Review Article

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The Ergogenic Potentials of Nutraceutical Amino Acids: a Review

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ABSTRACT

Nutraceuticals are immersing as product that provide association of food with drugs. The global market of nutraceuticals has been excelling over past decades and has established itself as a competitive industry of global market. With increasing public consciousness towards dietary remedy for physical fitness and diseases prevention and treatment, consumption of nutraceuticals is one rise. This gives an equal opportunity to the pharmaceutical, food, agricultural, biotechnology, nutrient supplements sectors to explore and expand more in this field. There is paucity of data on various nutraceutical products and its economic share in Nepalese market. Nevertheless, it can be promising economic outreach of Nepalese pharmaceutical sector which is prospering well in drug production and distribution. Athletes are particularly concerned for their fitness level. They regularly consume various nutraceuticals to enhance their power and performance. Various nutraceutical products targeting a definite functional enhancement are available in the market at present. Consumers should acquire adequate information on use, appropriateness, proper selection and associated effects of nutraceuticals prior to consuming. The manufacturers and distributors should also commit in educating the consumers. This review article aims to analyze the ergogenic potentials amino acid nutraceuticals in various athletes.

Key words: Amino acids; athletes; exercise; nutraceuticals; nutrition

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INTRODUCTION

The term nutraceutical was coined from 'nutrition' and 'pharmaceutical' in 1989 by Stephen Defelice and the Foundation for Innovation in Medicine (figure 1). Later in 1994 the term was defined as "any substance that may be considered a food or part of a food and provides medical or health benefits, including the prevention and treatment of disease. Such products may range from isolated nutrients, dietary, supplements and diets to genetically engineered 'designer' foods, herbal products, and processed foods such as cereals, soups, and beverages."[1] Nutraceuticals have been contributory in management of health problems such as arthritis, pain, cold and cough, sleeping disorders, osteoporosis, blood pressure, cholesterol and diabetes.[2] This is the major reason why nutraceuticals now challenge the conscientious concept of associating foods with nourishment and drugs with disease prevention and treatment.[3]

Athletes have shown keen interest in nutraceuticals since long ago. As a result, products such as weight gainers and protein powders were popular among the sports nutritionist twenty years back. In mid to late 1980s, bodybuilders and athletes were immensely attracted towards claiming that 'protein adds muscle' and 'calories add weight'. MetRx company was a celebrated sports nutrition company of its time which brought a movement in sports nutrition. Following the path, similar companies were established elsewhere in the late 1990s with a greater emphasis on drug-free fitness and convenience that could well convince the consumers. At present, nutraceuticals targeting a definite functional enhancement are available in the market. Their demand is increasing with an increase in awareness and acceptance of nutraceuticals among consumers including individuals who participate in recreational workouts.[4] According to

Business Communications Company (BCC) research, the global nutraceutical market of $198.7 billion in 2016 is expected to reach $285.0 billion by 2021 at a compound annual growth rate (CAGR) of 7.5%,in just a half decade.[5] The market in 2018 is $230.9 billion and the CAGR now is 7.8%. At this rate, the global nutraceutical market would progress to $336.1 billion by 2023.[6] There is paucity of data to specifically comment on the status of available nutraceutical products in the Nepalese market and its economic share. Furthermore, Nepalese pharmaceuticals have been excelling well in drugs production and distribution. Since, nutraceutical sector in Nepal is at the stage of conception and thus pharmaceutical along with food and agricultural companies of Nepal have a high potential to explore and establish themselves in meeting the immersing demand of nutraceuticals.

