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Femoroacetabular Impingement Syndrome in the Athletic Population: From Morphology to Return to Sport

Authors

Wiktoria Tłoczek
Medical University of Silesia
Poniatowskiego 15, 40-055 Katowice
wiktoriatloczek10@interia.pl
https://orcid.org/0009-0004-7722-5037

Daria Twardowska
Medical University of Silesia
Poniatowskiego 15, 40-055 Katowice
daria.twardowska@interia.pl
https://orcid.org/0009-0004-5807-4915

Wiktoria Śliwa
Medical University of Silesia
Poniatowskiego 15, 40-055 Katowice
wiki00727@gmail.com
https://orcid.org/0009-0009-2406-853X

Barbara Jelonek
Medical University of Silesia
Poniatowskiego 15, 40-055 Katowice
jel.basia2000@gmail.com
https://orcid.org/0009-0007-5238-0710

Barbara Tomczak
Medical University of Silesia
Poniatowskiego 15, 40-055 Katowice
basia.tom335@wp.pl
https://orcid.org/0009-0004-3113-4922

Dagmara Porada
Medical University of Silesia
Poniatowskiego 15, 40-055 Katowice
dagmaraporada15@gmail.com
https://orcid.org/0009-0000-5326-3996

Dominika Żukowiecka-Sęga
Medical University of Silesia
Poniatowskiego 15, 40-055 Katowice
dominikazukowiecka@gmail.com
https://orcid.org/0009-0000-3426-7393

Małgorzata Wandzel
Medical University of Silesia
Poniatowskiego 15, 40-055 Katowice
gosiawandzel29@gmail.com
https://orcid.org/0009-0003-1151-3346

Kamil Topolski
Medical University of Silesia
Poniatowskiego 15, 40-055 Katowice
kamil2158@op.pl
https://orcid.org/0009-0002-8552-8332

Karolina Klubikowska
Medical University of Silesia
Poniatowskiego 15, 40-055 Katowice
k.klubikowska@gmail.com
https://orcid.org/0009-0002-7893-3081

Abstract

Background: Femoroacetabular impingement syndrome (FAIS) is a recognized cause of hip pain and functional limitation, particularly in young and physically active individuals.
The condition results from abnormal hip morphology leading to mechanical conflict within the joint and is associated with an increased risk of early hip osteoarthritis. Although awareness is rising, key aspects of the disease in athletes remain unclear.

Aim: The aim of this study was to review current evidence regarding the epidemiology, risk factors, pathophysiology, clinical presentation, diagnostic strategies and treatment options for FAIS with particular emphasis on athletes.

Material and methods: The review of the literature was conducted using available studies concerning FAIS in the PubMed database. Peer-reviewed articles published in English were analyzed, including in the fields of orthopedics, sports medicine and musculoskeletal imaging.

Results: FAIS predominantly affects young athletes involved in high-demand sports requiring repetitive hip flexion and rotation. Cam morphology is common in males and appears to develop during skeletal immaturity under repetitive mechanical loading. Diagnosis requires a combination of symptoms, positive clinical tests and imaging-confirmed morphological abnormalities. Nonoperative management can alleviate symptoms in selected patients, however arthroscopic surgery has demonstrated superior outcomes. Return to sport rates after arthroscopic management are generally high, although return to pre-injury performance levels varies.

Conclusions: FAIS is a multifactorial condition with significant clinical implications for young and athletic populations. Early recognition, accurate diagnosis with individualized treatment strategies are essential to optimize functional outcomes and delay degenerative joint changes. Further high-quality, sport-specific research is needed to refine prevention strategies and improve long-term outcomes, particularly in athletes.

Keywords: femoroacetabular impingement syndrome, FAIS, FAI, hip pain, athletes, cam morphology, hip arthroscopy, return to sport, hip biomechanics.

