

# Aging with Amino Acids

## Introduction

When we think about our health the general public has been educated to connect nutrition with wellness and longevity. However, they typically lack adequate information to integrate optimum nutrition into their lifestyle. I believe the general public has never been taught to translate nutrition into nutrients. It's such a simple leap. But, a powerful leap towards true health.

The most common approach to improved nutrition, besides improving the diet, is to purchase specific nutritional products such as a multivitamin/mineral or a single cofactor such as vitamin B, D, K, folic acid and or minerals such as calcium, iron and or zinc. Some people choose to select the essential fatty acids supplements such as omega 3 fish oil. There is also a new movement to purchase a high quality probiotic for gastrointestinal health. Given our body's needs for these essential nutrients to restore and maintain health, these are all actually extremely good choices as a starting point.

However, what I have observed over a 25-year career as a practicing health physician is that most individuals taking expensive nutritional supplements, for the most part, still have the chronic ailments that led them to take the supplements in the first place.

In the early 2000's I began introducing my patients to free form amino acid supplements as an adjunct to chiropractic care—as a type of metabolic tune up. I first started using single high doses of amino acids, such as L-Tryptophan for mood and sleep disorders; Tyrosine for a short memory problem and depression and GABA for anxiety. These are a few of the classic approaches to individual's ailments and the use of amino acid therapy.

What I discovered during my quest to find the perfect metabolic tune up for my patients is the robust potency of supplementing with broad spectrum free form amino acids. This nutritional approach to health—

amino nutrients—provides the synergy necessary for wellness and longevity.

According to Dr. Robert Lue, Ph.D. of Harvard University, “We have over 70 trillion living cells in our body.” These cells range from heart cells, bone cells, brain cells, pancreas cells, gastrointestinal cells and so on. “In each of these trillions of cells there are tens of thousands of enzymatic chemical actions occurring every second.” Think about that! These are astronomical numbers. The essential needs of fueling these cells every second and the fuel for these enzymes are ALL amino acids. It is staggering and also demonstrates the beauty and miracle of the body and the universal intelligence that allows all this to happen in an order that maintains our human health.

Amino acids are the building blocks for all protein structures. Amino acids are the precursors, the building blocks, to ALL the enzymes in your body. Other jobs these amino acids have are to strengthen our immune system, construct and synthesis over 50 neurotransmitters in your brain and central nervous system. They strengthen your bones and in fact are over 80% of the density of the bone marrow. Amino acids build strong nails, hair and provide healthy skin. The list of the values of amino acids goes on and on, as amino acids are the building blocks for every cell in your body.

Additionally, of the classic 22 amino acids, 10 essential and 12 non-essential, one third of them tear down tissue and or aid to detoxify pollutants in your system that are produced from environmental chemicals, body waste, medicines, nicotine, alcohol, refined processed foods and so on. Amino acids are the most critically misunderstood essential nutrient requirement for healthy support to the body from infancy, childhood, adults and senior citizens.

## **As We Age**

As we age nutritional needs may actually increase as appetite may decrease. [23] Amino acids have been found to be lower in both blood and muscle of aged humans. [63,77] Amino acid supplements have shown exciting potential to restore and maintain the health of aging men and women, improving muscle mass, protecting from heart

damage, increasing muscle strength, improving insulin sensitivity and more. [1,5,10,12,27,30,40,43,55,57,60,61,66,68,71-74,78]

We are all concerned about the seemingly inevitable increases in heart disease, adult onset diabetes, sarcopenia (muscle wasting associated with aging), age related depression, and loss of memory. Research over the past few years has shown daily supplementation of essential amino acids improves muscle mass with or without exercise [3,29,58], as well as improving insulin resistance, [2,60,61,72-74] a common complication of aging and precursor to the development of type II adult onset diabetes.

Amino acid supplements protect the brain and heart and increase muscle mitochondria while reducing muscle fibrosis (inactive fibrous tissue replacing healthy muscle). [10,28,55] Mitochondria are the powerhouses of all of our cells and aging is associated with decreased mitochondria in muscle and brain. Restoring essential mitochondria is an important part of any anti-aging program.

