Risk Factors Associating with Femoroacetabular Impingement in Soccer Players

Evgenia Trevlaki. Georgios Leptourgos, Emmanouil Trevlakis, Anna Chalkia, Nikitas Papazoglou
Department of Physical Therapy, International Hellenic University, Sindos, Greece.
evgeniatrevlaki@gmail.com

***Abstract* — Purpose:** Femoroacetabular Impingement has been gaining more recognition over the last several years, especially the cam-type deformity in young male athletes. The aim of this review is to investigate the prevalence of asymptomatic Femoroacetabular Impingement and whether the stating age of soccer, the intensity of training, the kicking limb, and previous hip abnormalities are associating factors of the impingement. **Methods:** A research of PubMed, PEDro and ScienceDirect was completed for the prevalence of FAI. The inclusion criteria were the publication date (through 2010-2021), the population (soccer players) and the syndrome. 14 out of 346 studies were included. **Conclusion:** The participation during skeletal immaturity as a risk factor is yet unclear. The right leg has proved to be preferred as the kicking one and is not positively related as a cause for the development of the syndrome. The level of training presents as a positive correlation with the development of the impingement possibly due to the higher impact and stressful intensity on the hip during kicks in soccer playing at a professional level. All the studies showed a high prevalence of asymptomatic Femoroacetabular Impingement among soccer players. Anatomical features of deformity were found to be related to lesions of the femoral cartilage, chondrolabral damage, or both injuries.

Keywords* — *femoroacetabular impingement, soccer players, functional indicators, athletes, football players

I. INTRODUCTION

Femoroacetabular Impingement (FAI) has been gaining more recognition over the last several years, especially in the younger athletic population. [1] FAI causes frequent abnormal contact between femoral head-neck junction and the acetabular rim during flexion and internal rotation at the hip, resulting in labral lesion and cartilage delamination. [2-5] The symptoms of the syndrome usually include pain in the groin area, anterolateral hip pain as indicated by patients with the C-sign, and pain aggravated with hip flexion, for example, prolonged sitting. [6] Pincer morphology is characterized by overcoverage of the acetabulum, whereas cam morphology is characterized by an increase in bone formation at the femoral head-neck junction. [7] FAI can occur as a result of bony overgrowth of the femoral neck or the acetabulum resulting in structural abnormalities which cause friction between the joint structures and microtrauma to the labrum and cartilage. [8-9]

There are two types of FAI. Cam deformity appears to be the most common type, [10] it has been reported in up to 60–90% of athletic populations. [11-13] Males, young age (boys aged 12-14 years) and white race have more tendency to present FAI findings. [8, 10-15] However, high prevalence of the deformity was observed in Arabic, black and Persian population. [10] Patients with FAI may demonstrate hip biomechanical impairments during walking and squatting, with minimal literature available to comment on other tasks. [16] It is associated with the development of labral tears [17-18] and an increased risk of hip osteoarthritis (OA).

Diagnosis of the impingement requires a systematic physical examination that includes inspection for muscular hypotrophy, swelling, or redness; palpation of the groin, sacroiliac joint, ischial tuberosity, and symphysis pubis; measurement of passive and active range of motion (ROM) of the affected hip for comparison with the contralateral hip; impingement test; FABER (flexion, abduction, external rotation) test; and neurovascular examination. [2, 19-20] Recent recommendations from the Warwick agreement concluded that FAI has a complex presentation and can only be diagnosed with the presence of assessment findings, symptoms in positions of impingement (flexion and internal rotation) and variances in bony hip morphology. [21] A variety of diagnostic criteria were used for the radiographic definition of FAI with minimal alpha angles ranging from 50° to 60° and CEA from 35° to 39°. [16] Plain radiographic and magnetic resonance imaging are also critical supplements to the physical examination. [20]

Several studies have reported the success of surgical intervention for patients with this syndrome. [22-26] The details of postoperative rehabilitation programs are often unclear or inconsistent. [27-33] According to Reiman et al. scoping review of 169 studies the surgical outcome does not provide sufficient detail or consistency for practicing clinicians to replicate a postoperative rehabilitation protocol for patients with FAI syndrome/labral tear. [34]

Factors affecting the likelihood and rate of this progression are not yet well understood. [35-36] Therefore, the purpose of this review is to investigate whether the stating age of soccer, the intensity of training, the kicking limb, and previous hip abnormalities appear as associating factors of the

impingement, and the prevalence of asymptomatic FAI.