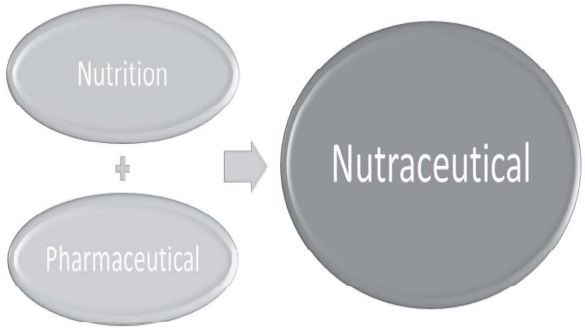

Figure 1. Concept of Nutraceuticals

Exercise and Nutraceuticals

Exercise is an activity that causes increased energy expenditure by skeletal muscles which basically involves repetitive contraction and relaxation of the skeletal muscles.[7] There are various sources of energy for muscular contraction during exercise. For the first 8 to 10 seconds, the phosphagen system is responsible for providing Adenosine Triphosphate (ATP). Then, in addition to this, the glycogen-lactic acid system provides the required energy for 1.3 to 1.6 minutes whereas the aerobic system by oxidation of foodstuffs in the mitochondria can provide energy for unlimited period of time until the nutrients last.[8]

Carbohydrates are mostly utilized by the muscles during the early stages of exercise. They may be provided by the stored glycogen in the muscle or the liver. In addition to carbohydrates, muscles also utilize large amount of fat in the form of fatty acids and acetoacetic acid, as well as proteins in the form of amino acids but to a much lesser extent. Following initial first 3 to 4 hours of an endurance event, more than 50% of the energy requirement of the muscles is derived from fat.[8]

In response to exercise, the muscles undergo certain structural and functional changes. The adaptation to regular exercise is referred as training. According to the intensity and duration of exercise, training can be either strength training or endurance training.

Strength (anaerobic) training involves intense muscular activity for short period of time like weight lifting, sprint, etc. Strength training leads to hypertrophy of the muscle involved by the increase in production of contractile proteins such as actin and myosin. Likewise this leads to increase in formation of more number of cross bridges which results in increase in force during muscle contraction.

Endurance (aerobic) training involves exercise involving slow and prolonged contraction of muscles such as long distance running, cycling, etc. It enhances the mitochondrial enzymatic activity, increases the muscular glycogen stores and vascularity of the muscles as well as enhances the capacity of muscle to extract oxygen from blood. However, there is no change in the muscle fiber composition and speed of contraction. Thus, the training improves ability of both the fast and slow twitch muscle fibers to provide energy during prolonged exercise.[7]

Classification

On the basis of chemical nature, nutraceuticals has been divided into carbohydrate and derivatives, protein and derivatives, fat and derivatives, minerals and microbial

Table 1. Classification of Nutraceuticals

Carbohydrate and derivatives	Protein and derivatives	Fat and derivatives	Minerals	Microbes
Vitamin C	Branched chain amino acid	Polyunsaturated fatty acid	Calcium	Probiotics
Oligosaccharide	Leucine	Conjugated linoleic acid	Selenium	Prebiotics
Nonstarch polysaccharide	Arginine	Monounsaturated fatty acid	Potassium	
	Creatine	Sphingolipids	Copper	
	Glutamine	Lecithin	Zinc	
	Glucosamine			

(Table 1).[1]

In this article, we have discussed about the 'protein and derivatives' category of nutraceutical.

Branched Chain Amino Acids and Leucine

Branched chain amino acids (BCAA) are the amino acids with branched side chain linked to the carbon atom. They include leucine, isoleucine and valine, which are essential amino acids. They are principally metabolized in the skeletal muscles where they are used as source of energy.[9] Chief sources of BCAA are whey powder, cooked soyabean, low-fat cheese, turkey breast, tuna fish, halibut, 1% cottage cheese and lean pork.[1] Whey powder is the dried form of whey, a milk protein. After milk is processed for curd or cheese synthesis, whey remains in an aqueous solution. Not only does whey protein improve muscle strength but also enhances immunity, possesses antimicrobial property and prevents cardiovascular diseases and osteoporosis.[10]

BCAA contribute to skeletal muscle replenishment after exercise through enhanced protein synthesis.[1] The performance of an individual after a certain time duration of extensive exercise starts declining due to development of fatigue. Fatigue has central and peripheral component. BCAA helps to attenuate both components of fatigue. Central fatigue is the sensation of fatigue due to neurochemical changes in brain following exercise. It is mediated by many neurotransmitters, where tryptophan and serotonin metabolites level in brain play a key role. During exercise, tryptophan is displaced from albumin by the mobilization of free fatty acids and thus increasing the free fraction of tryptophan in plasma. As a consequence, tryptophan uptake across blood brain barrier increases. The role of BCAA in reducing central fatigue is due to its competition with tryptophan for carriers in the brain. Therefore, BCAA rich diet is favorable for muscle endurance exercise.[11]

