



# THE SCIENCE BEHIND P.P.K.<sup>TM</sup>

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## The Future Of Pre-Workout Supplements

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## THE SCIENCE BEHIND P.P.K.™

Pre-workout supplements are abundant throughout the sports nutrition industry. Many of which seem to be quite similar with a familiar recipe: lots of caffeine combined with several other ingredients that lack scientific support. The market is flooded with products containing ingredients that are either ineffective, or in miniscule quantities, hidden under proprietary labels. As someone who wants to get the best outcome from your workout, you deserve a research backed formula that provides real functional benefits.

### THE PUMP

Weight lifters love it, critics dismiss it completely as an ergogenic benefit, but one of the most sought-after feelings from a great workout is a great muscle pump. In the simplest sense, the muscle pump is evidence of enhanced muscle perfusion (blood flow to the muscles) during intense physical activity, localized to a particular muscle group. As the increased blood volume travels to the muscle, some fluid crosses into individual muscle cells causing them to swell (“the pump”). The superficial benefit of the pump is the positive biofeedback of a hard workout. This association with the feeling of large swollen muscles serves as reinforcement to keep working harder. However, that is not all “the pump” is good for. Evidence suggests that the cell swelling that occurs with a muscle pump is a positive stimulus that drives muscle protein synthesis and leads to muscle hypertrophy over time.

More importantly, muscle perfusion is required for the delivery of oxygen and other nutrients to the working muscle, and also for the removal of metabolic waste products. Intense resistance exercise produces metabolites such as lactate that accumulates in the muscle and contributes to muscle fatigue while exercising. During rest intervals, the enhanced muscle perfusion functions to remove metabolites, such as lactate, and allow for faster recovery between sets. The expedited removal of lactate results in less fatigue and thus greater muscle performance during subsequent sets.

P.P.K.™ is designed specifically to enhance the muscle pump to the maximum effect and is suitable for long duration, muscular-endurance style workouts where you push for higher repetitions, sets, or otherwise overall higher volume. Many preworkout supplements may claim to improve the “muscle pump”, but fail to show any evidence of it. P.P.K.™ provides a unique pump that will push you longer into your workout with two specialized pump ingredients.

### **L-Citrulline DL-Malate**

All muscle pumps start with a molecule called nitric oxide (NO). Making more of it during exercise simply means greater muscle pumps. Arginine is the precursor for NO, but oral arginine ingestion has a very limited bioavailability and hardly makes its way to the bloodstream. The most effective way to increase plasma arginine levels is to ingest the arginine precursor, citrulline. In the body, citrulline is efficiently recycled into arginine which can then produce NO. Unlike arginine, citrulline catabolism is minimal in the intestines as well as with its extraction from the liver. This results in the majority of citrulline passing into the systemic circulation before its conversion to arginine. Due to this and its noncompetitive uptake for cell transport, oral citrulline supplementation has been shown to be highly effective in increasing plasma arginine levels, and consequently, biomarkers of increased NO. Studies indicate that 6 grams of citrulline malate for 7 days significantly increases plasma arginine and nitrate levels and furthermore, improves oxygen handling at the muscle cell and enhances exercise performance. Multiple studies have shown improvements during upper- and lowerbody multiple bout resistance exercise performance.

### **Agmatine Sulfate**

Agmatine is a great companion to citrulline with its ability to amplify a muscle pump by working synergistically with citrulline. Agmatine is the decarboxylation product of arginine that has been shown in many biological models to produce benefits in an athletic population. To understand how these can work together, you first need to understand how NO is produced.



