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PREVALENCE OF FEMOROACETABULAR IMPINGEMENT IN SOCCER PLAYERS

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ABSTRACT

Objective: This review aims to examine the prevalence of Femoroacetabular Impigement (FAI) in soccer players with regard to age, gender, gene (genetics - predisposing factors), ethnicity and type. **Methods**: A research of PubMed, PEDro and ScienceDirect (through 2010-2021) was completed for the prevalence of FAI. The inclusion criteria were the publication date, the population (soccer players) and the syndrome. Out of 346 studies, 13 were included. **Results**: Cam impingement was significantly more common in athletes. Males, white race and the age between 12- and 14-years old face higher odds of developing FAI. Physical examination can provide evidence of impingement, but it is not reliable on itself. FABER and FADDIR test reported to be the two most reliable tools. FAI occurs mainly in young athletes, who show pain in the groin and limited movement of the hip. The impact findings showed that the main angles, that are influenced, are the Femoral head-neck offset, Centre-edge angle of Wiberg, Crossing ratio and A-angle. **Conclusion**: The results of the review showed that FAI appears to be a common type of deformity in soccer athletes. The physical therapy and training communities must be educated to identify, treat, and prevent FAI efficiently.

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INTRODUCTION

Femoroacetabular impingement syndrome (FAI) is a motion-related condition with a complex presentation of morphology, symptoms and clinical signs. (Griffin DR, 2016) Morphologic abnormalities of the femoral head-neck junction or acetabulum are presented (Ganz R *et al*., 2003; Byrd JW, 2010) which causes frequent abnormal contact between femoral head-neck junction and the acetabular rim during flexion and internal rotation (IR) at the hip, resulting in labral lesion and cartilage delamination. (Kennedy MJ *et al*., 2009; Bedi A, *et al*., 2011; Harris JD *et al*., 2013) There are two types of FAI. The first type, Cam, concerns the increased bone formation of the femoral head-neck of the thigh and the second type, Pincer, the overcoverage of the acetabulum. (Byrd JW, 2014) In some patients a cam and pincer impingement, mixed-type combination, might also be detected. (Peelle M. W., 2005; M. Tannast *et al*., 2007; Kapron, A. L. *et al*., 2012) Factors affecting the likelihood and rate of this progression are not yet well understood. (Beck M *et al*., 2005; Fairley J *et al*., 2016) Cam morphology has been reported in up to 60–90% of athletic populations. (Siebenrock KA *et al*., 2011; Johnson AC *et al*., 2012; Agricola R *et al*., 2012; Lahner M *et al*., 2014). The symptoms of FAI 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. (Rikin V. Patel *et al*., 2019) There is a wide discrepancy in reporting prevalence rates for cam, pincer and mixed FAI, particularly among distinct populations, such as groups of asymptomatic or symptomatic subjects and athletese. (D. Moher *et al*., 2009; Vasco V. Mascarenhas *et al*., 2016) High contact sports athletes, such as soccer, are more prone to such annoyances. The participation of people from a young age, 12-13 years old, in these sports shows a higher prevalence of hip deformity. Diagnosis of FAI syndrome requires a systematic physical examination that includes inspection for muscular hypotrophy, swelling, or redness; palpation of the groin, sacroiliac joint, ischial tuberosity, and symphysispubis; measurement of passive and active range of motion of the affected hip for comparison with the contralateral hip; impingement test; FABER (flexion, abduction, external rotation) test; and neurovascular examination. (Philippon MJ *et al*., 2007; Byrd JW, 2010; Frangiamore S *et al*., 2017; Haldane C. E et at., 2017). Plain radiographic and magnetic resonance imaging are also critical supplements to the physical examination. (Philippon MJ *et al*., 2007) Anterior-posterior pelvis imaging should be considered as well as lateral image of the hip in question. (Enseki K *et al*., 2014). The femoral neck shaft angle (NSA) is an important anatomic measure,

which can evaluate and describe the geometry of the proximal femur and hip joint. The angle between the longitudinal femoral shaft axis and the femoral head neck axis is measured. The axis of the femoral neck is defined by a line bisecting the femoral neck through the center of the femoral head. The longitudinal femoral shaft axis is determined by two bisections of the femoral shaft at different locations. A known normal range is generally considered 125 to 135 degrees (126 degrees in Europe). (Gilligan I. *et al*.,2013)