Delayed onset muscle soreness is due to direct muscle damage following exhaustive exercise from inflammation and proteolysis. Increase in intrafiber pressure and metabolites like potassium ions, nucleotides and inorganic phosphate after exhaustive

exercise stimulate nerve endings resulting in muscle pain. During continuous exercise, muscle breakdown can be attenuated by supply of BCAA. BCAA are utilized as a source of energy after the exhaustion of available short-term glycogen stores in muscle. Additionally, it spares muscle breakdown.[11]

There are many experiments supporting the performance enhancing effect of BCAA during exercise. In a double blinded crossover study by Matsumoto et al., 12 long distance young runners of age 20 ± 1 years had undergone two intensive training periods each lasting for three days. They were supplemented with either BCAA or an isocaloric placebo drink. Whole body soreness and fatigue sensation was assessed based on a visual analogue scale method whereas the extent of muscle damage and inflammation was assessed based on biological markers namely plasma creatine kinase, lactate dehydrogenase and granulocyte elastase. BCAA supplementation was noted effective in attenuation of muscle soreness. Similarly, the difference in biological markers supported that muscle damage and inflammation was actually lesser with BCAA compared to placebo (Table 2).[12]

However, in a double-blind, placebo-controlled and randomized experimental study by Areces et al, 46 experienced runners were divided into two groups, one with BCAA supplementation (*n*=25, supplemented with 5 g day-1 of powdered leucine: isoleucine: valine in ratio of 1:0.5:0.5, during the 7 days before competition) and the other as control group(*n*=21, supplemented with an isocaloric placebo). Leg muscle power was measured with a maximal counter movement jump while urine myoglobin concentration was measured as an indirect marker for muscle damage. Leg muscle pain during the race was assessed with a visual analog scale. The study found no difference among these parameters between the two groups (table 2).[13] BCAA are available in market in the form of powder, tablet, capsule, pills.

Beta-hydroxy-beta-methylbutyrate (HMB)

HMB is a metabolite of leucine, an essential amino acid.[14] It is produced endogenously in humans and animals from leucine.[15] It is one of the popular ergogenic aids marketed among resistance training individuals including bodybuilders with the claims of increasing strength, muscle bulk and lean body mass.[16-18] Various studies have been conducted to check for the efficacy of HMB but there have been conflicting results. Some studies have their results in favor of HMB as an ergogenic while others do not.

After ingestion of leucine, only a part of it is converted to α-ketoisocaproate, which is mainly metabolized to isovaleryl-CoA and only a small portion is metabolized to HMB. On the whole, only 5% of consumed leucine gets metabolized to HMB which is the reason why HMB is supplemented instead of leucine. Regarding the latter consideration, an individual would have to consume over 600 grams of high quality protein in order to gain 60 grams of leucine, the amount required to produce 3 grams daily dosage of HMB. This quantity of protein is practically inconvenient and probably unhealthy as well. A dose of 3 grams of HMB is frequently used in studies.[15]

Some mechanisms by which HMB produce these benefits have been proposed. One of these is its ability to enhance skeletal muscle protein synthesis by mTOR pathway stimulation. The other is by attenuation of protein degradation by decreasing the upregulation of caspases and expression of proteasome and its activity during catabolic state. Decreased activity of proteasome implies that the ubiqutine-proteasome pathway of protein degradation is attenuated.[17, 19] Similarly, HMB is believed to be metabolized to β-hydroxy-β-methylglutaryl-CoA in the saroplasm which provides carbon for cholesterol synthesis. This enhanced synthesis of cholesterol is thought to add integrity to the sarcolemma and stability of muscle cells.[17] Apart from these, Kornaiso et al. has shown that HMB increases proliferation and differentiation of satellite muscle cells during normal growth and period of cell starvation by decreasing apoptosis of satellite cells. Satellite cells in skeletal muscle are primarily responsible for muscle regeneration throughout life.[20] Thus, it minimizes protein breakdown and cell damage during intense exercise. In addition, it is also believed that HMB increases muscle cell fatty acid oxidation leading to decrease in fat mass. It is claimed to have more anticatabolic activity than anabolic activity that contributes to increase strength and lean body mass.[14]