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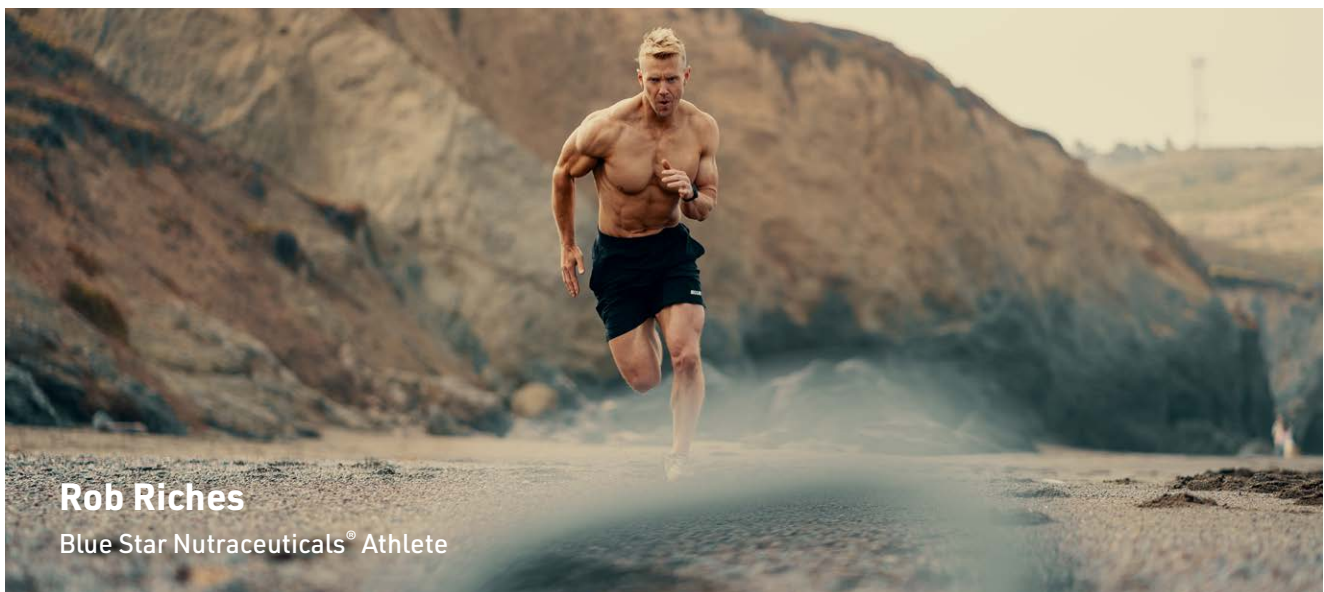
NO is produced from arginine with the help of an enzyme called NOS, but NOS exists in different forms to produce NO in different tissues. Endothelial-NOS (eNOS) is the isozyme that produces increased blood flow and enhanced muscle pumps, whereas the neuronal-NOS (nNOS) consumes arginine and produces NO in the nervous system rather than the peripheral vascular system. While producing NO is what you want during exercise, you also want it to occur where your muscles can benefit from it. Agmatine functions to reduce the activity of the nNOS thus indirectly focusing the NO production at the eNOS, potentiating the role of citrulline, and producing more powerful muscle pumps.

## THE POWER

P.P.K.™ is designed to achieve maximum power with every workout. Peak ATP® is the newest cutting-edge wonder ingredient in P.P.K.™ that constantly overdelivers. Research is clear for the first time that oral ingestion of Peak ATP® increases blood levels of ATP and that those levels remain elevated even following repeated bouts of exercise. This breakthrough has led to many other discoveries about what enhanced levels of ATP in the bloodstream can offer.

