

Taurine - an Essential Non-Protein Amino Acid

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Introduction

Taurine ((2-aminoethane-sulfonic acid), a sulfur-containing amino acid is the second most abundant amino acid in the body, the most abundant free amino acid found in skeletal muscle tissue, the heart and brain. It's also one of the most abundant amino acids in most organs in the body. Although it's one of the few amino acids not directly used for protein synthesis, it can indirectly increase protein synthesis.

Taurine has a myriad of beneficial functions in the body, including the musculoskeletal, cardiovascular, and central nervous systems, from development to cytoprotection in all age groups, and an organic osmolyte involved in cell volume regulation as well as being involved in the formation of bile salts and the modulation of intracellular free calcium concentration.¹²³⁴⁵

It's been shown that taurine may attenuate exercise-induced DNA damage and enhance the capacity of exercise due to its cellular protective properties.⁶⁷

Taurine also provides a substrate for, and plays a role in the modulation of intracellular free calcium concentration

Taurine is often considered a non-essential or hesitantly a conditionally essential amino acid for humans since it can be synthesized by the body from methionine and cysteine. However, the limiting enzyme required for biosynthesis of taurine is very low in humans and biosynthesis may not be adequate for times when the need for taurine is increased.

Since inadequate taurine levels are a real concern, and to make sure there's enough taurine available when needed, taurine has been added to infant formulas as well as to intravenous solutions used for various medical conditions.

Because of its many functions and suboptimal levels in most people, I consider taurine an essential amino acid for anyone looking to improve body composition (add muscle and reduce body fat) and/or increase exercise/sports performance.⁸⁹

Food Sources of Taurine

Taurine is highest in meat and seafood and the average person, nonvegan, takes in around 60 mg per day. However, over twenty times that amount can be beneficial for improving body composition and performance, increasing health and wellbeing, and as complimentary treatment for prevention and treatment of various diseases, including sarcopenia and musculoskeletal disorders.¹⁰¹¹

Vegans and Taurine

Vegan intake of taurine is usually much lower than non-vegans and I always recommend taurine supplementation for vegans, especially vegan athletes. As an aside I always recommend other forms of supplementation for vegans, and again especially for vegan athletes, depending on how carefully a vegan structures their diets, including vitamins D, B2, B12, B6, and niacin, zinc, iron, selenium, calcium, L-carnitine, carnosine and/or beta-alanine, omega-3 fatty acids, and creatine.¹²¹³¹⁴¹⁵¹⁶

Effect on Bacterial and Viral Infections

Taurine is useful in combating bacterial and viral infections including the coronaviruses.¹⁷¹⁸

There are patents on the use of taurine in prevention and/or treatment of diseases induced by viruses of genus coronavirus and/or genus rotavirus (<https://patents.justia.com/patent/10314799>).

Highlights

- **Prior gut infection increases the microbiota's resistance to subsequent infection**
- **Infection induces host taurine production and the expansion of taurine utilizers**
- **The gut microbiota converts taurine to sulfide, inhibiting pathogen respiration**
- **Sulfide sequestration unleashes endogenous respirers in the gut microbiota**

Summary

The microbiota shields the host against infections in a process known as colonization resistance. How infections themselves shape this fundamental process remains largely unknown. Here, we show that gut microbiota from previously infected hosts display enhanced resistance to infection. This long-term functional remodeling is associated with altered bile acid metabolism leading to the expansion of taxa that utilize the sulfonic acid taurine. Notably, supplying exogenous taurine alone is sufficient to induce this alteration in microbiota function and enhance resistance. Mechanistically, taurine potentiates the microbiota's production of sulfide, an inhibitor of cellular respiration, which is key to host invasion by numerous pathogens. As such, pharmaceutical sequestration of sulfide perturbs the microbiota's

composition and promotes pathogen invasion. Together, this work reveals a process by which the host, triggered by infection, can deploy taurine as a nutrient to nourish and train the microbiota, promoting its resistance to subsequent infection.

A recent study found that taurine helps the gut recall prior infections and kill invading bacteria.¹⁹ During the study, the researchers realized that a single mild infection is sufficient to prepare the microbiota to resist subsequent infection, and that the liver and gallbladder -- which synthesize and store bile acids containing taurine -- can develop long-term infection protection. The study found that taurine given to mice as a supplement in drinking water also prepared the microbiota to prevent infection.

