Proceedings of the 7th International Conference on Educational Innovation and Psychological Insights
DOI: 10.54254/2753-7048/2026.32944

Hip Injuries in Young Athletes Risk Factors and Physiotherapeutic Interventions

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Abstract. Femoroacetabular impingement (FAI) syndrome is a leading cause of hip pain and functional disability in young athletes and the condition has far-reaching consequences on the sport activity and the future of joint health. The present paper is a suitable synthesis of existing evidence aimed at explaining the profile of multifactorial risks and assessing evidence-based physiotherapeutic approaches to the management of FAI in this group of patients. A combination of structural predispositions and easily manipulated extrinsic factors, such as high-risk biomechanics in sports, neuromuscular impairments and training load errors, determines the development of symptomatic FAI. Intervention structured, exercise-oriented physiotherapy, in orienting the effective conservative management, neuromuscular re-education, neuromuscular strength and movement pattern correction is of paramount importance. Extracorporeal shockwave therapy (ESWT) is a kind of adjunctive modality that can be used to give synergistic effects, especially on the modulation of pain. In patients with severe mechanical pathology, the results of hip arthroscopy are better than those of extensive non-operative treatment. It is recommended that a stepped-care approach, including prevention, individualized rehabilitation, and an efficient consideration of surgery in time, is a way of maximizing functional recovery, enabling safe sport recovery, and conserving joint health. The paper presents a summarized evidence-based model that can serve as a guideline to help healthcare practitioners in managing young athletes with FAI.

Keywords: Femoral acetabular syndrome, active sports participants-adolescent age, non-surgical treatment

1. Introduction

Hip groin trauma is a major and widely occurring issue in sports rehabilitation, especially among adolescent and young adult athletes participating in high-impact, pivotal sports, i.e., soccer, ice hockey and ballet [1]. Such injuries not only lead to immediate pain and compromised functionality with missed trainings and competitions, but also significantly increase the risk of early-onset osteoarthritis, and in the long-term, to the health and quality of life in joints [2]. Of these conditions, the femoroacetabular impingement (FAI) syndrome has become a popular pathoetiological diagnosis. FAI is defined as premature, pathologic contact between the proximal femur and acetabular rim, which mainly results in either cam-type (asphericity of the junction between the head and neck of the femur), pincer-type (acetabular overcoverage) or a combination of both bony

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DOI: 10.54254/2753-7048/2026.32944

morphological types [3]. Such a mechanical and repetitive conflict leads to a cumulative microtrauma of the acetabular labrum and the surrounding articular cartilage, which is a characteristic of the syndrome and the major cause of pain and mechanical symptoms [3]. The current literature further enhances our perspective on FAI, and lately, new amendments indicate that there is a necessity to incorporate the latest diagnosis implications and updated concepts of the perioperative administration [4].

Globally, FAI study has changed over time since the publication of the first description by an anatomist to achieve a complex view of the etiology and treatment of the multifactorial anatomical phenomenon. There is a general agreement regarding the important role of bony morphology (cam, pincer) as one of the main intrinsic risk factors [3]. However, modern studies note that morphology is not enough to determine the development of symptoms, as it is of paramount importance to interact with extrinsic, modifiable factors. These involve sport-specific biomechanical stress, neuromuscular control impairments, and training load mismanagement error, which contribute to the dynamic triggering of a silent anatomical variant to a painful clinical syndrome [1,5]. The paradigm has been changed to a structured, evidence-based approach, which is therapeutically oriented. The top-quality randomized controlled trials and systematic reviews have proven the structured exercise therapy, implying the neuromuscular re-education and movement pattern correction as the key to effective conservative management [5,6]. At the same time, Level I evidence is favorable to the use of surgical intervention (hip arthroscopy) in patients who experience appropriate selection failure to remain in the conservative care, which proves its overall effectiveness to yield better patient-reported outcomes in the short to medium term [7,8]. The recent studies also indicate that the incidence of the phenomenon of the osseous cam, in turn, in the general population, may turn out to be greater than the situation up to now, which makes it even more important to diagnose this problem with high accuracy and approach each of them in a unique manner [4].

2. Physiotherapeutic interventions and risk factors of hip injuries in young athletes

The cause of hip pathologies, especially FAI syndrome in the young athletic population, is not among the factors that have a monofactorial impact. It is the result of intricate and dynamic interplay between the intrinsic predispositions, as well as the extrinsic and changeable triggers [1,2]. Such a subtle interpretation of this risk matrix is one of the key aspects to utilize preventive programs and offer personalized treatment plans.