### Peak ATP®

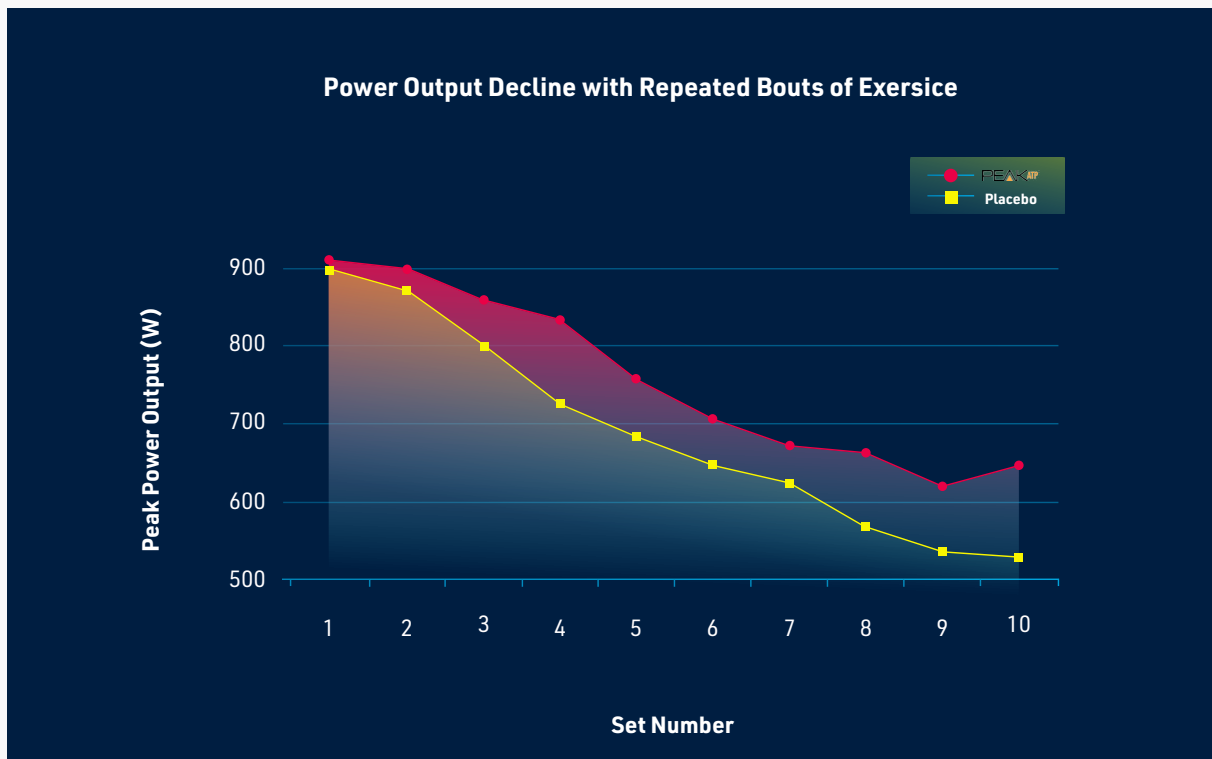
The most impressive aspect of Peak ATP® is its ability to increase muscle excitability. In other words Peak ATP® increases the sensitivity for muscles to contract relative to the level of muscle activation from the nervous system. In essence, improved muscle excitability is the ability to improve the strength of a



muscle contraction without increasing the amount of effort put-forth. By exploiting this effect, maximal effort can be more impactful without any change in the level of effort. With this ingredient, you will be able to push through set after set with improved power output.

Increased plasma-ATP levels lead to an increase in ATP being stored in nerve terminals. Upon muscle activation, ATP is released together with acetylcholine in a ratio of 1:5 onto the motor endplate of skeletal muscle. Extracellular ATP interacting with the P2Y receptors lead to the formation of inositol triphosphate and ultimately the mobilization of intracellular calcium thereby enhancing the muscle contraction. Preliminary research analyzing the ratio between muscle power-output and muscle activation revealed that oral ATP increased muscle excitability during early bouts and prevented the decrease in muscle excitability observed during later bouts of repeated sprint bouts. This means that significant performance enhancements can be observed in an acute time frame.

As illustrated (**Figure 3**), muscle power output follows a steep decline from one set to the next such that by the end of full workout of a specific muscle group, those muscles can feel quite sluggish. The effects of



**Figure 3.** Improved muscle excitability generated by Peak ATP® allows for a prolonged maintenance of power output during repeated bouts of fatiguing exercise.

Peak ATP® results in a less dramatic decline in power output. For example, this clinical study shows that after a grueling workout that lasts up to 8 or 10 sets on a single muscle group, supplementation with Peak ATP® significantly amplifies muscle power, specifically at those later sets. The mechanism behind this phenomenon is quite interesting because these data indicate that this occurs without affecting muscle activation at all.