Effects on Health, and Physical and Mental Performance

Taurine is a nutrient that enhances the training effect by its many roles in improving musculoskeletal function and protection including increasing growth hormone and IGF-1, and decreasing inflammation, muscle soreness, and injury.²⁰²¹²²²³²⁴²⁵²⁶²⁷²⁸²⁹³⁰³¹³²³³³⁴ A recent study concluded that **“taurine administration exhibited protective effects by inhibiting MMP-3 and CHOP expression, and subsequently alleviated the OA symptoms in experimental rat models.”**³⁵

As well, taurine has immune system benefits, insulin like effects as far as increasing protein synthesis and decreasing muscle breakdown and cell volumizing effects. The volumizing effect on certain nutrients on muscle cells is also felt to lead to an increase in protein synthesis.

Over the years, oral taurine administration has been shown to help muscle cramping in patients with liver cirrhosis and myotonic dystrophy. Several studies have suggested that it may also help to alleviate muscle soreness and cramps occurring during and after exercise.³⁶

Studies on mice and rats show that taurine is useful for reducing physical fatigue, muscle damage, and exercise induced muscle injury during exercise training, presumably due to its antioxidant effects and the beneficial effects that taurine has on metabolism and on muscle and cardiac functions.³⁷³⁸³⁹ It's also been shown to improve the electrical and contractile properties of skeletal muscle fibers.⁴⁰

Another study on rats has shown that oral taurine supplementation may increase muscle performance and reduce muscle injury caused by exercise.⁴¹ The aim of the study was to determine if increasing muscle levels of taurine would decrease free radical damage after exercise-induced injury. The authors found that first of all taurine levels rose in muscle after supplementation, and secondly that running performance was improved by the taurine supplementation.

Thus, it appears taurine supplementation may facilitate exercise performance and reduce some of the counterproductive muscle injury caused by exercise.

In humans, taurine supplementation in patients with heart failure increases their exercise capacity.⁴² It's been shown that taurine decreases oxidative stress in skeletal muscle after eccentric exercise⁴³ This study found that taurine supplementation decreases superoxide radical production, CK, lipoperoxidation and carbonylation levels and increases total thiol content in skeletal muscle after eccentric exercise.

Another recent study found that oral taurine taken prior to exercise improved improved both critical power and performance in a range of exercise intensities.⁴⁴

The above studies suggest that taurine affects skeletal muscle contraction by decreasing oxidative stress, in association with decreased superoxide radical production. Thus, it appears taurine supplementation may facilitate exercise performance and reduce some of the counterproductive muscle injury caused by exercise.

Another study on cyclists found that taurine increased fat oxidation by 16% during sub maximal cycling.⁴⁵ A recent study found that taurine supplementation increases lipolysis and contributes to energy systems, exerting its effects on increasing endurance.⁴⁶ A recent Meta-Analysis concluded that **“Human endurance performance can be improved by orally ingesting a single dose of taurine in varying amounts (1-6 g).”**⁴⁷ 2 other studies by the same team found that “Oral taurine can be taken prior to exercise to enhance endurance performance”⁴⁸ and that taurine improves power and exercise tolerance.⁴⁹

A recent paper shows that taurine supplementation increases irisin levels after high intensity training.⁵⁰ Irisin is an exercise-induced myokine/adipokine that increases thermogenesis in adipose tissue and thus improving the body composition effects of exercise. Another study published this year (Aug 2019) concluded that the pleiotropic and beneficial properties of irisin “may be a potential option to prevent and treat civilization-related diseases which are, nowadays, considered to be the major health problems in Western societies.”⁵¹

These findings are especially important in athletes and people looking to improve body composition, and performance and who are following my phase shift diets since one of the main goals of my diets is to become fat adapted and thus increase the use of body fat as a main source of energy while at the same time maintaining the ability to use glycolysis for high intensity training beyond the VO2max.