Amino acid supplements increase the production of essential enzymes which enhance and protect muscle (including the heart) and brain. We often think of enzymes in terms of digestion, and amino acids do support healthy digestion, but every metabolic change throughout the body and brain is controlled and modified by enzymes. [5,61,65,70,78]

Exercise is important for both body and brain. Significant daily exercise reduces blood pressure, heart disease, insulin resistance, obesity, osteoporosis and even depression. [4,22,23,26,45,46,49,50,53,54,58,67,80] When exercising is difficult, because of fatigue, weakness, or muscle insufficiency, amino acid supplements have been shown to improve exercise capacity. [1,6,21,23,69-71]

Inactivity, often accompanying aging and illness, alters the body's ability to utilize protein. Amino acid supplements, which require no digestion, show potential to reverse this condition, as well as the muscle wasting caused by corticosteroid medications. [25,56] This in turn may allow one to begin a regular program of physical activity further increasing longevity.

Total Amino Solution™ is a complete amino acid supplement which addresses issues of aging by providing not just a complement of essential amino acids but further increases its effectiveness by providing several conditionally essential amino acids. These include L-carnitine to improve fat burning, cognitive function, and heart function [35,38,39,44,48,51], and taurine, a membrane stabilizer, antioxidant, and calcium stabilizer, as well as a key component of the functioning muscle, heart, brain and eye. [11,14,20,33,36,41,47,52,62,64,79] In addition, taurine, along with other aminos, has shown benefit to learning and memory retention and is necessary for a functioning immune system. [19,65]

Total Amino Solution™ has been further enhanced by the addition of a complement of the B vitamins niacinamide, riboflavin, pyridoxal-5-phosphate, and B-12 which provide the essential elements for production of critical enzymes throughout the body and brain. These B vitamins have been clinically shown to decrease homocysteine, a problematic by product of metabolism that when elevated is associated with dementias, heart disease, osteoporosis, depression, and even mobility. [7-9,15-17,24,31,34,37,42]

B vitamin status is often overlooked in the diet of seniors. Hyperhomocysteinemia (elevated homocysteine) is a common finding in this group and both additional B vitamins, especially B-6, folic acid and B-12, and protein, which might include a complete amino acid such as Total Amino Solution™, lower homocysteine. [7,13,32,76]

Further B-12, folic acid, and elevated homocysteine have been shown to be related to thyroid insufficiency in aging. [75] These two important B vitamins have also been associated with hearing loss in older adults. [18,59] Thyroid problems increase incidence of immobility and depression and dramatically decrease quality of life, as does loss of hearing.

The amino acids found in Total Amino Solution™ combined with the complex of B vitamins synergistically support healthy aging. As we age understanding our decreased need for calories combined with an increased need for essential nutrition, including amino acids and B vitamins, gives us the knowledge we need to support our bodies so that we may enjoy a long and healthy life.