Content

1. Introduction

The concept of femoroacetabular impingement (FAI) was introduced by Ganz, Beck, and colleagues as a mechanical pathological process resulting from anatomical abnormalities of the acetabulum and the femoral head-neck junction [1, 2, 3]. Since then it has been recognized as a leading cause of hip pain in young and physically active individuals, particularly athletes [4, 5, 6]. FAI has evolved from the description of isolated bony deformities, classified as cam and pincer types, to a broader clinical entity known as femoroacetabular impingement syndrome (FAIS). FAIS encompasses the coexistence of morphological abnormalities, clinical symptoms, such as activity-related groin pain or restricted internal rotation of the hip, and functional impairment of the joint. [7, 8]. Studies indicate that a substantial proportion of adult patients presenting with groin pain exhibit morphological features consistent with FAI. However, not all individuals with such features are symptomatic. This highlights the importance of an integrated diagnostic approach that combines thorough clinical evaluation, including functional tests (e.g., the FADIR test), with appropriate imaging modalities [7, 8, 9]. FAI is classified into three morphological types based on the injury mechanism – cam, pincer and mixed. “Morphology” is now the preferred terminology for describing bony abnormalities, replacing the previously used terms cam and pincer “lesions” [7, 8, 10]. If left untreated, FAIS is not only recognized as an important risk factor for the early development of hip osteoarthritis in both professional and recreational athletes but also limits performance or participation in sports [2, 6, 11].

2. Epidemiology

The epidemiology of FAIS is difficult to determine due to the limitations of existing studies, which may not have sufficient power, employ various radiographic standards or fail to follow the diagnostic triad in their population analyses [5, 8]. Despite these challenges, recent studies have focused on FAIS incidence within specific groups. Higher prevalence rates have been observed among younger athletes and participants in high-demand sports requiring repetitive hip flexion such as american football, hockey, basketball, and football [5, 12]. In fact, studies have demonstrated that cam morphology is observed more frequently in male patients [13]. A systematic review and meta-analysis conducted by Nepple et al. demonstrated that male athletes engaged in sport-specific training at a high competitive level have up to an eightfold increased risk of developing this type compared with non-athletic controls [14]. Hip X-rays evaluation of 120 white male professional football players from four

Spanish First Division teams revealed cam-type femoroacetabular impingement in 61.6% of athletes, compared with 11.6% in controls [15]. In contrast, the association between pincer morphology and athletic activity has not been clearly characterized [8]. In addition this type is more commonly observed among middle-aged women engaged in regular physical activity.

3. Risk Factors

The development of FAI is believed to be driven by cumulative and repetitive mechanical loading of the hip joint [16]. The systematic review conducted by Canetti et al. suggests that FAI is more likely to develop in occupations involving intense, high-impact activities and repetitive excessive loading of the hip joint involving flexion (e.g., kicking and squatting) [17]. Engagement in sports before skeletal maturity may result in femoral neck deformities, with consequent increases in α angle and cam-type lesion prevalence. A study tracking skeletal development over two years in 63 adolescent male soccer players (mean age 14 years) identified significant radiographic alterations correlated with FAI development [12, 18]. Other factors have also been identified to increase the risk of developing FAI and eventually FAIS, including younger age, Caucasian ethnicity and a familial predisposition to FAIS morphology [19, 20, 21]. Siblings of individuals with symptomatic FAI were found to have a 2.8-fold higher likelihood of developing cam-type deformities with alpha angles greater than 62.5° compared to spouses. Moreover, parents of patients with FAI showed nearly a twofold increase in the prevalence of hip osteoarthritis or the need for total hip replacement. These findings indicate a strong familial pattern that points toward a possible genetic predisposition, although shared environmental factors remain an important confounding influence [16]. In addition individuals with a history of proximal femoral pathology, including slipped capital femoral epiphysis (SCFE), femoral neck fractures, developmental dysplasia of the hip (DDH) and Legg–Calvé–Perthes disease (LCPD), have been shown to develop cam-type lesions [22, 23, 24]. At a mean follow-up of 6.1 years after surgical fixation, roughly one-third of patients with SCFE demonstrated positive impingement findings on physical examination, while 70% showed radiographic evidence of FAI. No association was found between slip severity and the subsequent development of FAI [25].

