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Multiple Nutritional Effects of Essential Amino Acids

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Abstract

Muscle plays a central role in protein metabolism throughout the body. It is a major reservoir of amino acids. The importance of muscle mass, strength, and metabolic function in athletic performance is well known, and exercise-induced muscle injuries can also reduce muscle function and cause pain and discomfort. Syndromes such as sarcopenia and cachexia are also defined in part by a loss of muscle mass and strength. Elevated plasma amino acids stimulate muscle protein synthesis. The degree of stimulation depends on the dose and the profile of amino acids given. Essential amino acids are closely related to human protein synthesis and locomotion ability especially leucine, which is the substrate for new muscle protein synthesis and initiates the signal of rate-limiting translation initiation step of muscle protein synthesis. Supplementation of Essential Amino Acids can promote muscle protein synthesis and improve muscle mass and strength in exercise and elderly people. It can also improve exercise fatigue and recovery after exercise; In addition, it has a positive effect on age-related bone health. However, the interaction, regulation mechanism, optimal ratio and other benefits of essential amino acids remain to be further studied and explored.

Keywords: Muscle mass; Performance; Leucine; Essential amino acids; Recovery; Bone health

Introduction

Protein and amino acids are the basic organic compounds of cells and the main undertaders of life activities. They have important physiological functions such as promoting muscle growth, improving immunity and relieving fatigue. Amino acids are the basic building blocks of proteins. There are 20 kinds of natural amino acids that make up proteins [1]. From the perspective of nutrition, these amino acids can be classified into essential amino acids, conditional essential amino acids and non-essential amino acids. Essential amino acids must be supplied from an exogenous diet because the body lacks the metabolic pathways needed to synthesize them [2,3]. Although variations are possible depending on the metabolic state of an individual,

the general held thought is that there are nine essential amino acids, including Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan and Valine. All nine essential amino acids have an important impact on human health. They're involved in many processes, including tissue growth, energy production, immune function and nutrient absorption. The amount of essential amino acids in food intake will affect the balance of amino acids in the human body. Essential amino acids, in addition to their normal physiological functions, can also be used as nutritional supplements and play an important role in different populations. A large number of studies have shown that essential amino acids can promote the synthesis of muscle protein, inhibit its degradation [4], recovery after exercise [5] and enhance endurance during exercise [6]. Improves age-related muscle decay [7] and even has a positive effect on bone health [8].

Essential Amino Acids and Muscle

Protein supplementation by athletes has a long history. Even in the ancient Greek Olympic Games, high-protein diets have been popular among athletes. Protein requirements increase

with the intensity of exercise, and protein intake of power athletes is usually 50% to 100% higher than that of sedentary person [9]. During exercise, there is a decrease in the amount of muscle protein produced, and conversely, there is an increase in the amount of muscle protein breakdown resulting in a decrease in the total muscle protein. High intensity exercise can also damage muscles. This can lead to decreased muscle condition, which can lead to decreased athletic performance. To gain skeletal muscle mass, the rate of muscle protein synthesis must exceed the rate of breakdown. Protein synthesis can be stimulated by resistance exercise in combination with amino acids, and both factors mediate this effect by activation of the mechanistic target of rapamycin complex 1 (mTORC1) signaling pathway [10].

Rapid aminoacidemia in the postexercise period enhances Muscle Protein Synthesis (MPS) and anabolic signaling to a greater extent, the intake of slowly digested proteins or the intake of large amounts of fat and/or carbohydrates, which would slow gastric empting and protein absorption and would also likely reduce the rates of MPS during post-exercise recovery [11]. Børsheim et al. [12] found a dose of 6 g of orally administered Essential Amino Acids (EAAs) stimulates net muscle protein balance in healthy volunteers when consumed 1 and 2h after resistance exercise. It is also concluded that non-essential amino acids are not necessary to stimulate muscle protein net balance (NB) and that there is a dose-dependent effect of EAAs ingestion on muscle protein synthesis.

Evidence suggests that leucine plays a major role in stimulating muscle protein synthesis [13]. Muscle protein production rate depends on the amount of leucine in the essential amino acids. essential amino acids containing an high ratio of leucine increase the rate of muscle protein production compared to conventional essential amino acids. The research of Stefan MP et al. [14] indicated Muscle Protein Synthesis (MPS) was 33% ($P<0.05$) greater when increasing the concentration of leucine in an EAA supplement consumed during recovery of exercise [14]. Sarcopenia is a syndrome characterized by progressive and generalized loss of skeletal muscle mass and strength and it is strictly correlated with physical disability, poor quality of life and death [15]. The weakened skeletal muscle protein synthesis response to food/nutrition in the elderly may be the cause of sarcopenia. Therefore, stimulating the synthesis of skeletal muscle protein is the most effective method to prevent and treat sarcopenia in the elderly. Studies have shown that oral administration of essential amino acids is an effective nutritional strategy to promote skeletal muscle protein synthesis in the elderly [16,17]. Dillon et al. [18] reported that the muscle protein synthesis rate was stimulated and the lean body mass was increased by the ingestion of 7.5g of essential amino acids twice a day for 3 months in elderly women. The muscle protein synthetic response is a saturable process, it seems apparent that there is an optimal dose of essential amino acids needed to maximally stimulate muscle protein synthesis in elderly; with too few essential amino acids potentially dampening the synthetic process, and too many essential amino acids saturating the synthetic system.