***Centre – edge angle of Wiberg*:** The lateral center edge angle (LCEA) and the anterior center edge angle (ACEA) are commonly used to assess acetabular coverage of the femoral head. A greater og 39 degrees LCEA indicates a pincer type impingement. (Hanson, J. A. *et al*., 2015)

The upper - lateral coverage of the femoral head: The mean angle is higher of 20 degrees under 55 years old, lower of 24 degrees over 55 years old, and over 40 degrees declares over coverage. (Johnson, A. C., 2012)

Crossing ratio: Values ranges from 14 to 20 degrees at the equatorial level of the acetabulum and gradually decreases towards the acetabular roof, where normal values range from 0 to 5 degrees. The posterior inclination of the upper part of the acetabulum has been associated with a Pincer impact. On X-ray, the presence of a "crossing point" is produced when the posterior wall of the acetabulum crosses the anterior wall before reaching the acetabular roof. It is a sign of acetabular inversion and has been associated with excessive coverage and impact. However, this sign has been described in 6% of the normal population. The transit rate, which normal value is <20 degrees is considered to be more important than the sign of a crossing point. (Ruiz Santiago F. *et al*., 2016; Diaz-Ledezma C *et al*., 2013)

A-angle: The alpha angle is measured by first fitting a circle to the femoral head. Then a line is drawn through the center of the neck and the center of the head. A second line is drawn from the center of the head to the point where the head-neck junction first departs from the circle. The alpha angle is the angle between these two lines. A deformity of a Cam is considered when the alpha angle is >60 degrees and pathological Cam when it is >78. (Agricola R. *et al*., 2014) FAI is a common disorder in soccer players that has yet to be analyzed in depth from the physical therapy point of view. This review aims to address this by examining the prevalence of FAI in soccer players with regard to age, gender, gene (genetics - predisposing factors), ethnicity and type. Reference is also made to the physical examination, which helps diagnose the syndrome and its reliability. Increased research effort is required from the physical therapy and training communities to identify, treat, and prevent FAI efficiently.

MATERIALS AND METHODS

Protocol and registration: The protocol of this systematic review was developed and has been registered in the International Prospective Register of Systematic Reviews (PROSPERO CRD42021259586). This review was conducted in line with the Prisma statement guidelines. (Moher d *et al*., 2009)

Eligibility criteria: The clinical question was the prevalence of FAI in soccer players. Studies were in- or excluded based on following criteria:

- publication date: from 2010 to 2021;
- type of participants: studies included both amateur and professional soccer players. No restrictions were made regarding age. 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;
- type of injury-syndrome: all studies examined FAI.

Information sources and search: Studies were identified by searching three electronic databases: Medline databases (via PubMed), PEDro (Physiotherapy Evidence Database) and ScienceDirect. The terms used were 'the prevalence of femoroacetabular impingement', 'femoroacetabular impingement and soccer players' and 'biomechanical and functional indicators'. A search strategy was developed and refined based on preliminary screenings.

Study selection: Eligibility screening of the studies was conducted in a blinded standardized way by two independent reviewers (G.L. and E.T.). Titles and abstracts were screened using 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 (G.L. and E.T.). Disagreements between authors during any stage of the screening process were resolved by consulting a third reviewer (K.C.).

Study selection: The original search results were 346 articles. The articles that finally met all the inclusion criteria and were analysed, after the removal of the copies, the reading of the title, the summary or even the whole text, were 13. The flow diagram in Figure 1 presents the details of study screening and selection.