## Reference List

- [1] Aquilani R, Viglio S, Iadarola P, Opasich C, Testa A, Dioguardi FS, Pasini E. Oral amino acid supplements improve exercise capacities in elderly patients with chronic heart failure. *Am J Cardiol* 2008;101(11A):104E-10E.
- [2] Arwert LI, Deijen JB, Drent ML. Effects of an oral mixture containing glycine, glutamine and niacin on memory, GH and IGF-I secretion in middle-aged and elderly subjects. *Nutr Neurosci* 2003;6(5):269-75.
- [3] Borsheim E, Bui QU, Tissier S, Kobayashi H, Ferrando AA, Wolfe RR. Effect of amino acid supplementation on muscle mass, strength and physical function in elderly. *Clin Nutr* 2008;27(2):189-95.
- [4] Boveris A, Navarro A. Brain mitochondrial dysfunction in aging. *IUBMB Life* 2008;60(5):308-14.
- [5] Brocca L, D'Antona G, Bachi A, Pellegrino MA. Amino acid supplements improve native antioxidant enzyme expression in the skeletal muscle of diabetic mice. *Am J Cardiol* 2008;101(11A):57E-62E.
- [6] Brooks N, Cloutier GJ, Cadena SM, Layne JE, Nelsen CA, Freed AM, Roubenoff R, Castaneda-Sceppa C. Resistance training and timed essential amino acids protect against the loss of muscle mass and strength during 28 days of bed rest and energy deficit. *J Appl Physiol* 2008;105(1):241-8.
- [7] Buell JS, Arsenault LN, Scott TM, Qiao QW, Rosenberg IH, Folstein MF, Tucker KL. Multivitamin use and B vitamin status in a homebound elderly population. *J Nutr Health Aging* 2007;11(4):299-303.
- [8] Carlsson CM. Homocysteine lowering with folic acid and vitamin B supplements: effects on cardiovascular disease in older adults. *Drugs Aging* 2006;23(6):491-502.
- [9] Carlsson CM, Pharo LM, Aeschlimann SE, Mitchell C, Underbakke G, Stein JH. Effects of multivitamins and low-dose folic acid supplements on flow-mediated vasodilation and plasma homocysteine levels in older adults. *Am Heart J* 2004;148(3):E11.
- [10] Chen SC, McCauley RB, Yuan Z, Di RJ, Patel D, Putt J, Raddino R, Allebban Z, Abboud J, Scarabelli GM, Chilukuri K, Gardin J, Saravolatz L, Faggian G, Mazzucco A, Scarabelli TM. Oral administration of amino acidic supplements improves protein and energy profiles in skeletal muscle of aged rats: elongation of functional performance and acceleration of mitochondrial recovery in adenosine triphosphate after exhaustive exertion. *Am J Cardiol* 2008;101(11A):42E-8E.
- [11] Conte CD, Tricarico D, Pierno S, Desaphy JF, Liantonio A, Pusch M, Burdi R, Camerino C, Frayssse B, De LA. Taurine and skeletal muscle disorders. *Neurochem Res* 2004;29(1):135-42.
- [12] Corsetti G, Pasini E, D'Antona G, Nisoli E, Flati V, Assanelli D, Dioguardi FS, Bianchi R. Morphometric changes induced by amino acid supplementation in skeletal and cardiac muscles of old mice. *Am J Cardiol* 2008;101(11A):26E-34E.
- [13] Dankner R, Chetrit A, Lubin F, Sela BA. Life-style habits and homocysteine levels in an elderly population. *Aging Clin Exp Res* 2004;16(6):437-42.
- [14] Dawson R, Jr. Taurine in aging and models of neurodegeneration. *Adv Exp Med Biol* 2003;526:537-45.
- [15] Delport R. Hyperhomocyst(e)inemia, related vitamins and dementias. *J Nutr Health Aging* 2000;4(4):195-6.
- [16] Dimopoulos N, Piperi C, Salonicoti A, Psarra V, Gazi F, Nounopoulos C, Lea RW, Kalofoutis A. Association of cognitive impairment with plasma levels of folate, vitamin B12 and homocysteine in the elderly. *In Vivo* 2006;20(6B):895-9.
- [17] Dimopoulos N, Piperi C, Salonicoti A, Psarra V, Gazi F, Papadimitriou A, Lea RW, Kalofoutis A. Correlation of folate, vitamin B12 and homocysteine plasma levels with depression in an elderly Greek population. *Clin Biochem* 2007;40(9-10):604-8.
- [18] Durga J, Verhoef P, Anteunis LJ, Schouten E, Kok FJ. Effects of folic acid supplementation on hearing in older adults: a randomized, controlled trial. *Ann Intern Med* 2007;146(1):1-9.
- [19] El IA. Taurine improves learning and retention in aged mice. *Neurosci Lett* 2008;436(1):19-22.