2.1. Non-modifiable (intrinsic) risk factors: structural and constitutional predilections

These are the pillars that are the basic soil on which injury can be formed. These are mostly innate to the person and provide the baseline susceptibility, and have a low ability to be altered clinically. The focus of this group is on the bony morphology and structural abnormalities, which make the pathoanatomical core of FAI, as well as the demographic and genetic factors, which determine the basis of injury risks. The literature is also unanimous on three major morphological types associated with FAI including Cam deformity, characterized by localized or global coverage of the acetabulum, the Pincer deformity, characterized by localized or global coverage of the acetabulum, and the Mixed type, the most common clinical expression, with cam-type as the most common single etiology [3,4,9]. The Cam lesion develops a non-spherical head of the femur, resulting in an outside-in shearing of the acetabular cartilage and labrum during movements that demand hip flexion and internal rotation, e.g., kicking and cutting. On the other hand, a pincer lesion produces a linear

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impingement, which occurs mainly due to crushing of the labrum between the rim of the acetabulum and the neck of the femur [3].

Significant epidemiological results have shown that the prevalence of the asymptomatic Cam morphology is up to 95% among elite soccer players in adolescence, though only 15-20% develop symptomatic FAI syndrome [1]. Research has demonstrated that cam morphology, which may be two to eight times more frequent in athletes than in the general population, thus emphasizing the immense contribution to phenotype selection and phenotype development by athletic activity [9]. There is good evidence of the mechanistic relationship between these bony abnormalities and intra-articular damage [3]. Other clinically important structural variants of FAI exist, such as acetabular dysplasia, or the inadequate coverage of the femur head and therefore, the instability of the joint and long-term excessive superolateral burden of the labrum and cartilage. Remodelings in the femoral or acetabular version, e.g., excessive anteversion or retroversion, also change the functional range of motion of the hip, which could lead to impingement at other ranges of motion or further instability [3]. As an example, the Cam-type impingement in femur retroversion may initiate earlier hip flexion, resulting in more mechanical strain on the intra-articular structures.

The contextual layer of intrinsic risk that has powerful population-specific trends is on age, sex, and genetic background. Symptomatic FAI is highest at the math period of greatest athletic activity and skeletal development and is generally highest in the late adolescence-third-decade of life age interval, which is the same age interval encompassing most young competitive athletes [1,2]. There is a strong sex difference with Cam deformities occurring much more frequently in male athletes, particularly in contact sports and kicking sports and Pincer deformities and other disorders involving generalized ligamentous laxity being observed more frequently in females, particularly in gymnastics and dance [1,2,9]. Moreover, a family history of hip osteoarthritis or morphological peculiarities is likely to indicate a heritable element in the formation of bony architecture, which predisposes to FAI, as proven by the literature [2].

2.2. Extrinsic (modifiable) risk factors dynamic triggers and modifiable drivers

The intrinsic structural predispositions alone do not fit the criteria of an independent susceptibility to symptomatic hip trauma but are synergistically and interactively dubbed with extrinsic factors by transforming asymptomatic morphological types into clinical FAI syndrome. This group includes both the mechanical loading of the predisposed anatomy and the ability of the athlete to absorb and control the same, as the main aspects of clinical and training-based intervention. Involvement in high-demand, repetitive-impact sports is the most effective extrinsic risk factor and the following sports are specifically named as high-risk activities: soccer, ice hockey, American football, gymnastics, and ballet [1,9]. The unifying mechanical characteristic is the repetition of the movements propelling the hip into the standard Flexion-Adduction-Internal Rotation (FADIR) position, being the main instigating factor of FAI [3]. Such movements are the soccer kick, ice hockey skating stride, football cutting manoeuvre and ballet grand plie. They give rise to no bony deformity, but again and again, they overload the pre-existing anatomical variations, frequently transforming pathological variants in the case into symptomatic clinical syndromes.

The neuromuscular control defects and muscle imbalances fall into this category, as well, and these factors are the critical biomechanical connection between static anatomy and dynamic impairments, which directly increase the risk of intrinsic injury. Usually noted weaknesses include gluteal muscle weakness with reflex activation of gluteus medius and maximus that disrupts pelvic stability in single-leg stance, as in running and landing, resulting in a dynamic hip adduction and internal rotation, also called Trendelenburg or hip drop, to force the joint into an impingement-prone

DOI: 10.54254/2753-7048/2026.32944

position in a mechanical manner. Other deficiencies include core muscle inadequacy being associated with inability to control the lumbopelvic-hip complex which alters effective force transfer along the lower extremity kinetic chain which causes aberrant repetitive loads on the hip joint, tightness and inflexibility in the muscles when chronic tightness of the hip flexors or abductors increases the pelvic tilt and positioning of the femur head within the acetabulum, exerts additional stress on poor joint mechanics. These shortcomings, which rehabilitation and prevention studies have emphasized, tend to set in prior to the onset of symptoms and to render structural deficiencies more significant, instead of simply occurring in response to pain [5,6]. Moreover, systemic reasons such as joint hyperlaxity are also being analyzed as possibly causing the occurrence of FAIS and the results of the post-treatment evaluation [4].

