PERFORMANCE ENHANCEMENT IN ATHLETES

Designer oil and amino acid blends

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The sports nutrition industry is responsible for bringing to market a very wide array of novel natural health product ingredients. While the majority of these offerings are disturbingly lacking in evidence of safety and efficacy, a handful of agents have proven themselves immensely valuable for delivering modest yet significant enhancement to performance of elite athletes. Simple strategies of timing of meals with respect to workouts (Moore 2009), glycogen supercompensation (Hawley 1997), and proper hydration (Horswill 1998) have all been demonstrated to impart significant impact to athletic performance. From a natural health products perspective, caffeine (Tarnopolsky 2008), creatine (Wyss 2000), and L-carnitine (Ho 2010) have likewise reproducibly demonstrated outcomes of considerable significance for elite athletes.

Healthcare providers must be extremely cautious when attempting to navigate the exhaustive selection of offerings marketed towards athletes. Many commonly utilized ingredients have considerable safety concerns, notably synephrine (extract of bitter orange peel that replaced ephedrine in fat burning products) (Health Canada 2007) and conjugated linoleic acid (CLA), a trans fatty acid touted as a fat burner that has demonstrated disturbing findings in preclinical toxicological studies including increased liver and spleen weight (DeLany 1999, West 1998). Health Canada has made impressive strides in trying to regulate such products out of the market, but much more work is needed.

One advantage that has emerged from the overzealousness of the sports nutrition industry is the discovery of non-athletic applications of many of the substances marketed towards athletes. Isolated L- glutamine became widely available on the market almost exclusively due to marketing towards athletes. While its impact on athletic performance is questioned, integrative healthcare providers have since found a role for L- glutamine supplementation in conditions of inflammatory bowel disease and other states of compromised gastrointestinal function (Kanauchi 2003). Creatine secured its market position through application in athletes, yet today integrative healthcare providers have come to rely on it for preventing atrophy in immobilization injury (Eijnde2005, Hespel 2001), delaying sarcopenia in the elderly (Brose 2003), and as a supplement for individuals suffering from a wide array of neuromuscular disorders (Kley 2007, Tarnopolsky 2007). L- carnitine, while demonstrating modest impact for performance enhancement, has become entrenched among integrative healthcare providers as a first- line treatment for patients in settings of secondary coronary prevention (Ferrari 2004), as well as for coadministration with valproic acid as a means of minimizing adverse effects associated with the medication (Russell 2007).

The following review will present a basis for application of two novel natural health product blends in elite athletes; one blend is recommended for enhancing endurance performance, while the other blend is recommended for enhancing strength. The application of these two novel blends for athletes is unfortunately for the most part theoretical. The evidence upon which the blends were recommended to athletes by the author will be presented. The author has been recommending the two blends to elite athletes for approximately six years now, with a very impressive magnitude of success according to anecdotal reports from the athletes prescribed the blends. While the evidence base in support of the blends certainly requires development, the blends are accompanied by a large, unquestioned safety profile. The impressive magnitude of benefit from anecdotal reports has led the author to outline the blends in question.

A BLEND OF FUNCTIONAL OILS (ALPHA LINOLENIC ACID, MEDIUM CHAIN TRIGLYCERIDES, AND PLANT STEROLS) MAY ENHANCE ENDURANCE PERFORMANCE IN ATHLETES.

Dr Peter Jones, PhD, Director of the Richardson Centre for Functional Foods and Nutraceuticals, an affiliate of the University of Manitoba, oversaw the development of a novel oil blend. The research team hypothesized that the oil blend would increase energy expenditure and thus operate as a weight loss aid. In a tightly- controlled, inpatient laboratory setting, the oil was administered to overweight, sedentary, men and women (see Table 1) (Bourque 2003, St- Onge 2003A, St- Onge 2003B). Among both men and women, the oil blend achieved significant increases to energy expenditure (assessed through indirect calorimetry). Multiple- section whole body MRI was used to determine impact of the oil blend on various adipose compartments. In men, the oil blend significantly reduced total body volume, subcutaneous adipose tissue, upper body adipose tissue, and total adipose tissue. In women, the oil blend demonstrated a "trend for significance" for these variables, but failed to significantly impact volume of adipose compartments described for the trial in men.