II. Materials and Methods

Review design: This review was registered before its initiation (PROSPERO identifier: CRD42021259586). The results are presented as per the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) reporting guideline (supporting checklist/diagram). [37]

Eligibility criteria: We included all intervention studies designed to evaluate FAI in soccer athletes published 2010-2021. All types of study designs were included, except of case reports and case series. There is a confusion between the terms ´football players´ and ´soccer players´, as American and Australian football is considered rugby, while European football is referred as soccer. Both terms were used, but rugby articles were rejected.

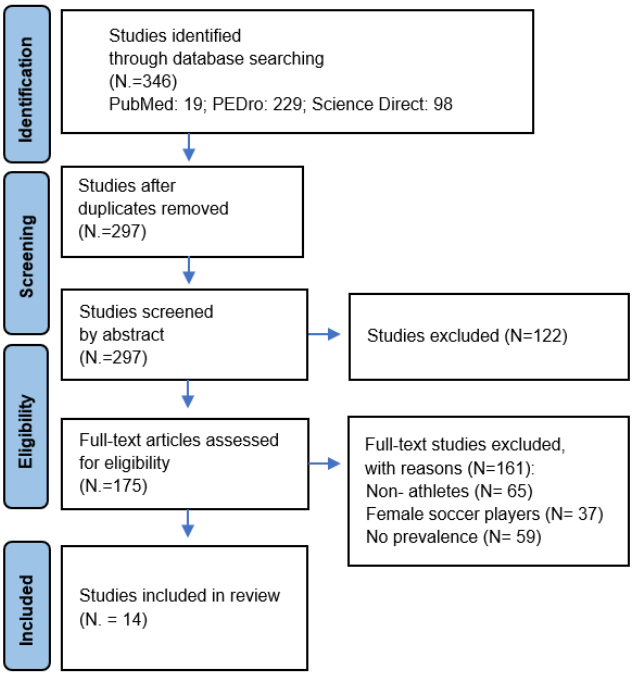

Fig. 1. *PRISMA Flow diagram of study selection process in the systematic review.*

Study selection: Eligibility screening of the studies was conducted in a blinded standardized way by two independent reviewers (E.T. and G.L.). Titles and abstracts were screened, and duplicate articles were excluded. After screening titles and abstracts, full paper copies were retrieved. Full text screening was also performed blinded by the same reviewers (E.T. and G.L.). Disagreements between authors during any stage of the screening process were resolved by consulting a third reviewer (A.C.).

Data Sources and Search Strategy: A search strategy was developed based on the intersection of 2 search themes: soccer players and femoroacetabular impingement. The following databases were searched: Medline databases (via PubMed), PEDro (Physiotherapy Evidence Database) and ScienceDirect. Prisma methodology was used, and the original search results were 346 articles. The initial search strategy generated 297 references after duplicate removal. All 297 were kept for full-text review, 14 unique studies were included in the review and are presented in detail in Table 1.

III. Results

Starting age of soccer

In 2012 Johnson et al. [11] studied 100 participants, 50 male and 50 female. The participants were divided in group A: high-level soccer during skeletal immaturity, 25 male and 25 female, and group B: people who had never participated in high-level soccer, 25 male and 25 female. The results showed that 15/25 athletes had evidence of cam deformity compared with 14/25 nonathletes. No significant changes were found as far as young athletes and non-athletes. Regarding the left hip the alpha angle was 55.1 (male soccer players) and 54.4 (male control group).

According to Agricola et al. in 2014 [38] a cam deformity begins and continues to grow in adolescent hips (pre professional soccer players, n=63) with an open growth plate. Cam deformity is gradually acquired and probably only during skeletal maturation (especially from 12 to 14 years). Soccer players from the age of 13 years had a cam impingement (26%) in comparison with the control group (17%).

The aim of Tak et al. [39] research in 2015 was to investigate whether the frequency and age at which an athlete (at the stage of skeletal maturation) starts training or even playing football can influence the formation of cam deformity. In this research, 63 football players participated (n=126 hips). The presence of cam deformity (α angle >60 degrees) for amateur footballers aged 12 or over, which was explored through antero-posterior and frog-leg lateral views, was quite low (40.2%), compared to professionals (63.6%), who started playing football at the age before of 12. The results showed a higher prevalence of cam deformities was found in players who report starting high-frequency football training before 12 years of age.

