A HYPOTHESIZED PRE-WORKOUT SUPPLEMENT

DESIGNED TO IMPROVE ATHLETIC PERFORMANCE

A Project
Presented
to the Faculty of California State University, Chico

In Partial Fulfillment of the Requirements for the Degree Master of Arts in Kinesiology

by

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DEDICATION

This project is dedicated to all of those in pursuit of a healthy, active lifestyle.
The purpose of this project is to provide individuals with tools and educational measures
to maximize physical performance within athletic or other active endeavors via proper
nutritional supplementation.
ACKNOWLEDGEMENTS

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ABSTRACT

A HYPOTHESIZED PRE-WORKOUT SUPPLEMENT DESIGNED TO IMPROVE ATHLETIC PERFORMANCE

By

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Master of Arts in Kinesiology

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Spring 2016

This project proposes a pre-workout supplement that could theoretically boost performance and mentally prepare athletes for training and competition. A compounded formula is proposed based on evidence-based effects of individual supportive ingredients. Each ingredient appears on the US Food and Drug Administration’s list of chemicals and food additives that are generally recognized as safe (GRAS), which are exempted from the Federal Food, Drug, and Cosmetic Act (FFDCA) that dictate additive tolerance requirements (reference: http://www.fda.gov/Food/IngredientsPackagingLabeling/GRAS/ucm2006850.htm). The end goal would be to have an effective product formulation that can be used prior to exercise to facilitate increased performance and enhanced capabilities during physical activity.

The need for this project is explained further in Chapter I regarding the importance of maximizing physical and athletic performance. There are few effective pre-workout products on the market. This project proposes a supplement containing a
combination of ingredients that would create a higher standard of quality and effectiveness.

The project will propose a supplement formula that may improve performance and fitness. Ingesting key ingredients, (explained further in Chapter II), can potentially enhance performance in practice and competition settings.
CHAPTER I

INTRODUCTION TO THE PROJECT

Purpose of the Project

This project serves to expand the knowledge and application of sports nutrition based pre-exercise supplementation. The combination of ingredients should theoretically improve athletic performance and mental acuity and improve exercise capacity. Much research supports individual ingredients that enhance exercise capacity and optimize the training environment. This is significant because the research discussed in this project will potentially benefit athletes all over the world. Maximizing performance is of utmost concern, especially for those looking to progress within their specific sports. For competitive athletes, less than optimal physical and mental capacity will not lead to competitive success. Consuming the combination of ingredients explained in Chapter II before training or competition may increase the ability and capacity to perform.

Scope of the Project

This project will discuss the evidence-based benefits of each ingredient within proposed compounded supplement. The intended audience will be people interested in physical wellness, sports, recreation, game and play, as those interested in furthering the understanding of improving physical and cognitive performance. The combined ingredients are expected to increase physical performance (strength, speed, and overall ability to perform), enhance mental acuity and alertness, and improve overall sense-of
well being. Supporting research is discussed in detail in Chapter II. The scope of this project encompasses anyone involved with physical activity seeking peak performance.

Significance of the Project

This project represents an ideal approach to maximizing performance via nutritional supplementation prior to exercise. It is a fairly novel concept within the field of exercise physiology, and has been studied more extensively in fields such as sports nutrition and sports medicine. We can bring together aspects of both areas of study to increase overall understanding as well as proper application of pre-workout nutrition.

The primary focus of this project is the development of a high quality and effective ergogenic aid. Detailed information is presented on each component of the proposed formula and a rationale for combining them in a compounded formula. The need for this project deals with the great importance of maximizing physical and athletic performance. The formulation has been designed to provide individuals with a boost in performance and take their active endeavors to new heights, which may impact their overall success and happiness. As mentioned previously, there is a lack of effective pre-workout products on the market. The formulation of ingredients is theorized to create a high quality pre-workout product.
Limitations

The content of this discussion will be limited to current research on the ingredients contained within the formula. Although there are many well-designed studies that provide robust support for the ingredients in the product, there will always be individual differences in response. Everyone responds differently to specific ingredients, and even when most may see benefits, some people still receive less effective responses. No research exists for the combination of specific ingredients within the formula, and although individual ingredient research is supportive, the combination of ingredients has yet to be studied in depth. For this reason, it cannot be verified that the specific combination of ingredients will be effective. Further, the formulation is in no way connected to California State University, Chico.
Definition of Terms

AAKG: arginine alpha ketoglutarate

DMAE: dimethylaminoethanol

LNAA: large neutral amino acid

PEA: phenylethylamine
CHAPTER II

REVIEW OF LITERATURE

Existing research has provided a much better understanding of the benefits that ingesting certain compounds before exercise. For purposes of specificity, the majority of research is focused on the primary ingredients of the combination formulation. This review will summarize studies on the effects of the main ingredients on physical performance.

L-Arginine

The first proposed ingredient is arginine alpha-ketoglutarate (AAKG). AAKG is a naturally occurring amino acid that has demonstrated ability to boost blood levels of nitric oxide (Maxwell et al., 2001). By increasing levels of nitric oxide, blood flow to tissues throughout the body is improved, which thereby allows for better delivery of oxygen as well as vital nutrients to working muscle. Nitric oxide is a gas secreted by the endothelial cells of blood vessels, which promotes vasodilation. This increases the body’s ability to transport nutrients and clear metabolic by-products, which can facilitate better overall health and performance. This can improve athletic performance and enhance metabolic health (Álvares, Meirelles, Bhambhani, Paschoalin, & Gomes, 2011).

The majority of the benefits of arginine come from its role in producing nitric oxide. This process is aided by an enzyme known as nitric oxide synthase (Fahs, Heffernan, & Fernhall, 2009). Nitric oxide (NO) is a small molecule with high mobility that allows it to move into and between cells very readily. Once it is synthesized from arginine, NO acts as a cell-signaling molecule, which potentiates many effects within the body. A well-
known function of NO in regulating blood flow (Joshi, Ferguson, Johnson, Johnson, Parthasarathy, & Lancaster, 2007). This process is known as vasodilation, which causes decreased vascular resistance and improved blood flow. This process increases tissue blood flow, oxygen delivery, transports of essential nutrients, and the elimination of wastes. The physical aspects of blood flow are collectively referred to as hemodynamics. Enhanced hemodynamic activity can lead to enhanced exercise capacity and increased metabolic health (Maxwell et al., 2001).

Arginine may also improve hemodynamics in cardiovascular disease. Nagaya et al. (Nagaya et al., 2001) showed that oral arginine supplements increased blood flow and enhanced oxygen delivery to tissue (Nagaya et al., 2001). In this particular study, 19 subjects with pulmonary hypertension were analyzed to establish what effects occurred regarding blood parameters when supplementing with arginine. Test subjects were given an average dose of 3.5 grams of arginine, and their cardiovascular response was observed over the following two hour time period. Pulmonary blood pressure decreased from 53 to 48 mmHg. Also, they saw a ~16% reduction in the resistance to blood-flow within the arteries in the lungs. Cardiovascular condition was significantly improved (Nagaya et al., 2001).