4. Pathomechanisms and Etiology

Patients with FAI commonly experience substantial hip pain leading to functional impairment, along with concerns regarding progression to advanced osteoarthritis. Given the significant impact of FAI on young athletes - including the potential development of increased hamstring tendon tension and abnormal pelvic tilt, which may elevate the risk of hamstring injury, it is essential to better understand the underlying causes of the deformity and its associated symptoms in order to potentially prevent or modify disease progression [5]. The pathological process originates at the hip joint, a ball-and-socket articulation formed by the femoral head and the acetabulum. This joint includes the acetabular labrum, which restricts excessive motion, along with cartilaginous structures that contribute to joint stability. Abnormal femoral and/or acetabular morphology can cause mechanical impingement, clinically presenting as pain with repetitive motion. Overgrowth of bone, such as spur formation at the acetabulum or proximal femur, disrupts normal joint articulation, leading to impingement-related pain. As time goes by, abnormal joint mechanics increase friction and stress, potentially resulting in labral damage, reduced joint depth, capsular degeneration, and joint instability [5, 26]. Recent mechanobiological and biomechanical studies suggest that the development of FAI in athletes begins early, typically between 10 and 12 years of age, and does not appear to progress after physeal closure and skeletal maturation [18, 27, 28]. Hip deformities in athletes are believed to develop due to abnormal skeletal growth induced by repetitive impact-like loading during activities that place the hip in extreme ranges of motion [27]. Not all activities, but rather specific types of physical activity, causes developing cam-type deformity. In one of mechanobiological studies ossification patterns demonstrated higher mechanical stimulus for bone growth for external rotation and flexion compared with gait and internal rotation [27, 29]. Speirs and colleagues examined the biomechanical behavior and poroelastic properties of cartilage associated with cam-type FAI deformities. Compared to cadaver controls these osteochondral regions demonstrated a 71% reduction in stress-relaxation properties and a threefold increase in permeability, along with reduced proteoglycan concentration while the fibrillar components remained preserved [13, 30]. The etiology of pincer-type deformity remains poorly understood, particularly among athletes, as there is a lack of studies associating pincer impingement with athletic activity or developmental loading patterns [20].

5. Symptoms and Diagnosis

Although FAIS can occur in a heterogeneous population, it most commonly affects young athletes. This highlights the importance of assessing patient’s usual activity level, understanding how symptoms restrict their sport participation and identifying any specific goals related to return to activity. Thanks to the 2016 Warwick Agreement diagnosis is based on the concept of the diagnostic triad, according to which FAIS is diagnosed only when three components are present: characteristic clinical symptoms, positive functional test findings, and imaging-confirmed typical morphological abnormalities, thereby reducing the risk of overdiagnosis [6, 7, 8, 9].

5.1. Clinical presentation and provocative maneuvers

Patients with FAIS frequently present with pain, stiffness, clicking, catching, hip instability, and reduced range of motion. Pain is the most prevalent symptom, typically mechanical in nature - from the excessive friction between the femoral head and acetabulum - and most commonly localised to the groin. If the discomfort is located above the greater trochanter the patient typically positions their hand in a “C” shape, placing it over the affected hip - it is known as the “C-sign” [2, 6, 31, 32]. The pain can be characterised as slow-onset, persistent or intermittent and aggravated by physical exercise – especially deep hip flexion alone or coupled with rotation, long periods of walking or minor trauma [6]. Furthermore, prolonged static positioning of the hip joint, such as extended sitting or resting, can also provoke pain because of pressure on the joint itself [5]. Symptom distribution is variable, and discomfort may also be reported in the lateral hip, buttock, thigh, occasionally knee or the lower back [10]. The hip assessment should start with a careful evaluation through inspection, palpation, range of motion testing and gait observation. However, exam findings and provocative maneuvers used in physical examination are sensitive but nonspecific [6, 31]. FAIS is commonly associated with decreased hip range of motion, particularly in flexion and interna lor external rotation, frequently occurring bilaterally [6, 31]. Notably, internal rotation is markedly reduced when the hip is flexed to 90°. In a 2007 study patients without FAI morphology exhibited an average of 28° of internal rotation at 90° of hip flexion, compared with only 4° in those with FAI morphology [33]. Restricted hip internal rotation alters biomechanics and increases mechanical stress on surrounding soft tissues, which has been associated with a higher risk of sports-related injuries such as anterior cruciate ligament tears, iliopsoas tendinopathy and athletic pubalgia [6]. Patients with FAIS frequently demonstrate gait abnormalities, including Trendelenburg or antalgic gait, indicative of ipsilateral abductor weakness [6, 10]. Two provocative maneuvers have demonstrated clinical efficacy to evaluate for FAIS - FADIR (flexion, adduction, internal rotation) and FABER (flexion, abduction and external rotation). The first one evaluates impingement in the anterior region of the hip joint and is considered positive when it elicits pain or clicking. The second is considered positive for FAIS only if it provokes anterior hip pain or if the lateral femoral condyle is positioned farther from the edge of the examination table than on the contralateral side [6, 10].

FADIR demonstrates 60–100% sensitivity for identifying FAI, with inter-observer agreement reaching 96% [34].