There is some evidence to show that taurine may enhance training further by decreasing training induced fatigue. One study found that Na⁺-K⁺-ATPase activity is depressed with fatigue, regardless of training state, suggesting that this may be an important determinant of fatigue.⁵² Another paper associated fatigue and training with reduced Ca²⁺-ATPase activity.⁵³ Previous studies have shown that taurine stimulates Na⁺-K⁺-ATPase activity and also the pumping rate of the Ca²⁺-activated ATPase pump. One study found that taurine increased fat oxidation in endurance trained athletes.⁵⁴

Two recent studies in humans found that human endurance performance can be improved by orally ingesting as little as one gram of a single dose of taurine.^{55,56}

One study found that taurine administration increased taurine concentrations in skeletal muscles, reduced the decrease in taurine in skeletal muscles that is seen with exercise, increased physical endurance by increasing the duration of running time in rats, and was considered to reduce exercise-induced muscle fatigue.⁵⁷ Also taurine supplementation has been shown to increase skeletal muscle force production, protects muscle function and reduce oxidative stress.⁵⁸

Taurine and Testicular Function

Taurine is one of the most abundant free amino acids in the testes and is instrumental in the production of testosterone and in fertility. A recent study concluded that taurine plays important roles in male reproduction and that a taurine supplement could stimulate the secretion of LH and T, increase the levels of testicular marker enzymes, elevate testicular antioxidation and improve sperm quality.⁵⁹⁶⁰⁶¹⁶²⁶³⁶⁴⁶⁵⁶⁶⁶⁷⁶⁸⁶⁹⁷⁰⁷¹⁷²

Taurine and Branched Chain Amino Acids

Taurine also plays well with the branched chain amino acids (BCAA) as the combination has been shown to decrease delayed onset muscle soreness and muscle damage.⁷³ It's also likely that the beneficial effects of both taurine and the BCAA on skeletal muscle function are enhanced by other nutrients such as beta-alanine and carnosine.⁷⁴

Taurine is considered a potent antioxidant and cytoprotective agent that may be useful for combating the adverse effects of physical and psychological stress, and aging.^{75,76,77,78}

In a recent paper taurine was felt to have beneficial effects on periodontal disease, a disease that is wide spread and increases inflammation, which is counterproductive for optimal health and performance.⁷⁹⁸⁰

Taurine, because of its beneficial effects on skeletal muscle functioning is also likely useful therapeutically for skeletal muscle disorders.⁸¹⁸²

Performance and Body Composition Effects

Taurine has a number of effects in the body that contribute to weight and fat loss, and body composition, including beneficial effects on lipid metabolism and protein synthesis.⁸³ For example, taurine has been shown to increase GH in animals.⁸⁴

An early study showed that taurine decreases bodyweight in obese mice.⁸⁵ Another study on 30 Japanese college students found that taurine is effective in reducing body weight and fat mass, possibly due to its beneficial effects on lipid metabolism.⁸⁶ As well it may have an important role in cardiovascular disease prevention in overweight or obese subjects.

More recent studies have found that taurine supplementation can increase energy metabolism and expenditure in muscle, adipose tissue and liver, and the function of lipolytic enzymes, decrease body fat, especially visceral body fat, and has additive effects with exercise.⁸⁷⁸⁸⁸⁹⁹⁰

Other recent studies have found that taurine supplementation can increase energy expenditure and the function of lipolytic enzymes, decrease body fat especially visceral body fat, restore muscle function in overuse of exercised muscle, decrease catabolism of skeletal muscle, improve performance, and has additive effects with exercise.⁹¹⁹²⁹³⁹⁴⁹⁵

Taurine has also been shown to increase glucose sensitivity and enhance mitochondrial metabolic function.⁹⁶⁹⁷ The data suggest that taurine administration has a marked effect on lipid metabolism and can therefore be beneficial to persons looking to lose body fat. Also, that restoration of plasma taurine level could be critical in preventing or improving obesity-related -cell dysfunction.

As well, the data suggests that taurine depletion causes inadequate β -oxidation due to decreased pH buffering capacity, which consequently leads to metabolic dysfunction.

Besides the effects on fat metabolism and mitochondrial functioning, taurine also has effects on cellular hydration that increases protein synthesis and thus decreases the loss of muscle with weight loss.⁹⁸ The effects on cellular hydration and thermoregulation provide an ergogenic and thermoregulatory effect as shown in a recent study looking at the effects of oral taurine supplementation on cycling time to exhaustion at a fixed-intensity and thermoregulation in the heat. The authors found that taurine improved cycling performance and decreased heat stress. They

concluded that “a single dose of taurine 2 h prior to training or competition would provide an ergogenic and thermoregulatory effect.”