The authors' first experience with administering this oil blend to an athlete was for the basis of enhancing weight loss. The athlete was a professional hockey player, looking to lose 10-15lbs in a five week period prior to attending training camp for the upcoming season. The combination of caloric restriction, exercise, and the oil blend helped to achieve this outcome. Surprisingly, the athlete described an interesting situation; his aerobic training regime had been identical throughout his 12- year professional hockey career; stationary cycle at a set speed and power output for 45 minutes, five days per week. Upon follow- up with the patient, he reported "I don't know why, but I am not getting tired on my bike… I have never done the bike for more than 45 minutes per session. For the past week, my sessions have been 60-80 minutes in duration".

Table 1: Clinical trials of a functional oil blend in humans

Reference	Description	Outcomes
St-Onge 2003A St-Onge 2003B	30 overweight men randomly assigned to 1of 2 interventions (4 weeks each, with washout) in crossover design. Inpatient setting. Both interventions; 15% PR, 40% fat, 45% CHO. 75% of total fat intake was "treatment fat". Control fat = olive oil (OO). Treatment fat = "functional oil" (FO): 67% MCT, 14% Oleic acid, 5% ALA, Phytosterols 3.4% Multiple section whole body MRI served as measure of body composition. Indirect calorimetry served as endpoint measure of energy expenditure. Plasma lipids were measured.	TC decreased 0.68mmol/L FO and 0.25mmol/L OO. LDL-C decreased 0.48mmol/L FO and 0.15mmol/L OO. TG and HDL similar between groups. Energy expenditure was significantly elevated 2,3, and 4 hours following the consumption of a FO versus OO- based breakfast. Total body volume, subcutaneous adipose tissue, upper body adipose tissue, and total adipose tissue were significantly reduced by FO versus OO.
Bourque 2003	17 overweight women, inpatient setting, randomly assigned to 1 of 2 interventions (4 weeks each, with washout) in crossover design. Treatment intervention as above trial. Control intervention was beef tallow (BT).	TC decreased 9.1%, and LDL-C decreased 16% FO versus BT. No impact on TG and HDL-C. Energy expenditure was significantly elevated 2 and 3 hours following the consumption of a FO versus BT- based breakfast. "Trend for significance" regarding total body volume, subcutaneous adipose tissue, upper body adipose tissue, and total adipose tissue.

Legend: PR=protein, CHO=carbohydrate, OO=olive oil, FO=functional oil, MCT=medium chain triglyceride, ALA=alpha linolenic acid, BT=beef tallow.

Since this time, the author has administered the oil blend to 15+ elite athletes. Subjective reports of enhanced endurance are a routine finding among these athletes.

A BLEND OF AMINO ACIDS (ARGININE, TAURINE, AND GLUTAMINE) MAY ENHANCE STRENGTH PERFORMANCE IN ELITE ATHLETES.

In 2004, the author had the privilege of reviewing dozens of natural health product ingredients on behalf of the natural health products industry. Our team was assimilating evidence of safety and efficacy on behalf of the industry, and submitting the findings to the Natural Health Products Directorate of Health Canada for the purposes of obtaining Natural Product Numbers (NPNs) for sale of the products in question in Canada. While reviewing various products targeting performance enhancement of elite athletes, a short list of amino acids emerged as potential ergogenic aids for resistance-training athletes; arginine, taurine, and glutamine.

Custom compounding pharmacies were employed to formulate the blend. Each daily dose delivers 5g arginine, 5g glutamine, and 3g taurine. The athlete is instructed to use the blend as a post- workout recovery beverage. They are instructed to combine 13g of the blend with 15g of a standard whey protein isolate. A whole, overripe banana is added (serving two purposes; flavour as well as delivery of simple carbohydrate, which helps absorption and utilization of amino acids). One cup of milk is also added; rice or almond milk are typically recommended because they further contribute to the simple carbohydrate content of the beverage. The athlete is welcome to add additional fruit to the beverage.