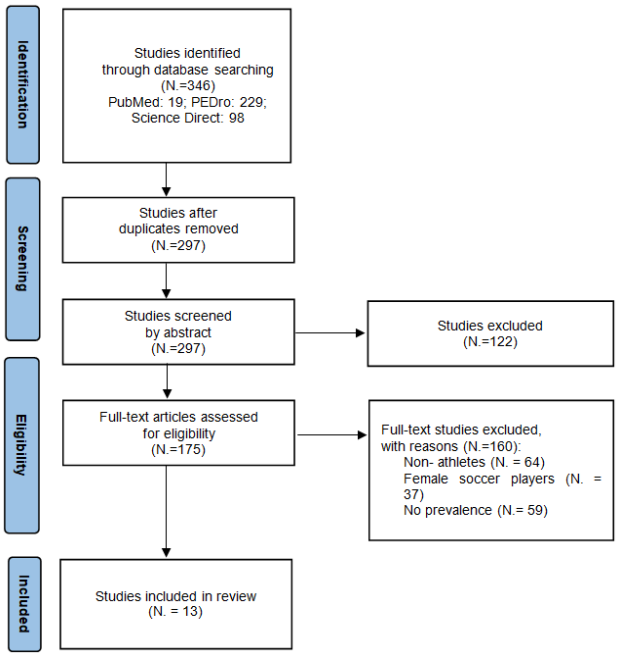

Figure 1. PRISMA Flow diagram of study selection process in the systematic review

RESULTS

Prevalence of types: A review of AP pelvis and frog-leg lateral radiographs of 75 male and 20 female soccer players (total 95 elite male and female soccer players) was conducted by Gerhardt *et al*. in 2012. They reported an incidence of 68% of Cam deformity for men and 50% for women. Pincer deformity was 26.7% for men and 10% for women. Agricola *et al*. in 2014 measured an important increase in the prevalence of Cam deformity in the follow-up of their previous study. The prevalence of a pathological Cam deformity (alpha angle >78 degrees) increased from 7.9% to 13.5%. A decreased NSA (mean 129.1 vs 133.6, respectively p=0.001) and an increased epiphyseal extension (mean 1,54 vs 1,43, respectively p=0.001) were associated with the presence of the deformity based on an alpha angle >60 degrees.

At baseline, 64/178 hips reported normal appearance of the anterosuperior head-neck junction, of which 35 developed either a flattening or prominence at follow-up. Cam deformations appear to continue to exist and develop progressively in skeletal development

and may remain the same until development is complete. The study showed that this deformity is the most common cause of hip pain and restricts the function in young adults. FAI was recognised as a major risk factor for the development OA. The overall prevalence in Mosler *et al*. study was 60% for Cam deformity and 3% for Pincer. A percentage of 72% of soccer players had at least 1 hip which presented Cam deformity and they defined it as an alpha angle greater than 60 degrees on AP pelvic or Dumm view radiographs. The measurements of alpha angle in Falotico *et al*. study showed that 92.5% (111/120 hips) in professional male soccer players, versus 28.1% in the controls, had an overall mean alpha angle of 83 degrees that indicates a Cam impingement (Ap pelvis radiograph, in supine position). Cam deformity was diagnosed in 21.7%, pincer deformity in 33.3% and mixed in 45%. (Kapron A. L. *et al*., 2012). The prevalence of FAI in the Marquez study in 2019 was 22.5% (n=18) of Cam deformity and 1.3% (n=1) a mixed type by 3T MRI. In 2017 Monckenberg *et al*. found that 47.2% in the first group (young elite soccer players) and 48.5% in the second group (adults elite soccer players) had positive signs of Cam deformity. Pincer deformity presented 30/72 (41.6%) from the first group and 36/70 (51.4%) from the second group. The recent research of Polat *et al*. in 2018, in which 214 football players (male) participated, aged 13.4 + -3.2 years (range 10-17), reported 30% of athletes with femoral congestion. The Cam type was found at 26.2%, the pincer at 1.9% and the mixed type at 1.9%.