With chronic supplementation of Peak ATP® before every workout, the individual improved workouts translate to better gains in the long run. A couple of studies focused on the long-term benefits of Peak ATP® supplementation with resistance training over 12 weeks showed significant improvements in muscle strength, lean body mass and muscle size. In fact, when compared to a placebo group, squat strength increased 215% higher, bench press 71% higher and deadlift 138% higher. When combined for total strength, Peak ATP® supplementation was associated for 147% greater increase in strength than a placebo group with the exact same training protocol (**Figure 4**).



**Figure 4.** Chronic supplementation of Peak ATP® resulted in noticeable and significant improvements in total muscle strength, detectable as early as 8 weeks.

In addition to strength, Peak ATP® was associated with doubling the increase in lean body mass and quadriceps circumference. In short, Peak ATP® is the key element to get the most out of the effort put towards training. A secondary benefit to Peak ATP® comes from its ability to increase blood flow during exercise. The data shows that during exercise, 400 mg of Peak ATP® can increase the rate of blood flow 54% higher than exercise with a placebo (**Figure 5**).



**Figure 5.** Peak ATP® acutely increases bloodflow and drives an enhanced muscle pump immediately during the onset of exercise.

The ATP molecules in the bloodstream bind to receptors in the endothelium that trigger the release of several factors to relax the surrounding smooth muscle to widen of the blood vessels in a process called vasodilation. By augmenting the amount of blood-ATP, through the ingestion of Peak ATP®, vasodilation will occur to a greater extent leading to greater “muscle pumps”.

## THE KICK

The kick is the most important part of P.P.K.™. Muscle adaptation occurs only after the muscles encounter a stimulus greater beyond its normal capabilities. This means exercises that are not pushed to the limits are not as beneficial as they could be. A lot of effort conducted in the gym will go to waste if the muscles are not exposed to this level of stimulation. That’s where the kick comes in. The P.P.K.™ nootropic blend of Caffeine, Huperzine A and Alpha GPC is designed to provide “the kick” needed to keep motivation level high in order to keep training hard all the way through each set.

## Huperzine A

As a naturally occurring compound found in *Huperzia serrata*, Huperzine A penetrates the bloodbrain barrier that inhibits an enzyme that degrades the CNS neurotransmitter, acetylcholine. The inhibition of this enzyme increases the life of acetylcholine, which improves nerve transmission, mental function and coordination. Pharmacokinetic studies in several species including healthy human volunteers indicated that Huperzine A is safe, absorbed rapidly, distributed widely in the body and eliminated at a moderate rate.

## Alpha GPC

Alpha Glycerylphosphorylcholine ( $\alpha$ -GPC) is a natural choline compound found in the brain. Choline is used in the synthesis of acetylcholine, which is the main neurotransmitter of the central nervous system. Supplementation of  $\alpha$ -GPC has been shown to cross the blood brain barrier and deliver an increase in choline to the brain, and serve as a precursor to acetylcholine. Elevated levels of acetylcholine has been attributed to support memory, mental clarity and healthy formation of synaptic connections between neurons. In double blind trials,  $\alpha$ -GPC boosted attention, concentration, memory, learning and mood.

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## YOU SHOULD KNOW

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Pre-workout supplements are abundant in the sports nutrition industry. Many of these seem to be quite similar with a familiar recipe: lots of caffeine combined with several other ingredients that lack scientific support. Real athletes deserve more – a research proven formula that provides functional benefits, great taste, incredible workouts, and real results.