This same group of test subjects participated in a different investigation that examined the effect of arginine on exercise capacity. For a week, nine patients in the treatment group were provided with 0.5 g of arginine per 10 kg of body weight three times per day (equal to 10.5g/day for a 155-pound person), while the remaining seven patients took a placebo. After one week on this protocol, the researchers observed and measured exercise capacity in each of the patients by analyzing their performance on a
stationary bicycle: the subjects pedaled at 55 rpm for one minute, and the work rate was increased gradually until they achieved maximum exercise capacity. One week of arginine supplementation demonstrated an increase peak oxygen volume by about 8%, and exercise capacity by about 12%. One of the measurements utilized within this particular study was peak oxygen volume. After arginine supplementation for an entire week, subjects increased their peak oxygen volume by 8%; specifically from 831 ml/min to 896 ml/min (milliliters per minute). Exercise capacity increased by 12% and power output on a cycle ergometer was greater than the control group (Nagaya et al., 2001).

The results described previously (improved blood flow, blood pressure, and exercise capacity) might be attributed to arginine-stimulated increases in nitric oxide. If NO can help reduce the problem of inadequate oxygen delivery to the cells when afflicted by pulmonary hypertension, it might help in cases of high-altitude hypoxemia as well. Hypoxemia is low levels of oxygen in the blood, which can be a limiting factor at high altitudes. Researchers from Case Western Reserve University in Cleveland noted that individuals who live at altitudes of around 4000 meters in the Andes or Himalayas produce higher levels of nitric oxide than Americans who live at low altitudes, near sea level (Beall et al., 2001). Interestingly, the Tibetans have about double the nitric oxide levels as lower elevation dwelling Americans. Their oxygen saturation within tissues during physical exertion is considerably higher at these elevations than in individuals who live at lower altitude, such as Europeans and Chinese. Nitric oxide enhances hemoglobin's oxygen carrying and delivery capacity. This provides further support that nitric oxide performs a pivotal role in physiological functions, and validates the use of arginine supplementation in the proposed supplement (Beall et al., 2001).
Considering their findings, the researchers examined the effects of increased nitric oxide on oxygen uptake within the lungs during exposure to hypoxia. As the nitric oxide within the inhaled air increased, oxygen uptake also increased. They proposed that hemoglobin in red blood cells is affected by the nitric oxide, which increases oxygen carrying and delivering efficiency. This offers even more support for the beneficial aspects of nitric oxide – and therefore of arginine supplementation for improving oxygen carrying and delivering ability.

Arginine has demonstrated its efficacy and importance in a number of vital body functions. When supplementing with nitric oxide-enhancing compounds such as AAKG, quality of exercise as well as quality of life can be improved (McKnight et al., 2010). Some of the life changing beneficial effects of boosting nitric oxide will be explained. These effects branch into more broad and general physiological occurrences but may indirectly facilitate improved exercise performance due to overall improved state of well being.

The health benefits of nitric oxide include increased longevity and improved heart, reproductive, and sexual health. Nitric oxide is produced by the endothelium—the inner lining of the blood vessels. The endothelium is extremely reactive to the chemical and physical environment within the blood vessels (Casas et al., 2006). At times when the endothelium receives input of ideal conditions that positively affect the heart, for example during strenuous activity, or when lower cholesterol levels are present, it releases an increased amount of nitric oxide, which has positive physiological effects. Nitric oxide enlarges blood vessels, which increases flow of blood and decreases potential plaque formations as well as clotting. Conversely, when the endothelium
receives input of conditions such as high blood pressure, high cholesterol, or mental and physical stress, nitric oxide production decreases, which increases the risk of atherosclerosis. Penile erection relies on the production of nitric oxide. Drugs such as Viagra, inhibit phosphodiasterase-5—a enzyme that breaks down nitric oxide. Impotence and atherosclerosis are closely related. Erectile dysfunction is an early predictor and risk factor for myocardial infarction. Factors that impair metabolic health, such as physical inactivity, obesity, smoking, or stress, can potentially decrease nitric oxide and promote cardiovascular disease (Casas et al., 2006).

Exercise provides many positive physiological effects. It boosts cardiovascular health, caloric expenditure, boosts nitric oxide production, and reduces inflammation (Casas et al., 2006). Sexual intercourse also improved nitric oxide production. Sexual activity also reduces stress and may indeed lead to better sense of overall well being which may indirectly improve overall functional abilities. Sexual relations cause an increase in the body’s production of oxytocin, which enhances well-being, improves healing of wounds, and may reduce the risk of some cancers (Casas et al., 2006).

There are many other positive effects of increased nitric oxide, in addition to its effects on exercise. So, in review of the health promoting benefits of nitric oxide boosting capabilities of arginine, it is clear that its addition into the formulation will enhance blood flow, and can improve other aspects of human physiology, which could lead to an overall better quality of life.

L-Tyrosine
L-tyrosine is the next ingredient contained within the proposed formula that has positive effects on athletes. Tyrosine is a conditionally essential amino acid. Under normal circumstances, it can be synthesized in adequate quantities via conversion of phenylalanine (Neri et al., 1995). Tyrosine (LNAA) is a large neutral amino acid due to its chemical structure and properties. Tyrosine provides material to make up different proteins and is also a precursor for the production of many bioactive compounds, some of which include neurotransmitters and hormones (O’Brien, Mahoney, Tharion, Sils, & Castellani, 2007). Within the body, tyrosine acts as a precursor for the synthesis of thyroxin, melanin, and neurotransmitters such as dopamine and norepinephrine. Thyroxin is the main thyroid hormone within the body, while melanin is responsible for skin and hair pigmentation. Foods that contain tyrosine are typically protein rich and include eggs, milk, almonds, fish, chicken, lima beans, nuts, pumpkin seeds, wheat germ, and avocados (Neri et al., 1995).

To cross the blood-brain barrier and enter the brain, tyrosine is transported via a carrier system, which is shared by other LNAA, which include leucine, valine, tryptophan, isoleucine, and phenylalanine. Considering that the pathway is shared with other amino acids, the amount of other LNAAs can directly impact how much tyrosine can enter the brain and initiate catecholamine synthesis (Davison et al., 2011). There is competitive inhibition within other amino acids when crossing the blood brain barrier. Considering this competitive inhibition, ingesting pure tyrosine by itself results in a larger increase in plasma concentrations as opposed to when it is consumed as part of a protein or with other amino acids that share the same pathway. This is another supporting
reason that free form L-tyrosine was incorporated into the proposed supplement rather than within other LNAA’s or with protein.