Arginine

Supplementation of arginine is very popular among

professional athletes and body builders despite very little evidence supporting arginine as an ergogenic. Arginine is a conditionally essential amino acid because it functions as an essential amino acid during conditions of pregnancy, growth, or injury. It plays a significant role in protein synthesis, ammonia detoxification through urea cycle and the synthesis of creatine and nitric oxide(NO).[21] Besides, arginine is claimed to have an ergogenic potential with respect to its role in the secretion of growth hormone, as well as creatine and NO synthesis.[21] Arginine is found in foods rich in animal proteins such as fish, red meat, breast chicken, and dairy products as well as plant proteins like coconut, oats, cereal, nuts, walnuts and sunflower seeds.[22]

Growth hormone release

Arginine infusion is documented to stimulate release of growth hormone from anterior pituitary by inhibiting somatostatin release.[21] However, arginine intake and its effect on growth hormone release have not been shown to go in parallel by investigations. Growth hormone (GH) has lipolytic effect that accounts for a rise in plasma level of fatty acids and glycerol. This increases the availability of fatty acids, a source of sustenance to skeletal muscle to enhance the individual's ability to perform physical activity. GH also elevates blood glucose level. When cells take up glucose, it is metabolized to pyruvate by glycolytic pathway. Pyruvate dehydrogenase enzyme normally reduces pyruvate to acetyl CoA that enters tricarboxylic acid cycle for oxidative phosphorylation and ATP synthesis. However, under the influence of GH, the so formed pyruvate undergoes anaerobic metabolism to form lactate. The reason behind the promotion of anaerobic metabolism of glucose is the reduction of enzyme, pyruvate dehydrogenase by GH.[23] ells can mobilize lactate as a fuel by converting it to pyruvate and glucose. Furthermore, there are recent evidences that cast a doubt on lactate accumulation being detrimental to muscle activity.[23] These proposed mechanisms are, however, not supported by many studies.

In a randomized, double-blind, placebo-controlled study by Abel et al., 30 male endurance-trained athletes divided into three groups viz. with a high concentration of 5.7 gram arginine and 8.7 gram aspartate, with a low concentration of 2.8 gram arginine and 2.2 gram aspartate or placebo for four weeks. The objective of the study was to observe if arginine and aspartate in two different dosages enhanced endurance exercise performance and if it affected specific performance, endocrine and metabolic parameters including growth hormone concentration. Determination of maximal oxygen uptake (VO_2 peak) and time to exhaustion was carried out on a cycling ergometer in an incremental exercise test before and after arginine and aspartate supplementation. Concentration of human growth hormone and lactate was also measured before and after each incremental exercise test. No significant differences was found on these factors compared to placebo after chronic supplementation (table 2). Similarly, there was no influence of the dosage found on the endurance performance.[24]

NO synthesis

The other significance of arginine lies in the synthesis of NO, a powerful vasodilator. Arginine is the substrate for nitric oxide synthase (NOs) enzyme which synthesizes NO. Though the vasodilatory capacity of NO can provide the possibility of an increase in blood flow to skeletal muscle with fuel substrates such as glucose and fatty acid, there is still no strong evidence that NO improves exercise performance.[21,23] Tsung-Han Liu et al. carried out a randomized cross-over, placebo-controlled trial among 10 elite male college judo athletes with similar body weight. The athletes consumed 6g/day arginine or placebo for 3 days and performed an intermittent anaerobic exercise test on a cycle ergometer. Collections of blood samples was done before supplementation, before and during exercise, and 0, 3, 6, 10, 30 and 60 minutes after exercise. No significant difference was established in plasma nitrate and nitrite concentrations in both trials suggesting that arginine supplementation for short period had no influence on NO production (table 2). In addition, the performance in two groups in intermittent anaerobic exercise test was observed similar.[25]

Creatine synthesis

Role of arginine in the synthesis of creatine is another accrediting factor claimed for its ergogenic potential although the contribution of arginine through creatine synthesis to performance enhancement is still suspicious. Creatine is pivotal to energy metabolism

in muscle cells. It has been shown that creatine increases muscle strength and muscle fiber size.[22] Arginine is found in the market in the form of capsule, tablet, powder and injectable.

