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Prevalence of Abnormal Hip Alpha Angle in Football Players- A Potential Contributory Factor to Other Pathologies

Roberto Seijas[1,2*], Oscar Ares[2,4], Andrea Sallent[5], D Barastegui[1,3], P Alvarez-Díaz[1,2,3], E Rivera[1,3], G Steinbacher[3], X Cuscó[1], Cugat Ramon[1,3]

[1]Arthroscopy GC, Fundacion Garcia Cugat, Hospital Quirón, Barcelona, Spain

[2]International University of Catalonia, Spain

[3]Catalan Mutuality of Soccer players, Spanish Federation of Soccer-RFEF, Spain

[4]Hospital Clínic Barcelona, Hospital Quiron Teknon Barcelona, Spain

[5]Hospital de la Vall d'Hebron Barcelona, Spain

[*]**Corresponding author:** Roberto Seijas, Arthroscopy GC, García Cugat Foundation Quirón Hospital Barcelona, Universitat Internacional de Catalunya, Plaza Alfonso Comín 5-7 Floor -1 08023 Barcelona, Spain. Tel: +34932172252; Fax: +34932381634; Email: roberto6jas@gmail.com

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Abstract

Femoroacetabular Impingement (FAI) is associated with a higher risk of Osteoarthritis (OA). One of the most frequently used measurements is the alpha angle. An angle greater than 55° is considered abnormal, and can promote mechanical and biological impairments in the form of OA. Athletes display a higher rate of abnormal alpha angle. We conducted a descriptive study to evaluate the rate of abnormal alpha angle in a population of affiliated football players. To this end, different groups were selected: asymptomatic volunteers and patients who had undergone FAI, Osteitis Pubis (OP), meniscus or Anterior Cruciate Ligament (ACL) surgery. The rates of abnormal angle were 20% in healthy volunteers, 42% in meniscus patients, 46% and 73% in ACL patients (in hip contralateral and ipsilateral, respectively, to the ACL lesion), 88% in OP and 100% in FAI.

The rates observed in the meniscus patients and contralateral hip of ACL patients are similar to those seen in various series of athletes. The high rates observed in the ipsilateral hip of ACL patients and in OP patients could modify the mechanics and contribute to the pathophysiology of the lesion. In conclusion, the mean rate of abnormal alpha angle was over 40%, exceeding 80% in other typical pathologies of football players.

Keywords: Alpha Angle; Femoroacetabular Impingement; Hip

Introduction

Femoroacetabular pathology has gained high importance in recent years, attracting greater levels of interest in the last decade, as is apparent from the number of publications about this pathology and about its treatment with hip arthroscopy [1]. It is currently one of the leading causes of hip pain in young adults, and is considered a potential cause of early hip Osteoarthritis (OA) [2-5].

Femoroacetabular Impingement (FAI) has been described as a deformity in the sphericity of the femoral head (cam type) or acetabular over coverage of the femoral head (pincer type) or a combination of both in mixed types. It remains difficult to diagnose, and its radiological evaluation remains controversial. The most common method used to evaluate FAI deformities radiologically, particularly the cam type, is the alpha angle [6,7] (Figure 1).

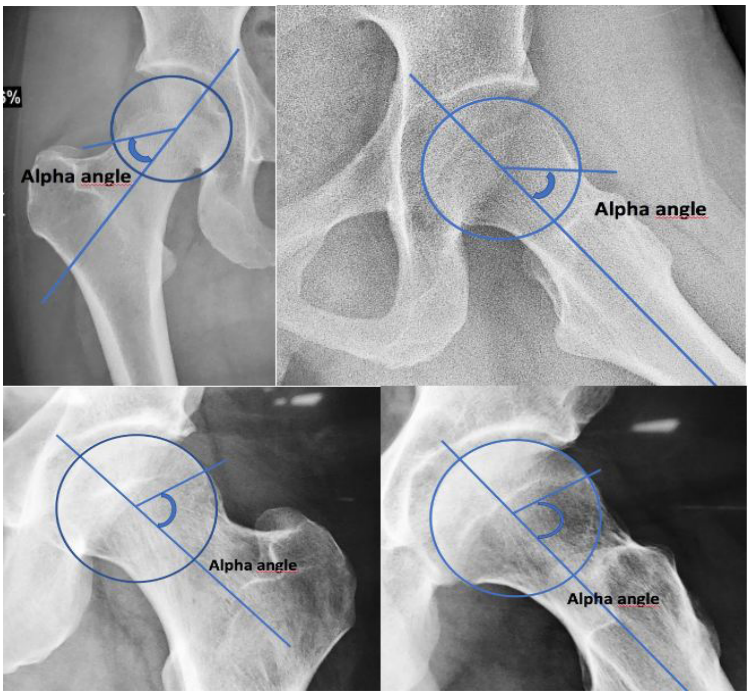

Figure 1: Calculation of the alpha angle in a normal and pathological hip in a X-ray study (Nötzli 2002 JBJS).