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## Caffeine

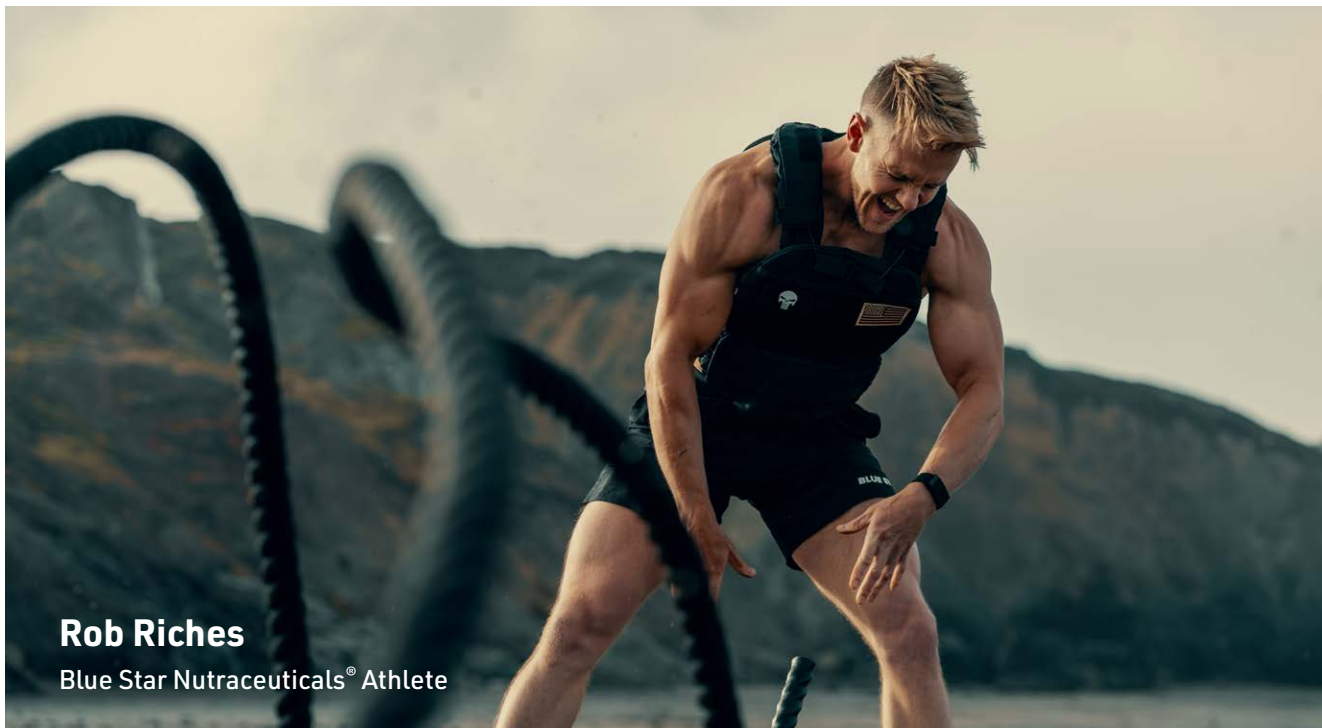
Probably the most well-known property of caffeine is to antagonize adenosine receptors in the brain, which promotes alertness and the mental ability to push through physical discomfort. Caffeine also acts as a mild cognitive enhancer, improving concentration and mood through enhanced dopamine signaling. Another mechanism through which caffeine improves performance is by increasing the secretion of  $\beta$ -endorphins. It has been established that plasma endorphin concentrations are enhanced during exercise and their analgesic properties may lead to a decrease in pain perception and allow you to push through each set harder.



The effects of caffeine are dose dependent, but a moderate dose does a lot, and more than that is associated with increased risk of caffeine tolerance, dependency and a few other negative effects, some of which can in fact interfere with its benefits. For this reason, P.P.K.™ uses a responsible dose of caffeine of 300 mg in order to achieve its maximum benefits while also minimizing the negative effects with chronic use.

## HYDRATION + ELECTROLYTES

The final feature to the performance enhancing effects of P.P.K.™ is the hydration support. The inclusion of key electrolytes works to assist with fluid transport into the muscles, and increasing cell volume. Specifically, sodium, potassium and chloride, work together to assist with water balance by creating an osmolarity gradient that pulls water into the cells from the bloodstream. The flux of fluid moving into the cells triggers an increase in thirst that replenishes blood volume. Insufficient cell hydration can interfere with muscle contraction. Thus, the hydrating properties of P.P.K.™ allows for normal muscle contraction for the duration of the workout. Simply drinking mass amounts of water is not always an optimal method to hydrate. Drinking plain water can dilute the existing electrolytes in the bloodstream causing a condition called hyponatremia. Therefore, supplementing with these nutrients will ensure optimal muscle functioning during the workout and prevent hyponatremia.