- [20] Eppler B, Dawson R, Jr. Cytoprotective role of taurine in a renal epithelial cell culture model. *Biochem Pharmacol* 2002;63(6):1051-60.
- [21] Evans WJ. Protein nutrition and resistance exercise. *Can J Appl Physiol* 2001;26 Suppl:S141-52.:S141-S152.
- [22] Evans WJ. Effects of exercise on senescent muscle. *Clin Orthop Relat Res* 2002;(403 Suppl):S211-S220.
- [23] Evans WJ. Protein nutrition, exercise and aging. *J Am Coll Nutr* 2004;23(6 Suppl):601S-9S.
- [24] Feng L, Ng TP, Chuah L, Niti M, Kua EH. Homocysteine, folate, and vitamin B-12 and cognitive performance in older Chinese adults: findings from the Singapore Longitudinal Ageing Study. *Am J Clin Nutr* 2006;84(6):1506-12.
- [25] Ferrando AA, Paddon-Jones D, Wolfe RR. Alterations in protein metabolism during space flight and inactivity. *Nutrition* 2002;18(10):837-41.
- [26] Fillit H, Nash DT, Rundek T, Zuckerman A. Cardiovascular risk factors and dementia. *Am J Geriatr Pharmacother* 2008;6(2):100-18.
- [27] Flati V, Pasini E, D'Antona G, Specia S, Toniato E, Martinotti S. Intracellular mechanisms of metabolism regulation: the role of signaling via the mammalian target of rapamycin pathway and other routes. *Am J Cardiol* 2008;101(11A):16E-21E.
- [28] Friguet B, Bulteau AL, Petropoulos I. Mitochondrial protein quality control: implications in ageing. *Biotechnol J* 2008;3(6):757-64.
- [29] Fujita S, Volpi E. Amino acids and muscle loss with aging. *J Nutr* 2006;136(1 Suppl):277S-80S.
- [30] Gheorghade M, Filippatos GS, Fonarow GC, Anker SD. Nutritional supplementation with amino acids in cardiovascular and metabolic diseases: hypermetabolic syndrome as a therapeutic target. Introduction. *Am J Cardiol* 2008;101(11A):1E-2E.
- [31] Gonzalez-Gross M, Marcos A, Pietrzik K. Nutrition and cognitive impairment in the elderly. *Br J Nutr* 2001;86(3):313-21.
- [32] Gonzalez-Gross M, Sola R, Albers U, Barrios L, Alder M, Castillo MJ, Pietrzik K. B-vitamins and homocysteine in Spanish institutionalized elderly. *Int J Vitam Nutr Res* 2007;77(1):22-33.
- [33] Grimble RF. The effects of sulfur amino acid intake on immune function in humans. *J Nutr* 2006;136(6 Suppl):1660S-5S.
- [34] Haan MN, Miller JW, Aiello AE, Whitmer RA, Jagust WJ, Mungas DM, Allen LH, Green R. Homocysteine, B vitamins, and the incidence of dementia and cognitive impairment: results from the Sacramento Area Latino Study on Aging. *Am J Clin Nutr* 2007;85(2):511-7.
- [35] Hooshmand S, Balakrishnan A, Clark RM, Owen KQ, Koo SI, Arjmandi BH. Dietary l-carnitine supplementation improves bone mineral density by suppressing bone turnover in aged ovariectomized rats. *Phytomedicine* 2008;15(8):595-601.
- [36] Hu S, Zhao X, Yin S, Meng J. [A study on the mechanism of taurine postponing the aging process of human fetal brain neural cells]. *Wei Sheng Yan Jiu* 1997;26(2):98-101.
- [37] Jacques PF, Selhub J, Bostom AG, Wilson PW, Rosenberg IH. The effect of folic acid fortification on plasma folate and total homocysteine concentrations. *N Engl J Med* 1999;340(19):1449-54.
- [38] Janson M. Orthomolecular medicine: the therapeutic use of dietary supplements for anti-aging. *Clin Interv Aging* 2006;1(3):261-5.
- [39] Kaczor JJ, Ziolkowski W, Antosiewicz J, Hac S, Tarnopolsky MA, Popinigis J. The effect of aging on anaerobic and aerobic enzyme activities in human skeletal muscle. *J Gerontol A Biol Sci Med Sci* 2006;61(4):339-44.
- [40] Kalantar-Zadeh K, Anker SD, Horwich TB, Fonarow GC. Nutritional and anti-inflammatory interventions in chronic heart failure. *Am J Cardiol* 2008;101(11A):89E-103E.
- [41] Kim SJ, Ramesh C, Gupta H, Lee W. Taurine-diabetes interaction: from involvement to protection. *J Biol Regul Homeost Agents* 2007;21(3-4):63-77.
- [42] Kuo HK, Liao KC, Leveille SG, Bean JF, Yen CJ, Chen JH, Yu YH, Tai TY. Relationship of homocysteine levels to quadriceps strength, gait speed, and late-life disability in older adults. *J Gerontol A Biol Sci Med Sci* 2007;62(4):434-9.
- [43] Lainscak M, Filippatos GS, Gheorghade M, Fonarow GC, Anker SD. Cachexia: common, deadly, with an urgent need for precise definition and new therapies. *Am J Cardiol* 2008;101(11A):8E-10E.