The deformities may lead to pain and functional impairments in some hips, but a very large proportion of hips remain asymptomatic from a clinical viewpoint despite the presence of radiological FAI deformities [8]. Consequently, there have been attempts to quantify the rate of these deformities in the population, the majority of whom may be asymptomatic [9-15]. Studies in Western countries have shown high rates of deformity, from 14% to 66% [9-20]. Studies in Asian countries appear to show lower rates, between 0.6% and 50% [2,18,21-24]. However some studies have pointed to the discordance between clinical and radiological findings, such that radiological deformities alone should not be considered FAI [16,25-29]. A very strong association has also been shown between the presence of FAI and sports, possibly due to lesions of soft tissue, especially of the acetabular labrum [30-39]. Furthermore, the rates of deformity as evaluated using the alpha angle are higher in these athletic populations [30,31,40,41].

The primary clinical consequence is evolution to OA [5,19,28,33,42,43]. A lower rate of hip OA has been reported in Asian countries [44,45], reinforcing the notion of a lower rate of FAI [18,24,46], nevertheless, studies have reported divergent findings [22,23,47]. The aim of our study was to obtain preliminary data on the proportion of football players with an abnormal alpha angle, in relation to different clinical situations, thereby laying the groundwork for future studies.

Materials and Methods

The study population consisted of 121 males practicing association football as members of federation-affiliated clubs: 51 who underwent surgery for Osteitis Pubis (OP); 21 who underwent surgery for FAI; 15 who underwent ligamentoplasty for an Anterior Cruciate Ligament (ACL) lesion; 14 who underwent meniscal surgery; and 20 asymptomatic healthy volunteers. Data for OP and FAI patients were collected retrospectively; data for the other patient groups were collected prospectively. In OP patients, a weight-bearing AP pelvis radiograph had been performed as part of routine preoperative workup for this pathology at our center, in order to rule out a tumor process. FAI patients did not require any additional assessments beyond those performed for the purposes of their surgery. In both meniscus and ACL groups, the AP and axial radiographs on both hips were added to the preoperative workup, after consent to participate in our study was obtained from the patients. Previous hip pathology and previous knee surgery were exclusion criteria.

The asymptomatic group was drawn from a separate study evaluating the prevalence of abnormal alpha angles in subjects aged 12 to 14 years. The objective of our study was explained and consent was obtained from the players themselves, and from their parents or guardians, to perform AP and axial radiographs on both hips. Given the highly heterogeneous nature of our sample, in terms of pathology, we decided to reduce the impact of possible sex differences [48] by including only male subjects. All radiographs were read by two people: the study coordinator (who performed hip arthroscopic surgeries) and one of the other surgeons (who performed hip surgeries). The mean of the two measurements was used. The second readers did not know from which patient group the radiographs they evaluated belonged to. The AP radiographic

view was selected as it was the one obtained in the pubis protocol and to minimize the costs of the study, in a population consisting exclusively of affiliated football players, who had been practicing for at least 5 years, with at least 4 training sessions or games per week. The AP views were considered correct when the coccyx tip and pubic symphysis was aligned and the distance between them was 1 to 3 cm, and iliac wings and obturator foramina were symmetrical with a 15-20° rotation of both hips [49] To calculate the cam, the alpha angle was measured using the methodology [6]. A line is drawn passing through the center of the femoral head and along the axis of the femoral neck. A circumference having as its center the center of the femoral head and a radius encompassing the entire head is drawn. The point where the transition between the head and neck crosses the circumference is taken as the section point; a radius is drawn from the center of the circumference passing through this section point. The angle formed by the two lines is the alpha angle (Figure 1). A normality test was performed in all groups then parametric or non-parametric tests used accordingly. Data were analyzed by a statistics specialist using the statistics program SPSS, version 18.0.

Results

In the group of asymptomatic volunteers, aged between 12 and 14 years (mean 12.7 years, SD 0.6), who had been practicing their sport as an affiliate for a mean period of 6.9 years (SD 2.1), the alpha angle was abnormal (>55°) in 20% of them in the AP view. This group also underwent an axial study, which showed a 32% rate of abnormal alpha angle. In the meniscus group (mean age 24.2 years, SD 7.3), 12 of the 28 (42.8%) analyzed hips had an abnormal alpha angle. In the ACL group (mean age 24.7 years, SD 8.3), the overall rate was 60% and a statistically significant difference was seen by laterality: the rate was 73% in the hip ipsilateral to the lesion versus 46% in the contralateral hip. In the osteitis pubis group (mean age 26.8, SD 5.6), an abnormal angle was found in 88.2% of them, and was bilateral in 84% of them. In the FAI group (mean age 26.5 years, SD 7.1), 100% of patients had an abnormal angle (Figure 2).