5.2. Imagining diagnosis

If suspicion for FAIS remains following a thorough history and physical examination, imaging evaluation should be performed. FAI consists of three morphological types; cam, pincer, and mixed. Cam-type morphology is characterized by an aspherical femoral head resulting from excessive bone formation at the femoral head–neck junction. This abnormality leads to impingement against the superior acetabulum during hip flexion and internal rotation [5, 8, 10]. It is also described as “pistol-grip” deformity and leads to abrasion of the acetabular cartilage, followed by detachment from the labrum and underlying subchondral bone [6].
Pincer-type morphology, commonly associated with acetabular retroversion, results from excessive acetabular coverage of the femoral head-neck junction and may cause labral tearing. This morphology typically shows minimal acetabular articular cartilage damage on radiographic imaging. Mixed-type morphology exhibits features of both cam and pincer types [5, 8, 10]. A plain pelvic and hip radiograph is the first-line imaging modality for diagnosing FAI [5]. Anterior-posterior (AP) and lateral or Dunn views are favoured to prevent missing cam lesions that can be challenging to identify on an AP radiograph [35]. The AP pelvic X-ray should be centered on the pubic symphysis and obtained without pelvic rotation or tilt to ensure accurate measurements and allow comparison between both sides [8]. It is an essential view for hip joint space assesment and should be measured at three locations: the medial, central, and lateral aspects of the acetabular sourcil, perpendicular (90°) to the subchondral bone. This measurement is clinically important, as a joint space of 2 mm or less has been associated with advanced osteoarthritis and poor outcomes following hip arthroscopy [10, 36]. Cam morphology is assessed using the alpha angle, which is determined by first drawing a circle along the margins of the femoral head. a line from the center of the circle along the axis of the femoral neck, a second line from the center of the circle to the point where the femoral head-neck junction diverges from the circle. The angle formed between these two lines is defined as the alpha angle. Experts recommend using an alpha angle greater than 60° as a definitive criterion for diagnosing a cam lesion [5]. According to Smith, Gerrie et al., the Dunn 45° view is the most sensitive method for evaluating cam lesions, as it provides optimal visualization of the anterosuperior femoral head-neck junction, the site where cam morphology most frequently occurs [8, 37]. The lateral center-edge angle (LCEA, Wiberg angle) and the Tönnis angle are measured on AP pelvic X-ray to define pincer morphology. The

Wiberg angle is assessed between a line along the femoral head's vertical axis and a line from the center of the femoral head to the lateral acetabular rim. Values above 40° are used in FAI diagnosis. To evaluate the the Tönnis angle one line is drawn from the medial to the lateral edge of the acetabular sourcil, and a second line is drawn along the horizontal plane of the pelvis - the angle between these two lines is then measured. The Tönnis angle below 0° is indicative of pincer morphology [5, 10]. Advanced imaging is usually performed for a more detailed evaluation. In the first international consensus on FAI imaging modalities magnetic resonance imaging (MRI) with a dedicated protocol is considered the gold standard for hip assessment, as it allows precise characterization of bone morphology - particularly cam lesions - evaluation of chondral and labral injuries, and investigation of differential diagnoses. Furthermore, imaging studies such as MRI and MRA (Magnetic Resonance Arthrography) can reliably detect severe or extensive cartilage damage, which is clinically significant as these lesions may guide the decision between surgical and non-surgical management [38, 39]. However, due to the absence of empirically validated imaging guidelines for diagnosing FAI syndrome, the sensitivity and specificity of these imaging techniques remain uncertain [5].

A recent study reported that 3.0-T MRI demonstrated relatively high sensitivity (83.7%) and specificity (82%) for detecting acetabular chondral delamination (ACD) in patients with FAI, suggesting it may be a reliable tool for preoperative diagnosis. However, the study was limited by its retrospective design and the inclusion of only patients who underwent surgery, potentially resulting in selection bias [40].

6. Treatment, outcomes and return to sport

Treatment strategies for FAIS range from nonoperative to surgical management and are determined by patient-specific factors including: age, functional status, labral and chondral condition, timing for resuming athletic activity, duration of treatment and symptom severity [10, 41].