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**Coconut water powder** is known for its concentrations of electrolytes, vitamins and minerals. This will enhance cell volume and hydration, stimulate thirst to keep you drinking water and also prevent cramping during exercise. Coconut water is high in, potassium, magnesium, and calcium. Potassium helps maintain water balance, stimulates metabolism of proteins and carbohydrates, helps muscles use glycogen, prevents muscle fatigue and enables normal muscle contraction. Magnesium participates in the conversion of ATP, decreases pain, prevents muscle cramps and spasms. Calcium helps muscles contract and work properly. Rather than pulling calcium out of your bones, coconut water can preserve your bone by supplying the calcium for you.

**Pink Himalayan sea salt** is high in sodium. Since coconut water is low in sodium, pink Himalayan sea salt is a great companion to coconut water powder to get the full spectrum of electrolytes naturally. It also provides additional potassium, magnesium, and calcium. Sodium helps maintain water balance, activates thirst response, prevents water intoxication and hyponatremia, prevents cramps, enables normal muscle contraction. Also enables nerve impulse transmission and maintains normal blood pressure.

## CONCLUSION

P.P.K.™ is the only truly complete pre-workout supplement that contains only the ingredients relevant to any workout. P.P.K.™ is designed exclusively for extracting the highest potential benefit from exercise by delivering the most clinically researched pump ingredients, the most powerful performance enhancers, and the best-in-class nootropic kick truly worthy of the athlete who knows what they want from their workout and wants to get the best possible outcomes.



## References

Jager R, Roberts MD, Lower RP, Joy JM, Cruthirds CL, Lockwood CM, Rathmacher JA, Purpura M, Wilson JM. Oral adenosine-5'-triphosphate (ATP) administration increases blood flow following exercise in animals and humans. *J Int Soc Sports Nutr.* 11; doi: 10.1186/1550-2783-11-28, 2014.

Jordan AN, Jurca R, Abraham EH, Salikhova A, Mann JK, Morss GM, Chruich TS, Lucia A, Earnest CP. Effects of oral ATP supplementation on anaerobic power and muscular strength. *Med Sci Sports Exerc.* 36; 983-990, 2004.

Li YX, Zhang RQ, Li CR, Jiang XH. Pharmacokinetics of huperzine A following oral administration to human volunteers. *Eur J Drug Metab Pharmacokinet.* 32; 183-187, 2007.

Purpura M, Rathmacher JA, Sharp MH, Lowery RP, Shields KA, Partl JM, Wilson JM, Jager R. Oral Adenosine-5'-triphosphate (ATP) Administration Increases Postexercise ATP Levels, Muscle Excitability, and Athletic Performance Following a Repeated Sprint Bout. *J Am Coll Nutr.* doi: 10.1080/07315724.2016.1246989, 2017.

Rathmacher JA, Fuller JC, Baier SM, Abumrad NN, Angus HF, Shar RL. Adenosine-5'-triphosphate (ATP) supplementation improves low peak muscle torque and torque fatigue during repeated high intensity exercise sets.

Wang Rui, Yan H, Tang X. Progress in studies of huperzine A, a natural cholinesterase inhibitor from Chinese herbal medicine. *Acta Pharmacologica Sinica.* 27; 1-26, 2006.

Wilson JM, Joy JM, Lowery RP, Roberts MD, Lockwood CM, Manninen AH, Fuller JC, De Souza EO, Baier SM, Wilson SMC, Rathmacher JA. Effects of oral adenosine-5'-triphosphate supplementation on athletic performance, skeletal muscle hypertrophy and recovery in resistance-trained men. *Nutr Metab.* 10; doi: 10.1186/1743-7075-10-57, 2013.

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Dr. David Gundermann is an award winning nutritional product development scientist, clinical researcher, and known expert in muscle health and metabolism. He developed his passion for health & fitness at a very early age growing up in a family of accomplished competitive athletes.

As Director of Research and Development at Blue Star Nutraceuticals®, he leads all efforts concerning product formulation, key ingredient research, flavor science, long-term scientific assessment, and proprietary development.

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