Monckeberg's study [40] in 2017 involved 72 young elite soccer players with skeletal maturity (group 1) and 70 adult elite soccer players (group 2). No significant differences in FAI appearance were found between the 2 groups (63.8% and 75% respectively). The results of this study suggest that the prevalence of radiological signs of FAI in adult soccer players has no significant difference in players with incomplete skeletal maturity and adult elite soccer players. Once the hip deformity appears in developmental age, the deformity will continue to develop at a slower rate (almost none) once growth is complete.

Physical activity during bone growth may lead to the deformity according to Yepez et al. study. [41] The

subjects of the study were 56 asymptomatic youth soccer players aged 13-18 (mean age 15.3 years) and the prevalence of FAI was 84.4%. Physical activity during bone growth was shown to be a risk factor for the development of FAI. The results showed that cam is formed even before physeal plate growth is completed.

In Falotico et al. study [42] in 2018 a total of 60 footballers participated, 37/60 of the soccer players (61.6%) started playing soccer at a competitive level (more than 4 times a week) before the age of 12. This age was found to be inversely proportional to the α angle ($p < 0.001$). The prevalence of cam and pincer morphology in athletes was high (92.5%) supposably due to the early participation at soccer in Brazil.

In 2018 Polat et al. [43] found that pediatric football players, playing football more than 3 years, more than 12.5 per week, had an increased risk of developing FAI. The average sport participation was 4 years, and the athletes were divided according to their age into 3 groups. In the first group participated 25 people, aged 10-12 years, in the second group 104 people, aged 13-15 years, and in the third group 85 people, aged 16-17 years. The first group had a mean α angle of 47.8 degrees in the right and 45.8 degrees in the left hip. The second group had a mean α angle of 47.9 degrees in the right and 48.1 in the left hip. The third group had a mean α angle 53.1 degrees for the right and 52.3 degrees for the left hip. The first group presented 0% of a cam type impingement, 12.5% of the second group and 50.6% of the third group. The deformity of FAI can reach up to 60% in the 16 - 17 age group. Athletes who played football for less than 3 years were found to have a prevalence of FAI of 13.7%, while athletes who played for 3 or more years had a prevalence of 39.5%. FAI appearance was 13.7% for players that played less than 3 years, 39.5% for players who played for 3 or more years, 22.9% of the players who trained less than 12.5 hours per week and 41.7% players who trained for more than 12.5 hours per week.

Frequency and intensity level

In the study of Lahner et al. [13] in 2014 two groups of soccer players participated. The first group, semi-professional athletes, was training 4 times per week, 2 hours per time, for 10 months and the second group, control group, consisted of male amateur soccer players that were training less than 5 hours per week. The researchers found that the first group (semi-professionals soccer players) have a higher prevalence of an increased α angle versus the second group (amateurs soccer players). Statistically 62.5% of the semi-professional group showed an increased α angle greater than 55 degrees (cam deformity) versus 27.3% of amateur players.

One of the purposes from Marom et al. study [44] in 2020 was to analyse the effect of competition level on soccer players. The athletes who participated at high level was 24.9% (105 hips), at competitive was 46.1 (194 hips) and at amateur-recreationl level was 17.8% (75 hips). The level was not recorded at 47 hips (11.2%). Soccer players from the first group had higher α angles from the other groups and for that reason presented more often an acute onset of symptoms.

The intensity of soccer participation during skeletal immaturity - at least within the range of activity at Johnson's study [11] population - did not appear to affect the developing hip. The study results showed no significant difference in the presence of cam deformity in players who participated in high-level soccer as youth compared with those who did not participate.

Kicking limb

In 2012 Johnson et al. [11] found that 12/25 of the male athletes (soccer players in high-level as youths) had a cam deformity in both hips, 2/25 had the deformity only in the right side of the hip and 1/25 in the left hip. The mean α angle was 57.5 degrees (right hip) and 55.1 degrees (left hip). 10/25 from the men in the control group presented a cam deformity in both hips, 2/25 only in the right and 2/25 only in the left hip. The mean α angle was 55.4 and 54.4 degrees.

Agricola et al. [38] reported that most deformities (58.0%) involved both hips, 19.4% were located only in the right femur, 22.6% in the left femur. Although, the study did not include the prevalence of the kicking limb, it states that there was no association between the dominant leg and cam deformity.