Gender: In 2020 Marom *et al*. found that female soccer players had a significant difference in the internal rotation of the hips (15 degrees instead of 8 degrees) than male soccer players, lower values of the alpha angle than males (57.5 vs 68.5 degrees) and for this reason were less prone to developing findings of FAI. This may be a result of the higher number of male soccer players who participated in high - level of competition (77/257 male hips vs 28/164 female hips). The differences in radiographs between (75) male and (20) female professional soccer players, for whom the state of their symptoms was unknown, was studied by Gerhardt *et al*. in 2012. They found that the mean alpha angle (frog-leg lateral view radiograph), was 65.6 degrees for male soccer players and 52.9 for female. Specifically, a total of 72% (54/75) male athletes and 50% (10/20) women showed hip deformity. Cam deformity occurred in 68% of male (51/75) and 50% offemale (10/20). In 76.5% (39/51) of the male cases and in 90% (9/10) of the female appeared in both lower extremities. Pincer deformity occurred in 26.7% (20/75) of male and 10% (2/20) of female. The age between the two sexes was quite close, 25.8 for male and 23.8 for female. However, there was a big difference in terms of total years of playing football (5.9 years for male and 1.1 for female). The average aplha angle in male was 65.6 degrees and in female was 52.9. In 2012 Johnson *et al*. study reported significant differences between the genders. A total of 22/50 (44%) male showed deformity in both hips, 4/50 only on the right and 3/50 only on the left, while the mean alpha angle was 56.4 and 54.7 degrees. However, 10/50 (20%) female showed deformity in both hips, 5 only on the right and 2 only on the left, while the mean alpha angle was 49.3 and 49.1 degrees.

Ethnicities: Different nationalities (Arabic 59%, Black 24%, Persian 7%, White 6%, East Asian 2% and other 2%) participated in the study of Mosler *et al*. in 2016. The results showed that the only group with a low alpha angle (Cam deformity, which measured with AP pelvis and Dunn radiographs and triangular index) was the group with East Asians (18.8% for the East Asian vs 60.0% to 71.7% in the other 4 groups). The higher alpha angle reported the white group (33.3%) compared with the black group (17.8%). Therefore, the Pincer deformity, which measured with LCEA greater than 40 degrees, was unusual (3%) in all ethnicities.

Age: In the first study of Agricola *et al*., in 2012, participated 89 football players and 92 non athletes (control group) aged 12-19 years old. The training frequency of the athletes was 7.96 + - 1.77 hours per week. The hip morphology for a Cam deformity was a ratio of 44% in the first group. Few people aged just 12 years (3/25) were found to have an alpha angle greater than 60 degrees. In total, 23/89 athletes showed an alpha angle greater than 60 degrees, while respectively 16/92 people in the control group. Athletes were found to have an increased alpha angle (greater than 60 degrees) and Cam deformation in 35% of AP and frog-leg lateral radiographs, while no one was found in the control group. In 30% of athlete's cases Cam deformity occurred in both hips. In the study of Agricola *et al*., in 2014, 126 hips were studied by young football players, aged 12 to 19 years. The players were divided into 3 age groups: 12-13 years (44 hips), 14-15 years (48 hips) and 16-19 years (34 hips). Boy's baseline presented an increased prevalence of a flattened head-neck during follow-up (13,6% to 50%). In more details, from the age of 12 to 14 years, 50% of the normal hips acquired a flattened head-neck junction. After the 14 years and until growth plate closure, the flattening continued to evolve. The prevalence of a Cam deformity showed no significant increase after closure of the proximal femoral growth plate. In terms of an open growth plate at baseline the prevalence of a projection increased from 2,1% to 17.7%. No differences were found between the age groups. A positive relationship was found between boys aged from 12 to 15 years with an open growth plate and a Cam deformity at baseline. The NSA was found similar between hips with and without a Cam deformity in the older soccer players and in those with a closed growth plate. The study noted that because the NSA angle decreases as the individual grows, there is a greater risk of developing a Cam deformity when the individual enters adulthood, and the angle becomes more varus.

