneficial for high-intensity exercise, including team sports such as soccer and rugby, both of which are categorized by intermittent activity within a period of prolonged duration.

Goldstein et al. JISSN. 7:5, 2010

Sodium Phosphate

- Involved in acid-base balance, energy metabolism, and heart function.
- 4 gm/d x 3 to 6-d of sodium phosphate
- Increases VO2 max & AT by 5 -10%.
- Effective aid primarily for endurance athletes but may also be helpful for short-duration and/or intermittent high intensity exercise.
- May cause stomach upset and stool softening.
Sodium Phosphate

<table>
<thead>
<tr>
<th>Study</th>
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<td>Cade et al., MSSE, 1984</td>
<td>Trained runners; 9% ↑ in VO₂max; ↓ submaximal lactate levels</td>
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<tr>
<td>Kreider et al., MSSE, 1990</td>
<td>Trained runners; 9% ↑ in VO₂max; 12% ↑ in VANT; NS but 14-s faster 5-mile run time</td>
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<tr>
<td>Stewart et al., Res. Q., 1990</td>
<td>Trained cyclists; 11% ↑ in VO₂max; 20% ↑ in time to exhaustion</td>
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<td>Kreider et al., IJSN, 1992</td>
<td>Trained cyclists &amp; triathletes; 9% ↑ in VO₂max; 10% ↑ in VANT; 17% ↑ in power during 40 km race; 13% ↑ in EJ and 24% ↑ MFS</td>
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Effect of sodium phosphate supplementation on repeated high-intensity cycling efforts


- Trained male cyclists were randomized to 6 days of SP supplementation (50 mg/kg FFM/d) or PLA.
- Performance was assessed at baseline and 1 and 4 days post-supplementation on an air-braked cycle ergometer.
- Compared with baseline, the SP group recorded significantly improved (P < 0.05) work and mean power output values in both the sprint (baseline, 259 kJ/719 W; day 1, 271 kJ/754 W; day 4, 271 kJ/753 W) and time-trial (baseline, 225 kJ/374 W; day 1, 235 kJ/398 W; day 4, 236 kJ/393 W) aspects of the performance test post-loading.
- No differences were seen in total work or power output in the PLA group.
- SP supplementation improved repeated-sprint and time-trial cycling efforts both 1 and 4 days post-loading in trained cyclists.
**Effects of sodium phosphate and caffeine loading on repeated-sprint ability**

- 12 female, team-sport players participated in four trials: 1) SP and CAF; 2) SP and PLA; 3) CAF and PLA; and 4) PLA + PLA with ~21 days separating each trial.
- Participants performed a simulated team-game circuit (4 x 15 min quarters) with 6 x 20-m repeated-sprints performed once before (Set 1), at half-time (Set 2), and after (Set 3).
- Total sprint times were faster after SP and CAF compared with PLA (Set 1: P = 0.003; Set 2: d = -0.51; Set 3: P < 0.001; overall: P = 0.020), CAF (Set 3: P = 0.004; overall: P = 0.033) and SP (Set 3: d = -0.67).
- Total sprint times were faster after SP supplementation compared with PLA (Set 1: d = -0.52; Set 3: d = -0.58).
- Best sprint results were faster after SP and CAF compared with PLA (Set 3: P = 0.007, d = -0.90) and CAF (Set 3: P = 0.024, d = -0.73).
- Best sprint times were also faster after SP compared to PLA d = -0.54 to -0.61 for all sets).
- Sodium phosphate and combined sodium phosphate and caffeine loading improved repeated-sprint ability.

**Effects of sodium phosphate and caffeine ingestion on repeated-sprint ability in male athletes**

- 11 team-sport males participated in four trials: 1) SP (50 mg/kg FFM / d for 6–d) and CAF (6 mg/kg FFM / d) ingested 1 h before exercise); 2) SP and PLA; 3) CAF and PLA; and 4) PLA + PLA.
- Participants performed a simulated team-game circuit (STGC) consisting of 2x30min halves, with 6x20-m repeated-sprint sets performed at the start, half-time and end of the STGC.
- SP resulted in the fastest times for all sprints, as supported by moderate to large effect sizes (ES; d=0.51-0.83) and ‘likely’ to ‘very likely’ chances of benefit, compared with PLA.
- Compared with CAF, SP resulted in ‘possible’ to ‘likely’ chances of benefit for FS, BS and TS for numerous sets and a ‘possible’ chance of benefit compared with SP+C for BS (set 2).
- Compared with PLA, SP+C resulted in moderate ES (d=0.50-0.62) and ‘possible’ to ‘likely’ benefit for numerous sprints, while caffeine resulted in a moderate ES (d=0.63; FS: set 3) and ‘likely’ chances of benefit for a number of sets.
- Results suggest that SP supplementation may improve repeated-sprint performance when compared with PLA.
Nitrates

