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EDITORIAL

FEEDING THE MUSCULOSKELETAL SYSTEM: NUTRITION AND PHYSICAL EXERCISE AS AN INTEGRATED APPROACH TO PREVENTION AND REHABILITATION

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EDITORIAL

Exercise is widely recognised as a core component of the management of many musculoskeletal conditions[1]. For example, progressive loading programs are considered a mainstay of conservative treatment for tendinopathy[2], and resistance training is recommended as the primary intervention for sarcopenia[3]. Nutrition, by contrast, is still frequently addressed in clinical practice through general recommendations rather than as a prescription with a defined dose, timing and target tissue.

Muscle, tendon and bone are metabolically active tissues, and their adaptation to mechanical load appears to depend, at least in part, on an adequate supply of energy, protein and micronutrients, and also for the eubiosis of microbiota[4,5]. In this framework, exercise provides the stimulus, while nutrition contributes the substrate needed to respond to it. When nutritional support is inadequate, the adaptive response to both training and rehabilitation may be attenuated. For this reason, appropriate nutrition should be regarded as an integral component not only of rehabilitation programs, but also, and perhaps above all, of preventive strategies aimed at preserving musculoskeletal health across the lifespan.

The relevance of this perspective has increased in recent years, in light of several clinical and epidemiological developments. Population ageing has increased the clinical relevance of sarcopenia, although this condition may also result from other causes, such as chronic disease, physical inactivity or malnutrition[6-8]. In this context, adequate nutrition, together with physical exercise, is considered fundamental for both its prevention and management[3]. Sarcopenic obesity, in which excess adiposity coexists with reduced muscle mass and function, is not limited to older age and may occur across the lifespan[9]. In this condition as well, nutrition and physical exercise represent the cornerstone of both prevention and treatment. At the same time, the growing use of pharmacological treatments for obesity has drawn attention not only to the amount of weight lost but also to its composition, and to the potential need for nutritional strategies that help preserve lean mass[10,11]. In addition, the sports medicine community increasingly acknowledges that low energy availability

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may have consequences beyond performance, including an increased risk of bone stress injuries[12]. This editorial briefly discusses and highlights some key developments at the interface between nutrition and exercise for musculoskeletal health, with particular attention to the preventive role of nutrition, and outlines possible directions for research and clinical practice.

Muscle: protein intake as part of the prescription

Evidence from randomised trials and meta-analyses suggests that an adequate dietary protein intake may enhance the muscular response to resistance training, particularly in terms of lean mass[13]. Population reference intakes, generally set at around 0.8–0.9 g/kg body weight/day for healthy adults, are intended to cover the requirements of most of the population[14]. Whether higher intakes provide additional benefit is likely to depend on age, training status and clinical condition.

The distribution of protein across the day may also be relevant. In health resistance-trained men, moderate doses of protein (about 20 g) ingested every three hours after exercise stimulated myofibrillar protein synthesis more effectively than fewer, larger boluses or more frequent, smaller doses[15].

In older adults, reference values are higher: ESPEN recommends 1.0–1.2 g/kg/day in healthy older people[16]. Moreover, daily amounts of 1.2–1.5 g/kg have been suggested for older persons with acute or chronic illness and up to 2.0 g/kg BW and day in case of severe illness, injury or malnutrition[16].

These considerations become particularly relevant in sarcopenic obesity, for which the ESPEN–EASO consensus has provided shared diagnostic criteria[17]. In this condition, weight loss that is not accompanied by adequate protein intake and physical exercise may further compromise muscle mass and function. Consistently, the Italian guideline on the treatment of overweight and obesity with metabolic comorbidities, published within the National Guidelines System of the Istituto Superiore di Sanità, recommends maintaining a protein intake of 1.2–1.5 g/kg body weight/day during energy-restricted diets[18].