Once tyrosine is ingested and absorbed, it can act in various different ways within the body. One possibility is that it may be metabolized into glucose and used for energy production; however, it is likely to be incorporated into specific tissues to form proteins or peptides, and also can be utilized as precursors to the neurotransmitters or hormones (Chiaroni, Azarin, & Bovier, 1990). Catecholamines play a key role in nervous system activities and affect mental function, movement, motivation, arousal, attention, “fight-or-flight” response, and heart rate. Tyrosine may be useful for treating Parkinson's disease, phenylketonuria, stress, depression, cognitive function and memory, and hypertension (Lemoine, Robelin, Sebert, Mouret, 1989).

Tyrosine facilitates the production of catecholamines. Fluctuations in the amount of tyrosine have affected the levels of both dopamine and norepinephrine. This is another reason for including it in many pre-workout products, its ability to boost the aforementioned key neurotransmitter levels and thus enhance focus and mental drive, which is critical during times of peak performance.

Due to tyrosine’s ability to facilitate catecholamine production, it may also reduce stress (Gelenberg, Wojcik, Growdon, Sved, & Wurtman, 1980). However, the studies that have investigated this show that instead of reducing stress, it can inhibit a reduction in mental performance due to certain types of physical stress commonly encountered by the military (Deijen, Wientjes, Vullinghs, Cloin, & Langefeld, 1999). These include cold stress, high-altitude stress, lower body negative pressure stress, and extended
wakefulness. Tyrosine facilitates the production of thyroid hormone, so it is found in some fat-burning supplements geared toward enhancing metabolism.

Much of the research on tyrosine used between 50 and 150 mg/kg bodyweight (Kishimoto & Hama, 1976). These amounts can only be obtained by consuming tyrosine powder or capsules. It would normally not be feasible to reach these concentrations from utilizing typical supplements that contain tyrosine. A theorized dosage for the formulation would be about 1.5 grams per serving, so two servings would meet the levels of intake that has been previously studied and thus would provide efficacious dosages and benefits.

Supplementation with tyrosine is generally considered to be safe with few side effects (Banderet & Lieberman, 1989). Occasional cases of nausea, headaches, insomnia, diarrhea, or vomiting have been noted by those taking in exceedingly high amounts of the supplement. Increased dopamine levels can occur when taking tyrosine, so taking it in the morning or midday will limit its effects on sleep. However, it is difficult to reach such high levels.

Dimethylaminoethanol

Dimethylaminoethanol (DMAE) has some favorable effects on cognitive ability, which could improve physical capacity. DMAE positively affects cognitive function and behavior, mental acuity and alertness, and functional capacity of the mind, which facilitates improved physical performance. These and other suggested benefits of DMAE will be explained and expanded upon with supported findings to follow.

Brain concentrations of DMAE in the brain are small. DMAE supplements have substantial brain-boosting effects. DMAE is a naturally occurring nutrient that is
commonly found in seafood such as sardines and anchovies (Honegger & Honegger, 1959). DMAE might help elevate mood, boost intelligence, improve memory and learning, and increase energy. Many choose it for its mild and safe stimulant effect. Even without its stimulant effects, it promotes sleep for many people. People have reported improved sleep quality, and having vivid and lucid dreams (Sergio, 1988). Individuals also have reported less fatigue during the day and sounder deep sleep at night.

DMAE has a stimulating effect that feels different than coffee or other stimulants. DMAE does not cause a rapid spike and drop with its effects, but rather a more sustained response. Interestingly, several weeks of DMAE ingestion causes a mild boost in energy levels with no negative side effects. Moreover, there is no letdown or depression when they stop taking it (Anderson & Anderson, 1987).

DMAE is sometimes categorized as nootropic. The characterization of a nootropic is classified by the stimulation high-functioning integrative mechanisms in the brain, which assists in maintaining healthy cortical vigilance, telencephalic selective functionality, and enhanced nervous system activation (Sergio, 1988). Nootropics are involved with cortical events—events within the mind, which have a direct effect on consciousness. Even though we do not fully understand nootropics and their mechanisms, they can affect certain aspects of cell membranes, such as their permeability, stress resistance, strength, and stability. DMAE’s ability to boost and maintain brain functions may lend support to enhancing overall cognitive efficiency. Further, it may make up for various neuropsychological impairments ranging from cognitive processes to aging (Sergio, 1988).
Riker Laboratories created a pharmaceutical compound called Deaner, which is a molecular modified form of DMAE and has almost identical effects. They promoted this compound to treat hyperactivity, reduced attention-span, reading and speech difficulties, learning disorders, impaired motor coordination, and behavior problems in children (Anderson & Anderson, 1987).

DMAE works by enhancing the activity and utilization of acetylcholine, which is a primary neurotransmitter. This facilitates a boost in mental abilities, and also supports optimal memory function in older adults. Additionally, DMAE reduces the breakdown of choline, thereby increasing circulating choline, which can enter the brain and activate cholinergic receptors (Haubrich, Gerber, & Pflueger, 1981; Millington, W. R., McCall, A. L., & Wurtman, 1978).

Caille (1986) measured the effect of DMAE on mood and vigilance in four test subjects who were classified as anxiety afflicted and four control subjects. They were given 1200 mg of DMAE for five consecutive days. DMAE synergistically affected the two hemispheres of the brain more than the control group. The synchronization of the two hemispheres enhanced neuromotor control, increased verbal memory, and improved control in specific rhythmic reactivity (Caille, 1986).

DMAE mitigated behavior and learning problems in attention deficit disorder and hyperkinesia. Pfeiffer, et al., in a study of 25 females and 83 males, showed that DMAE supplementation led to enhanced behavior in two-thirds of the males and three-fourths of the females. Hyperactivity and irritability were drastically reduced and attention span improved along with scholastic ability and intelligence quotient (Pfeiffer CC et al., 1957).
Similar findings were observed when 500 mg of DMAE was provided to children with learning disabilities. These children were analyzed for psychiatric or neurological illnesses prior to supplementation. DMAE was administered for 3 months. Screening included standard psychometric parameters, as well as behavior and reaction time. Results showed substantial overall improvements, and also showed enhanced performance in children with behavior and learning disorders (Lewis, Young, Deanol, 1975).

Pfeiffer, in a study of 100 subjects, found that DMAE reduced chronic fatigue and mild depression—probably by its effects on motivation and energy production. In addition, DMAE caused improvements in personality and reduced insomnia (Pfeiffer CC, 1959). Also, Destram (1961), doses of 400-800 milligrams were administered on a daily basis to 52 subjects improved symptoms in disorders of the central nervous system.

