Taurine - an Essential Non-Protein Amino Acid

Mauro Di Pasquale, B.Sc. (Hons), M.D.
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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, brain, spinal cord, and retina. It's also one of the most abundant amino acids in most organs in the body and accounts for approximately 0.1% of total human body weight.[1]

Although technically an amino acid, it does not contain a carboxyl group but instead contains a sulfonic acid group, rather than the carboxylic acid moiety found in other amino acids and as such it is one of the few amino acids not directly used for protein synthesis. It can, however, indirectly increase protein synthesis.

Because of its many physiological functions, including membrane stabilization, osmoregulation and cytoprotective effects, antioxidant and anti-inflammatory actions, taurine has a myriad of beneficial effects and 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.[234567]

It's been shown that taurine may attenuate exercise-induced DNA damage and enhance the capacity of exercise due to its cellular protective properties.[89]

A recent review pointed out taurine's many benefits as a "cytoprotective molecule due to its ability to sustain normal electron transport chain, maintain glutathione stores, upregulate anti-oxidant

responses, increase membrane stability, eliminate inflammation and prevent calcium accumulation. In parallel, the synergistic effect of taurine with other potential therapeutic modalities in multiple disorders" are highlighted in this review.[10]

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 be deficient and not be adequate especially 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 acids for anyone looking to improve body composition (add muscle and reduce body fat) and/or increase exercise/sports performance.[11][12]

Food Sources of Taurine

Taurine is highest in meat and seafood. The average person, non-vegan, 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.[13][14]

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.[15][16][17][18][19]

Effect on Bacterial and Viral Infections

Taurine is useful in combating bacterial and viral infections including the coronaviruses.[20][21]

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.[22] 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, oxidative stress, muscle soreness, and injury.[23242526272829303132333435363738 39] 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."**[40]

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.[41]

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.[424344] It's also been shown to improves the electrical and contractile properties of skeletal muscle fibers.[45]

Another study on rats has shown that oral taurine supplementation may increase muscle performance and reduce muscle injury caused by exercise.[46] 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.[47] It's been shown that taurine decreases oxidative stress in skeletal muscle after eccentric exercise[48] 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 both critical power and performance in a range of exercise intensities.[49]

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.[50] A recent study found that taurine supplementation increases lipolysis and contributes to energy systems, exerting its effects on increasing endurance.[51] 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)."**[52]

A recent paper shows that taurine supplementation increases irisin levels after high intensity training.[53] Irisin is an exercise-induced myokine/adipokine that increases thermogenesis in adipose tissue and thus improving the body composition effects of exercise. Another recent study 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."[54]

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.[55] Another paper associated fatigue and training with reduced Ca2+-ATPase activity.[56] 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.[57]

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.[58][59]

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.[60] Also taurine supplementation has been shown to increase skeletal muscle force production, protects muscle function and reduce oxidative stress.[61]

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. Recent studies have shown 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 reproductive function and sperm quality.[62636465666768697071727374757 6]

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.[77] 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.[78]

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.[79,80,81,82 83]

In a recent paper taurine was felt to have beneficial effects on periodontal disease, a disease that is widespread and increases inflammation, which is counterproductive for optimal health and performance.[8485]

Taurine, because of its beneficial effects on skeletal muscle functioning is also likely useful therapeutically for skeletal muscle disorders and improving age related changes in skeletal muscle function.[868788]

As well it is a potent antioxidant, taurine has significant anti-inflammatory properties, increases insulin sensitivity, increases cell volume and therefore protein synthesis, and acts as a cytoprotective agent in the central nervous system and muscle.

Taurine is also useful in regenerative therapies. A recent study looked at the effects of taurine in chondrogenesis when used with stem cells. However, the use of taurine may well aid in chondrogenesis when used along other ingredients present in Joint Support and as such may be useful of increasing the repair of cartilage in joints, including the vertebral column facets in degenerative spinal osteoarthritis.[89] The same study also looked at the beneficial effects of Taurine on telomerase and for anti-aging.

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. [90] For example, taurine has been shown to increase GH in animals.[91]

An early study showed that taurine decreases bodyweight in obese mice.[92] 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.[93] 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, including increasing lipid oxidation post-exercise.[949596979899100]

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 strength and endurance performance, decrease muscular fatigue, increase enzymatic antioxidants modulate cytokines, improve cognition and physical fitness, and has additive effects with exercise.[101102103104105106 107108]

One recent study found that even a low dose of taurine taken before performing strength enhancing exercises can decrease muscular fatigue and increase enzymatic antioxidants while higher doses can decrease DNA damage and lactate levels. [109]

Taurine has also been shown to increase glucose sensitivity and enhance mitochondrial metabolic function.[110111] 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 and age-related skeletal muscle and cellular dysfunction.[112] A recent study found that taurine increases mitochondrial respiratory function and suggests that supplementation with taurine has potential for the treatment of obesity and metabolic disease.[113]

As well, the data suggests that taurine depletion causes inadequate ß-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.[114] 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.[115] A recent study looked at Because of it's properties in skeletal muscle it's been suggested as a treatment for various muscle disorders.[116]

Taurine, because of its effects on increasing insulin sensitivity, growth hormone levels, and protein synthesis (secondary to its effects on osmoregulation and cell volumizing[117],[118],[119]), 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..[120121]

As well, the use of taurine decreases metabolic risk factors and improves the lipid profile when used with a weight loss diet.[122]

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

Protective role of taurine against oxidative stress (Review)

Stella Baliou[1], Maria Adamaki[1], Petros Ioannou[2], Aglaia Pappa[3], Mihalis I Panayiotidis[4], Demetrios A Spandidos[2], Ioannis Christodoulou[1], Anthony M Kyriakopoulos[5], Vassilis Zoumpourlis[1]
Mol Med Rep. 2021 Aug;24(2):605.
doi: 10.3892/mmr.2021.12242. Epub 2021 Jun 29.

Abstract

Taurine is a fundamental mediator of homeostasis that exerts multiple roles to confer protection against oxidant stress. The development of hypertension, muscle/neuro-associated disorders, hepatic cirrhosis, cardiac dysfunction and ischemia/reperfusion are examples of some injuries that are linked with oxidative stress. The present review gives a comprehensive description of all the underlying mechanisms of taurine, with the aim to explain its anti-oxidant actions. Taurine is regarded as a cytoprotective molecule due to its ability to sustain normal electron transport chain, maintain glutathione stores, upregulate anti-oxidant responses, increase membrane stability, eliminate inflammation and prevent calcium accumulation. In parallel, the synergistic effect of taurine with other potential therapeutic modalities in multiple disorders are highlighted. Apart from the results derived from research findings, the current review bridges the gap between bench and bedside, providing mechanistic insights into the biological activity of taurine that supports its potential therapeutic efficacy in clinic. In the future, further clinical studies are required to support the ameliorative effect of taurine against oxidative stress.

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

Chaoyue Wen[1], Fengna Li[2,3], Lingyu Zhang[2,4], Yehui Duan[2], Qiuping Guo[2,4], Wenlong Wang[1], Shanping He[1], Jianzhong Li[1], Yulong Yin[2,3]

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 SD[3], Tallent J[3], Jeffries O[3].

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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