Creatine

Creatine is a nitrogenous organic compound, the supplementation of which is very popular among athletes. In human body, majority of creatine is present in skeletal muscle (approximately 95%). It is present intracellularly in the muscle, about two-third in the form of phosphocreatine and the remaining as free creatine.[26] The phosphocreatine prevents rapid ATP depletion during muscle activity. This is the rationale behind its supplementation among athletes. Creatine is produced endogenously in the liver and kidneys.[27] The dietary sources of creatine are meat, poultry and fish.[28]

Phosphocreatine shuttle and anaerobic glycolysis are the sources from which muscle fibres obtain ATP during high-intensity exercises of short duration. Muscle activity is fast and intense in this type of activity. When effort is at maximum, in the first 10 second, phosphocreatine shuttle plays a dominant role in ATP production. ATP during 10 to 30 seconds is supplied by anaerobic glycolysis. In the phosphocreatine shuttle system, the high-energy phosphate from ATP is transferred to creatine by the action of mitochondrial creatine kinase enzyme generating phosphocreatine in mitochondria. Phosphocreatine then diffuses to cytoplasm, where under the action of cytoplasmic creatine kinase enzyme releases high-energy phosphate that participates in the resynthesis of ATP.[29] This helps maintain ATP availability to active muscles particularly in anaerobic sprint-type exercise and contributes in delaying muscle fatigue.[30]

In a study conducted by Tang et al, the observations were directed towards the role of creatine in clearing plasma lactate concentration during recovery from endurance exercise (table 2). The reason has been attributed to sparing of muscle glycogen degradation for energy by ATP-phosphocreatine system during recovery from endurance exercise.[28]

Creatine supplementation increases the concentration of creatine in muscle particularly when the endogenous stores are low. Furthermore, creatine availability facilitates generation of ATP and phosphocreatine. This enhances exercise performance and training adaptations.[26] Contrarily, its supplementation will not benefit the athletes with full stores of creatine in their muscles.[30]

Studies about effect of creatine supplementation in adolescents, young adults and older age groups have been in favor of ergogenic benefits of creatine with no clinically significant side effects.[26] Most frequently reported side effect in the literature has been water retention, which appears transiently in the early stages of supplementation.[30] However, when taken at doses above the recommendation or in combination with other supplements, liver and renal complications may arise. This has raised concerns about effects of creatine loading on kidneys. During urinary excretion, creatine is metabolized to methylamine and formaldehyde, known cytotoxic compounds which can adversely affect kidneys. Significant rise in these toxic compounds after short-term creatine supplementation at loading doses has been seen whilst extensive studies are necessary for further evaluation of this suspicion.[30] Creatine is traded in the form of capsules, gel, gum, powder, liquid, bar and candy.

Glutamine

Glutamine is a glucogenic amino acid synthesized from glutamate by its amidation, a reaction catalyzed by glutamine synthetase. It is mostly produced and stored by skeletal muscle, and also by other tissue such as adipose tissue, lungs.[31] Entire human musculature release 8 to 9 grams of glutamine per day.[32] As glutamine is produced in the body but may be depleted in different conditions. In such cases it becomes necessary to supplemented it in diet and thus it has been considered as a conditionally essential amino acid. The various conditions which result glutamine depletion include clinical trauma, starvation, prolonged strenuous exercise, burns, sepsis.[31]

Such conditions require exogenous supplementation of glutamine as it has an important role in different physiological processes and homeostatic mechanism of the body. Most importantly, ammonia trapping and transportation from brain and other organs to the liver, proliferation of lymphocytes, maintenance of intestinal epithelial cells and tight junction.