DMAE reduced age pigment within the heart muscle and brain in some species of lab animals (Nandi K, 1968, Dylewski DP, et al., 1983). Roy et al demonstrated that could be due to increased concentrations of antioxidant enzymes within the brain (Roy D et al., 1983).

The effects of DMAE are enhanced when taken in combination with cholinergic drugs, which can alter the ideal dosage (Flood, Smith, & Cherkin, 1983). Over-dose has been linked to dull headaches, insomnia, and muscle rigidity. However, these undesirable side effects are typically eliminated if the dosage is reduced.

DMAE, works in synergy with other neuromodulating, brain-boosting ingredients contained within the formulation. Considering that the brain is the control center for physical performance, it is important to optimize neurological conditions.
Phenylethylamine

Phenylethylamine (PEA) is another significant ingredient, and has neuromodulating effects. It is primarily a stimulatory neurotransmitter that heightens mental activity and alertness. PEA is classified as a minor neurotransmitter, yet it still has significant effects. Phenylethylamine is an organic compound that has stimulatory and psychoactive effects. Phenylethylamine is a system neurotransmitter and neuromodulator (Hanson, Venturelli, & Fleckenstein, 2004). It is created from L-phenylalanine by enzymatic reactions (Sabelli et al., 1976). Phenylethylamine and its various metabolites comprise a complex and diverse class of compounds derived from phenylethylamine including stimulants, anorectics, bronchodilators, decongestants, and antidepressants. Based on its molecular structure, phenethylamine is a primary amine (Suzuki, Katsumata, & Oya, 1981).

Phenylethylamine increases norepinephrine and dopamine—effects similar to amphetamine (Nakamura, Ishii, & Nakahara, 1998). People with attention deficit hyperactive disorder (ADHD) typically excrete low amounts of phenylethylamine, which suggest a deficiency or metabolic deficit (Paterson I.A. 1993). Patients treated with amphetamine and methylphenidate showed marked increases in urinary phenethylamine (Parker et al., 1988). Furthermore, a literature review by Parker, et al. suggested that urinary phenethylamine levels could be a valid diagnostic marker for ADHD (Parker et al., 1988).

A large increase in urinary phenylacetic acid (the primary analogue of phenylethylamine) was found after thirty minutes of moderate to high-intensity physical (Scassellati, Bonvicini, Faraone, & Gennarelli, 2012). Studies have shown that these
urinary elevations on average increased 77% above base level. (Scassellati, Bonvicini, Faraone, & Gennarelli, 2012; Irsfeld, Spadafore, M., & Prüß, 2013). We can infer from these data that phenylethylamine drastically increases as a consequence of physical exercise. However, it is broken down quickly due to its brief half-life of about 30 seconds (Szabo, Billett, & Turner, 2001). In a resting state, phenethyamine is synthesized at about the same rate that dopamine is produced within catecholamine neurons from L-phenylalanine (Lindemann & Hoener, 2005). Due to the pharmacological relationship between phenethlamines and amphetamines, research suggests that phenylethylamine affects the mood-boosting euphoric type of effect of the so called “runner's high” (Scassellati, Bonvicini, Faraone, & Gennarelli, 2012; Irsfeld, Spadafore, M., & Prüß, 2013; Szabo et al., 2001).

Phenylethylamine has significant mental-boosting effects, which supports its inclusion within the formulation as an ingredient that may help to increase performance.

**B-Complex Vitamins**

The B-vitamin complex has many beneficial roles in boosting performance and overall well being. B vitamins play *many* roles within the human body, but for sake of specificity we will give an overview and discuss the general effects of B-complex vitamins on exercise and performance.

Vitamin B complex vitamins are included within the formulation for its positive effects on physical and mental performance. The B-complex is a group of water-soluble B vitamins that includes folic acid, biotin, thiamine, niacin, riboflavin, pyridoxine, pantothenic acid, and cobalamin (Jellin & Gregory, 2011). Choline, inositol, and para-
aminobenzoic acid, are also contained within some formulations of B complex (Jellin & Gregory, 2011), and are found within the specific B complex in the proposed supplement. These water-soluble B vitamins are essential for proper energy production and metabolism at rest and during activity. Folic acid (also known as folate) and vitamin B12 (also known as cobalamin) are involved in the production of red blood cells, tissue repair, and protein synthesis (Rodriguez et al., 2009). Vitamin B complex has favorable effects on cell regeneration, energy metabolism, and cognitive function (Balk, Raman, Tatsioni, Chung, Lau, & Rosenberg, 2007). An appropriate consumption of B vitamins is crucial to maintaining health and optimal performance (Rodriguez et al., 2009). Insufficient and reduced concentrations of B-vitamins can inhibit physical abilities and overall work capacity (Woolf & Manore, 2006). To address the significance and critical aspects of each B-Vitamin, we will discuss the consequences of vitamin B deficiencies. Due to the many important roles of B vitamins, symptoms of deficiency become very apparent and severe when they occur. Vitamins within the vitamin B complex have different functions, and therefore demonstrate unique deficiency symptoms.

Thiamine (Vitamin B1) deficiency can cause beriberi, a disease that involves the nervous system and causes weight loss, impaired sensory perceptions, swelling, memory loss, and irregular heartbeats. In extreme cases, heart failure and even death can result. It can also cause ariboflavinosis characterized by cracks in the lips, inflammation of the tongue, hyperemia of facial tissues, sensitivity to sunlight, and swelling of the throat.

Niacin (Vitamin B3) deficiency causes pellagra. Symptoms include weakness, confusion, dermatitis, aggression, sleeplessness, and irregular bowel movements. In extreme cases, it can cause dementia and death (Woolf & Manore, 2006).
Deficiency of pantothenic acid (vitamin B5) can cause acne as well as paresthesia, which is tingling of the skin. Deficiency of pyridoxine (vitamin B6) can cause water retention, high blood pressure, anemia, and depression. Biotin (Vitamin B7) does not have any outstanding symptoms of deficiency in adults. However, in babies’ biotin deficiency can cause inhibited growth and neurological problems.

Folic acid (Vitamin B9) deficiency may result in increased levels of homocysteine. Pregnant women who have low levels of vitamin B9 may experience birth defects in their child. Research has also demonstrated that folic acid has the potential to reduce the negative effects that aging has on the brain (Balk et al., 2007).

Cobalamin (vitamin B12) is a B-vitamin with extensive roles within the body and is important for many different functions. Vitamin B12 deficiency can cause macrocytic anemia, memory loss, elevated homocysteine, as well as other negative cognitive effects.