The incidence of developing FAI in young people (with skeletal maturity) was studied by Monckeberg *et al*. at 72 young (skeletally mature) professional soccer players and 70 adults professionals. No notable differences were found from the research, as the incidence of FAI occurred with a rate of 63.8% in the first group and with 75% in the second group. The Cam deformity was found to be 47.2% in the first group and 48.5% in the second group. As far as Pincer deformity is concerned, the differences were also not very significant (41.6% vs 51.4%). Similar results were reported in the Johnson *et al*. study. A total of 50 athletes (25 men and 25 women) and 50 non-athletes (25 men and 25 women) participated during skeletal maturation. At 12/25 of the male athletes (soccer players in high-level as youths) was reported a Cam deformity in both hips, 2/25 only in the right hip and 1/25 in the left hip. The mean alpha angle was 57.5 degrees (right hip) and 55.1 degrees (left hip). In the cortrol group 10/25 men presented a Cam deformity in both hips, 2/25 only in the right and 2/25 only in the left hip. The mean alpha angle was 55.4 (right hip) and 54.4 (left hip) degrees. In the same study, 25 women participated during skeletal immaturity, who also played soccer in high-level. Four of them were diagnosed with Cam deformity in both hips, four only in the right hip and one of them only in the left. The mean alpha angle was 50.0 degrees (right hip) and 49.2 (left hip). In the control group 6/25 women appeared with Cam deformity in both hips, 1/25 only in the right and another one only in the left. The mean alpha angle was 48.5 and 49.1 degrees. The differences in Cam deformity and alpha angle were not also significant. Out of a total of 50 participants, who were athletes, 16 showed a deformity in both hips, 6 only on the right and 2 only on the left. The average alpha angle was 53.8 and 52.1 degrees. In the non-athlete group (control group), out of the 50 participants, 16 showed Cam deformation on both hips, 3 only on the right and another 3 only on the left. The average alpha angle was found to be 52.0 and 51.7 degrees. The differences were not significant between the groups in the period of skeletal immaturity. The study showed that children's participation, at development age, in high levels of competition (soccer) is not a significant risk factor for the development of Cam deformity in hip.

The study by Polat *et al*. involved 214 paediatric male soccer players with an average age of 13 years (from 10 to 17 years old). The average participation in the sport was 4 years. 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.