The aim of the study from Lahner et al. [13] was to compare the prevalence of FAI in male semi-professional and amateur soccer players. In the semiprofessional group, 19 soccer players had a right kicking leg, 1 soccer player had a left kicking leg, and 2 soccer players kicked with two feet. In the semiprofessional group, the mean value of the α angle of the kicking leg (57.3 ± 8.2°) was significantly higher than in the amateur group (51.7 ± 4.8°, $p = 0.008$). In the semiprofessional group, 15 (62.5 %) of 24 kicking legs had an increased α angle >55°, while 5 (27.3 %) kicking legs of the amateur group had an α angle >55°.

In Polat et al. [43] study participated 214 pediatric footballers. The mean α angle at the right hip was 50.7 degrees and the left at 50.3 degrees, while the mean lateral center-edge angle was 28.6 degrees for the right and 29.5 for the left. The 172/214 athletes had the right foot as dominant, while 42/214 the left. There were no significant differences in the appearance of FAI between the two extremities.

The study of Yepez et al. [41] involved 56 athletes (112 hips) with an average age of 15.3 years and the dominant side on the right (45/65, 80.3%). There were no significant differences in the prevalence of FAI.

Falotico et al. study [42] in 2018 involved 60 athletes (asymptomatic) and 32 non-athletes to investigate whether football and training frequency affect the occurrence of FAI. The dominant limb in the athletes was the right (43/60, 71.6%) and the left for 17/60 (28.4%). The average α angle in the dominant limb of the athletes was found to be 84.6 degrees (+/- 6, 3 degrees), while in the non-dominant limb 81.3

degrees (+/- 6.5 degrees). In the control group the mean α angle was 67.5 degrees (+/- 8.4 degrees) and 66.6 degrees (+/-7.8 degrees).
In Marom et al. study [44] noted an 87.5% of right kicking leg for both genders. There were no significant differences concerning the symptomatic dominant and non-dominant hips in players that underwent bilateral FAI.

Asymptomatic FAI

In the study of Lahner et al. [45] the mean value of the α angle was lower in the amateur group. There was no significant difference of the α angle in the amateur group (51.65 ± 4.43°), which increases the odds of appearance of FAI. In the soccer group, the mean value of the α angle was 55.16 ± 6.58. In another study of Lahner et al. [13], 17/22 semi-professional soccer players were clinically asymptomatic and only 5/22 presented clinical symptoms. The α angles of the kicking leg (right leg in 86% cases) in the first group were significantly higher than in the amateur group. No participant of the amateur group showed pathological results in the clinical examination (p =0.0484). Overall, semi-professional soccer players had a higher proportion of an increased α angle than the amateur group.
The study of Gerhardt et al. [46] examined 95 elite male and female soccer players (75 male and 20 female) with mean age 25.8 years. Seventy-two percent (54/75) of men and 50% (10/20) of women had some evidence of radiographic hip abnormality consistent with FAI. Cam lesions were present in 68% (51/75) of men, with 76.5% (39/51) of the cam-positive men having bilateral hip involvement. Cam lesions were identified in 50% (10/20) of women, with 90% (9/10) of the cam-positive women demonstrating bilateral hip involvement. Pincer lesions were present in 26.7% (20/75) of men, with 80% (16/20) showing bilateral involvement. Pincer lesions were present in 10% (2/20) of women, with 100% (2/2) demonstrating bilateral findings. A total of 70% asymptomatic athletes presented radiographic abnormalities of FAI.
In the Yepez et al. study [41] is the first study to assess the prevalence of MRI changes consistent with FAI morphology in asymptomatic youth soccer players. The prevalence of MRI changes indicative of FAI morphology in the present sample was 84.8%. The high prevalence of FAI in asymptomatic athletes highlights the importance of a careful examination of footballers.
Falotico et al. [42] in 2018 study examined 60 asymptomatic athletes and 32 non-athletes. A total of 111/120 hips (92.5%) precented cam or pincer deformity in athletes and 18/64 hips (28.1%) for non-athletes (control group).

Previous hip abnormalities

Only the Marquez study [47] in 2019 examined previous hip abnormalities. Regarding personal history of the participants, 35% (n=14) of players reported a history of hamstring tear, 10% (n=4) quadriceps tear, 10% (n=4) had adductor tears, 12.5% (n = 5) had pubalgia and 17.5% (n=7) low back pain. FAI morphology prevalence appeared at 25%. Anatomical features of the deformity were found to be related to lesions of the femoral cartilage (p <.001), chondrolabral damage (p =.042), or both injuries (p <.001).