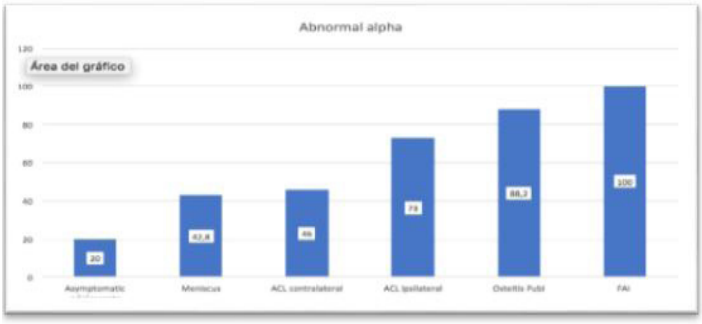

Figure 2: Percentage of patients with abnormal alpha angle (above 55°) in AP radiographs.

None of the groups displayed a normal distribution on the basis of the Kolmogorov-Smirnov test ($p<0.05$), hence non-parametric tests were performed (Mann-Whitney U test).

Discussion

In this series, we demonstrated a clear relationship between abnormal alpha angle and specific pathologies. Correlation was complete (100%) in patients who required hip corrective surgery, 88.2% in patients who required surgery for osteitis pubis, 73% in ipsilateral hip in patients who required anterior cruciate ligament reconstruction surgery. The abnormality was present in less than half of contralateral hips in ACL patients and patients requiring meniscus surgery (42% and 46% respectively). The prevalence of hip OA in the European population is around 10% of the general population [50] and anatomic abnormalities are present in more than 90% of these patients [51,52]. There is a close relationship between hip OA and an abnormal alpha angle [53]. In fact, bone deformities are a common finding in patients with hip pain [54], and FAI is considered a precursor to OA [33,43,55]. Some authors have found a correlation between FAI and reduced internal rotation [56]. The main way of diagnosing a cam-type deformity is an abnormal alpha angle [57]. Correction of the alpha angle is associated with clinical improvement and is considered predictive of outcome [1,58]. The abnormal angle criterion has been described in studies [6,20] it is considered abnormal above 50°. The rate of this deformity in the general population is calculated to be around 14% if they are asymptomatic, but the figure is much higher in the symptomatic population [11]. It has been calculated that around 80% of hips with a clinical picture of pain could have a FAI deformity [13,53]. Even in cases of hip OA, the risk of having a deformity in the contralateral hip is higher than 80%, even though symptoms are only found in slightly more than 10% of them [59].

Although plain radiographic studies find lower rates than CT or MRI, they are a much cheaper and simpler option for evaluating asymptomatic patients [9-11,13,20,60-62]. The cam-type deformity is usually defined in two ways: i) alpha angle >55° in the anterolateral area [6,63,64] and (ii) alpha angle >83° in any part of the femoral neck circumference [65]. There is a relationship between FAI and the practice of sport [63,64,66,67], and this is attributed to vigorous activity at ages at which bone is growing [41,48,68]. In fact, there is a direct relationship between practice of intense sports and a higher risk of cam deformity and hence higher risk of developing hip OA secondary to FAI [39,51,69,70]. It has been calculated that the risk of developing OA is 3 to 8.5 times higher in practitioners of intense sports than in the non-athletic population, for sports such as football, basketball, handball, athletics, martial arts and generally all those that involve running around a playing area [36-38,69,71-73]. The primary mechanism promoting this deformity is the effect of the mechanical impact [32,74-76]. described that 16% of American football players had FAI-type modifications, but with significant variations between different playing positions.

Angle changes have been detected during the adolescent growth phase [77], but it is not possible to determine changes over time when one compares a population of adults aged under 40 years with others aged over 60 years [17]. However it has been demonstrated that intense athletic activity under the age of 12 years promotes a higher rate of abnormal alpha angle [78]. This is why we focused the present study on the highly specific population of affiliated football players. In this respect, the first group we analyzed, aged between 12 and 14 years, with 20% rate of abnormal angle in the AP view and 32% in the axial view, which is consistent with published data for the general population with asymptomatic hips [11,20]. It is possible that the results obtained in this age group rise from values closer to 14% described previously [11] to the values observed in the adult athletic population which fluctuates above 40% [11]. In populations of football players, a 40% rate of cam deformities was found [11], while a rate of 19.6% was found in non-athletic populations [20], but in some series a rate of up to 75% of cam-type deformities was found [31]. It is generally accepted that the rate of abnormal alpha angles in the normal population is around 20%, and double that in the athletic population, around 40-50% [66]. Consequently, it has been concluded that a higher alpha angle of the hip is associated with a higher rate of hip OA [77,79-82].