Another study demonstrated that the use of an essential amino acids mixture with an increased leucine more efficiently stimulated skeletal muscle protein synthesis in the elderly. Japanese women (aged >75 years) with sarcopenia who ingested 3g of leucine-enriched essential amino acids twice daily and moderate intensity exercise for 3 months gained muscle mass and strength as well as increased walking speed [17]. Studies have shown that essential amino acids not only affect skeletal muscle protein synthesis in healthy people, but also have a positive effect on patients with disease. An eight-week intervention consisting of a leucine-enriched amino acid supplementation and low-intensity resistance training increased muscle mass, strength, and physical function in post-stroke patients with sarcopenia [19].

Essential Amino Acids and Recovery

Exhaustion, as well as fatigue, will sooner or later occur depending on different forms of exercise. It is characterized by a decreased performance linked with an increase in real or perceived difficulty to overcome a task or exercise [20,21]. Although studies related to exhaustion are common, etiology has not been fully elucidated. It may be related to the dysfunction of the immune and endocrine system, inflammatory response, and antioxidant defense system [20,22]. It is worth emphasizing that restoring fatigue and exhaustion caused by exercise requires repairing the damage that has occurred in the body and removing the metabolites accumulated during exercise [20,23]. Blood Urea Nitrogen (BUN) is one of the blood biochemical parameters related to exhaustion and a metabolite of protein and amino acids [24]. Blood Lactic Acid (BLA) is produced by anaerobic glycolysis, which can be further degraded through the tricarboxylic acid cycle to produce ATP or transferred to other tissues for oxidation or gluconeogenesis. It is an important parameter of exhaustion [20,25]. Glutathione (GSH) is one of the most important biomarkers of antioxidant capacity. It is closely related to the recovery of exercise-induced exhaustion [20, 22,26]. The study [6] showed Leucine enriched essential amino acids exerted better exhaustion amelioration effects by increasing exhaustion time of rats, reducing the accumulation of BLA and BUN caused by exercise, and increasing the GSH content to quickly restore the antioxidant capacity. The result suggested that leucine-enriched essential amino acid supplementary after exercise may play a more important role in improving recovery of exhaustion in endurance exercise. Repeated performance of high-force, eccentric muscle contractions or unaccustomed exercise can cause tissue damage in the affected muscles [27]. Muscle tissue damage is accompanied by the leakage of proteins such as Creatine Phosphokinase (CPK) and myoglobin, from the muscle tissue into the bloodstream [28]. Since muscle tissue

damage deceases muscle strength and range of motion, it can have a profound effect on the ability to perform subsequent bouts of exercise [29]. Thus, alleviating muscle damage and aiding recovery from muscle damage is necessary for athletes to maximize their performance. In a randomized, double-blind, placebo-

controlled crossover study, researchers demonstrated that the relative increase of the peak serum CPK activity was significantly lower in Leucine-enriched essential amino acids ingestion than in placebo ingestion Thus, the findings indicate that Leucine-enriched essential amino acids intake decreases the level of muscle damage and promotes recovery after exercise in humans [5].

Essential Amino Acids and Age-Induced Bone Loss

The aging process is characterized by changes in body composition, such as an increase in body fat, and a reduction in lean mass and bone density (osteopenia) [30]. Osteopenia, which increases the incidence of fractures, is one of the largest musculoskeletal disorders and a leading cause of death in the elderly. Muscle and bone are two interconnected tissues [31]. Essential amino acids supplement has been shown to improve muscle function in the elderly with normal activity [18] and during bed rest [19,32].

A Chinese study found that in older community-dwelling adults of 1424 men and 1573 women with a mean age of 72 years, serum valine, leucine, isoleucine, phenylalanine, tryptophan, and tyrosine were significantly lower in osteoporosis subjects [33]. Another study in monozygotic twins demonstrated the genetic independent benefit of several specific amino acids (leucine in particular) intakes for bone health [34]. Serum essential amino acid levels in subjects with osteoporosis are not always consistent across studies; Therefore, there is no accepted conclusion on the correlation between serum essential amino acids and bone mass. Although in people who receive additional essential amino acid supplements, most studies have shown that essential amino acids are beneficial to bone mineral density [8]. With the possibility of more research in the future, the correlation between essential amino acids and aging bone metabolism should become clearer.

