



March 3rd to 6th Euganean Thermae and Padua, Italy

PADUA DAYS ON MUSCLE AND MOBILITY MEDICINE 2026

ABSTRACT N. 096

EUROPEAN MEDICAL THERMALISM AND THE WORLD FEDERATION OF HYDROTHERAPY AND CLIMATOTHERAPY (FEMTEC)

HIDDEN ENERGY DEFICIENCY AND THERAPEUTIC STRATEGIES FOR ITS CORRECTION

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Energy consumption and production in the human body underpin the metabolic processes essential for life. Adenosine triphosphate (ATP) is the universal energy currency for all biochemical metabolic reactions; its synthesis and turnover require a supply of energy substrates and are maintained by the body's self-regulating systems in a state of homeostasis. The concept of energy deficit is an umbrella term and is not always clinically apparent. The aim of the study was to describe the causes of and approaches to correcting the "invisible" energy deficit. Based on an analysis of the literature, we review mechanisms of ATP consumption and production in mitochondria and the causes and consequences of mitochondrial dysfunction. The roles of the immune system and the human microbiota in hidden energy deficit are described, and evidence-based approaches to correcting disturbances of energy metabolism through direct and indirect replenishment of energy substrates are presented. Metabolic energy supply in the organism is provided by anaerobic (creatine kinase, glycolytic, myokinase) and aerobic (oxidative phosphorylation) mechanisms, primarily fueled by creatine phosphate, glucose, fatty acids, and amino acids. Impaired ATP resynthesis may arise from an imbalance between supply of energy substrates and ATP demand, or from the development of mitochondrial dysfunction due to organelle damage. Mitochondrial dysfunction, in turn, leads to various pathophysiological reactions that manifest clinically as functional disorders as well as severe pathologies of different organs and systems. The most rapid way to correct an energy deficit is administration of phosphocreatine, which quickly supports ATP synthesis without additional energy expenditure. Importantly, dietary creatine and oral supplements do not suffice to compensate for a significant energy deficit, especially in cardiomyocytes; intravenous administration of phosphocreatine is required for this purpose. Oral use of L-carnitine, citrulline malate, and creatine monohydrate may serve as adjunctive energy sources to support metabolic processes. [1] There is convincing evidence that beta-hydroxy-beta-methylbutyrate (HMB), vitamin D, omega-3 polyunsaturated fatty acids, vitamin C, and collagen enhance recovery processes in functional energy deficit. Widely used pharmaceuticals and nutraceuticals from the classes of antihypoxants, adaptogens, antioxidants, and cytoprotectors protect cells from hypoxia; howev-

er, their use requires an individualized approach with monitoring of efficacy and safety. Routine modulation of the immune system to prevent and treat energy deficit also requires special consideration with respect to interference in human homeostasis. A systematic review of clinical trials demonstrated that administration of vitamin C (for prevention of acute respiratory viral infections only), vitamin D, and probiotics has a reliable level of evidence for positive effects on immune defense functions.[2] Thus, vitamin D administration is advisable not only for its immunomodulatory action; its further conversion to 1,25-dihydroxycholecalciferol positively affects the endocrine and skeletal systems, skeletal muscle, and the gastrointestinal tract, contributing to increased endurance, greater muscle mass, accelerated regeneration, enhanced mineralization, and optimization of bone matrix structure. [3] The human microbiome — the collective genomes of microbial populations residing in the host — is of particular importance for health and metabolic processes. The gut microbiome performs numerous key functions: metabolic (facilitating digestion), barrier (preventing translocation of pathogens and toxins across the intestinal mucosa), protective (participating in immune cell development), and maintenance of mucosal enzymatic activity. The microbiome also contributes to regulation of angiogenesis, biosynthesis of vitamins and amino acids, drug metabolism, and modulation of bone tissue. Bidirectional communication between the brain and the gut — the gut-microbiota-brain axis — is mediated by neural, endocrine, and immune pathways; dysregulation of these pathways leads to a range of disorders, including immune and central nervous system pathologies such as insomnia, fatigue, and depression. Pharmacological correction of microbiota disturbances is achieved by administration of probiotics (live microorganisms), prebiotics (dietary substrates), or their combination (synbiotics). Key requirements for probiotic products include a minimal effective dose of 10⁸-10⁹ CFU/day. The most effective probiotic formulations include strains of *Lactobacillus*, *Bifidobacterium*, *Saccharomyces boulardii*, and *Streptococcus thermophilus*. [4] In conclusion, the primary measures to prevent hidden energy deficit are adequate provision of energy substrates, maintenance of immune system homeostasis, and a balanced composition of the gut microbiota.



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