TABLE I. RESULTS OF STUDIES INCLUDED IN THE REVIEW OF ATHLETES WITH FAI

Researchers	Participants	Assessment	Assessment tools	Results
Agricola R., et al., 2012	N=89 elite preprofessional footballers (178 hips), with a mean age 14.8 years, and N=92 non-athletes (184 hips), with a mean age 13.8 years (range 12 - 19 years for both groups)	Age, groin pain, medical history, and demographic data. ROM, alpha ankle, anterosuperior head-neck junction BMI, training intensity, soccer experience	Questionnaire, goniometer impingement test (FADDIR), AP pelvic and frog-leg lateral radiograph of the hip. SSM software	Although cam deformities were present from the age of 12 in some footballers and control group, in soccer players was found more often (26%) than in control group (17%). Cam deformity develops during adolescence and is likely to be influenced by high impact sports practice.
Gerhardt B. M., et al., 2012	N=95 elite male and female soccer players (75 male and 20 female) with mean age 25.8 years. No exclusion criteria, players with a history of hip or groin injuries were included	Hip or groin injury, an angle	Injury history, Anteroposterior pelvis and frog-leg lateral radiographs	51/75 (68%) men had a cam deformity which 39/51 had cam deformity bilateral. 20/75 had a pincer deformity (26.7%) which 16/20 had bilateral. 10/20 women (50%) had a cam deformity, which 9/10 had cam deformity bilateral. 2/20 (10%) had a pincer impingement, which all of them had pincer impingement bilateral.
Johnson A. C., et al., 2012	N=100 (18 - 30 years old, 50 men and 50 women). N= 50 (25 men and 25 women,) high - level soccer during skeletal immaturity.	Age, sex, height, weight, body mass index, alpha angles (cam deformity)	Questionnaire, pelvic radiographs (anteroposterior and frog - lateral)	15/25 male athletes had evidence of CAM deformity, compared with 14/25 male controls. 9/25 female athletes had evidence of CAM deformity, compared with 8/25 female controls. Alpha angle (right hip) was 57.5 degrees in male athletes' group and 55.4 degrees in male control group. Female athletes found to have 50

	N= 50 (25 men and 25 women) not participate in high - level soccer.			degrees alpha angle (right hip) and 48.5 degrees in control group. Neither of these differences was statistically significant.
Lahner M., et al., 2014	N= 22 asymptomatic semi-professionals (range 18 - 30 years with a median of 23.3 years of age) and N= 22 male amateur soccer players (students who played soccer as recreational athletes) with a median of 22.5 years of age (control group, range 18 - 29 years)	Height, Weight, Body mass index, alpha angle (of Nötzil, of the kicking legs), CEA, ROM	Questionnaire, MRI, Hip Outcome Score (HOS with 19 - item activities of daily living an a scored 0 - item sports subscale), clinical hip examination and impingement tests	In the semi-professional group, the mean value of the alpha angle (kicking leg) was 57.3 +- 8.2 degrees while in the amateur group was 51.7 +- 4.8 degrees. 19/22 of the semi – professional group had the right hip as kicking leg. 62.5% of the semi-professional soccer players had an alpha angle greater than 55 degrees while only 27.3% of the amateur group had an alpha angle greater than 55 degrees.
Agricola et al., 2014	N=63 preprofessional soccer players, mean age 14.43, range 12-19 years	Demographic data (age, weight, height, BMI, soccer experience, training intensity), anterosuperior head-neck junction, alpha angle, neck shaft angle (NSA) and growth plate extension.	MATLAB, anteroposterior (AP) and frog-leg lateral radiographs. The amount of internal hip rotation, growth plate extension into the neck and neck shaft angle were determined	The prevalence of a flattened head-neck junction in the age 12-13 years old, increased during follow – up from 13.6% to 50.0%). The alpha angle increased (59.4 degrees at baseline to 61.3 degrees at follow – up). In total, the prevalence of alpha angle increased from 36.5% at baseline to 38.5% at follow-up.
Lahner M., et al 2014	N=14 Semi Professional group, age 22.21 with range 2.28 N=14 Amateur group, age 22.71 with range 2.88	Rearfoot motion, plantar pressure, ground reaction forces, tibial acceleration, alpha angle of Nötzil	MRI of the right hip. In a biomechanical laboratory setting, each group ran in two shoe conditions	In the semi-professional group, the mean value of the alpha angle was 55.1 +- 6.58 degrees and 51.6 +- 4.43 degrees in the amateur group. Maximum rearfoot motion is about 22% lower in the semi – professional group compared to the amateur group in both shoe conditions.
Tak I., et al., 2015	N=63 elite soccer players with a mean age 23.1 years (+-4.2 years), 126 hips	Age, height, weight, BMI, starting age of playing soccer (at least 3times per week), leg of dominance, frequency of practice, a angle	Personal files, questionnaires, anteroposterior and frog leg lateral radiographs	The prevalence of cam deformity in frog – leg lateral view, was significantly lower in amateur footballers from the age of 12 years or above (40.2%), than in professional footballers before the age of the 12 years (63.6%). The prevalence of a cam deformity in footballers who started playing from the age of 12 years was lower (17%) than those who started playing before the age of 12 years (51%). The frequency of football practice during skeletal growth can affect the development of a cam deformity.
Mosler A., et al., 2016	N= 445 male soccer players (890 hips, mean age 25 with range 4.9 years). Arabic (59%), black (24%), Persian (7%), white (6%), East Asian (2%), and other (2%)	Demographic characteristics (ethnicity, age, height, weight, BMI) alpha angle, triangular index, lateral center-edge angle (acetabular dysplasia).	Cohen d, generalized estimating equations (GEE), AP pelvic and Dunn views (alpha angle) and AP pelvic view (triangular index). AP pelvic view (lateral center - edge angle, LCEA)	The prevalence of cam deformity ranged from 57.5% to 71.7% (4/6 groups), and the East Asians group had a lower prevalence (18.8%). A large cam deformity (alpha angle > 78 degrees) was more prevalent in white 33.3% compared with black soccer players (17.8%) and was absent in East Asian players.
Monckeberg J., et al., 2016	N= 72 young elite soccer players with skeletal immaturity (group 1) and N= 70 adult elite soccer players (group 2), asymptomatic and no history of hip disease	Lateral centre edge angle, Wiberg's angle (pincer impingement) and the presence of focal acetabular retroversion, the 'cross - over ' sign). The alpha angle and the anterior offset (cam impingement)	Anteroposterior pelvic and cross-table hip radiographs	34/72 (47.2%) from group 1 versus 34/70 (48.5%) from the group 2 had cam impingement. 30/72 (41.6%) from the group 1 and 36/70 (51.4%) from the group 2 had a pincer impingement. No significant differences were found between the two groups.