6.1. Conservative treatment

The first-line management of femoroacetabular impingement sydrome consists of nonoperative strategies including physical therapy, lifestyle modifications and anti-inflammatory agents. Athletes are generally advised to initially cease participation in their sport. Physical therapy targets core strengthening, postural retraining, and normalization of hip–pelvic dynamic function and it is tailored to the patient's specific symptoms [6, 42, 43]. Rehabilitation should aim to correct identified muscle imbalances. The most frequently observed physical deficits in FAI syndrome include reduced hip muscle strength and compromised single-leg balance [41]. Athletes can be guided by physical therapists and athletic trainers to correct movement mechanics within tolerated pain levels and maintain appropriate pelvic tilt [6]. Activities like cycling, treadmill running or singletrack running should be limited during the early phase of treatment, as they require combined hip flexion and internal rotation. Running on a wider, zigzag course may be used as an alternative, as it limits excessive hip motion in the frontal and transverse planes while incorporating some abduction and external rotation during directional changes. Walking and swimming may also serve as suitable alternative forms of exercise for patients with FAIS [41]. For elite athletes who are able to maintain a high level of performance despite ongoing symptoms, in-season management may include targeted exercise programs and non-opioid analgesics. Local intra-articular injections may also be considered to control symptoms during the competitive period including corticosteroid injections, which typically provide more rapid pain relief, and hyaluronic acid injections associated with a more gradual improvement in function [43]. A positive analgesic response to intra-articular injections supports the diagnosis of FAI and may serve as a helpful prognostic indicator. However, it do not reliably predict which patients will achieve favorable outcomes following arthroscopic treatment [44]. Both prospective and retrospective studies have indicated that an initial course of non-surgical treatment lasting at least three months can reduce pain and relieve symptoms for up to five years, suggesting the possibility of delaying or even avoiding surgical intervention [42, 45, 46]. Despite the growing body of literature on non-surgical management of FAIS there is a lack of research on the outcome in athletes. Although nonoperative treatment may alleviate symptoms in appropriately selected patients it is not adequate as an initial approach for everyone. Studies have shown that individuals with cam-type deformities tend to respond less favorably to conservative management compared with other forms of FAIS [5, 47].

6.2. Surgical treatment and postsurgical management

Even after prolonged physical therapy programs, surgical intervention has been shown to yield significantly superior outcomes compared with physical therapy alone [47, 48]. The objective of surgical treatment for FAI syndrome is to restore normal hip joint anatomy and biomechanics, thereby improving joint function. Radiologic evaluation plays a key role in determining surgical candidacy, alongside factors such as symptom severity, physical examination findings and unsuccessful nonoperative treatment [5]. Surgical strategies depend on the underlying pathology and may include arthroscopic intervention and open techniques such as: femoral derotational osteotomy, periacetabular osteotomy (PAO) and surgical hip dislocation (SHD). Arthroscopic treatment of FAIS has gained prominence as the surgical treatment of choice for FAI due to quicker recovery, earlier return to sport and a lower complication rate compared with open procedures [49, 50]. However, open surgical techniques may remain the preferred option in certain cases involving complex hip pathology, such as FAI associated with dysplasia or Legg–Calvé–Perthes disease [51]. Arthroscopic procedures include acetabuloplasty, femoroplasty, labral debridement or repair, management of ligamentum teres lesions and articular cartilage with the specific intervention are selected based on the type of impingement combined with the extent of associated structural damage [48]. Arthroscopic intervention is indicated in patients who have not responded to conservative treatment, those who experience symptom relief after an intra-articular injection (indicating intra-articular pathology), and those with an alpha angle exceeding 65°. Contraindications include a joint space under 2 mm, narrowing of 50% or more of articular space, obesity that prevents adequate access to the joint and Tönnis grade 2 or higher osteoarthritic changes [10].

Numerous studies have investigated the outcomes of arthroscopic procedures, most of them focused on short-term results. However, a recent reviews provided long-term analysis. During the 10-year follow-up period a total of 478 patients were included: 29% of patients required reoperation, 10% underwent revision arthroscopy, and 32% ultimately required conversion to total hip arthroplasty [52]. Lindman et al. examined elite athletes five years after arthroscopic treatment for FAIS. In their study, 54% of patients were still participating in competitive sports at the five-year mark, but only 21% maintained the same level of competition. This decline may reflect a natural decrease in competitive participation, given that the average age at surgery was 24 ± 6 years [53]. There are limited data comparing results between athletes and non-athletes. Migliorini et al. revealed that both groups experienced comparable patient-reported outcomes and complication rates following arthroscopic treatment of femoroacetabular impingement at a mean follow-up of roughly two years. Significant gains in function and pain relief were observed in both groups, demonstrating that hip arthroscopy is beneficial across different levels of physical activity [50]. Moreover, one of the studies indicates that

the procedure is effective for athletes participating in various sports despite differences in preoperative functional scores [54]. After a surgery, a structured physical therapy program is universally advised to help patients regain their prior level of physical activity. Current literature commonly supports a four-phase protocol. **Phase 1** focuses on protecting

the surgically repaired tissues, controlling pain and inflammation, and recovering approximately 80% of full range of motion with functional and isometric exercises. **Phase 2** facilitates a gradual transition to full weight-bearing, allowing the patient to restore functional independence and gait progres due to adding cardiovascular fitness. **Phase 3** aims to regain muscular strength and endurance while enabling the patient to engage in recreational activities without symptoms and return to pre-injury functional status through exercises such as hip flexors and discipline-specific drills. **Phase 4** ultimately leads to a pain-free return to competitive sports or recreational pursuits [10, 55].