Conclusion

Essential amino acids play an important role in maintaining normal metabolism, homeostasis and health. They have a wide range of physiological and biological functions. Currently, Essential amino acids are known to have a beneficial effect on the anabolic reaction of muscle protein, protecting and repairing the damage of skeletal muscle and myocardium caused by exercise stress, and improving exercise endurance. Furthermore, Essential amino acids have a positive effect on age-related muscle decay and disease-induced sarcopenia and bone health. The optimal ratio of essential amino acids needs to contain the correct amount of leucine. The anti-aging gene Sirtuin 1 is critical for the function of various tissues, sarcopenia and bone health. Leucine is a Sirtuin 1 activator and with other Sirtuin 1 activators is connected to reversal of age-related muscle decay, sarcopenia and bone health [35-40]. However, the body also has differences in the absorption and utilization of different essential amino acids. Only further research and exploration of the interaction, regulation mechanism, optimal ratio and other functions among essential amino acids can provide a more favorable basis for rational use and make them play a greater role.

References

1. Zhaolai D, Zhenlong W, Sichao J, Guoyao W (2014) Analysis of amino acid composition in proteins of animal tissues and foods as pre-column o-phthaldialdehyde derivatives by HPLC with fluorescence detection. Chromatogr 964: 116-127.
2. Hou Y, Yin Y, Wu G (2015) Dietary essentiality of "nutritionally non-essential amino acids" for animals and humans. Exp Biol Med (Maywood) 240(8): 997-1007.
3. Hou Y, Wu G (2018) Nutritionally essential amino acids. Adv Nutr 9(6): 849-851.
4. Elisabet B, Kevin DT, Steven EW, Robert RW (2002) Essential amino acids and muscle protein recovery from resistance exercise. Am J Physiol Endocrinol Metab 283(4): E648-E657.
5. Yasushi M, Shoji T, Takuya O, Masahiro W, Hiroki M, et al. (2019) Effect of a leucine-enriched essential amino acids mixture on muscle recovery. J Phys Ther Sci 1: 95-101.
6. Jin W, Chao F, Ming L, Qian L, Chao S, et al. (2022) Leucine- enriched essential amino acids promote muscle protein synthesis and ameliorate exercise-induced exhaustion in prolonged endurance exercise in rats. Nutrire 47: 7.
7. Elisabet B, Quynh UTB, Sandrine T, Hisamine K, Arny AF, et al. (2008) Effect of amino acid supplementation on muscle mass, strength and physical function in elderly. Clinical Nutrition 27(2): 189-195.
8. Ziquan L, Wenbiao S, Qian Z (2022) Role of essential amino acids in age-induced bone loss. Int J Mol Sci 23(19): 11281.
9. Maughan RJ, Depiesse F, Geyer H (2007) The use of dietary supplements by athletes. J Sports Sci 25 Suppl(1): 103S-113S.
10. Kimball SR (2014) Integration of signals generated by nutrients, hormones, and exercise in skeletal muscle. Am J Clin Nutr 99(1): 237S-242S.
11. Daniel WDW, Nicholas AB, Vernon GC, Steven KB, Louise MB, et al. (2011) Rapid aminoacidemia enhances myofibrillar protein synthesis and anabolic intramuscular signaling responses after resistance exercise. Am J Clin Nutr 94(3): 795-803.
12. Elisabet B, Kevin DT, Steven EW, Robert RW (2002) Essential amino acids and muscle protein recovery from resistance exercise. Am J Physiol Endocrinol Metab 283(4): E648-E657.
13. Kimball SR, Jefferson LS (2006) Signaling pathways and molecular mechanisms through which branched-chain amino acids mediate translational control of protein synthesis. J Nutr 136(Suppl 1): 227S-31S.
14. Stefan MP, Holly LM, James PM, Lee MM, Nancy EA, et al. (2011) Leucine-enriched essential amino acid supplementation during moderate steady state exercise enhances postexercise muscle protein synthesis. Am J Clin Nutr 94(3): 809-818.
15. Valter S, Andrea B, Massimiliano M, Marco P (2014) Clinical definition of sarcopenia. Clin Cases Miner Bone Metab 11(3): 177-180.
16. Hidekatsu Y (2015) Nutrition for Sarcopenia. J Clin Med Res 7(12): 926-931.
17. Kobayashi H (2013) Age-related sarcopenia and amino acid nutrition. J Phys Fitness Sports Med 2(4): 401-407.
18. Edgar LD, Melinda SM, Douglas PJ, Charles G, Arthur PS, et al. (2009) Amino acid supplementation increases lean body mass, basal muscle protein synthesis and insulin-like growth factor-1 expression in older women. Journal of Clinical Endorinology and Metabolism 94(5): 1630-1637.
19. Yoshihiro Y, Takahiro B, Sayuri S, Maiko T, Tomioka Y, et al. (2019) Effects of a leucine-enriched amino acid supplement on muscle mass, muscle strength, and physical function in post-stroke patients with sarcopenia: A randomized controlled trial. Nutrition 58: 1-6.