Ye´pez A. K., et al., 2017	N=56 asymptomatic youth soccer players aged 13-18 (mean age 15.3 years)	Alpha angle or head-neck offset (CAM type), center-edge angle (Wiberg ankle) or acetabular index (PINCER), ROM, impingement	Manual goniometer, MRI, clinical examination, anterolateral (FADDIR) and posteroinferior (hanging leg with extension and external rotation) tests	Youth soccer players have a high prevalence of FAI 84.8% as diagnosed by MRI (95/112 hips). The alpha angle was greater than 55 degrees in 77% (87/112) of the hips. The anterior impingement test was positive in 15% of the hips evaluated. There is no correlation between physical examination findings and MRI evidence of FAI.
Polat G., et al., 2018	N= 214 asymptomatic male football players (youth league of 1 super league club and 7 amateur clubs, with a mean age of 13.4+-3.2 years First group n=25, 10-12 years old Second group n=104, 13-15 years old Third group n=85 16-17 years old	Alpha angle, lateral centre-edge angle, Tönnis angle and collo diaphyseal angle and morphological abnormalities. Dominant feet, weekly training time and time between beginning playing football until their last annual check – up	Anteroposterior pelvis and frog-leg radiographs, curriculum vitae of the athletes, their injuries, a previous medical profile, and real - time complaints were recorded.	In the first group was not found a cam or pincer impingement. In the second group, 13/104 (12.5%) had a cam impingement and only 1 person a pincer impingement. In the third group 43/85 (50.6%) had a cam impingement and 3/85 (3.5%) had a pincer impingement. The players, who had been playing football for 3 years or more and who had been training for 12.5 hours/week or more had a higher prevalence of FAI.
Falotico G., et al., 2018	N=60 professional adult male soccer players (18-40 years old), asymptomatic N=32 male controls (non-athletes) with a mean age 29.2 years	Weight, height, position on field, dominant limb, age, duration of the soccer career (at least 5 years), frequency of training, age at which they began playing soccer (in a team with a training frequency at least 4/week). Alpha angle, retroversion index, ischial spine signal and posterior wall signal	SPSS V20, McNemar's test and pelvic anteroposterior radiography	The prevalence of FAI in the soccer players was 92.5% versus the control group 28.1%. The mean alpha angle in the athletes was 83 +- 6.6 degrees and 67 +-8.1 degrees in the control group. The duration of the soccer career was positively correlated with the alpha angle ($p = 0.033$) and negatively correlated with the retroversion index ($p = 0.009$). The age, at which the players began to play competitive was inversely correlated with the alpha angle ($p<0.001$).
Ma´rquez W.H., et al., 2019	N=42 professional soccer players (84 asymptomatic hips) 18 - 31 years old, from 3 first division teams	Cam and pincer deformity (alpha angle and lateral centre edge ankle), ROM, BMI, height, body fat	3T magnetic resonance imaging and clinical assessment (FADIR, FABER, DEXRIT test, Tanita electronic scale, Seca 206 stadiometer, traditional formula, formula validated by Evans	The prevalence of cam deformity was 22.5% and 1.3% for pincer and mixed deformity. The prevalence of chondrolabral lesions was 57.6%. More specifically, 33.8% was for labral lesions, 13.8% for femoroacetabular cartilage and 10% for chondrolabral lesions.
Marom N., et al., 2020	336 athletes (421 hips), 257 (61.0%) men and 164 (39.0%) women. 105 athletes (24.9%) highly competitive, 194 (46.1%) competitive, 75 (17.8%) recreational and 47 (11.2%) no reported level. All patients underwent a primary hip arthroscopy for FAI from March 2010 to January 2016	Body mass index, laterality, leg dominance, level of competition), injury characteristics (acute nontraumatic or traumatic, chronic, duration, hip ROM) and clinical and radiographic characteristics (alpha angle, CEA, AIIS)	History (demographic, characteristics of symptoms, duration), clinical examination (FADIR and FABER) and radiographic data (MRI, CT	Female soccer players had significantly more mean hip internal rotation on physical examination than male soccer players (15 degrees vs 8 degrees). The mean alpha angle in male players was 68.5 +- 10.9 degrees (75.9%) and in female group was 57.5 +- 11.5 degrees (69.5%). Highly competitive soccer players had a mean alpha angle 68.5 +- 11.5 degrees (85.7%), while in the competitive group the mean alpha angle was 61.5 +- 12.4 degrees (77.8%). In the recreational group the mean alpha angle was 66.7 +- 10.4 degrees (84%).
AIIS= Anterior Inferior Iliac Spine, GEE= Generalized estimating equations, HOS= Hip Outcome Score, AR= Acetabular Retroversion, ROM= Range of motion, BMI= Body mass index				