Other modifiable risks include training load errors and the history of pre-injury. Their overuse in the form of what is referred to as too much, too soon, is a classic triggering factor of overuse hip injury; it consists of increasing the volume, intensity or frequency of training in a non-structured periodization and recovery approach. Such a trend enhances symptomatic FAI and heightens the risk of muscle strains and load-based stress reaction, with load management playing a critical role in the prevention of injury in adolescent athletes [1,6]. A history of ipsilateral or contralateral hip, groin, or lower back injury is a good predictor of recurrent hip problems and it is usually explained by the incompleteness of the rehabilitation process, resulting in neuromuscular residual deficits, compensatory movement strategies overworking noninjured structures, or biomechanical characteristics predisposing to a series of lower extremity injuries.

2.3. Physiotherapeutic and conservative interventions: evidence-based

A well-rounded evidence-based approach of conservative management is the first line of treatment suitable for young athletes who report hip pain, in line with skeletally immature and adolescent groups. Modern physiotherapy has been transformed into an active, education-based, and exercise-based paradigm of restoring functional movement and reducing modifiable risk factors rather than a traditional paradigm that is based on modality modalities. The modifiable neuromuscular risk factors described are addressed using specific exercise therapy, which has been the main focus in the application of effective conservative care in young athletes.

A successful program should be custom-made, gradual, and staged to involve the age of the athlete, skeletal maturity, and sport-specific needs in many major elements. Athletes get some education about FAI pathophysiology, and the need to temporarily avoid or alter provocative movements is taught to them, which includes deep squatting and extended sitting to alleviate inflammatory irritation [2]. The capsular restrictions and tight musculature (i.e., hip flexors, adductors and the iliotibial band) are treated by using manual therapy and targeted stretching to normalize hip kinematics, but with care taken not to overstress the softening skeletal muscles. The most critical step is concerned with the neuromuscular re-education and strength training that initiates and trains the hip stabilizers, such as the gluteus medius and maximus, deep core muscles, including the clamshells, bridges, and planks and closed-chain and functional movements, such as the single-leg squats and lunges, to enhance dynamic centration of the joint. The faulty mechanics (dynamic knee valgus, translate isolated strength gains) are corrected using the verbal, visual and tactile feedback and translated to an efficient and injury-resistant global movement. The last element is graded exposure to sport-specific drills such as agility, being able to change directions and jumping, so that the athlete represents the ability to withstand the competitive loads of the body in mechanics. There is strong evidence to support it: although Extracorporeal Shockwave Therapy (ESWT) produced short-term analgesia, only groups that incorporated exercise therapy reported

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significant and enduring changes in hip range of motion, gluteal and core endurance, and dynamic lower limb balance, with the beneficial effect lasting at 2-month follow-up [5]. This validates that proactive exercise provokes sustainable neuroplastic alterations that are essential in curing the symptoms on a long-term basis. A succession system of prevention exercises also justifies the planned progressive exercises targeting at-risk athletes [6]. Yet, it is also necessary to mention that there is evidence indicating that patients with cam deformity would also have poorer outcomes regarding their conservative treatment than their counterparts with other FAI forms, which would have to impact clinical expectations and decision-making [9].

2.3.1. Extracorporeal Shockwave Therapy (ESWT): a supplemental biological intervention

ESWT is a non-invasive supplemental therapy that is suitable as an added therapy alongside exercise therapy in the chronic symptomatic FAI and tendinopathies. The multimodal effects of therapeutic effects are: analgesia through nociceptor hyperstimulation and controlled microtrauma through which neovascularization is activated and inflammatory pathways are regulated. ESWT in conjunction with rehabilitation leads to an increase in serum inflammatory profiles, such as IL-6 and TNF-a following the treatment more effectively than rehabilitation [10]. Focused or radial shockwaves that are about 10 Hz are applied by standard protocols. Combined ESWT and exercise could be more effective than either single intervention, replacing one another in reducing pain and enhancing function, which indicates that it is an adjunctive intervention [5,10].