Table 1. Results of studies included in the review of athletes with FAI

Researchers	Subjects	Assessment	Assessment tools	Results
Agricola et al., 2014	n=63 preprofessional soccer players, 12-19 years old, meanage 14.43 years	Age, weight, height, BMI, soccer experience, training intensity, anterosuperior head-neck junction, an angle, neck shaft angle (NSA), 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	Flattenedhead-neck 13.6% to 50.0%. Alpha angle increased 59.4 degrees at baseline to 61.3 degrees at follow – up. alpha angle increased from 36.5% at baseline to 38.5% at follow-up.
Lahner M., et al 2014	N_1=14 Semi Professional group, age 22.21 with range 2.28 N_2=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	N_1 had alpha angle 55.1 +- 6.58 degrees and $N_2$51.6 +- 4.43 degrees. N_1 had maximum rearfoot motion about 22% lower.
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.	Body mass index, laterality, injury, acute nontraumatic or traumatic, chronic, duration, hip ROM, alpha angle, CEA, AIIS	History (demographic, characteristics of symptoms, duration), clinical examination (FADIR and FABER) and radiographic data (MRI, CT	Alpha angle>55 degrees in male was (75.9%) and in female group was (69.5%). Highly competitive (85.7%), while in the competitive group (77.8%). In the recreational group (84%).
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%)	ethnicity, age, height, weight, BMI, alpha angle, triangular index, lateral center-edge angle	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)	Cam deformity ranged from 57.5% to 71.7% (4/6 groups), and in the East Asians group (18.8%). A large cam deformitywas more prevalent in white 33.3% compared with black soccer players (17.8%) and was absent in East Asian players.
Johnson A. C., et al., 2012	N_1=100 (18 - 30 years old, 50 men and 50 women). N_2= 50 (25 men and 25 women,) high - level soccer during skeletal immaturity. mN_3= 50 (25 men and 25 women) not participate in high - level soccer.	Age, sex, height, weight, body mass index, alpha angles	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.
Lahner M., et al., 2014	N_1= 22 asymptomatic semi-professionals (range 18 - 30 years with a median of 23.3 years of age) And N_2= 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, 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	N_1had alpha angle 57.3 +- 8.2 degrees while in N_2 was 51.7 +- 4.8 degrees. N_1 (62.5%) had an alpha angle greater than 55 degrees while N_2only 27.3%
Monckeberg J., et al., 2016	N1= 72 young elite soccer players with skeletal immaturity (group 1) N2= 70 adult elite soccer players (group 2), asymptomatic and no history of hip disease	Lateral centre edge angle, Wiberg's angle, 'cross – over' sign, alpha angle, the anterior offset	Anteroposterior pelvic and cross-table hip radiographs	N1 34/72 (47.2%) vsN2 34/70 (48.5%) had cam impingement. 30/72 (41.6%) and 36/70 (51.4%) had a pincer impingement.
Polat G., et al., 2018	N= 214 asymptomatic male football players, mean age 13.4+-3.2 years N1=25, 10-12 years old N2=104, 13-15 years old N3=85 16-17 years old	Alpha angle, lateral centre-edge angle, Tönnis angle and collo diaphyseal angle	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 groupnocam or pincer impingement was found. N1, 13/104 (12.5%) cam impingement and only 1 person pincer impingement. N2 43/85 (50.6%) cam impingement and 3/85 (3.5%) pincer impingement.
Yepez 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, center-edge angleor acetabular index,	Manual goniometer, MRI, clinical examination, anterolateral (FADDIR) and posteroinferior (hanging leg with extension and external rotation) tests	FAI in Youth soccer players 84.8% (95/112 hips). Alpha angle 77% (87/112) of the hips.
Marquez W.H., et al., 2019	N=42 professional soccer players (84 asymptomatic hips) 18 - 31 years old	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.

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Falotico G., et al., 2018	N1=60 professional adult male soccer players (18-40 years old), asymptomatic N2=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	FAI in the soccer players was 92.5% vs the control group 28.1%. alpha angle N1 was 83 +- 6.6 degrees and 67 +-8.1 degrees in N2. 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 ($p<0.001$).
Agricola R., et al., 2012	N1=89 elite preprofessional footballers (178 hips), mean age 14.8 years, N2=92 non-athletes (184 hips), 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	N1 26% cam deformities, N2 17%.
Gerhardt B. M., et al., 2012	N=95 elite soccer players (75 male and 20 female) mean age 25.8 years. No exclusion criteria, players with a history of hip or groin injuries were included	Hip or groin injury, alpha 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.

AIIS= Anterior Inferior Iliac Spine, GEE= Generalized estimating equations, HOS= Hip Outcome Score, AR= Acetabular Retroversion, ROM= Range of motion, BMI= Body mass index

In the first group the appearance of FAI did not exist (0%), in the second group it was 19.1% and in the third group it was 60%. The prevalence of Cam deformity was reported to be similar between soccer players with open and closed physeal plates (7/11 athletes in 16 years old and 6/6 in 18 years old) in the research of Yepez *et al*. in 2017.