Considering the important roles that B-Vitamins play in the body, as well as the detriments of their respective deficiencies, it is clear that additional support via supplementation may indeed provide athletes with benefits. These health benefits include promoting cell growth and division, enhancing immune and nervous system function, maintaining a healthy skin and muscle tone, and increasing metabolic rate. B vitamins can mitigate issues with depression, stress, as well as cardiovascular disease.

Beta-Alanine

Beta-alanine is another important ingredient within the formulation and has profound effects in athletes. Also called 3-aminopropanoic acid, this non-proteogenic, non-essential amino acid is unique in that it is the only naturally occurring beta amino acid. Non-proteogenic amino acids perform different functions within the body and are
not used in the building of proteins (Zoeller et al., 2006). Here we will explore the effects that supplementation with beta-alanine has within the body, as well as provide relevant information to correspond and support these effects.

Beta-alanine boosts muscular anaerobic endurance, increases aerobic endurance, promotes muscle hypertrophy, boosts muscular strength and explosive power output, and increases exercise capacity so that athletes can train at peak capacities for extended periods (Hoffman Ratamess, Kang, Mangine, Faigenbaum, & Stout, 2006). When performing high intensity exercise, hydrogen ions (H\(^+\)) accumulate, which decreases muscle pH and inhibits peak performance. The metabolism and breakdown of adenosine triphosphate and the following increase in H\(^+\) accumulation is most apparent and drastic during the process of glycolysis, which produces lactate. The performance benefits of beta-alanine are not direct, but occur indirectly through the increased synthesis of carnosine (Harris, Hill, & Wise, 2003).

Carnosine is a dipeptide amino that is found in muscle fibers, with a specifically high concentration found within type 2 fibers. Type 2 muscle fibers are mainly utilized during strength and high intensity based exercise and are receptive to muscular growth. Carnosine may affect performance in multiple ways, but it is particularly effective as an intracellular buffer (Hill, Harris, Kim, Harris, Sale, Boobis, Kim, & Wise, 2006).

Carnosine facilitates the stabilization of pH within the muscle by buffering hydrogen ions (H\(^+\)), which accumulate during exercise. The body attempts to maintain pH by implementing systems that buffer excess acidity and promote balance between alkalinity and acidity. Basically, buffers can bind hydrogen ions to reduce acidity and thereby maintain an optimal pH balance. This is needed because we function most
effectively within a narrow pH range, and excessive acidity can reduce performance. By keeping the pH range optimal and not too acidic, muscular contractions can occur with higher capacity for a longer duration. Scientists have demonstrated beta-alanine’s efficacy in boosting intra-muscular carnosine levels by up to 65% within only four weeks (Hill et al., 2006). More extensive beta-alanine research lasting up to 10-12 weeks showed that carnosine levels could increase by 80% (Kim, Kim, Lee, Harris, Sale, Harris, & Wise, 2006). This is a very substantial increase in a strong intracellular buffer, which can be attributed to the increases power, strength, lean body mass, and muscular endurance that researchers have discovered from the usage of beta-alanine. By increasing intra-muscular carnosine levels with beta-alanine, muscle fibers (especially type 2) can stay within an optimal pH range, which allows a better ability to maintain peak performance throughout training and therefore facilitates improved muscular developments (Stout, Cramer, Zoeller, Torok, Costa, & Hoffman, 2006). However, one thing to note is that when carnosine is ingested intact, the majority is metabolized and deactivated in the gastrointestinal tract. A small amount of carnosine escapes the gastrointestinal tract intact but it gets rapidly processed into inactive metabolites within the blood via an enzyme called carnosinase (Suzuki, Ito, Mukai, Takahashi, & Takamatsu, 2002). Considering that ingesting carnosine causes rapid breakdown and enzymatic deactivation, consuming beta-alanine instead is a much better method of enhancing carnosine levels. Researchers have demonstrated this with muscle biopsies (Suzuki et al., 2002). 

Increasing muscle carnosine levels enhances athletic capacity and performance. Beta-alanine is an effective way to increase intra-muscular carnosine concentrations.
Thus, beta-alanine provides significant benefit within the formulation and may improve exercise performance.

Taurine

Taurine is the second most abundant amino acid in the body after glutamine. It may be even more abundant in type II muscle fibers than glutamine, which could account for some of its performance enhancing benefits. Taurine may increase power, muscle strength, muscle mass, reduce muscle damage, and boost recovery (Hamilton Berg, Easton, & Bakker, 2006; Yatabe, Miyakawa, Miyazaki, Matsuzaki, & Ochiai, 2003; Kleiner, 2007). The mechanisms behind its effects are not completely understood, but it is known that taurine has multiple key functions.

Taurine appears to enhance contractile capacity in muscle and may enhance force production and performance capacity during training or competition. High muscle taurine levels may improve maximal performance output in athletes (Yatabe et al., 2003).

Many studies have been performed on taurine. Yatabe et al. (2003), found that taurine supplements helped maintain blood taurine levels. The test subjects received either taurine or placebo. The two week long experiment involved depleting taurine with exhaustive exercise. Interestingly, taurine-supplemented subjects did not experience any down-regulation or lowering of taurine. Moreover, it was seen that endurance boosting effects might also occur from supplementation with taurine (Yatabe et al., 2003).

Hamilton et al. (2006), in a study of taurine-depleted muscles, found that discovered normal to elevated taurine levels increased force production. Taurine levels typically decrease during strenuous exercise, which promotes fatigue. Based on this
research, ingesting supplementary doses of taurine will optimize blood levels, which will enhance force production and maximal performance.

Another eye-opening investigation looked into the effect of exercise duration on the levels of taurine within the body. Yatabe, et al. examined the alterations of taurine levels in skeletal muscles and also within the blood stream before and after exercise. This study consisted of four different groups: a thirty minute exercise group, a sixty minute exercise group, a one-hundred minute exercise group, and a control group. The length of exercise had minimal impact taurine levels, but drastic reductions occurred in all groups after exercise. This indicates that regardless of the duration of exercise, whether short and intense or lengthy endurance activity, taurine reduction should be quite similar and also very significant. It seems that most active individuals or athletes looking to maintain optimal taurine levels would benefit from supplementing with taurine (Yatabe et al., 2003).

Other studies found that taurine influenced cardiovascular function. Kohashi & Katori (1983) found that 6 grams of taurine per day decreased diastolic, systolic, and mean blood pressure in subjects with hypertension. Fujita, et al. observed similar findings in a study that only lasted for seven days (Fujita et al., 1987). Other studies in endurance athletes found that left-ventricular cardiac contractility increased, which increased stroke volume and lowered heart rates during sub-maximal exercise (Kleiner, 2007).