Taurine has been shown to be an important amino acid in several tissues in the body, including muscle.⁹⁹ A recent study looked at Because of it's properties in skeletal muscle it's been suggested as a treatment for various muscle disorders.¹⁰⁰

Taurine, because of its effects on increasing insulin sensitivity, growth hormone levels, and protein synthesis (secondary to its effects on osmoregulation and cell volumizing^{101, 102, 103}), helps to spare muscle when dieting, with the result that weight loss is mostly from the loss of body fat. Taurine is also beneficial because of its effects on osmotic regulation of neuronal activity, and it's neuroprotective effects..¹⁰⁴¹⁰⁵

The bottom line is that taurine supplementation significantly enhances the body composition and performance benefits of exercise as well as improving health and well-being.

MDPlus/MetabolidDiet.com Nutritional Supplements Containing Taurine

The bottom line is that taurine supplementation significantly enhances the body composition and performance benefits of exercise, provides protection from heat stress, as well as improving health and well-being.

Several products in my nutritional supplement line contain 1 gram or more of taurine, especially Power Drink, Amino, [Creatine Advantage](#), and Resolve, with lower levels in several others including [GHboost](#), [Antiox](#), and [MVM](#).

The combination of [Resolve](#), [Power Drink](#) and [Amino](#), the combo that makes up my [Exersol](#) contains 2400 mg of free L-taurine.

Example of Papers Cited as References

Mol Nutr Food Res 2019 Jan;63(2):e1800536. doi: 10.1002/mnfr.201800536. Epub 2018 Oct 17.

Taurine is Involved in Energy Metabolism in Muscles, Adipose Tissue, and the Liver

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Abstract

Energy metabolism is a basic and general process, by which the body acquires and uses energy to maintain normal function, and taurine plays a vital role in energy metabolism. Taurine deficiency may cause a weak energy metabolism and energy metabolism dysfunction. Taurine biosynthetic ability is limited, and its supplementation in the diet can strengthen energy metabolism in muscle performance, cardiac function, liver activity, and adipose tissue. Combining taurine with other drugs

may have a superior effect in energy metabolism. In many metabolic disorders, taurine, or the combination of taurine with other drugs, also functions as a repair treatment for damaged tissues, and acts as a promoter for the balance of energy metabolism. The present study discusses the potential roles of taurine in energy metabolism.

Sports Med. 2018 May;48(5):1247-1253.

The Effects of an Oral Taurine Dose and Supplementation Period on Endurance Exercise Performance in Humans: A Meta-Analysis.

Waldron M^{1,2}, Patterson SD³, Tallent J³, Jeffries O³.

Abstract

BACKGROUND:

Taurine is central to many physiological processes, some of which are augmented by exogenous supply and have the potential to facilitate endurance performance; however, its independent effects on performance have not been systematically analyzed.

OBJECTIVE:

To evaluate the effects of isolated oral taurine ingestion on endurance performance and to assess the contribution of (1) the dose and (2) the supplementation period to the ergogenic effect.

METHODS:

A search was performed using various databases in September 2017. The studies were screened using search criteria for eligibility. Ten peer-reviewed articles were identified for inclusion. A sub-analysis of time-to-exhaustion (TTE) trials (n = 7) was also performed. The effects of (1) dose and (2) the acute (single dose) or chronic (> 1 day) supplementation periods were assessed using meta-regression. The doses of taurine ranged from 1 to 6 g/day and were provided in single doses and for up to 2 weeks among a range of subjects.

RESULTS:

Taurine ingestion improved overall endurance performance (Hedges' g = 0.40, 95% CI 0.12-0.67, P = 0.004), which was similar in TTE trials (Hedges' g = 0.43, 95% CI 0.12-0.75, P = 0.007). There were no differences between acute or chronic supplementation for the full sample (P = 0.897) or the TTE group (P = 0.896). The dose of taurine did not moderate its effect on endurance performance (P > 0.05).

CONCLUSION:

Human endurance performance can be improved by orally ingesting a single dose of taurine in varying amounts (1-6 g).

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