FATIGUE

Carnitine Transports fatty acids into mitochondria; Decreases both mental and physical fatigue in clinical trials.[15,31,32]

Chromium Promotes glucose uptake into cells, helping stabilize blood sugar.[16,33]

Zinc Deficiency lowers immunity and may cause muscle fatigue; Involved in several reactions for energy metabolism.[15,34,35]

Asparagine Supplementation of this amino acid delayed fatigue during exercise by decreasing the rate at which glycogen was used up; needed for gluconeogenesis, a process that allows glucose to be made from protein to prevent blood sugar from getting too low.[1,2,3]

B Vitamins Necessary for converting food into energy; Cofactors in the mitochondrial respiratory chain include B1, B2, B3, B5, B6, B12 and Folate.[8,15,16,26-30]

Biotin Helps liver utilize glycogen for energy. Animal studies confirm that biotin deficiency causes clinical fatigue.[4]

Vitamin D Low levels are seen in patients with chronic fatigue syndrome; Deficiency causes reduced muscle strength.[24,25]

Glutamine Mental and physical fatigue coincides with reduced levels of this amino acid in various tissues. Supplementation makes muscle more sensitive to insulin, increasing energy levels.[5,6,7]

Vitamin E Inverse correlation exists between fatigue and vitamin E levels.[23]

Serine Counteracts the overproduction of fatigue-causing stress hormones.[8,9]

Vitamin A When cellular levels of vitamin A are low, mitochondrial respiration and ATP production decreases.[22]

CoQ10 Deficiency causes fatigue due to its role in mitochondrial energy metabolism; therapeutic benefits particularly noticeable in chronic fatigue syndrome.[10,11,12,15]

Vitamin C Assists iron uptake and transport; Precursor to carnitine and several hormones that affect energy levels. Supplementation reduced fatigue in various trials.[15,16,21]

Antioxidants Several studies confirm that oxidative stress exacerbates clinical symptoms of fatigue. Mitochondrial dysfunction (inefficient energy metabolism) can be treated therapeutically with antioxidants such as Selenium, Cysteine, a-Lipoic acid and Glutathione, of which unusually low levels are seen in chronic fatigue patients.[12,16,18,19,20]

Magnesium Required to store energy molecule ATP; Repletion of magnesium in chronic fatigue patients shows clinical improvement in energy levels.[15,16,17]

Fructose Intolerance Fatigue (and hypoglycemia) are classic symptoms of this condition, since it depletes the main form of cellular energy, ATP.[13,14]

REFERENCES

[1]Marquezi M, Roschel H et al. Effect of aspartate and asparagine supplementation on fatigue determinants in intense exercise. *Int J Sport Nutr Exer Metab* 2003;13:65-75.

[2]Lancha A, Recco M et al. Effect of aspartate, asparagine, and carnitine supplementation in the diet on metabolism of skeletal muscle during a moderate exercise. *Physiol Behav* 1995;57:367-371.

[3]Efthivoulou M, Phillips J, Berry M. Abolition of the inhibitory effect of ethanol oxidation on gluconeogenesis from lactate by asparagine or low concentrations of ammonia. *Biochim Biophys Acta* 1995;1244:303-310.

[4]Osada K, Komai M et al. Experimental study of fatigue provoked by biotin deficiency in mice. *Int J Vitam Nutr Res* 2004;74:334-340.

[5]Jin G, Kataoka Y et al. Changes in plasma and tissue amino acid levels in an animal model of complex fatigue. *Nutrition* 2009;25:597-607.

[6]Prada P, Hirabara S et al. L-glutamine supplementation induces insulin resistance in adipose tissue and improves insulin signalling in liver and muscle of rats with diet-induced obesity. *Diabetologia* 2007;50:1949-1959.

[7]Greenfield J, Farooqi I et al. Oral glutamine increases circulating glucagon-like peptide 1, glucagon, and insulin concentrations in lean, obese, and type 2 diabetic subjects. *Am J Clin Nutr* 2009;89:106-113.

[8]Head K, Kelly G. Nutrients and botanicals for treatment of stress: adrenal fatigue, neurotransmitter imbalance, anxiety, and restless sleep. *Altern Med Rev* 2009;14:114-140.

[9]Starks M, Starks S et al. The effects of phosphatidylserine on endocrine response to moderate intensity exercise. *J Int Soc Sports Nutr* 2008;5:11.

[10]Mizuno K, Tanaka M et al. Antifatigue effects of coenzyme Q10 during physical fatigue. *Nutrition* 2008;24:293-299.

[11]Maes M, Mihaylova I et al. Coenzyme Q10 deficiency in myalgic encephalomyelitis / chronic fatigue syndrome (ME/CFS) is related to fatigue, autonomic and neurocognitive symptoms and is another risk factor explaining the early mortality in ME/CFS due to cardi. *Neuro Endocrinol Lett* 2009;30:47-476.