Blood concentrations of taurine decrease rapidly during high intensity exercise, perhaps because of its release from muscle fibers. Supplementing taurine could minimize depletion.
Taurine supplementation may have positive effects on athletic performance, which supports its inclusion within the proposed supplement. Some of the most noteworthy effects observed with taurine supplementation include preservation of optimal taurine concentrations during exercise, which facilitates peak performance capacity, reduction of blood pressure, and improved maximal anaerobic, aerobic, and mental performance. Maintaining optimal levels of taurine can boost strength, force production, and muscular power. Taurine has demonstrated efficacy in aiding and improving athletic performance and is a viable addition to the formulation.

Glutamine

L-Glutamine alpha-ketoglutarate (AKG) provides additional support for athletic performance. L-Glutamine is the primary compound of L-glutamine AKG. The difference between freeform (L-glutamine) and an analog with an attached group (such as glutamine AKG) is enhanced bioavailability and better absorption into the body.

Glutamine is a non-essential amino acid that can become “conditionally essentially” in athletes because it is largely stored within muscles and used up rapidly during exercise (Perriello et al., 1997). It is also used by the immune system. When glutamine deficiency occurs, the body’s immune system becomes depressed until glutamine concentrations are replenished by dietary consumption or supplementation (Perriello et al., 1997).

Glutamine plays a substantial role in supporting a healthy immune function (Rowbottom, Keast, & Morton, 1996). Glutamine is a glycogenic amino acid and thus facilitates glycogen production and storage. Glutamine has been studied for its anabolic functions of boosting muscle mass as well as strength (Candow, Chilibeck, Burke,
Glutamine may also help optimize growth hormone levels during exercise (Salehian, Mahabadi, Bilas, Taylor, & Ma, 2006).

Orally ingested glutamine supplementation promotes pH control. Welbourne (1995) found that oral ingestion of only 2 grams of glutamine boosted blood bicarbonate concentrations, which is correlated with improved intramuscular pH and enhanced performance (Welbourne, 1995).

Glutamine may also regulate myostatin levels (Salehian, Mahabadi, Bilas, Taylor, & Ma, 2006). Myostatin plays a major role in determining and limiting strength and muscle hypertrophy. Significant levels of myostatin may elicit muscle atrophy and overall reduction in strength. In this particular study, glutamine was discovered to reduce glucocorticoid induced muscle atrophy. Test subjects given glutamine experienced much less muscle loss and lower myostatin expression than the test subject who were not given glutamine.

Lacey & Wilmore (1990) showed that long-term supplementation was more effective than short-term at enhancing strength gains (Lacey & Wilmore, 1990).

Glutamine enhances immune function in athletes subjected to extremely intense regimens that normally cause immune suppression (Perriello et al., 1997). This may promote optimal health for athletes who participate in high intensity training during competition and practice (Rowbottom, Keast, & Morton, 1996).

Glutamine's impact on the immune system also becomes evident when examining patients who had undergone surgery and needed additional immune support. Oquz et al. (2007) performed a study in which test-subjects underwent colorectal surgery for cancer and were analyzed over five-years. Fifty percent of the test subjects were provided with
glutamine, while the other half received a placebo. Subjects who received glutamine had shorter hospital stay and fewer post-operative complications compared to control subjects.

Other studies have reinforced the positive effects of glutamine on immune system. Fuentes et al. (1987) found that glutamine ingestion reduced infectious morbidity during hospitalization. Li, et al. demonstrated that premature infants given intravenous glutamine supplementation had less hospital related infections and spent fewer days in the hospital (Li et al., 2007).

Castell, Pourtmans, & Newsholme (1996) studied the effects of glutamine after intense exercise in elite runners and rowers. Glutamine reduced the incidence of post-training infections and illness. Glutamine's role in enhancing immune system function has shown to be very conclusive in many studies.

Candow et al. (2001) investigated the impact of glutamine supplementation in combination with resistance training in young adults. Skeletal muscle and strength markers were assessed before as well as after the six-week examination in both the experimental and placebo groups (Candow et al., 2001). The study found increases in one repetition maximum squat, enhanced force production within knee extensors, and an improvement in lean musculature within the group that supplemented with glutamine.

When considering optimal dosage of glutamine, research differs based on application and intended goal. Some investigations such as Van Gammeren et al have shown a favorable response with a low dosage (2 grams per day) (Van Gammeren et al., 2002). Other researchers, including Candow et al. (2001), provided substantially larger
amounts of glutamine (up to 45 grams per day). Most of the studies show that 4-10 grams of glutamine per day provides optimal benefits (Hultman et al., 1996).

After examining the research, there is substantial evidence justifying glutamine supplementation in athletes. The advantages of glutamine supplementation include supporting a healthy immune system, prevention of muscle atrophy and weight loss, reduced myostatin expression, increased growth hormone levels, decreased catabolism in muscle, increased anabolic effects, enhanced protein synthesis, and improved buffering capacity. These factors could potentially lead to increases in muscle mass, strength, and power and positively affect performance, which validates its inclusion in the formula.

Caffeine

Caffeine is one of the most well known and commonly consumed ingredients in athletic supplements. A large body of literature supports their effects of caffeine (specifically caffeine anhydrous) on athletic performance. Due to the vast amount of existing literature as well as the importance and profound impact that caffeine has, it will be covered in depth.

Caffeine increases strength, endurance, team sport performance, and recovery. In order to fully comprehend the effects and benefits that caffeine provides, it is imperative to understand how caffeine functions within the body. Caffeine uptake occurs rapidly via the GI tract (gastrointestinal tract) (McArdle et al., 2007). Subsequently, it enters through cell membranes efficiently (Freedhom et al., 1999). Caffeine, also known as 1,3,7-trimethylxanthine, is processed by the liver and results in three analogues: theophylline, paraxanthine, and theobromine (Harland, 2000). Increased concentrations of caffeine
occur within the bloodstream after 15-45 min of consumption, and peak levels are seen one hour after ingestion (Robertson et al., 1978).

Caffeine also crosses the blood-brain barrier easily because it is lipid soluble (McCall, Millington, & Wurtman, 1982). The kidneys expel caffeine analogues, and about 3-10% is excreted unaltered in urine. Circulating levels of caffeine are reduced by about 50-75% after 3 to 6 hours of consumption (McArdle et al., 2007). Therefore, excretion is relative to the rate of uptake and processing of caffeine.

Many studies show that caffeine competes with adenosine at its receptor sites (Spriet & Gibala, 2004). Spriet, et al examined the effect of caffeine on sport performance. The results suggest that since caffeine crosses the membranes of nerve and muscle cells, the effects may be more predominantly neural rather than muscular. Although its effects may be noticed more within muscular activities, more significant actions may be occurring within excitatory contractility elicited by neurological impulses (Spriet, 1995).