- Nitrate ingestion has been shown to reduce the oxygen cost of exercise and improve exercise tolerance.
- Larsen et al. (Acta physiologica. 2007;191:59–66) reported a reduction in maximal oxygen consumption; yet a trend for improvement in time-to-exhaustion accompanying the ingestion of sodium nitrate intake at 0.1 mmol/kg/day for three days.
- Larsen et al. (Free Radic Biol Med. 2010;48:342–7) reported a significant reduction in oxygen consumption and improvement in gross efficiency at sub-maximal workloads using the same ingestion schema.
- Bescos et al., (Med Sci Sports Exerc. 2011;43:1979–86) found that the consumption of 10 mg/kg of sodium nitrate prior to a cycle ergometer test reduced VO$_{2peak}$ without influencing time to exhaustion or maximal power output in highly trained cyclist and triathletes.

Inorganic nitrate supplementation improves muscle oxygenation, O(2) uptake kinetics, and exercise tolerance at high but not low pedal rates

- 7 subjects completed severe-intensity step cycle tests at pedal cadences of 35 rpm and 115 rpm during separate 9-d supplementation periods with NO3 rich beetroot juice (BR) (providing 8.4 mmol NO3/d) and PLA.
- Compared with PLA, plasma nitrite concentration increased 178% with BR (P < 0.01).
- There were no significant differences in muscle oxyhemoglobin concentration ([O2Hb]), phase II VO2 kinetics, or Tlim between BR and PLA when cycling at 35 rpm (P > 0.05).
- When cycling at 115 rpm, muscle [O2Hb] was higher at baseline and throughout exercise, phase II VO2 kinetics was faster (47 +/- 16 s vs. 61 +/- 25 s; P < 0.05), and Tlim was greater (362 +/- 137 s vs. 297 +/- 79 s; P < 0.05) with BR compared with PLA.
- Results suggest that short-term BR supplementation can increase muscle oxygenation, expedite the adjustment of oxidative metabolism, and enhance exercise tolerance when cycling at a high, but not a low, pedal cadence.
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.

Muscle glycogen supercompensation is enhanced by prior creatine supplementation


- 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.
Creatine and Glycerol Hyperhydration in Trained Subjects Before Exercise in the Heat

Chris Easton, Stephen Turner, and Yannis P. Pitsiladis

Recovery Nutrition
Recovery Nutrition

Considerations

- Rehydration
- CHO
- PRO/EAA
- Creatine
- Anti-inflammatory Nutrients
  - Tart Cherries
  - Nitrates

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

- 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.
Amino acid supplements and recovery from high-intensity resistance training

• 8 RT males were assigned to BCAA or PLA groups.
• Subjects consumed supplements for 3 weeks before commencing a 4th week 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.
• BCAA supplementation produced a net anabolic hormonal profile while attenuating training-induced increases in muscle tissue damage.
• BCAA supplementation during heavy training periods may increase subsequent competitive performance while decreasing the risk of injury or by maintaining an anabolic environment.

Creatine supplementation enhances muscle force recovery after eccentrically-induced muscle damage in healthy individuals

• 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.
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.

The effects of creatine supplementation on muscular performance and body composition responses to short-term resistance training overreaching


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.

The effect of creatine supplementation upon inflammatory and muscle soreness markers after a 30km race

Effects of powdered Montmorency tart cherry supplementation on an acute bout of intense lower body strength exercise in resistance trained males
Levers et al. JISSN. 12:41, 2015

- 23 resistance-trained men were randomly assigned to ingest, in a double blind manner, capsules containing 480 mg/d of a PL or powdered tart cherries (TC) for 10-d prior to and for 48-h post-exercise.
- Subjects performed 10 sets of 10 reps at 70% of a 1-RM back squat exercise after 10-d of supplementation.
- Fasting blood samples, isokinetic MVCs, and quadriceps muscle soreness ratings were taken pre-lift, 60-min, 24-h, and 48-h post-lift.
- **TC supplementation attenuated muscle soreness, strength decrement during recovery, and markers of muscle catabolism in resistance trained individuals.**

Effects of powdered Montmorency tart cherry supplementation on acute endurance exercise performance in aerobically trained individuals
Levers et al. JISSN. 13:22, 2016