6.3. Return to sports after arthroscopic procedures

Most studies do not use clear definitions of return to sports (RTS) after arthroscopic management and sports performance is seldom measured. RTS rates are different depending on the type of sports and they differ among studies. According to a systematic review by Reiman et al., 74% of patients returned to sport after arthroscopic treatment for FAIS [56]. When applying a strict RTS definition, Ishøi et al. reported a lower overall rate of 57%, with just 17% of athletes returning at full performance and participation levels [57]. The most up-to-date literature demonstarates that roughly 80% of patients were able to return to sport at their previous or a higher level. In addition, it suggests that the specific surgical technique affects both the timing and likelihood of returning to sport. Variation in sport type may contribute to differences in clinical outcomes, as athletes participating in sports characterized by high impact forces such as hockey or football often experience distinct recovery patterns compared with those involved in activities associated with minimal joint impact like swimming. This variability further highlights the need for tailored, sport-specific rehabilitation programs to maximize successful return-to-sport outcomes [58].

7. Discussion and Conclusions

Femoroacetabular impingement syndrome represents a particularly relevant clinical problem in athletic populations, where high training loads, repetitive hip flexion, and extreme ranges of motion place unique mechanical demands on the developing and mature hip joint. Athletic participation - especially at a young age and at an elite level - is a significant contributor to the development of cam-type morphology, which is the most prevalent form of FAIS among athletes. Patients with FAIS often experience limitations in hip range of motion, particularly reduced internal rotation, which may contribute to the development of secondary sports-related injuries. As a result, FAIS should be considered not merely as an isolated hip pathology, but as a condition with potential consequences for the entire kinetic chain in athletes. Those who develop symptoms often experience substantial limitations in performance and sport participation, emphasizing the need for early diagnosis. Nonoperative management remains the first-line approach and can be effective in reducing symptoms and delaying surgery. However, current evidence suggests that individuals with cam-type deformities may respond less favorably to conservative treatment alone. Arthroscopic management has demonstrated favorable short and mid-term outcomes in athletes, with high overall return-to-sport rates, although a decline in return to the pre-injury level of competition is frequently observed over time. Variability in return to sport rates across studies likely reflects differences in sport-specific demands, surgical techniques, and rehabilitation protocols. Therefore, individualized, sport-specific rehabilitation and realistic expectations are essential to minimize reinjury risk and optimize long-term athletic performance. Future research should focus on establishing standardized, sport-specific definitions of return to sport that incorporate performance level and durability over time rather than participation alone. Additionally, further investigation into preventive strategies during skeletal maturation, optimal timing of intervention and individualized rehabilitation protocols may contribute to improved long-term outcomes and reduced injury burden among athletes.

Disclossure

Author Contributions

Conceptualization: Wiktoria Tłoczek, Barbara Jelonek, Dominika Żukowiecka-Sęga, Karolina Klubikowska, Barbara Tomczak, Dagmara Porada

Methodology: Wiktoria Tłoczek, Wiktoria Śliwa, Daria Twardowska, Kamil Topolski, Małgorzata Wandzel

Software: Dominika Żukowiecka-Sega, Karolina Klubikowska

Check: Wiktoria Tłoczek, Barbara Jelonek

Formal analysis: Barbara Tomczak, Dagmara Porada

Investigation: Kamil Topolski, Małgorzata Wandzel, Daria Twardowska

Resources: Karolina Klubikowska, Dominika Żukowiecka-Sęga, Barbara Jelonek

Data curation: Wiktoria Śliwa, Daria Twardowska, Dagmara Porada

Writing-rough preparation: Wiktoria Tłoczek, Barbara Tomczak, Wiktoria Śliwa

Writing-review and editing: Wiktoria Tłoczek, Małgorzata Wandzel, Kamil Topolski

Project administration: Wiktoria Tłoczek

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