One of the main activation sites from caffeine consumption is the central nervous system (CNS). Even caffeine’s metabolites paraxanthine and theophylline can affect the CNS through certain biochemical pathways (Freedhom et al., 1999). Nevertheless, it is not common that one single mechanism explains the effects of certain compounds within the body, so multiple mechanisms will be discussed. Since caffeine readily crosses the blood brain barrier in addition to membranes within all tissues (Spriet, 1995), it is difficult to identify which system— nervous or muscular— caffeine impacts most (Spriet, 1995).
Caffeine may improve endurance increasing the production of beta-endorphins. Laurent, et al. demonstrated increased beta-endorphin levels significantly after two hours of cycling at 65% \( \dot{V}O_{2\text{peak}} \) after consumption of caffeine (6 mg/kg) (Laurent et al., 2000). Grossman, et al. noted that endorphin levels are increased during exercise, and their analgesic characteristics may lead to decreased perception of fatigue (Grossman et al., 1985). Caffeine can alter neuromuscular function as well as skeletal muscular contraction (Lopes, Aubier, Jardim, Aranda, & Macklem, 1983). Kalmar & Cafarelli (1999) demonstrated that a moderate dose of caffeine (6 mg/kg) boosted isometric leg extension strength and lengthened the time to fatigue during a sub-maximal isometric leg extension.

Caffeine promotes a thermogenic response. A 100 mg dosage of caffeine caused substantial thermogenic activity even though subjects regularly consumed caffeine at dosages of 100-200 mg per day (Astrup, Breum, Madsen, Hein, Toubro, & Cannon, 1990). The heightened energy expenditure after consumption of caffeine had not returned to baseline even 3 hours after ingestion.

Endurance capacity has shown to be positively affected by caffeine consumption (Graham & Spriet, 1995), as well as team sport activities (Collomp, Ahmaidi, Chatard, Audran, & Prefaut, 1992), and also explosive power based modalities that involve strength (Woolf, Bidwell, & Carlson, 2008). In addition, caffeine ingestion has been investigated for its ability to aid military members when undergoing periods of sustained wakefulness that requires mental vigilance. McLellan et al. (2005) performed three studies investigating the impact of caffeine on military based personnel who are involved with Special Forces and are required to be fully alert during assignments. Soldiers were involved in specific attention-based duties over several days time with minimal sleep.
Specific tasks such as 6 km run, marksmanship tests, observation and reconnaissance, as well as psychomotor skills were observed (McLellan et al., 2005). Test subjects were given 600-800 mg of caffeine during these periods of wakefulness. In each study (McLellan et al., 2005, McLellan et al., 2005, McLellan et al., 2007), caffeine either maintained or heightened mental acuity and vigilance. Physical performance was also enhanced by caffeine consumption (McLellan et al., 2005).

Caffeine can positively affect endurance as well as cognitive performance (Hogervorst et al., 2008). Trained cyclists who consumed an average of 170 mg of caffeine per day were examined in three investigative trials of 2.5 hours of cycling at 60% VO$_{2\text{max}}$, then had five minutes of rest with a subsequent a ride to exhaustion at 75% VO$_{2\text{max}}$. Test subjects ingested a sports bar that contained either 50 grams of carbohydrates and 100 mg of caffeine, non-caffeinated-carbohydrate and isocaloric, or flavored water on three separate days for this investigation. Finding from a set of cognitive function tests showed that the caffeine treatment performed faster during the Stroop as well as Rapid Visual Information Processing Task after 140 min of submaximal cycling in addition to a ride to exhaustion. Time measurements for the ride to exhaustion were extended within the caffeine group compared to the non-caffeinated bar and flavored water (Hogervorst et al., 2008).

Foskett, et al. examined the impacts of caffeine on cognitive factors and intermittent sprint activity. A dose of 6 mg/kg (moderate) enhanced ball passing control and accuracy, causing an overall increase in motor performance in soccer players (Foskett et al., 2009).
According to the previously mentioned research, caffeine can provide benefit as an ergogenic aid for military personnel as those subject to stressful environments, including extended periods of sleeplessness. Caffeine has demonstrated enhancement in cognitive function, concentration, and alertness. Further, research has supported caffeine’s efficacy in boosting physical and cognitive abilities among endurance athletes as well.

The form and dosage of caffeine influence performance. Graham Hibbert, & Sathasivam (1998) showed positive effects when caffeine was consumed at 4.45 mg/kg in different forms. In this investigation, trained runners undertook five treadmill runs to exhaustion at about 85% \( \text{VO}_2\text{max} \) an hour after having received one of the following treatments: coffee, decaffeinated coffee, caffeine capsules plus water, regular decaffeinated coffee plus caffeine in capsule form, and placebo. Capsule form caffeine consumption resulted in substantially greater work capacity (Graham et al., 1998).

Further research done by Graham et al. (1998) and colleagues suggested that other compounds within coffee cause caffeine to be less effective than when consumed in anhydrous form. This theory was also supported by de Paulis, Schmidt, Bruchey, Kirby, McDonald, Commers, Lovinger, & Martin in a 2002 study that demonstrated constituents of chlorogenic acids are created from roasting coffee. Consequently, these constituents could possibly alter the affects of caffeine by antagonizing the actions of adenosine (de Paulis et al., 2002). The formulation uses only the pure anhydrous form of caffeine to maximize the benefits and minimize any negative conditions associated with other forms of caffeine.
Another interesting investigation performed by Woolf et al. (2008) showed that conditioned athlete test subjects increased peak power on the Wingate after consuming caffeine at 5 mg/kg dosage. In another study based on peak power output, Wiles, Tegerdine, & Swaine (2006) showed a 3.1% increase in performance time for a 1-kilometer time trial. Specific results for the time trial were 71.1 seconds for caffeine group, and 73.4 seconds for placebo group. This particular investigation utilized a caffeine dose of 5 mg/kg, and findings also included an increase in both mean and peak power. Another study focused on explosive power was performed by Glaister et al. (2008) which investigated what effects a 5 mg/kg dose of caffeine had on sprint interval performance. Test subjects consisted of trained and active men who performed 12 × 30 meter sprints at 35 second intervals. Findings demonstrated substantial improvements in sprint time for the first three sprints (Glaister et al., 2008).

When participating in team sports, intermittent bouts of high intensity activity are accompanied by long duration overall playing time. Considering the types of activity that occur during team sports, Stuart, Hopkins, Cook, & Cairns (2005) investigated the impact of a moderate dose of caffeine (6 mg/kg). The test subjects were trained rugby players. These rugby players performed circuits made to mimic occurrences on the field, such as ball passing and sprinting. Findings showed a 10% enhancement in ball-passing accuracy (Stuart et al., 2005). Furthermore, the test subjects who were given caffeine accurately passed the ball 90% of the time as opposed to 83% for the placebo group (Stuart et al., 2005). This was one of the first studies to show increased skill level and improved accuracy when supplementing with caffeine (Stuart et al., 2005). Another finding within
this study showed that the test subjects who were given caffeine maintained sprint times toward the end of the circuit (Stuart et al., 2005).