The meniscus patients had similar rates to the athletic population with asymptomatic hips [11], and similarly for the hip contralateral to the torn anterior cruciate ligament. Several authors have looked at the relationship between ACL lesions and hip modifications [83-86], and found a clear relationship between greater FAI-type deformity, with or without movement restriction, and a higher risk of ACL lesion. Although there are several possible causes of ACL lesions, an abnormal alpha angle could be a contributory factor to this lesion. In this respect, the patients in our series displayed a statistically significant difference in the side ipsilateral to the ACL lesion, with rates clearly higher to those of the contralateral side (73% vs 46%), which could influence the pathophysiology of the ACL lesion. Patients treated for OP had a very high correlation with hip deformities, which could include joint symptoms secondary to FAI, in our series (88.6%). Studies in a similar population found near identical results (86%) [31,87]. Although these studies point to subclinical FAI as the leading cause of OP, three elements should be borne in mind. First, that the success rate of OP surgery is very high, with a greater than 95% rate of resumption of athletic activity at the same level and revision rates below 5%, most of which are for insufficient initial tenotomy. As regards the rate of revision surgery for OP following surgery for FAI, we do not have these data and the few publications that exist simply establish a connection between both pathologies [31]. The second element is something that should not be overlooked: the studies that we have performed, the studies that have been published, and the follow-up we perform in sports clubs do not go beyond the period of affiliation of the players and we cannot perform a follow-up sufficiently long to see whether pathology manifests. The third very important element is that the rate of abnormal alpha angle in this population is 88.2%. This finding should lead one to suspect that it plays an important role in the pathophysiology of OP, and although we cannot consider these patients as clinical FAI, it is probable that the greater deformity of their hips contributes to impaired joint mobility and hence modifies adductor longus tone, as the studies by Williams suggested [88].

Limitations

Our study has significant limitations. The primary one concerns the selection of the study population. The design of the study did not go beyond its stated aim of describing the population of affiliated football players. Given the higher rate of deformity of the femoral head, we wanted to verify the situation with our patients. In view of the significant costs associated with additional investigations and the ethical considerations, we decided to carry out studies prospectively in patients requiring various surgeries. To avoid unnecessary irradiation and to obtain information on the prevalence of this angle, the study also included patients who had already undergone surgery and in whom the radiographs had already been obtained, in the OP and FAI groups. Another limitation we considered was that of including a population of healthy volunteers to compare similar ages. Given that the figures in meniscus surgery patients were very similar to those observed in similar studies, we considered that the ethical and economic limitations outweighed the information that we could have obtained in this group. Another major limitation concerns the calculation of the angle itself. The alpha angle is calculated on the basis of a single plane and can vary significantly according to the radiological position, providing estimates different to actual values [62,89], with underestimations in many cases. For a better calculation, the 3-dimensionality of the hip must be taken into account [90]. Use of CT or MRI would improve the calculation of the angle [65], but these additional investigations were ruled out because of the significant additional cost. In any case, the high rates we obtained underestimate the reality.

Conclusions

The present study describes the abnormal alpha angles in a population of football players, ranging from 20-30% in growing players, becoming established at around 40% in the adult population, but which can be higher, possibly exceeding 80%.

Future Studies

It is obvious that this descriptive study lays the groundwork for prospective studies evaluating the relationships between frequent pathologies in footballers or athletes in general and hip impairment, whether this be a radiological deformity or a functional impairment in terms of mobility.