Alpha angle and hip movement: The rearfoot motion and plantar pressure in male semi-professional soccer players with increased alpha angles to amateur players was compared in the study of Lahner. The athletes ran in two shoe conditions (regular running shoe, same shoe with inserted valgus wedges) at a speed of 3.3 m. The mean alpha angle was 55.16+-6.58 for the semi-professional group and 51.65+-4.43 for the amateur group. A total of 7/14 athletes of the semi-professional group and 5/14 of the control group had a varus malalignment of the mechanical axis. The differences in biomechanical measurements (ground reaction forces, peak tibial acceleration, rearfoot motion and plantar pressure parameters etc) from the 2 groups were not significant except from the peak pressure metatarsal head III (673 for the semi-professional vs 525 for the control group) and the peak pressure lateral midfoot (343 vs 263). Although hip motion during movement was not measured, the present data allow us to assume that the oscillation of the center of mass is different for each group. In the semi-professional group, the increased vertical forces were accompanied by reduced horizontal forces which resulted in a more intense upward and downward movement of the center of mass. Compared to asymptomatic individuals, patients with FAI have limited hip flexion during squatting which can be caused by hip pain. The deviation of the mechanical axis can affect the kinematics of gait. To compensate for the reduction in hip flexion found in patients with FAI while walking, the vertical oscillation of the center of mass is increased which could be used to neutralize the limitations in sagittal level of hip movement (Monckeberg J., 2017).

Physical Examination of FAI: In the study of Marom *et al*. in 2020 most of the players were symptomatic and the symptoms lasted for more than 6 months. The only report for an acute traumatic injury, which was the reason for hip symptoms, was reported only in 22 hips (5.2%). A total of 29 (11.3) hips for male were acute nontraumatic, 13 (5.1) acute traumatic, 146 chronic (56.8) and 69 (26.9) were not reported. In female soccer players, 15 (9.1) were acute nontraumatic, 9 (5.5) acute traumatic, 85 (51.8) chronic and 55 (33.5) were not reported. As for the physical examination, the average medial hip flexion was 10.5 degrees, for the external rotation 42 degrees and for the flexion 102 degrees. In an attempt to assess the physical examination, Yepez *et al*.used the range of motion (flexion-extension, adduction-abduction, internal - external rotation), which was measured with a manual goniometer and impact tests (posteroinferior and anterolateral) were applied. All tests were considered positive if they produced pain. No positive correlation was found between magnetic and physical examination. Only 15% of the anterior impingement test was found positive from the hips which were evaluated. The posteroinferior test was negative in all athletes. However, the studynotesthat the sample in the present study was asymptomatic. The FABER test was positive in 40% of the soccer players in the study of Marquez *et al*. in 2019. The right side was presented in 17.5% (n=7), the left side in 20% (n=8) and bilateral in 2.5% (n=1). The FADDIR test was positive for 20% of the athletes, 12.5% in the left hip (n=5) and bilateral in 7.5% (n=3). The study of Agricola in 2012reported no positive association between the anterior impingement test and FAI, either because in athletes labral injury was not yet present or because the test was not sufficiently sensitive. Internal rotation was reduced in hips with Cam deformity compared with hips without the deformity (19.7 vs 26.2 degrees). It was also applied to the hips with a flattening or prominence on the frog-leg lateral view compared with those without (20.4 vs 29.8 degrees). No such differences in range of motion were found when having a flattening or prominence on the AP view.

However, after 2 years of follow – up, in 2014, Agricola *et al*.found that limited internal rotation was a significant predictor (95%) for a Cam deformity in 15 hips which had an alpha angle greater than 60 degrees.

DISCUSSION

Many factors are contemplated to contribute to the development of FAI. Some of these are considered by many researchers to be more critical in FAI development, while others are more uncertain. According to the prevalence of FAI types, Cam deformity appears to bethe most common form of impact. (Gerhardt M. B. *et al*., 2012; Agricola, R *et al*., 2014; Yépez, A. K. *et al*., 2017; Monckeberg, J. 2017; Marquez, W. H. *et al*., 2019; Polat, G. *et al*., 2019) In total, more than 1500 people (over 3668 hips), about 1834 people and 3668 hips were studied in the present review. The Cam deformity was found in over 1000 people, about 1097 (59.81%). Only one study Falotico *et al*. in 2017 found that 21.7% of FAI was Cam deformity, 33.3% was pincer deformity and 45% was mixed. As far as gender is concerned as a risk factor for developing FAI, in all the studies males are presented more prone to appear the syndrome than females. (Agricola R. *et al*. 2012; Agricola R. *et al*., 2014; Marom, N. *et al*., 2020) In more details, males are almost twice as likely to develop a FAI deformity. This may be a result of lower alpha angle as suggested in Marom's study. (Marom, N. *et al*., 2020).