Schneiker, Bishop, Dawson, & Hackett (2006) examined the effects of caffeine on repeated sprints in athletes. This study used 10 male competitive team sport athletes who completed a 80 minute sprint test. Findings indicated an 8.5% increase in total sprint work within the group that had received caffeine during the first half and a subsequent 7.6% increase within the second half as compared to the placebo group (Schneiker Bishop, Dawson, & Hackett, 2006). Based on the reviewed research, moderate caffeine supplementation (specifically 4-6 mg/kg) can provide benefits to either short term or intermittent extended duration high-intensity performance.

Research on caffeine consumption in relation to strength based activity is not as plentiful, but is still emerging more and more as investigations aim to uncover more concrete findings. Woolf et al (2008) investigated the effects of 5 mg/kg of caffeine in trained male team sport athletes. The exercises included a leg press, chest press, and Wingate test. The leg press and chest press were based on muscular endurance performing repetitions to failure. Findings showed a significant boost in performance for the chest press as well as increased peak power on the Wingate test, however there was no significant advantage during the leg press (Woolf et al., 2008). Beck et al. (2006) studied the effects of caffeine consumption on strength, muscular endurance, and anaerobic capacity. Trained male participants ingested 201 mg of caffeine an hour before testing, and were measured for upper strength with bench press, and lower body strength with a bilateral leg extension. The muscular endurance component was comprised of repetitions to failure at 80% of individual one-repetition maximum. Test subjects were
also analyzed for peak and mean power by partaking in two different Wingate tests separated by four minutes of rest. The caffeine supplemented group showed an increase in 1RM bench press (2.1 kg or 2.1%).

The research on caffeine supplementation is very informative, and provides key insights into applications and benefits of use for athletes. It provides an advantageous environment for performance in several different instances. To summarize, findings have indicated the following:

Caffeine’s most potent form is the anhydrous state (as opposed to coffee). This provides support for usage of the anhydrous form within the proposed formula. Most of the research used an ingestion timing protocol of 30-60 minutes prior to activity, which is the recommended consumption protocol for the pre-workout combination. Caffeine has been shown to boost performance and minimize any negative side effects when it is consumed in low-to-moderate doses (~3-6 mg/kg). For this reason, the formulation’s dosage is moderate rather than high. Also, during suboptimal sleep periods, caffeine has been shown to increase alertness, mental acuity, and vigilance. This can be important to an athlete during exhaustive training periods when sleep quality and quantity may be less than optimal. Caffeine has also shown to be effective in boosting endurance capacity, and has demonstrated efficacy in increasing time trial performance. Furthermore, caffeine has shown to be effective for enhancing extended duration high-intensity exercise, which includes team sports. As discussed, there are many positive effects from caffeine supplementation, and it is a key ingredient in the proposed formula.

After reviewing the literature, it becomes evident that each ingredient within the proposed formula provides beneficial effects to athletes and individuals engaged in
physical activity who want to perform optimally. The formula contains components that
boost in physical and mental performance, which will help athletes and active individuals
improve and succeed in sports and physical activity.
CHAPTER III

METHODOLOGY

Process and Creation

This chapter will outline the steps and procedures that took place in order to complete this project and develop the specific ingredient combination formulation. The proposed formula is based on an evidence-based assessment of ingredients based on efficacy and safety.

Distribution and Target Audience

The pre-workout formulation is designed for athletes and active people. The combination of ingredients is most advantageous in individuals attempting to perform optimally within their endeavors. Therefore, athletes and active individuals ranging across the board from all different and respective interests can choose to optimize performance by utilizing the combination formulation prior to engaging competition or practice.
CHAPTER IV

THE PRODUCT

The nature of this project requires the design of a possible product in place of a results section. The proposed product is based on the specific combination of researched ingredients hypothesized to increase athletic performance. These ingredients could be theoretically compounded in a pre-workout product, which has no affiliation with California State University, Chico.

Proposed Product Summary

The proposed formula appears in Figure 1. This formula should theoretically maximize exercise performance, enhance energy levels, and improve the quality of workouts.

Figure 1

Theoretical Formula (~10,000mg serving)

L-Arginine AKG: 3,000mg
L-Tyrosine: 750mg
Dimethylaminoethanol: 500mg
Phenylethylamine: 500mg
B Complex Vitamins (100%RDA)
Beta-Alanine: 3,000mg
Taurine: 1,500mg
Glutamine AKG: 500mg
Caffeine anhydrous: 250mg

Each of the ingredients contained within the formula appear on the US Food and Drug Administration’s list of chemicals and food additives that are generally recognized as safe (GRAS), which are exempted from the Federal Food, Drug, and Cosmetic Act.
(FFDCA) that dictate additive tolerance requirements (reference: http://www.fda.gov/Food/IngredientsPackagingLabeling/GRAS/ucm2006850.htm).
CHAPTER V

SUMMARY

This project is based on the combination of specific ingredients hypothesized to improve performance in athletes and active individuals. Maximizing performance is very important for athletes looking to succeed and be the best that they can be. Effectively, by optimizing intake of efficacious compounds, athletes and active people can potentially enhance their abilities in practice and competition. Based on the evidence within the Literature Review (Chapter II), we can conclude that the main ingredients covered within the formula may provide a beneficial impact on performance and capacity.

Potential Outcomes

Expected outcomes are that supplementation with the combination ingredients will cause a boost in physical and mental aptitude. Specifically, expected effects of the combination of compounds include increased physical performance (strength, speed, and overall aptness and ability to perform), heightened mental acuity and alertness, as well as an overall sense-of well being. These expectations are based upon the evidence that has been provided within the literature of the potential benefits of each ingredient contained within the formula.

On a more widespread scale, we expect and hope to see athletes and active individuals from many different areas benefit from this type of formulation. Non-responders or even some cases where negative reactions to certain ingredients may occur, and there never have been any studies on the full combination of ingredients. This is another reason why discretion is advised when it comes to supplementation, and
individuals with sensitivities are recommended to avoid using any supplements that may exacerbate any symptoms. One should contact their physician prior to using any type of combination formulation or individual aforementioned ingredients.

Future/Projected Outlook

The future holds many possibilities for the utilization and expansion of the formulation. The goal is for this type of formula to eventually be used by active individuals worldwide, helping to maximize their potential in all different types of engagements. Further out into the future, newer compounds will be studied and put to use, and the original formulation may be altered to maintain current, innovative, cutting-edge effects and appeal.
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