References

1. Seijas Vázquez R, Ares Rodríguez Ó, Sallent Font A (2016) Indicaciones en artroscopia de cadera, exploración y evaluación de resultados Indications in hip arthroscopy, exploration and evaluation of outcomes. Rev Española Artrosc y Cirugía Articul 23: 11-18.
2. Ahn T, Kim C-H, Kim TH, Chang JS, Jeong MY, et al. (2016) What is the Prevalence of Radiographic Hip Findings Associated with Femoroacetabular Impingement in Asymptomatic Asian Volunteers? Clin Orthop Relat Res 474: 2655-2661.
3. Agricola R, Heijboer MP, Bierma-Zeinstra SMA, Verhaar JAN, Weinans H, et al. (2017) Cam impingement causes osteoarthritis of the hip: a nationwide prospective cohort study (CHECK). Ann Rheum Dis 72: 918-923.
4. Glyn-Jones S, Palmer AJR, Agricola R, Price AJ, Vincent TL, et al. (2017) Osteoarthritis. Lancet (London, England) 386: 376-387.
5. Tannast M, Goricki D, Beck M, Murphy SB, Siebenrock KA (2008) Hip damage occurs at the zone of femoroacetabular impingement. Clin Orthop Relat Res 466: 273-280.
6. Nötzli HP, Wyss TF, Stoecklin CH, Schmid MR, Treiber K, et al. (2016) The contour of the femoral head-neck junction as a predictor for the risk of anterior impingement. J Bone Joint Surg Br 84: 556-560.
7. Mast NH, Impellizzeri F, Keller S, Leunig M (2011) Reliability and agreement of measures used in radiographic evaluation of the adult hip. Clin Orthop Relat Res 469: 188-199.
8. Rubin DA (2017) Femoroacetabular impingement: fact, fiction, or fantasy? AJR Am J Roentgenol 201: 526-534.
9. Chakraverty JK, Sullivan C, Gan C, Narayanaswamy S, Kamath S (2013) Cam and pincer femoroacetabular impingement: CT findings of features resembling femoroacetabular impingement in a young population without symptoms. Am J Roentgenol 200: 389-395.
10. Diesel CV, Ribeiro TA, Scheidt RB, Macedo CA de S, Galia CR (2015) The prevalence of femoroacetabular impingement in radiographs of asymptomatic subjects: a cross-sectional study. Hip Int 25: 258-263.
11. Hack K, Di Primio G, Rakhra K, Beaulé PE (2010) Prevalence of Cam-Type Femoroacetabular Impingement Morphology in Asymptomatic Volunteers. J Bone Jt Surgery-American 92: 2436-2444.
12. Jung KA, Restrepo C, Hellman M, AbdelSalam H, Morrison W, et al. (2011) The prevalence of cam-type femoroacetabular deformity in asymptomatic adults. Bone Joint J 93: 1303-1307.
13. Kang ACL, Gooding AJ, Coates MH, Goh TD, Armour P, et al. (2010) Computed Tomography Assessment of Hip Joints in Asymptomatic Individuals in Relation to Femoroacetabular Impingement. Am J Sports Med 38: 1160-1165.
14. Laborie LB, Lehmann TG, Engesæter IØ, Eastwood DM, Engesæter LB, et al. (2011) Prevalence of Radiographic Findings Thought to Be Associated with Femoroacetabular Impingement in a Population-based Cohort of 2081 Healthy Young Adults. Radiology 260: 494-502.
15. Lee AJJ, Armour P, Thind D, Coates MH, Kang ACL (2015) The prevalence of acetabular labral tears and associated pathology in a young asymptomatic population. Bone Joint J 97: 623-627.
16. Miguel OF, Cabrita HB de A, Rodrigues MB, Croci AT (2012) A comparative radiographic investigation of femoroacetabular impingement in young patients with and without hip pain. Clinics (Sao Paulo) 67: 463-467.
17. Omoumi P, Thiery C, Michoux N, Malghem J, Lecouvet FE, et al. (2014) Anatomic Features Associated with Femoroacetabular Impingement Are Equally Common in Hips of Old and Young Asymptomatic Individuals Without CT Signs of Osteoarthritis. Am J Roentgenol 202: 1078-1086.
18. Joo JH, Lee SC, Ahn HS, Park JS, Lee WJ, et al. (2013) Evaluation of the alpha angle in asymptomatic adult hip joints: analysis of 994 hips. Hip Int 23: 395-399.
19. Ganz R, Leunig M, Leunig-Ganz K, Harris WH (2008) The Etiology of Osteoarthritis of the Hip. Clin Orthop Relat Res 466: 264-272.
20. Gosvig KK, Jacobsen S, Sonne-Holm S, Gebuhr P (2008) The prevalence of cam-type deformity of the hip joint: a survey of 4151 subjects of the Copenhagen Osteoarthritis Study. Acta 49: 436-441.
21. Fukushima K, Uchiyama K, Takahira N, Moriya M, Yamamoto T, et al. (2014) Prevalence of radiographic findings of femoroacetabular impingement in the Japanese population. J Orthop Surg Res 9: 25.
22. Kim J, Choi J-A, Lee E, Lee KR (2015) Prevalence of Imaging Features on CT Thought to Be Associated With Femoroacetabular Impingement: A Retrospective Analysis of 473 Asymptomatic Adult Hip Joints. Am J Roentgenol 205: W100-105.
23. Mimura T, Kawasaki T, Itakura S, Hirata T, Fuzikawa H, et al. (2015) Prevalence of radiological femoroacetabular impingement in Japanese hip joints: detailed investigation with computed tomography. J Orthop Sci 20: 649-656.
24. Takeyama A, Naito M, Shiramizu K, Kiyama T (2009) Prevalence of femoroacetabular impingement in Asian patients with osteoarthritis of the hip. Int Orthop 33: 1229-1232.
25. Nepple JJ, Martel JM, Kim Y-J, Zaltz I, Clohisy JC (2012) Do plain radiographs correlate with CT for imaging of cam-type femoroacetabular impingement? Clin Orthop Relat Res 470: 3313-3320.
26. Nepple JJ, Prather H, Trousdale RT, Clohisy JC, Beaule PE, et al. (2013) Clinical Diagnosis of Femoroacetabular Impingement. J Am Acad Orthop Surg 21: S16-19.
27. Ranawat AS, Schulz B, Baumbach SF, Meftah M, et al. (2011) Radiographic predictors of hip pain in femoroacetabular impingement. HSS J 7: 115-119.
28. Sankar WN, Nevitt M, Parvizi J, Felson DT, Agricola R, et al. (2013) Femoroacetabular impingement: defining the condition and its role in the pathophysiology of osteoarthritis. J Am Acad Orthop Surg 21: S7-15.
29. Anderson SE, Siebenrock KA, Tannast M (2010) Femoroacetabular Impingement: Evidence of an Established Hip Abnormality. Radiology 257: 8-13.
30. Philippon MJ, Ho CP, Briggs KK, Stull J, LaPrade RF (2013) Prevalence of Increased Alpha Angles as a Measure of Cam-Type Femoroacetabular Impingement in Youth Ice Hockey Players. Am J Sports Med 41: 1357-1362.
31. Larson CM, Sikka RS, Sardelli MC, Byrd JWT, Kelly BT, et al. (2013) Increasing Alpha Angle is Predictive of Athletic-Related “Hip” and “Groin” Pain in Collegiate National Football League Prospects. Arthrosc J Arthrosc Relat Surg 29: 405-410.
32. Nepple JJ, Brophy RH, Matava MJ, Wright RW, Clohisy JC (2012) Radiographic Findings of Femoroacetabular Impingement in National Football League Combine Athletes Undergoing Radiographs for Previous Hip or Groin Pain. Arthrosc J Arthrosc Relat Surg 28: 1396-1403.