IV. Discussion

This review of 14 clinical studies, including 3668 hips among 1834 athletes of soccer examined the associating factors of FAI. In more detail, the factors presented was the stating age of soccer, the intensity of training, the kicking limb, asymptomatic FAI, and previous hip abnormalities.

Most studies reported that the participation of young people in soccer in the period of skeletal immaturity did not appear as a risk factor for the development of cam deformation. [11, 42, 43] Johnson et al. reported that the participation in elite soccer during skeletal immaturity do not increase the risk of developing cam-type deformity in adulthood. [11] Yepez et al. study supported that the prevalence of cam deformity was similar between athletes with open and closed physeal plates, which suggest that the cam is formed even before physeal plate growth is completed. [41] If this lesion is caused by stress from bone impaction, the earlier it starts, the greater the potential damage can be; the immature skeleton is more complacent and can easily be remodeled by abnormal forces.

Whereas the prevalence of FAI in Polat et al. study reached up to 60% in the 16-17 age group, which showed a positive correlation between starting age and FAI especially in athletes who played for 3 or more years. [43] Tak et al. study showed a positive relationship between the training frequency and the appearance of cam deformity at young individuals, before 12 years of age. The starting age of soccer seems to play an important role in developing the deformity. [39] Some studies led to the conclusion that once the hip deformity appears at developmental age, the deformity will continue to develop at a slower rate (almost none) once growth is complete. [38, 40]

According to Lahner et al. and Marom et al. the intensity and the frequency level of training appeared to increase the appearance of FAI. In more details, high level athletes showed higher level of alpha angle than amateur soccer players. [13, 44] Johnson et al. study suggests that participation in high performance sports, at least in soccer, during skeletal immaturity would not be responsible for an increase in the prevalence of hip deformities in the adult population. There is a relatively high prevalence of cam deformity in young adults. [11]