Trial data support a combined approach. In older adults with obesity undergoing a weight-loss program, combining aerobic and resistance exercise improved physical function more than either modality alone, and attenuated the reduction in lean mass and bone mineral density compared with aerobic exercise alone[19].

Injury and immobilisation: nutrition during rehabilitation

Periods of injury and immobilisation are when nutrition is most neglected and possibly most needed. Skeletal muscle atrophy begins within days of disuse[20], and the muscle lost during short periods of inactivity may be difficult to regain, especially in older individuals. A common but counterproductive reaction to injury is to reduce food intake substantially in anticipation of lower energy expenditure.

Energy requirements during injury are often lower than during training, but less than assumed. The metabolic cost of tissue repair, and in some cases of walking with crutches, is not trivial. Current recommendations therefore emphasise avoiding a substantial energy deficit and maintaining a high, well-distributed protein intake during rehabilitation[21].

Low energy availability: a preventive target

The 2023 IOC consensus statement on Relative Energy Deficiency in Sport (REDs) highlights how problematic low energy availability affects bone health and is associated with bone stress injuries, in both female and male athletes[12]. For clinicians managing recurrent stress fractures or poor responses to rehabilitation, screening for low energy availability should be part of routine assessment.

Measuring what matters: body composition as a clinical outcome

Body weight and body mass index (BMI) remain the most commonly used outcome measures in both clinical practice and research[22]. However, they do not distinguish changes in fat mass from changes in fat-free mass, nor do they provide information on muscle quality. In the musculoskeletal setting, where the preservation of functional tissue is a primary goal, this represents a relevant limitation[23].

Bioelectrical impedance analysis (BIA) is a widely available, non-invasive and inexpensive method that may support the longitudinal monitoring of body composition in clinical settings[24]. In addition to estimates of fat-free mass, raw bioelectrical parameters, particularly the phase angle, have been proposed as indicators of cellular integrity and have shown prognostic value in several clinical populations. However, BIA-derived estimates are influenced by hydration status and measurement conditions, and predictive equations are specific to the population and device for which they were developed. BIA should therefore be performed under standardised conditions, using validated equations, and interpreted together with measures of muscle strength and physical performance, in line with current diagnostic frameworks for sarcopenia[6]. Emerging technologies may further increase accessibility, but will require validation against reference methods before routine clinical use.

Future directions

Several priorities can be identified for future research and clinical practice. Adequately powered randomised controlled trials are needed to evaluate combined nutritional and exercise interventions, using clinically relevant musculoskeletal outcomes such as muscle strength and physical function, bone health, injury incidence, re-injury and return to activity, rather than body

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weight alone. Many available studies have examined nutritional or exercise interventions in isolation, which limits the assessment of their potential interaction.

In parallel, the concept of nutrition periodisation, developed mainly in the context of athletic training, could be explored in rehabilitation settings, where nutritional targets might be adapted to the different phases of recovery, from immobilisation to progressive loading and return to activity. At present, however, evidence supporting this approach in clinical populations is limited, and dedicated studies are required.

Equally important is the need to refine nutritional recommendations according to individual characteristics, including age, sex, energy availability, comorbidities and concurrent pharmacological treatment, with particular attention to the growing number of patients receiving anti-obesity medications.

Lastly, the implementation of these strategies is likely to benefit from an interdisciplinary approach, in which nutrition professionals work alongside orthopaedic, sports medicine and rehabilitation specialists in both preventive and therapeutic settings.

In conclusion, exercise remains the primary stimulus for musculoskeletal adaptation, but its effects are likely to be influenced by nutritional status. Available evidence suggests that adequate protein intake, an appropriate distribution of protein across the day and sufficient energy availability may contribute to the response to both training and rehabilitation. Systematic monitoring of body composition may help to evaluate the effectiveness of these interventions. Nutrition should therefore be considered an integral component of both preventive and rehabilitative strategies for musculoskeletal health. Further well-designed studies are needed to define more precisely how nutritional and exercise interventions can best be combined in different populations.

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