Regarding the age of the development of FAI, the results of the studies differ from each other. Most studies agree that age, on average 12 to 14 years old, may contribute to the development of the syndrome. (Agricola R. *et al*., 2012; Lahner M. *et al*., 2014; Yépez A. K., 2017; Falotico, G. G. *et al*., 2019) These researchers support the theory that young people who are involved in football, especially in the developmental age, have a higher prevalence of Cam deformity. Agricola *et al*. suggested that Cam deformation is probably related to the frequency of athletic activities, which exert repetitive forces on the femoral head and can be developed only during skeletal development, when the femoral head responds more to mechanical loads. (Agricola R. *et al*., 2014) Yepez's study suggested that Cam deformity is formed even before physeal plate growth is completed. (Yépez A. K. *et al*., 2017) If this lesion is caused due to forces from bone impaction, the earlier it starts, the greater the potential damage. The immature skeleton is more complacent and for that reason can easily be remodelled by abnormal forces. However, Moncheberg' s study showed that age (skeletal maturity) is not a risk factor, nor have soccer players at this age a higher incidence of developing femoral congestion. (Monckeberg J. *et al*., 2017). The only research which studied ethnicity as a possible risk factor for FAI development was Mosler *et al*. in 2016. The study reported that the white people group had the highest alpha angle (33.3%) compared to the group of black people (17.8%). Overall, all groups were found to have a high prevalence (Arabic, black, Persian, white) except from East Asian (18.8% vs 60.0% to 71.7%). Finally, the capability of physical examination as a diagnostic tool of FAI is questionable. Some authors agree that internal hip flexion, FADDIR and FABER tests can diagnose FAI. (Gerhardt M. B. *et al*., 2012; Marquez W. H. *et al*., 2019; Marom N. *et al*., 2020) Yepez's and Agricola first research shows that FAI cannot be diagnosed by goniometry through change of range of motion. (Agricola R. *et al*., 2012; Yépez A. K. *et al*., 2017) However, on the second study of Agricola it was noted that interior rotation was significantly reduced at hip with Cam deformity. (Agricola R. *et al*., 2014).

CONCLUSION

Femoroacetabular impingement (FAI) is a condition in which the hip is deformed. The deformity may involve only the acetabulum (Pincer impingement) or only the femoral head (Cam impingement) or both (mixed type). Cam deformity appears to be the most common type, while males seem to be more prone to the syndrome. Specifically, boys aged 12-14 years and white race have more tendency to present FAI findings. The impact often injures other soft tissues that are normally present in the hip joint (articular cartilage, acetabular labrum). FAI occurs mainly in young athletes, who show pain in the groin and limited movement of the hip. As far as the physical examination is concerned two tests have stand out, the FABER and the FADDIR. The reliability of those tests in the diagnosis of the syndrome has not yet been determined. Finally, the impact findings showed that the main angles influenced are the Femoral head-neck offset, Centre-edge angle of Wiberg, Crossing ratio and A-angle.

Although the review has reached its aims, there were some unavoidable limitations. Firstly, the literature on FAI in soccer players is indigent. Secondly, a confusion is appeared between the terms soccer and football players, and some research has been inaccurate in defining the term. Based on the results of the present review, further research is needed. Furthermore, the research that has been done to study the nationality of individuals and whether the physical examination is a reliable tool for diagnosing FAI is minimal and so no accurate and reliable conclusion can be drawn. It is necessary to have more studies examining the corelation of external hip rotation and focus on the reliability of multiple tests of the physical examination in diagnosing FAI. Due to the limited research, especially in the group of soccer players, it is considered necessary for future researchers to study the specific deformity in the hip joint. Many matters are still unclear. Future research may study the factor of the "dominant" foot and whether the kicking leg is more prone to deformity. As well as the position of each player, the practise frequency, and pervious hip abnormalities must be examined.

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