33. Ganz R, Parvizi J, Beck M, Leunig M, Nötzli H, et al. (2003) Femoroacetabular impingement: a cause for osteoarthritis of the hip. Clin Orthop Relat Res 417: 112-120.

34. Beck M, Kalhor M, Leunig M, Ganz R (2005) Hip morphology influences the pattern of damage to the acetabular cartilage: femoroacetabular impingement as a cause of early osteoarthritis of the hip. J Bone Joint Surg Br 87: 1012-1018.

35. Dickenson E, O'Connor P, Robinson P, Campbell R, Ahmed I, et al. (2016) Hip morphology in elite golfers: asymmetry between lead and trail hips. Br J Sports Med 50: 1081-1086.

36. Lindberg H, Roos H, Gärdsell P (1993) Prevalence of coxarthrosis in former soccer players. 286 players compared with matched controls. Acta Orthop Scand 64: 165-167.

37. L'Hermette M, Polle G, Tourny-Chollet C, Dujardin F (2006) Hip passive range of motion and frequency of radiographic hip osteoarthritis in former elite handball players. Br J Sports Med 40: 45-49.

38. Vingård E, Alfredsson L, Malchau H (2017) Osteoarthrosis of the hip in women and its relationship to physical load from sports activities. Am J Sports Med 26: 78-82.

39. Siebenrock KA, Ferner F, Noble PC, Santore RF, Werlen S, et al. (2011) The cam-type deformity of the proximal femur arises in childhood in response to vigorous sporting activity. Clin Orthop Relat Res 469: 3229-3240.

40. Agricola R, Bessems JHJM, Ginai AZ, Heijboer MP, van der Heijden RA, et al. (2012) The Development of Cam-Type Deformity in Adolescent and Young Male Soccer Players. Am J Sports Med 40: 1099-1106.

41. Siebenrock KA, Ferner F, Noble PC, Santore RF, Werlen S, et al. (2011) The Cam-type Deformity of the Proximal Femur Arises in Childhood in Response to Vigorous Sporting Activity. Clin Orthop Relat Res 469: 3229-3240.

42. Harris WH (2009) The correlation between minor or unrecognized developmental deformities and the development of osteoarthritis of the hip. Instr Course Lect 58: 257-259.

43. Tanzer M and Noiseux N (2004) Osseous abnormalities and early osteoarthritis: the role of hip impingement. Clin Orthop Relat Res 429: 170-177.

44. Hoaglund FT, Oishi CS, Gialamas GG (1995) Extreme variations in racial rates of total hip arthroplasty for primary coxarthrosis: a population-based study in San Francisco. Ann Rheum Dis 54: 107-110.

45. Nevitt MC, Xu L, Zhang Y, Lui L-Y, Yu W, et al. (2002) Very low prevalence of hip osteoarthritis among Chinese elderly in Beijing, China, compared with whites in the United States: the Beijing osteoarthritis study. Arthritis Rheum 46: 1773-1779.

46. Dudda M, Kim Y-J, Zhang Y, Nevitt MC, Xu L, et al. (2011) Morphologic differences between the hips of Chinese women and white women: Could they account for the ethnic difference in the prevalence of hip osteoarthritis? Arthritis Rheum 63: 2992-2999.

47. Mori R, Yasunaga Y, Yamasaki T, Nakashiro J, Fujii J, et al. (2014) Are cam and pincer deformities as common as dysplasia in Japanese patients with hip pain? Bone Joint 96: 172-176.

48. Agricola R, Waarsing JH, Thomas GE, Carr AJ, Reijman M, et al. (2014) Cam impingement: defining the presence of a cam deformity by the alpha angle. Osteoarthr Cartil 22: 218-225.