Lymphocytes, macrophages utilize glutamine at a rate that is either similar to or greater than that of glucose. Some of the carbon atoms of glutamine are utilized for production of energy. Also, it provides nitrogen that is utilized in production of purines and pyrimidines necessary for DNA and RNA synthesis during the process of proliferation of lymphocytes. So, glutamine stimulates the immune system, increases the CD4+/ CD8+ T-cell ratio and ensures appropriate host defense against various opportunistic pathogens.[33] Also, glutamine inhibits free radicals and enhances bactericidal activity of neutrophils.[34]

Athletes usually involved in prolonged exhaustive exercise, continuous extensive training and marathon runners experience decrease in plasma glutamine level as the rate of utilization is much more increased relative to the rate of synthesis.[35] There is decreased proliferation of lymphocytes, with a reduction in CD4+/CD8+ T-cell ratio, where a ratio lower than 1.5 indicates immunosuppression.[31] As a result, they are more prone to infections, mostly Upper Respiratory Tract Infections.[36] On contrary, glutamine supplement is noted to helping maintaining gastrointestinal integrity while competing in heat. [37]

In a double-blind trial conducted by Castell and Newsholme,151 marathon and ultra-marathon runners were supplemented once with either 5 grams of glutamine or placebo in 330 ml of water immediately after completing the run and again after 2 hours. Occurrence of infection 7 days following the event was significantly lower in individuals who had taken glutamine than those who received the placebo (19.2% as compared to 51.2%; $p<0.001$).[38]

Also, due to presence of innervations by sympathetic vasoconstrictor fibers and presence of α-receptors in the blood vessels that perfuse intestine, there is reduced blood flow to the intestine during exercise caused by vasoconstriction due to sympathetic stimulation. Increased mental stress due to competitiveness of any sport event also exacerbates reduction in splanchnic circulation. This leads to disruption of the tight junction due to damage to the intestinal epithelial cells. Increase in permeability followed by disruption of the barrier is accompanied by entry of bacteria and lipopolysaccharide present in abundance in the intestine into the circulation causing bacteremia, septicemia and endotoxemia. Increased lipopolysaccharide levels in athletes has been found to be associated with gastrointestinal symptoms such as nausea, vomiting and diarrhea. Additionally, circulating endotoxin can impact on physical performance and delay recovery.[39]

In the mitochondria of the epithelial cells, glutamine is converted to glutamate and then to α- ketoglutarate which enters the Krebs cycle and thus help in production of ATP. Glutamine, being an important fuel for intestinal epithelial cells, prevents epithelial damage in spite of reduced blood flow during exercise and restores intestinal barrier homeostasis and maintains integrity of the gastrointestinal tract. So, it helps in prevention of entry of bacteria and lipopolysachharide into the circulation.[39]

Also, presence of increased amount of glutamine in muscle has an anabolic effect for body builders and other athletes.[35] The major dietary sources of glutamine include protein rich foods such as meat, fish, legumes, dairy products like milk, cheese, and yogurt. Also important vegetable source of glutamine include uncooked cabbage and beet.[34] Glutamine is administered in various dosage forms such as powder, capsules, tablets, intravenous injection.

Glucosamine

Glucosamine is an amino sugar found in the human tissues, especially in the articular cartilage, intervertebral disc and synovial fluid. It is one of the major constituent of glycolipids, glycosaminoglycans and glycoproteins in its acetylated form and contributes in maintaining the strength, elasticity and flexibility of the tissues.[34]

Many exercises or sports such as soccer, bicycling involve repetitive impact and torsion loading on the joints that elevates the risk of cartilage injury and degeneration leading to osteoarthritis.[40] There is degradation of the cartilage in osteoarthritis and is characterized by pain and decreased mobility. [41] Glucosamine, being an important constituent of the articular cartilage of the joint, is used as a dietary supplement primarily for osteoarthritis. The supply of glucosamine leads to increase in production of glycosaminoglycans which are the major building blocks of articular cartilage.[42]

Table 2. Findings of various studies done with different amino acids supplements in various athletes