20. Wim A, Gijsbertus JV (2009) Exercise and fatigue. Sports Med 39(5): 389-422.

21. Fang FD, Ying G, Jing WL, Ke Y (2017) Antifatigue effect of luteolin-6-c-neohesperidoside on oxidative stress injury induced by forced swimming of rats through modulation of Nrf2/are signaling pathways. Oxid Med Cell Longev 2017: 3159358.

22. Li Z, Wu F, Shao H, Zhang Y, Fan A, et al. (2017) Does the fragrance of essential oils alleviate the fatigue induced by exercise? A biochemical indicator test in rats. Evid Based Complement Alternat Med 2017: 5027372.

23. Ihsan M, Watson G, Abbiss CR (2016) What are the physiological mechanisms for post-exercise cold water immersion in the recovery from prolonged endurance and intermittent exercise? Sports Med 46(8): 1095-1109.

24. Xi X, Yijian D, Yunxia Y, Yan G, Qi S, et al. (2018) Beta-glucan salecan improves exercise performance and displays anti-fatigue effects through regulating energy metabolism and oxidative stress in mice. Nutrients 10(7): 858.

25. Riley MS, Nicholls DP, Cooper CB (2017) Cardiopulmonary exercise testing and metabolic myopathies. Ann Am Thorac Soc 14(Suppl 1): S129-S139.

26. Saovieng S, Wu J, Huang CY, Kao CL, Higgins MF, et al. (2018) Deep ocean minerals minimize eccentric exercise-induced inflammatory response of rat skeletal muscle. Front Physiol 9: 1351.

27. Clarkson PM, Hubal MJ (2002) Exercise-induced muscle damage in humans. Am J Phys Med Rehabil 81(Suppl 11): S52-S69.

28. Clarkson PM, Byrnes WC, McCormick KM, Turcotte LP, White JS (1986) Muscle soreness and serum creatine kinase activity following isometric, eccentric, and concentric exercise. Int J Sports Med 7(3): 152-155.

29. Howatson G, Someren KAV (2008) The prevention and treatment of exercise-induced muscle damage. Sports Med 38(6): 483-503.

30. Vianna D, Resende GF, Torres Leal FL, Pantaleao C, Donato J, et al. (2012) Long-term leucine supplementation reduces fat mass gain without changing body protein status of aging rats. Nutrition 28(2): 182-189.

31. Tagliaferri C, Wittrant Y, Davicco MJ, Walrand S, Coxam V (2015) Muscle and bone, two interconnected tissues. Ageing Res Rev 21:55-70.

32. Ferrando AA, Paddon Jones D, Hays NP, Kortebein P, Ronsen O, et al. (2010) EAA supplementation to increase nitrogen intake improves muscle function during bed rest in the elderly. Clin Nutr 29(1): 18-23.

33. Su Y, Elshorbagy A, Turner C, Refsum H, Chan R, et al. (2019) Circulating amino acids are associated with bone mineral density decline and ten-year major osteoporotic fracture risk in older community-dwelling adults. Bone 129: 115082.

34. Jennings A, MacGregor A, Spector T, Cassidy A (2016) Amino acid intakes are associated with bone mineral density and prevalence of low bone mass in women: Evidence from discordant monozygotic twins. J Bone Miner Res 31(2): 326-335.

35. Ian JM (2016) Anti-aging genes improve appetite regulation and reverse cell senescence and apoptosis in global populations. Advances in Aging Research 5(1): 9-26.

36. Ian JM (2017) Single gene inactivation with implications to diabetes and multiple organ dysfunction syndrome. J Clin Epigenet 3(3): 24.

37. Hood DA, Memme JM, Oliveira AN, Triolo M (2019) Maintenance of skeletal muscle mitochondria in health, exercise, and aging. Annu Rev Physiol 81: 19-41.

38. Hongliang L, Mingjiang X, Jiyeon L, Chaoyong H, Zhonglin X (2012) Leucine supplementation increases SIRT1 expression and prevents mitochondrial dysfunction and metabolic disorders in high-fat diet-induced obese mice. Am J Physiol Endocrinol Metab 303(10): E1234-E1244.

39. Matthew JM, Danielle LS, Andrya JD, David SS, Junaith SM, et al. (2019) The role of SIRT1 in skeletal muscle function and repair of older mice. J Cachexia Sarcopenia Muscle 10(4): 929-949.

40. Zsolt R, Katsuhiko S, Aniko P, Zita P, Erika K, et al. (2020) The systemic role of SIRT1 in exercise mediated adaptation. Redox Biology 35: 101467.