49. Clohisy JC, Carlisle JC, Beaulé PE, Kim Y-J, Trousdale RT, et al. (2008) A systematic approach to the plain radiographic evaluation of the young adult hip. J Bone Joint Surg Am 90 :47-66.

50. Ingvarsson T, Hägglund G, Lohmander LS (1999) Prevalence of hip osteoarthritis in Iceland. Ann Rheum Dis 58: 201-207.

51. Harris WH (1986) Etiology of osteoarthritis of the hip. Clin Orthop Relat Res 213: 20-33.

52. Ng KCG, Lamontagne M, Adamczyk AP, Rahkra KS, Beaulé PE (2015) Patient-Specific Anatomical and Functional Parameters Provide New Insights into the Pathomechanism of Cam FAI. Clin Orthop Relat Res 473: 1289-1296.

53. Allen D, Beaule PE, Ramadan O, Doucette S (2009) Prevalence of associated deformities and hip pain in patients with cam-type femoroacetabular impingement. J Bone Jt Surg - Br 2009 91: 589-594.

54. Ochoa LM, Dawson L, Patzkowski JC, Hsu JR (2010) Radiographic Prevalence of Femoroacetabular Impingement in a Young Population with Hip Complaints Is High. Clin Orthop Relat Res 468: 2710-2714.

55. Tönnis D and Heinecke A (1999) Acetabular and femoral anteversion: relationship with osteoarthritis of the hip. J Bone Joint Surg Am 81: 1747-1770.

56. Scheidt RB, Galia CR, Diesel CV, Rosito R, Macedo CA de S (2017) Prevalence of radiographic markers of femoroacetabular impingement in asymptomatic adults. Rev Col Bras Cir 41: 36-42.

57. Ayeni OR, Sansone M, de Sa D, Simunovic N, Bedi A, et al. (2016) Femoro-acetabular impingement clinical research: is a composite outcome the answer? Knee Surgery, Sports Traumatology, Arthroscopy 2016.

58. de SA D, Urquhart N, Philippon M, Ye J-E, Simunovic N, et al. (2014) Alpha angle correction in femoroacetabular impingement. Knee Surgery, Sport Traumatol Arthrosc 22: 812-821.

59. Şahin N, Atici T, Öztürk A, Özkaya G, Özkan Y, et al. (2011) Prevalence of femoroacetabular impingement in asymptomatic contralateral hips in patients with unilateral idiopathic osteoarthritis. J Int Med Res 39: 790-797.

60. Jung KA, Restrepo C, Hellman M, AbdelSalam H, Morrison W, et al. (2011) The prevalence of cam-type femoroacetabular deformity in asymptomatic adults. J Bone Joint Surg Br 93: 1303-1307.

61. Pollard TC, Villar RN, Norton MR, Fern ED, Williams MR, et al. (2010) Femoroacetabular impingement and classification of the cam deformity: the reference interval in normal hips. Acta Orthop 81: 134-341.

62. Milone MT, Bedi A, Poultsides L, Magennis E, Byrd JWT, et al. (471) Novel CT-based three-dimensional software improves the characterization of cam morphology. Clin Orthop Relat Res 471: 2484-2491.

63. Lahner M, Bader S, Walter PA, Duif C, von Schulze Pellengahr C, et al. (2014) Prevalence of femoro-acetabular impingement in international competitive track and field athletes. Int Orthop 38: 2571-2576.

64. Lahner M, Walter PA, von Schulze Pellengahr C, Hagen M, von Engelhardt LV, et al. (2014) Comparative study of the femoroacetabular impingement (FAI) prevalence in male semiprofessional and amateur soccer players. Arch Orthop Trauma 134: 1135-1141.

65. Gosvig KK, Jacobsen S, Palm H, Sonne-Holm S, Magnusson E (2007) A new radiological index for assessing asphericity of the femoral head in cam impingement. J Bone Joint Surg Br 89: 1309-1316.

66. Frank JM, Harris JD, Erickson BJ, Slikker W, Bush-Joseph CA, et al. (2015) Prevalence of Femoroacetabular Impingement Imaging Findings in Asymptomatic Volunteers: A Systematic Review. Arthroscopy 31: 1199-1204.

67. Nepple JJ, Vigdorchik JM, Clohisy JC (2015) What Is the Association Between Sports Participation and the Development of Proximal Femoral Cam Deformity? Am J Sports Med 43: 2833-2840.

68. Siebenrock KA, Kaschka I, Frauchiger L, Werlen S, Schwab JM (2013) Prevalence of Cam-Type Deformity and Hip Pain in Elite Ice Hockey Players Before and After the End of Growth. Am J Sports Med 41: 2308-2313.

69. Murray RO and Duncan C (1971) Athletic activity in adolescence as an etiological factor in degenerative hip disease. J Bone Joint Surg Br 53: 406-419.