- [44] Lesnefsky EJ, He D, Moghaddas S, Hoppel CL. Reversal of mitochondrial defects before ischemia protects the aged heart. *FASEB J* 2006;20(9):1543-5.
- [45] Lindwall M, Rennemark M, Berggren T. Movement in mind: the relationship of exercise with cognitive status for older adults in the Swedish National Study on Aging and Care (SNAC). *Aging Ment Health* 2008;12(2):212-20.
- [46] Lopez-Lluch G, Irueta PM, Navas P, de CR. Mitochondrial biogenesis and healthy aging. *Exp Gerontol* 2008.
- [47] Louzada PR, Lima AC, Mendonca-Silva DL, Noel F, De Mello FG, Ferreira ST. Taurine prevents the neurotoxicity of beta-amyloid and glutamate receptor agonists: activation of GABA receptors and possible implications for Alzheimer's disease and other neurological disorders. *FASEB J* 2004;18(3):511-8.
- [48] Malaguarnera M, Cammalleri L, Gargante MP, Vacante M, Colonna V, Motta M. L-Carnitine treatment reduces severity of physical and mental fatigue and increases cognitive functions in centenarians: a randomized and controlled clinical trial. *Am J Clin Nutr* 2007;86(6):1738-44.
- [49] Martinez GK, Clebis NK, Stabille SR, De Britto MR, De Sousa JM, De Souza RR. Exercise reduces inhibitory neuroactivity and protects myenteric neurons from age-related neurodegeneration. *Auton Neurosci* 2008;141(1-2):31-7.
- [50] Masley SC, Weaver W, Peri G, Phillips SE. Efficacy of lifestyle changes in modifying practical markers of wellness and aging. *Altern Ther Health Med* 2008;14(2):24-9.
- [51] Mat di San FC, Taylor MR, Mestroni L, Botto LD, Longo N. Cardiomyopathy and carnitine deficiency. *Mol Genet Metab* 2008;94(2):162-6.
- [52] Militante J, Lombardini JB. Age-related retinal degeneration in animal models of aging: possible involvement of taurine deficiency and oxidative stress. *Neurochem Res* 2004;29(1):151-60.
- [53] Myers JS. Factors associated with changing cognitive function in older adults: implications for nursing rehabilitation. *Rehabil Nurs* 2008;33(3):117-23.
- [54] Nichol KE, Poon WW, Parachikova AI, Cribbs DH, Glabe CG, Cotman CW. Exercise alters the immune profile in Tg2576 Alzheimer mice toward a response coincident with improved cognitive performance and decreased amyloid. *J Neuroinflammation* 2008;5:13.
- [55] Nisoli E, Cozzi V, Carruba MO. Amino acids and mitochondrial biogenesis. *Am J Cardiol* 2008;101(11A):22E-5E.
- [56] Paddon-Jones D, Wolfe RR, Ferrando AA. Amino acid supplementation for reversing bed rest and steroid myopathies. *J Nutr* 2005;135(7):1809S-12S.
- [57] Pansarasa O, Flati V, Corsetti G, Brocca L, Pasini E, D'Antona G. Oral amino acid supplementation counteracts age-induced sarcopenia in elderly rats. *Am J Cardiol* 2008;101(11A):35E-41E.
- [58] Parise G, Yarasheski KE. The utility of resistance exercise training and amino acid supplementation for reversing age-associated decrements in muscle protein mass and function. *Curr Opin Clin Nutr Metab Care* 2000;3(6):489-95.
- [59] Park S, Johnson MA, Shea-Miller K, De Chicchis AR, Allen RH, Stabler SP. Age-related hearing loss, methylmalonic acid, and vitamin B12 status in older adults. *J Nutr Elder* 2006;25(3-4):105-20.
- [60] Pasini E, Aquilani R, Dioguardi FS, D'Antona G, Gheorghiane M, Taegtmeier H. Hypercatabolic syndrome: molecular basis and effects of nutritional supplements with amino acids. *Am J Cardiol* 2008;101(11A):11E-5E.
- [61] Pellegrino MA, Patrini C, Pasini E, Brocca L, Flati V, Corsetti G, D'Antona G. Amino acid supplementation counteracts metabolic and functional damage in the diabetic rat heart. *Am J Cardiol* 2008;101(11A):49E-56E.
- [62] Pierno S, De LA, Camerino C, Huxtable RJ, Camerino DC. Chronic administration of taurine to aged rats improves the electrical and contractile properties of skeletal muscle fibers. *J Pharmacol Exp Ther* 1998;286(3):1183-90.
- [63] Pitkanen HT, Oja SS, Kempainen K, Seppa JM, Mero AA. Serum amino acid concentrations in aging men and women. *Amino Acids* 2003;24(4):413-21.
- [64] Rivas-Arancibia S, Dorado-Martinez C, Borgonio-Perez G, Hiriart-Urdanivia M, Verdugo-Diaz L, Duran-Vazquez A, Colin-Baranque L, Vila-Costa MR. Effects of taurine on ozone-induced

memory deficits and lipid peroxidation levels in brains of young, mature, and old rats. *Environ Res* 2000;82(1):7-17.

