GUT MICROBIOTA DYSBIOSIS AND SARCOPENIA: PATHOPHYSIOLOGICAL MECHANISMS AND MODERN APPROACHES TO PREVENTION AND MANAGEMENT

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Abstract. Sarcopenia is a progressive skeletal muscle disorder characterized by reduced muscle strength, muscle mass and physical performance. In addition to ageing, chronic inflammation, metabolic disorders, inadequate nutrition and physical inactivity contribute to its development. Increasing evidence suggests that intestinal microbiota dysbiosis may participate in the development and progression of sarcopenia through metabolic, immunological and endocrine mechanisms. A narrative review of scientific publications addressing sarcopenia, intestinal microbiota, microbial metabolites, intestinal barrier function and microbiota-targeted interventions was conducted. Particular attention was paid to recent reviews, clinical studies and international recommendations.

Keywords: sarcopenia, gut microbiota, dysbiosis, gut–muscle axis, intestinal permeability, short-chain fatty acids, chronic inflammation, probiotics, muscle function.

Introduction. Sarcopenia is a progressive skeletal muscle disorder characterised by reduced muscle strength, mass and physical performance. It is common in older adults but may also occur in patients with chronic diseases, metabolic disorders, malnutrition and physical inactivity. Sarcopenia increases the risk of falls, disability and reduced quality of life [1]. Recent studies suggest that

intestinal microbiota may influence muscle metabolism through the so-called “gut–muscle axis”. Dysbiosis, defined as an imbalance in intestinal microbial composition and activity, may promote inflammation, metabolic disturbances and impaired muscle function. Understanding these mechanisms may contribute to developing new preventive and therapeutic approaches [2,3].

Pathophysiological mechanisms linking dysbiosis and sarcopenia

1. Altered microbiota and intestinal barrier function. Dysbiosis may reduce beneficial microorganisms and increase potentially pro-inflammatory bacterial populations. This can impair intestinal barrier integrity and increase permeability, allowing bacterial components such as lipopolysaccharides to enter the circulation and stimulate systemic inflammation [3,4].

2. Chronic inflammation and muscle protein degradation. Increased inflammatory mediators, particularly TNF-α and IL-6, may activate pathways responsible for muscle protein breakdown and suppress protein synthesis. Consequently, muscle mass and strength gradually decrease [3,4].

3. Reduced production of short-chain fatty acids. Short-chain fatty acids (SCFAs), including acetate, propionate and butyrate, are produced through bacterial fermentation of dietary fibre. They support intestinal barrier function, regulate inflammation and influence metabolic processes. Reduced SCFA production may contribute to impaired muscle metabolism and increased inflammatory activity [2,3].

4. Impaired energy metabolism and insulin resistance. Dysbiosis-associated inflammation may negatively affect insulin sensitivity and glucose utilisation in skeletal muscle. Mitochondrial dysfunction and oxidative stress may further reduce muscle energy production, endurance and recovery [3,4].

5. Nutritional imbalance. Insufficient protein, energy and dietary fibre intake may negatively affect both microbiota composition and muscle protein synthesis. Therefore, nutritional deficiencies can contribute to the progression of sarcopenia [2,5, 7].

Clinical assessment and early diagnosis. According to the EWGSOP2 consensus, reduced muscle strength is the primary indicator of probable sarcopenia. Reduced muscle quantity confirms the diagnosis, while impaired physical performance indicates severe sarcopenia [1]. Clinical assessment includes handgrip strength, chair stand testing, gait speed and muscle mass measurement using bioelectrical impedance analysis (BIA) or dual-energy X-ray absorptiometry (DXA). Laboratory investigations may include complete blood count, serum albumin, C-reactive protein, glucose, glycated haemoglobin, renal function, vitamin D and thyroid function tests. Microbiota analysis and microbial metabolite assessment remain mainly research tools and are not currently recommended as routine diagnostic tests for sarcopenia [2,3,6].

Modern approaches to prevention and management

Nutritional intervention. Adequate energy and protein intake is essential for maintaining muscle mass. In older adults, protein intake of approximately 1.0–1.2 g/kg/day is commonly considered, with individual adjustment according to clinical condition and comorbidities. Patients with chronic kidney disease require particular attention to protein recommendations. A balanced diet containing vegetables, fruits, whole grains and dietary fibre may also support beneficial microbial activity.

Physical activity and resistance exercise. Resistance training is a key evidence-based approach to improving muscle strength and physical performance. Combining strength, balance and aerobic exercises may provide additional

benefits. Exercise programmes should be adapted to the patient's age, functional capacity and associated diseases [3,5].

Probiotics, prebiotics and microbiota-targeted strategies. Probiotics and prebiotics may influence intestinal microbial balance, SCFA production and inflammatory responses. Preliminary studies suggest potential benefits for muscle function; however, clinical results remain inconsistent. Postbiotics and other microbiota-targeted interventions are also being investigated, but further clinical evidence is required. Faecal microbiota transplantation is not an established treatment for sarcopenia [2,3].

Individualised multidisciplinary management. Sarcopenia management should include assessment of nutritional status, physical activity, metabolic disorders and chronic diseases. Cooperation between internists, endocrinologists, nutrition specialists, rehabilitation professionals and laboratory specialists may improve prevention and treatment outcomes.

Conclusion. Gut microbiota dysbiosis may contribute to sarcopenia through intestinal barrier dysfunction, chronic inflammation, reduced SCFA production, insulin resistance and mitochondrial impairment. These mechanisms highlight the importance of the gut–muscle axis in skeletal muscle health.

Adequate nutrition, resistance exercise and management of associated diseases remain the main evidence-based interventions. Microbiota-targeted therapies are promising but require further clinical investigation. A personalised multidisciplinary approach may improve the prevention and management of sarcopenia.

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