2.3.2. IMHC individualized multimodal conservative care

Comprehensive conservative care involves exercise with supportive therapies. Selective use of short-term oral non-steroidal anti-inflammatory (NSAIDs) is applied during the acute inflammatory period to relieve pain and swelling, and provide early active participation in active rehabilitation [1,2]. Image-based intra-articular injection that involves a mixture of corticosteroid and local anesthetic has both diagnostic and therapeutic functions. The existence of pain as the primary generator of the hip is confirmed by diagnostic relief, whereas the effect of the treatment interrupts the pain cycle and allows complete involvement in active rehabilitation [2].

2.3.3. Combined stepwise-care pathways: prevention to individualized control

Physiotherapeutic services are provided in a continuous graded care continuum that covers prevention, primary care, and postoperative care. In young athletes who have developed symptomatic FAI with a new onset or mild-to-moderate symptoms, 12 weeks of intensive and structured physiotherapy is the therapy of first choice. It is a therapy and diagnostic phase since a positive response implies that symptoms are caused by neuromuscular deficits that can be modified, whereas little or no improvement when severe morphological pathology exists implies the need to refer to the surgical treatment [2,7].

Systematic reviews and meta-analyses of high quality support that hip arthroscopy provides better patient-reported follow-up (1-2 years) in mechanical symptomatic, and severe morphological abnormality patients who do not respond to conservative therapy [7,8]. This fact characterizes the perioperative critical role of physiotherapy in terms of pre- operation rehabilitation and post-operation rehabilitation. Prehabilitation is the predetermined exercise prior to surgery to decrease the pain and get the best possible strength as the baseline. Functional recovery in the postoperative phase needs postsurgery rehabilitation to fix structural abnormalities, and a phased approach to

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protocols should be related to the tissue healing schedules. Innovations in the arthroscopic methods including labral reconstruction proven to bring with them major short and medium-term improvements [4].

Clinical practice is supported by a clear clinical stepped-care decision algorithm which begins with an extensive diagnostic assessment. The second step is the beginning of the first-line multimodal care with individual exercise therapy at the center. Re-assessment is done after 3-6 months to reinstate further action, and responders are kept on conservative care, or non-responders are subjected to surgical intervention. The last measure will be the provision of integrated perioperative care with smooth flow of rehabilitation before and after surgery [2,5-7].

The best approach to prevent young athletes is the most affordable, with a three-level model of schools and clubs [6]. Primary prevention is based on universal education as to hip health and proper movement mechanics. Secondary prevention entails screening the vulnerable athletes who have high-risk factors alongside early neuromuscular training. Tertiary prevention provides worked-out athletes with targeted rehabilitation to avoid recurrence. Preventive training combines core strengthening and gluteal strengthening and appropriate movement mechanics with regular training in the team and targets the modifiable risk factors before the onset of the symptoms [6].

3. Conclusion

The disorder of multidimensional etiology of FAI syndrome has a complex and integrated management approach that requires in young athletes. The synthesized evidence presented in this review continues to indicate that symptomatic FAI does not occur because of a single cause, but as a result of the interplay of intrinsic bony vulnerabilities and responsive extrinsic stimuli, including high-risk sporting mechanisms, neuromuscular incompetencies, and training compensations. This etiological knowledge has a direct implication on therapeutic priorities. A patient-centered, step-care model is based on effective management. Their exercise-based physiotherapy aimed at the restoration of neuromuscular control and movement patterns is an indispensable basis of the first-line conservative care. Hip arthroscopy offers a well-validated intervention for patients with pronounced mechanical pathology who fail to respond to an extended non-operative trial in order to relieve the symptoms and improve the functioning. More importantly, the principles of physiotherapeutic procedures play a crucial role in the overall care delivery process, which is essential to maximize pre-operative conditioning and guarantee a successful post-operative recovery and active participation in sporting activity.

In prospect, implementation of the following evidence-based framework into standard clinical practice and better patient outcomes would necessitate taking into consideration several important spheres. The future research needs a long-term comparative research to further define what is best to select patients on surgical or non-surgical paths, and how to create phenotype-specific rehabilitation strategies. At the same time, more intensive attention should be paid to the implementation and assessment of primary and secondary prevention programs among youth sports systems to prevent exposure to risk before injury. Clinicians can respond optimally to the twin tasks of restoring both immediate and long-term hip function of the young athlete by adopting a step-wise, holistic approach to prevention, personalized rehabilitation, and carefully planned surgical intervention.

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