- [65] Roth E. Immune and cell modulation by amino acids. *Clin Nutr* 2007;26(5):535-44.
- [66] Scarabelli TM, Townsend PA, Chen SC, Yuan Z, McCauley RB, Di RJ, Patel D, Putt J, Allebban Z, Abboud J, Chilukuri K, Gardin J, Saravolatz L, Knight RA, Latchman DS, Stephanou A. Amino acid supplementation differentially modulates STAT1 and STAT3 activation in the myocardium exposed to ischemia/reperfusion injury. *Am J Cardiol* 2008;101(11A):63E-8E.
- [67] Schwab P, Klein RF. Nonpharmacological approaches to improve bone health and reduce osteoporosis. *Curr Opin Rheumatol* 2008;20(2):213-7.
- [68] Scognamiglio R, Negut C, Palisi M, Dioguardi FS, Coccato M, Iliceto S. Effects of oral amino acid supplements on cardiac function and remodeling in patients with type 2 diabetes with mild-to-moderate left ventricular dysfunction. *Am J Cardiol* 2008;101(11A):111E-5E.
- [69] Scognamiglio R, Negut C, Piccolotto R, Dioguardi FS, Tiengo A, Avogaro A. Effects of oral amino acid supplementation on myocardial function in patients with type 2 diabetes mellitus. *Am Heart J* 2004;147(6):1106-12.
- [70] Scognamiglio R, Piccolotto R, Negut C, Tiengo A, Avogaro A. Oral amino acids in elderly subjects: effect on myocardial function and walking capacity. *Gerontology* 2005;51(5):302-8.
- [71] Scognamiglio R, Testa A, Aquilani R, Dioguardi FS, Pasini E. Impairment in walking capacity and myocardial function in the elderly: is there a role for nonpharmacologic therapy with nutritional amino acid supplements? *Am J Cardiol* 2008;101(11A):78E-81E.
- [72] Solerte SB, Fioravanti M, Locatelli E, Bonacasa R, Zamboni M, Basso C, Mazzoleni A, Mansi V, Geroutis N, Gazzaruso C. Improvement of blood glucose control and insulin sensitivity during a long-term (60 weeks) randomized study with amino acid dietary supplements in elderly subjects with type 2 diabetes mellitus. *Am J Cardiol* 2008;101(11A):82E-8E.
- [73] Solerte SB, Gazzaruso C, Bonacasa R, Rondanelli M, Zamboni M, Basso C, Locatelli E, Schifino N, Giustina A, Fioravanti M. Nutritional supplements with oral amino acid mixtures increases whole-body lean mass and insulin sensitivity in elderly subjects with sarcopenia. *Am J Cardiol* 2008;101(11A):69E-77E.
- [74] Solerte SB, Gazzaruso C, Schifino N, Locatelli E, Destro T, Ceresini G, Ferrari E, Fioravanti M. Metabolic effects of orally administered amino acid mixture in elderly subjects with poorly controlled type 2 diabetes mellitus. *Am J Cardiol* 2004;93(8A):23A-9A.
- [75] Stella G, Spada RS, Calabrese S, Bosco P, Anello G, Gueant-Rodriguez RM, Romano A, Benamghar L, Proto C, Castellano A, Fajardo A, Lipari L, Sirna S, Gueant JL. Association of thyroid dysfunction with vitamin B12, folate and plasma homocysteine levels in the elderly: a population-based study in Sicily. *Clin Chem Lab Med* 2007;45(2):143-7.
- [76] Stolzenberg-Solomon RZ, Miller ER, III, Maguire MG, Selhub J, Appel LJ. Association of dietary protein intake and coffee consumption with serum homocysteine concentrations in an older population. *Am J Clin Nutr* 1999;69(3):467-75.
- [77] Sturenburg HJ, Stangneth B, Schoser BG. Age related profiles of free amino acids in human skeletal muscle. *Neuro Endocrinol Lett* 2006;27(1-2):133-6.
- [78] Taegtmeier H, Harinsein ME, Gheorghide M. More than bricks and mortar: comments on protein and amino acid metabolism in the heart. *Am J Cardiol* 2008;101(11A):3E-7E.
- [79] Takihara K, Azuma J, Awata N, Ohta H, Sawamura A, Kishimoto S, Sperelakis N. Taurine's possible protective role in age-dependent response to calcium paradox. *Life Sci* 1985;37(18):1705-10.
- [80] Wagner KH, Haber P, Elmadfa I. Thanks to body exercise, getting mobile and being less dependent. *Ann Nutr Metab* 2008;52 Suppl 1:38-42