Outcomes based on anecdotal feedback from administration of the blend are of considerable significance and magnitude. The strategy quickly and powerfully increases strength performance for the athlete. The academic basis for the blend is provided below.

Arginine has demonstrated a variety of outcomes in controlled human studies of significance for performance enhancement of elite athletes. Among untrained individuals, arginine has demonstrated the ability to reverse compromised endothelial function (Clarkson 1996, Lauer 2008, Lucotti 2006, Siasos 2009), a metabolic complication of several detrimental lifestyle habits, including lack of physical activity, obesity, insulin resistance, and consumption of substances contributing a net oxidant load to the body, notably foods rich in saturated and trans fat, smoking, excessive alcohol consumption, etc. Arginine has also demonstrated efficacy in the management of

mild hypertension (Ast 2010, Palloshi 2004, Rytlewski 2005, Siani 2000). Hypotensive action and reversal of compromised endothelial function are credited to arginine serving as the substrate for nitric oxide synthase, acting as a direct precursor for endothelium- derived nitric oxide production. In theory, this function of arginine may enhance performance by enhancing vasodilation and thus blood delivery to muscle during exercise or subsequently during recovery from a bout of training. Furthermore, arginine has demonstrated an ability to enhance glucose utilization and improve insulin resistance in several populations (Lucotti 2006, Lucotti 2009, Piatti 2001).

Arginine supplementation has also been evaluated in situations of athletic performance. Again, a number of outcomes support the ergogenic impact of arginine supplementation among an elite athlete population. Koppo et al (2009) demonstrated an acceleration of pulmonary VO2 kinetics among trained subjects performing six minute cycle sprints at 80% of ventilator threshold. The outcome suggests an ability of arginine to decrease the amount of time skeletal muscle takes to adapt to a large increase in workload, reducing the oxygen deficit created at the onset of high-intensity activity. Camic et al (2010A, 2010B) utilized high-intensity cycle ergometry to demonstrate improved physical working capacity at the fatigue threshold (PWC_{FT}) among men supplemented with arginine engaged in a four week training regime. The outcome is a measure of maximum power output that can be maintained without neuromuscular evidence of fatigue. This was accompanied by a significant increase in the gas exchange threshold, peak oxygen uptake, and power output among arginine supplemented subjects. In another trial, healthy, untrained adult males participated in a five- week progressive strength training program and were administered arginine and ornithine or placebo. Subjects receiving arginine and ornithine demonstrated significantly increased total strength and lean body mass relative to gains experienced with exercise training supplemented with placebo (Elam 1989). In a placebo- controlled trial among resistance- trained men, individuals assigned to arginine supplementation demonstrated significantly improved one repetition maximum bench press and Wingate peak power performance (Campbell 2006).

Mechanistically, a clinical trial in strength- trained athletes demonstrated increases in serum levels of growth hormone and insulin- like growth factor-I (IGF-1) following intense resistance training and arginine supplementation relative to the same training regime and supplementation with placebo (Zajac 2010). Among untrained, healthy adult subjects, arginine supplementation was shown to reduce exercise- induced increases in plasma lactate and ammonia levels (Schaefer 2002).

Interest in glutamine supplementation among elite athletes began with interest in elevated rates of upper respiratory tract infection among long distance elite athletes following an event. Glutamine had been observed to poor out of skeletal muscle during infection, a preferred energy source for white blood cells. Interest surfaced in elucidating if supplementation with glutamine leading up to and following a long distance event would reduce risk of upper respiratory tract infection. The impact of glutamine supplementation on this outcome appears to remain unclear (Castell 2003).