[12] Logan A, Wong C. Chronic fatigue syndrome: oxidative stress and dietary modifications. *Altern Med Rev* 2001;6:450-459.

[13]Guery M, Douillard C et al. Doctor, my son is so tired... about a case of hereditary fructose intolerance. *Ann Endocrinol* 2007;68:456-459.

[14]Litherland G, Hajduch E et al. Fructose transport and metabolism in adipose tissue of Zucker rats: diminished GLUT5 activity during obesity and insulin resistance. *Mol Cell Biochem* 2004;261:23-33.

[15]Werbach M. Nutritional strategies for treating chronic fatigue syndrome. *Altern Med Rev* 2000;5:93-108.

[16]Huskisson E, Maggini S, Ruf M. The role of vitamins and minerals in energy metabolism and well-being. *J Int Med Res* 2007;35:277-289.

[17]Moorkens G, Manuel Y et al. Magnesium deficit in a sample of the Belgium population presenting with chronic fatigue. *Magnes Res* 1997;10:329-337.

[18]Maes M, Mihaylova I et al. Not in the mind of neurasthenic lazybones but in the cell nucleus: patients with chronic fatigue syndrome have increased production of nuclear factor kappa beta. *Neuro Endocrinol Lett* 2007;28:456-462.

[19]Bounous G, Molson J. Competition for glutathione precursors between the immune system and the skeletal muscle: pathogenesis of chronic fatigue syndrome. *Med Hypotheses* 1999;53:347-349.

[20]Nicolson G, Conklin K. Reversing mitochondrial dysfunction, fatigue and the adverse effects of chemotherapy of metastatic disease by molecular replacement therapy. *Clin Exp Metastasis* 2008;25:161-169.

[21]Suh S, Bae W et al. Intravenous vitamin C administration reduces fatigue in office workers: a double-blind randomized controlled trial. *Nutr J* 2012;11:7

[22]Acin-Perez R, Hoyos B et al. Control of oxidative phosphorylation by vitamin A illuminates a fundamental role in mitochondrial energy homoeostasis. *FASEB J* 2010;24:627-636.

[23]Vecchiet J, Cipollone F et al. Relationship between musculoskeletal symptoms and blood markers of oxidative stress in patients with chronic fatigue syndrome. *Neurosci Lett* 2003;335:151-154.

[24]Berkovitz S, Ambler G et al. Serum 25-hydroxy Vitamin D Levels in Chronic Fatigue Syndrome: a Retrospective Survey. *Int J Vitam Nutr Res* 2009;79:250-254.

[25]ShinchukL, HolickM. Vitamin D and rehabilitation:improving functional outcomes.*Nutr Clin Pract* 2007;22:297-304

[26]Heap L, Peters T, Wessely S. Vitamin B status in patients with chronic fatigue syndrome. *J R Soc Med* 1999;92:183-185.

[27]Shimizu T, Hoshino H et al. Anti-fatigue effect of dicethiamine hydrochloride is likely associated with excellent absorbability and high transformability in tissues as a Vitamin B(1). *Eur J Pharmacol* 2010;635:117-123.

[28]Nozaki S, Mizuma H et al. Thiamine tetrahydrofurfuryl disulfide improves energy metabolism and physical performance during physical-fatigue loading in rats. *Nutr Res* 2009;29:867-872.

[29]Engels A, Schroer U, Schremmer D. Efficacy of a combination therapy with vitamins B6, B12 and folic acid for general feeling of ill-health. Results of a non-interventional post-marketing surveillance study. *MMW Fortschr Med* 2008;149 Suppl 4:162-166.

[30]Lundell K, Qazi S et al. Clinical activity of folinic acid in patients with chronic fatigue syndrome. *Arzeimittelforschung* 2006;56:399-404.

[31]Malaguarnera M, Cammalleri L et al. 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;86:1738-1744.

[32]Vermeulen R, Scholte H. Exploratory open label, randomized study of acetyl- and propionylcarnitine in chronic fatigue syndrome. *Psychosom Med* 2004;66:276-282.

[33]Cefalu W, Rood J et al. Characterization of the metabolic and physiologic response to chromium supplementation in subjects with type 2 diabetes mellitus. *Metabolism* 2010;59:755-762.

[34]Maes M, Mihaylova I et al. In chronic fatigue syndrome, the decreased levels of omega-3 poly-unsaturated fatty acids are related to lowered serum zinc and defects in T cell activation. *Neuro Endocrinol Lett* 2005;26:745-751.

[35]Cordova A, Alvarez-Mon M. Behaviour of zinc in physical exercise: a special reference to immunity and fatigue. *Neurosci Biobehav Rev* 1995;19:439-445.

For more references, go to http://www.spectracell.com/online-library-mnt-fatigue-abstracts/