70. Thomas GER, Palmer AJR, Batra RN, Kiran A, Hart D, et al. (2014) Subclinical deformities of the hip are significant predictors of radiographic osteoarthritis and joint replacement in women. A 20-year longitudinal cohort study. Osteoarthr Cartil 22: 1504-1510.

71. Drawer S and Fuller CW (2001) Propensity for osteoarthritis and lower limb joint pain in retired professional soccer players. Br J Sports Med 35: 402-408.

72. Kettunen JA, Kujala UM, Räty H, Videman T, Sarna S, et al. (2000) Factors associated with hip joint rotation in former elite athletes. Br J Sports Med 34: 44-48.

73. Mariconda M, Cozzolino A, Di Pietto F, Ribas M, Bellotti V, et al. (2014) Radiographic findings of femoroacetabular impingement in capoeira players. Knee Surgery, Sport Traumatol Arthrosc 22: 874-881.

74. Bigliani LU, Codd TP, Connor PM, Levine WN, Littlefield MA, et al. (1997) Shoulder motion and laxity in the professional baseball player. Am J Sports Med 25: 609-613.

75. Caine D, DiFiori J, Maffulli N (2006) Physeal injuries in children's and youth sports: reasons for concern? Br J Sports Med 40: 749-760.

76. Carson WG and Gasser SI (2017) Little Leaguer's shoulder. A report of 23 cases. Am J Sports Med 26: 575-580.

77. Agricola R, Heijboer MP, Bierma-Zeinstra SMA, Verhaar JAN, Weinans H, et al. (2012) Cam impingement causes osteoarthritis of the hip: a nationwide prospective cohort study (CHECK). Annals of the Rheumatic Diseases 72: 918-923.

78. Tak I, Weir A, Langhout R, Waarsing JH, Stubbe J, et al. (2015) The relationship between the frequency of football practice during skeletal growth and the presence of a cam deformity in adult elite football players. Br J Sports Med 49: 630-634.

79. Nicholls AS, Kiran A, Pollard TCB, Hart DJ, Arden CPA, et al. (2011) The association between hip morphology parameters and nineteen-year risk of end-stage osteoarthritis of the hip: a nested case-control study. Arthritis Rheum 63: 3392-3400.

80. Pollard TCB, McNally EG, Wilson DC, Wilson DR, Mädler B, et al. (2010) Localized cartilage assessment with three-dimensional dGEMRIC in asymptomatic hips with normal morphology and cam deformity. J Bone Joint Surg Am 92: 2557-2569.

81. Beaulé PE, Hynes K, Parker G, Kemp KA (2012) Can the alpha angle assessment of cam impingement predict acetabular cartilage delamination? Clin Orthop Relat Res 470: 3361-3367.

82. Johnston TL, Schenker ML, Briggs KK, Philippon MJ (2008) Relationship between offset angle alpha and hip chondral injury in femoroacetabular impingement. Arthroscopy 24: 669-675.

83. Ellera Gomes JL, Palma HM, Becker R (2010) Radiographic findings in restrained hip joints associated with ACL rupture. Knee Surgery, Sport Traumatol Arthrosc 18: 1562-1567.

84. Philippon M, Dewing C, Briggs K, Steadman JR (2012) Decreased femoral head–neck offset: a possible risk factor for ACL injury. Knee Surgery, Sport Traumatol Arthrosc 20: 2585-2589.

85. VandenBerg C, Crawford EA, Sibilsky Enselman E, Robbins CB, Wojtys EM, et al. (2017) Restricted Hip Rotation Is Correlated with an Increased Risk for Anterior Cruciate Ligament Injury. Arthrosc J Arthrosc Relat Surg 33: 317-325.

86. Lopes OV, Tragnago G, Gatelli C, Costa RN, de Freitas Spinelli L, et al. (2017) Assessment of the alpha angle and mobility of the hip in patients with noncontact anterior cruciate ligament injury. Int Orthop 2017.

87. Economopoulos KJ, Milewski MD, Hanks JB, Hart JM, Diduch DR (2014) Radiographic Evidence of Femoroacetabular Impingement in Athletes With Athletic Pubalgia. Sport Heal A Multidiscip Approach 6: 171-177.

88. Williams JG (1978) Limitation of hip joint movement as a factor in traumatic osteitis pubis. Br J Sports Med 12: 129-133.

89. Rakhra KS, Sheikh AM, Allen D, Beaulé PE (2009) Comparison of MRI alpha angle measurement planes in femoroacetabular impingement. Clin Orthop Relat Res 467: 660-665.

90. Mascarenhas V V, Rego P, Dantas P, Gaspar A, Soldado F, et al. (2016) Cam deformity and the omega angle, a novel quantitative measurement of femoral head-neck morphology: a 3D CT gender analysis in asymptomatic subjects. Eur Radiol 27: 2011-2023.