Supplement	Laboratory findings	Study results
BCAA [Placebo: isocaloric drink]	plasma creatine kinase, lactate dehydrogenase and granulocyte elastase	Decreased muscle soreness, muscle damage and inflammation with BCAA (Matsumoto et al.)
Leucine: Isoleucine: Valine: 5 g of powdered form in 1:0.5:0.5 ratio	urine myoglobin concentration	No significant differences (Areces et al)
Arginine and Aspartate: high supplement (5.7g arginine and 8.7g aspartate) and low supplement (2.8g arginine and 2.2g aspartate) group	Maximal O_2 uptake and time to exhaustion; GH and lactate concentration before and after each incremental exercise test	No significant differences (Abel et al.)
Creatine: 12 g/day; 60 min running exercises (endurance trial) before and after supplementation, followed by a 5-day washout period. Subsequently, 100m sprint (power trial) before and after 15 days of supplementation	Plasma glucose, lactate, BCAAs, free-tryptophan, glutamine, alanine, hypoxanthine, uric acid. Urine hydroxyproline, 3-methylhistidine, urea nitrogen, creatinine	Decrease muscle glycogen and protein degradation, especially after endurance However, it induce collagen proteolysis in sprint (Tang et al.)
Arginine: 6g/day	plasma nitrate and nitrite	No significant difference in short duration (Liu et al.)
Glutamine: 5g [placebo in 330ml of water]	Plasma glutamine, white blood cell count, lymphocytes	Significantly lower infection after 7 days (Castell et al.)
Glucosamine: either 3 mg/ day or 1.5mg/day [Placebo: cornstarch 0.9mg/day]	urinary CTX-II, serum CPII	CTX-II decreased by 23% in 3g/day; 18% in 1.5g/day; 17% in placebo. CPII decreased by 7% in 3 g/day; 13% in 1.5 g/ day; 22% placebo (Momomura et al.)

BCAA: Branched Chained Amino Acid; CTX-II: Cterminal crosslinked telopeptides of type II collagen; CPII: C-terminal propeptides of type II procollagen; GH: Growth Hormone

Glucosamine is needed for the synthesis of glycosaminoglycans such as hyaluronic acid which is a major constituent of cartilage, connective tissue and synovial fluid and contribute to maintain structural and functional integrity of the joints. It also suppresses the expression of proinflammatory cytokine genes such as Il-6, Il-24, TNF-αgenes. It also suppresses the production of NO and PGE2. This has an anti-inflammatory action and thus exhibits the protective action on joints.[42]

In an experiment by Momomura et al. competitive bicycle racers of age 19 to 22 years who used to actively train for competitive cycling for 6 days each week for 5 hours a day were included as participants. The total study duration was of 3 months and the participants were divided into 3 groups with members of each group being given glucosamine either 3 mg/ day or 1.5mg/day or cornstarch 0.9mg/day as placebo. In the experiment, the urinary level of Cterminal crosslinked telopeptides of type II collagen (CTX-II), a marker of degradation of cartilage specific type II collagen, was shown to be decreased by 23% from the baseline in those receiving 3gm/day of glucosamine as compared to decrease by 18%

in those receiving it 1.5 gm/day and decrease by 17% in those receiving cornstarch as placebo. Also the level of serum C-terminal propeptides of type II procollagen (CPII) , a marker of synthesis of cartilage specific type II collagen, was shown to be decreased by only 7% in those receiving glucosamine 3 gm/day compared to a decrease by 13% in those receiving 1.5 gm/day and a decrease by 22% in those receiving placebo. This suggests that glucosamine may exert chondroprotective action in a dose dependent manner by preventing the degradation of articular cartilage associated with exercise in athletes (table 2).[40]

The major dietary source of glucosamine include chitosan and chitin exoskeleton of crustaceans such as shellfish.[34] Glucosamine is administered in various forms such as pills, cream, intramuscular injection.

CONCLUSIONS

There have been rising global consumption and demand of various nutraceuticals. Despite paucity of data on the availability of various nutraceuticals products and its economic importance, Nepalese pharmaceutical industries along with food and agricultural sectors have immense potential to explore and establish itself in this field. Nutraceuticals with ergogenic potentials have high demand particularly in athletic communities. This review on the ergogenic potentials of various amino acids points BCAA, creatine, glutamine and glucosamine have significant positive effects in various athletes. Athletes should acquire proper knowledge of the appropriateness of desired type of nutraceuticals to suit their sport and general health as well. However, studies in large sample athletes and more detailed analysis on the various amino acids can elaborate more its ergogenic potentials.

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