

PREVENTION OF OVERUSE INJURIES THROUGH THE EARLY DETECTION OF KINEMATIC ALTERATION: THE ROLE OF MOVEMENT ANALYSIS

Andrea Demeco

Department of Medical and Surgical Science, University Magna Graecia of Catanzaro, Italy
e-mail: andrea.demeco@unicz.it

Overuse injuries represent a critical event in both athletic and general populations. These conditions typically develop gradually, resulting from the cumulative effects of repetitive mechanical stress exceeding the tissue capacity of self-repairing. In particular, tendons, cartilage or ligaments, that cause a pain affecting the athletic gesture. Given their insidious onset, effective prevention requires early identification of biomechanical alterations, that represent a risk factor for articular pain.¹ Altered kinematics, such as joint misalignment, segmental coordination deficits, or delayed neuromuscular activation, can precede clinical symptoms by weeks or even months. These patterns often reflect modifiable risk factors, including muscle imbalance, previous injury, or suboptimal motor control. When detected early, it is possible to plan a personalized preventive intervention.² Modern movement analysis technologies, including inertial measurement units (IMUs), 3D motion capture, surface electromyography (sEMG), and markerless video-based systems, now provide objective, quantitative insight into movement patterns during real-life and sport-specific tasks. These tools allow clinicians to carry out a detailed analysis of the segmental movement, to identify deviations from normative data that may predispose individuals to chronic musculoskeletal conditions.³

For example, a delay in neuromuscular activation of the knee stabilized muscles could raise the risk of ACL injuries in footballer. Similarly, altered scapulothoracic rhythm and shoulder joint kinematics are recognized as risk factors for rotator cuff tendinopathies and subacromial impingement in overhead athletes. Moreover, in padel, the correct execution of the strokes could represent a risk factor of shoulder pain.^{1,4} The aim of the movement analysis goes beyond identifying risk, enabling the design of targeted preventive interventions. In particular, it is possible to plan exercise to improve the muscular activation or the articular movement to avoid the mechanical overload of the joint. Moreover, it is possible to monitor the progress of the athlete through the rehabilitation, verifying the efficacy of the treatment. In particular, wearable instruments allow for on-field monitoring of athletes performance, providing immediate feedback to the medical staff.^{5,6} However, clinicians must contextualize kinematic deviations within a broader clinical framework. Some movement patterns may be compensatory rather than causative, and their interpretation requires consideration of anatomical, functional, and training-related variables. Thus, movement analysis should be integrated with clinical examination, and patient history to support multifactorial injury prevention models. In conclusion, the early detection of kinematic alterations could lower the risk of injuries, detecting the pre-clinical risk factors, to tailor a preventive program.

Keywords: sport rehabilitation; overuse injuries; prevention

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