Several outcomes of interest for elite athletes have been demonstrated with glutamine supplementation. In two separate studies of elite athletes, glutamine supplementation was shown to reduce exercise- induced increases in plasma ammonia levels (Bassini- Cameron 2008, Carvalho-Peixoto 2007). Elevations in blood ammonia during exercise have been suggested to significantly contribute to fatigue. Glutamine has also demonstrated an ability to impact recovery following a bout of training. Glutamine supplementation alone following a bout of intense training was shown to achieve statistically similar levels of muscle glycogen deposition as post- training supplementation with carbohydrate. Combining glutamine with carbohydrate following a bout of training lead to greater glycogen deposition in muscle than either carbohydrate or glutamine alone (Bowtell 1999). Furthermore, exercise induces elevations in plasma levels of IL-6. IL-6 is suggested to act as a hormone- like molecule, priming liver and adipose tissue to supply substrates during exercise. In a controlled clinical trial, exercise alone induced an 11-fold increase in plasma concentrations of IL-6, while exercise plus glutamine supplementation induced an 18-fold increase (Hiscock 2003).

Taurine is actively concentrated in the intracellular compartment of muscle (~500 times higher than in plasma) and other excitable cells, where it acts a membrane stabilizer, an osmotic solute and may augment myofilament contraction (Cuisinier 2002, Hamilton 2006, Imagawa 2009, Ramamoorthy 1994). During exercise, contracted muscles release taurine into the bloodstream as an osmoregulatory mechanism in order to offset the increased muscle fiber osmolarity that occurs as a result of lactic acid and other metabolite build up (Cuisinier 2001, Cuisinier 2002, Hamilton 2006, Ward 1999).

Taurine directly modulates muscle contraction (Cuisinier 2002). Bakker (2002) found that taurine increases force production in skeletal muscle cells by increasing calcium release from the sarcoplasmic reticulum and increasing

myofilament sensitivity to calcium. Hamilton (2006) reported that taurine depletion caused a significant drop in force production by muscle fibres compared to normal cells ($p<0.05$), but interestingly slowed onset of fatigue, possibly due to lower ATP utilization and consequent accumulation of metabolic byproducts. Other in vivo experiments have shown up to 80% decreased exercise capacity in animals that lack the ability to concentrate taurine (Warskulat 2004). Miyazaki et al (2004) and Yatabe et al (2003) have found that taurine muscle concentration decreased significantly after exercise to exhaustion, and that oral taurine not only inhibited this decrease in taurine concentration but prolonged time to exhaustion of exercising animals. Imagawa (2009) found that use of taurine either with or without caffeine over a two week period enhanced endurance performance and significantly decreased muscle lactate in mice compared to controls ($p<0.01$).

Human trials of taurine alone for performance enhancement are sparse. Findings of increased plasma taurine representing muscle efflux following strenuous endurance exercise have been replicated in humans (Medelli 2003). Taurine has been studied in humans alongside caffeine, glucoronolactone, and B vitamins as part of various energy drink formulations. These combinations have repeatedly been shown to significantly increase aerobic and anaerobic performance in humans (Alford 2001, Geiss 1994, Ivy 2009). Independently, taurine has been shown to prevent an "exercise-induced decline in SOD [superoxide dismutase] activity and increased in GPx [glutathione peroxidase] activity during exercise," thereby exerting an antioxidant effect during exercise (Zembron-Lacny 2007).

CONCLUSION

Athletes routinely experiment with a very wide array of supplemental agents hypothesized to enhance performance. Both safety and efficacy of the majority of such agents warrants intense scrutiny. Integrative healthcare providers are poised to serve as a voice of reason and guidance in the area.

The functional oil blend described above has been eloquently demonstrated, in a tightly controlled metabolic unit, to increase energy expenditure, reduce adipose volume, and improve cardiovascular disease risk factors. Through predominantly anecdotal feedback, the blend may enhance endurance in elite athletes.

The amino acid blend described above has a modest evidence base in its support for enhancing strength among elite athletes. The amino acid blend is administered as a post- workout meal replacement. The provision of protein and carbohydrate immediately following a bout of exercise has been reproducibly demonstrated to enhance recovery from a bout of training. The author proposes that the provision of the specified doses of arginine, taurine, and glutamine achieve improvements in performance not delivered by simple protein and carbohydrate alone.

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