The review confirmed that the prevalence of the right leg as the kicking one. As far as the prevalence of FAI at each leg is concerned, most of the studies indicated that the dominant part is not positively related as a cause for the development of FAI. [11, 38, 41, 42, 43, 44] Yepez et al. study indicated that a possible explanation for the cam deformation presentation may be the forces received by the epiphysis (femur) during physical activities. [41]

Lahner et al. study showed that semi-professional players have a higher prevalence of an increased alpha angle in the kicking leg than the amateur group at the same age. [13] The kicking leg is predisposed for FAI. One possible cause is the higher impact and stressful intensity on the hip during kicks at the semi-professional level of soccer. By a forced flexion and internal rotation during the move of the kick, the aspheric part of the femoral head is squeezed into the acetabular fossa which may lead to high shear forces due to close anatomical guidance. With the chronicity of the microtrauma, an anticlinal alteration occurred in the further course on the ventral femoral head–neck junction.

Most of the studies reported cases of FAI without symptoms. [13, 38, 40, 41, 42, 43, 46, 47] Only in the Marom et al. study the athletes report pain for more than 6 months. [44] All the studies showed a high prevalence of asymptomatic FAI. In more details, Yepez et al. study showed a higher prevalence than Agricola's 2012, Gerhardt MB et al. 2012, Johnson AC 2012. [11, 38, 41, 46] When comparing the prevalence of pathological alpha angle only (≥55◦, cam-type deformity), the 77.7% rate found in Yepez study was higher than those reported by Gerhardt et al. 25 (68%) and Johnson et al. 26 (60%), both studies evaluated adult soccer players using plain radiography. [11, 41, 46] Yepez's results of pathological alpha angle reported higher prevalence (26%) than Agricola et al. who evaluated adolescent soccer players using plain radiography and considered the alpha angle abnormal if it was higher than 60◦. [38, 41] This can be explained by the greater sensitivity of MRI compared to plain radiography in identifying changes that characterize FAI. Furthermore, this suggests that MRI can reveal abnormalities consistent with FAI before they become apparent on the athlete or the clinical examination.

Only one study examined the co-existence of FAI and previous abnormalities. Anatomical features of FAI were found to be related to lesions of the femoral cartilage, chondrolabral damage, or both injuries. [47]

Practical Implications

Overall, FAI is strongly associated with athletic performance and can be discriminated between athletes from different sport disciplines and performance levels. The variables within this disorder should be considered when designing, conducting, and disseminating sport science research. The risk factors must be acknowledged by the training community and modifications in training protocols is advised to prevent the deformity. A limitation of the current study is the small sample of research investigating FAI in soccer players. Moreover, there is a lack of long-term research examining the development of the deformity from an early age. It should be acknowledged that there is a confusion between the terms ´football players´ and ´soccer players´, as American and Australian football is considered rugby, while European football is referred as soccer. Increased research effort is required from the physical therapy and training communities to identify, treat, and prevent FAI efficiently. Further research is needed to delineate the frequency of these findings in general populations, better define the

progression of these findings throughout the history of pathology, investigate the long-term effects of training aspects such as the position of each player and the way it affects the presence of the deformation.

V. Conclusion

This study examines multiple risk factors for FAI. The participation during skeletal immaturity as a risk factor is yet unclear. The right leg is proved to be preferred as the kicking one. As far as the prevalence of FAI at each leg is concerned, most of the studies indicated that the dominant part is not positively related as a cause for the development of the syndrome. A possible cause is the higher impact and stressful intensity on the hip during kicks in the soccer playing. By a forced flexion and internal rotation during the move of the kick, the aspheric part of the femoral head is squeezed into the acetabular fossa which may lead to high shear forces due to close anatomical guidance. With the chronicity of the microtrauma, an anticlinal alteration occurred in the further course on the ventral femoral head–neck junction. Once the hip deformity appears in developmental age, the deformity will continue to develop at a slower rate once growth is complete. The level of training (intensity and frequency) presents as a positive correlation with the development of the impingement possibly due to the higher impact and stressful intensity on the hip during kicks in the soccer playing on the professional level. By a forced flexion and internal rotation during the move of the kick, the aspheric part of the femoral head is squeezed into the acetabular fossa which may lead to high shear forces due to close anatomical guidance. With the chronicity of the microtrauma, an anticlinal alteration occurred in the further course on the ventral femoral head–neck junction. All the studies showed a high prevalence of asymptomatic FAI among soccer players. Anatomical features of the syndrome were found to be related to lesions of the femoral cartilage, chondrolabral damage, or both injuries.

Declaration of conflicting interests

The author(s) declare no conflict of interest.

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