- 27 endurance-trained athletes ingested, in a double-blind manner, capsules containing 480 mg of PL or powdered TC for 10-d prior to performing a half marathon and for 48-hr post-run.
- Fasting blood samples and quadriceps muscle soreness ratings were taken pre-run, 60-min, 24 and 48-h post-run.
- **TC supplementation attenuated markers of muscle catabolism, reduced immune and inflammatory stress, better maintained redox balance, and increased performance in aerobically trained individuals.**
Recovery facilitation with Montmorency cherries following high-intensity, metabolically challenging exercise

- 16 trained cyclists consumed 30 mL of PL or MC twice per day for 8-d.
- On day 5, participants completed a 109-min cycling trial designed to replicate road race demands.
- Functional performance (MVIC) cycling efficiency, 6-s peak cycling power) and DOM were assessed at baseline, 24, 48, and 72 h post-trial.
- Blood samples collected at baseline, immediately pre- and post-trial, and at 1, 3, 5, 24, 48, and 72 h post-trial.
- MVIC (P < 0.05) did not decline in the MC group (vs. PLA) across the 72-h post-trial period and economy (P < 0.05) was improved in the MC group at 24 h.
- IL-6 (P < 0.001) and hsCRP (P < 0.05) responses to the trial were attenuated with MC (vs. PLA).
- MC concentrate can be an efficacious functional food for accelerating recovery and reducing exercise-induced inflammation following strenuous cycling exercise.

The effects of Montmorency tart cherry concentrate supplementation on recovery following prolonged, intermittent exercise
Bell et al. Nutrients. 7(10):2016

- 16 semi-professional, male soccer players consumed either MC or PLA supplements for 8-d (30 mL x 2/d).
- On day 5, participants completed an adapted version of the Loughborough Intermittent Shuttle Test (LISTADAPT).
- MVIC, 20 m Sprint, counter movement jump (CMJ), agility and muscle soreness (DOMS) were assessed at baseline, and 24, 48 and 72 h post-exercise while measures of inflammation (IL-1-beta, IL-6, IL-8, TNF-alpha, hsCRP), muscle damage (CK) and oxidative stress (LOOH) were analysed at baseline and 1, 3, 5, 24, 48 and 72 h post-exercise.
- Performance indices (MVIC, CMJ and agility) recovered faster and muscle soreness (DOMS) ratings were lower in the MC group (p < 0.05).
- Acute inflammatory response (IL-6) was attenuated by MC.
- MC is efficacious in accelerating recovery following prolonged, repeat sprint activity, such as soccer and rugby.
The effects of beetroot juice supplementation on indices of muscle damage following eccentric exercise
Clifford et al. EJAP 116(2): 2016

- 30 males consumed high-dose BRJ (H-BT; 250 ml), a lower dose of BRJ (L-BT; 125 ml), or PLA immediately (x3 servings), 24 (x2 servings) and 48 h (x2 servings) following completion of 100-drop jumps.
- Maximal isometric voluntary contractions (MIVC), countermovement jumps (CMJ), pressure pain threshold (PPT), creatine kinase (CK), interleukin-6 (IL-6), interleukin-8 (IL-8) and tumour necrosis factor-alpha (TNF-alpha) were measured pre, post, 2 (blood indices only), 24, 48 and 72 h following the drop jumps.
- Acute BRJ supplementation attenuated muscle soreness and decrements in CMJ performance induced by eccentric exercise while MIVC, CK, IL-6, TNF-alpha and IL-8 were not affected.

Performance Enhancement Nutrition

Summary

- **Strength/Power/Sprint Athletes**
  - Moderate to High CHO/PRO diet
  - Water/GES
  - Post-Exercise PRO
  - Creatine
  - β-alanine
  - Sodium Bicarbonate
  - Nitrates (Beet Root Juice)

- **Endurance Athletes**
  - High CHO diet/CHO loading
  - Water/GES/Gels
  - Caffeine / Energy Drinks / PWS's
  - Sodium Phosphate
  - Nitrates (Beet Root Juice)
  - Creatine

- **Recovery Nutrition**
  - Rehydrate
  - CHO
  - Post-Exercise PRO/EAA
  - Creatine
  - Tart Cherry
  - Nitrates (Beet Root Juice)
Exercise & Sport Nutrition Trends

- Pre-Workout Supplements / Drinks
  - Enhance Acute Exercise
  - Improve Mental Focus / Attention
  - Reduce Catabolism
  - Convenient means to provide nutrients that can enhance training adaptations

- Identifying synergistic effects of ergogenic nutrients

- Recovery Nutrition

- Naturally derived bioactives

- Use of bioactive nutrients in functional foods

- Nutrigenomics — Individualized exercise / nutrition interventions

- Health benefits of exercise and sport nutrition methods
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