Prevalence of Increased Alpha Angles as a Measure of Cam-Type Femoroacetabular Impingement in Youth Ice Hockey Players

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Background: It has been reported that relative to other sports participants, ice hockey players suffer from cam-type femoroacetabular impingement (FAI) in higher numbers. α angles have been reported to increase with the likelihood of symptomatic FAI. It is unclear how prevalent increased α angles, commonly associated with cam FAI, are in asymptomatic young ice hockey players.

Hypothesis: There would be a higher prevalence of α angles associated with cam FAI in youth ice hockey players than in a non–hockey-playing (skier) youth control group.

Study Design: Cohort study; Level of evidence, 3.

Methods: A total of 61 asymptomatic youth ice hockey players (aged 10-18 years) and 27 youth skiers (controls) (aged 10-18 years) underwent a clinical hip examination consisting of the flexion/abduction/external rotation (FABER) distance test, impingement testing, and measurement of hip internal rotation. The hip α angle was measured by magnetic resonance imaging, and labral tears and articular cartilage lesions were documented. Hockey players were grouped according to their USA Hockey classification as peewees (ages 10-12 years), bantams (ages 13-15 years), and midgets (ages 16-19 years).

Results: Overall, ice hockey players had significantly higher α angles than did the control group, and hockey players had a significant correlation between increased age and increased α angles, while the control group did not. In the ice hockey group, 75% had an α angle of $\geq 55°$, while in the skier group, 42% had an α angle of $\geq 55°$ ($P < .006$). Hockey players were 4.5 times more likely to have an α angle commonly associated with cam impingement than skiers. Midget players had the highest risk of increased α angles.

Conclusion: Even at young ages, ice hockey players have a greater prevalence of α angles associated with cam FAI than do skier-matched controls. Properties inherent to ice hockey likely enhance the development of a bony overgrowth on the femoral neck, leading to cam FAI.

Keywords: femoroacetabular impingement; α angle; cam lesion; ice hockey; magnetic resonance imaging

Femoroacetabular impingement (FAI) has recently been studied with increased attention primarily because of its prevalence among elite athletes and the reported damage that it can inflict on the acetabular labrum and articular cartilage junction.[3,20,22,24] Cam and pincer mechanisms of FAI, defined by 2 different bony abnormalities of the hip joint that can occur alone or, more often, in combination, have been reported to compose the multiple etiological factors that can cause FAI[23,24] (Figure 1). A common objective measurement of the relative amount of cam impingement is the α angle. Increased hip α angles reportedly have been associated with greater articular cartilage damage and labral injury due to acetabular rim loading and also decreased hip range of motion.[7,21,22] Ice hockey players, in particular, have been reported to suffer from hip injuries as a result of FAI.[3,7,12-14,20,22,24]

It has been reported that the incidence of FAI may have been underreported in ice hockey players because of its misdiagnosis as hip or groin strains,[12] a previously commonly reported injury among ice hockey players.[1,4,5,10,29] It is still unknown whether the bony overgrowth associated with an increased α angle and FAI occurs because of genetic causation or as a result of repetitive microtrauma to the proximal femoral physes; however, it is generally accepted that the hockey skating motion can exaggerate FAI.[28] With 572,411 registered ice hockey players in Canada and 583,262 in the United States for the 2010-2011

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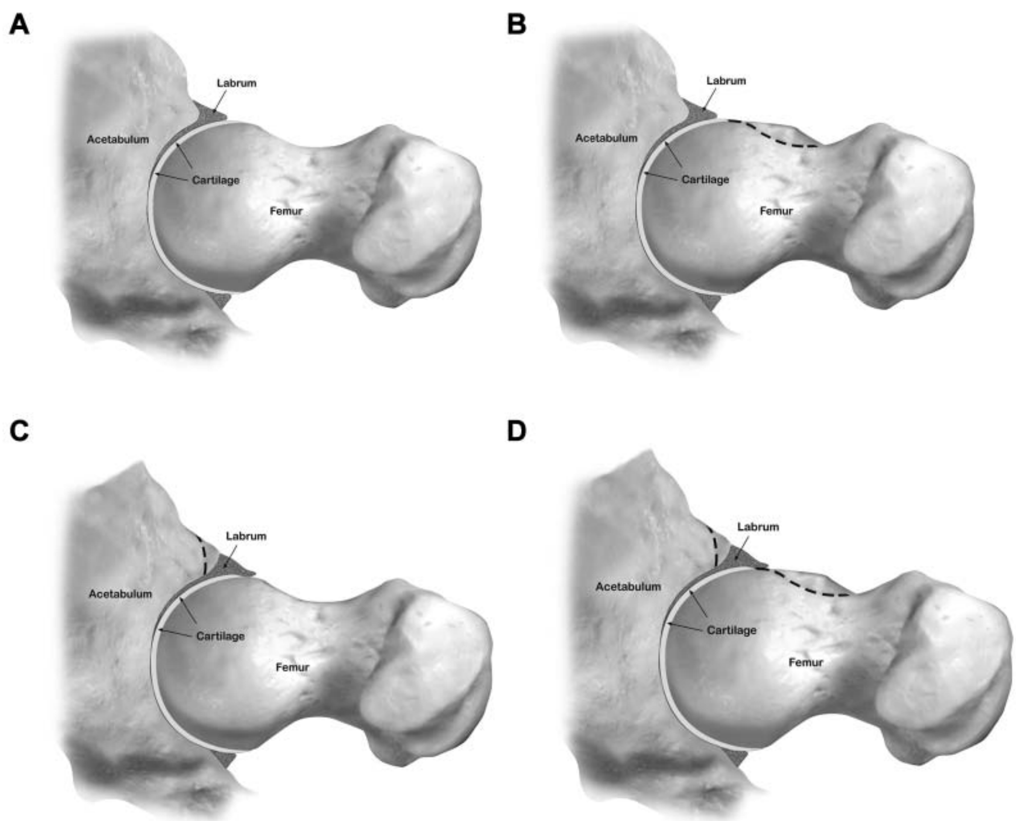

Figure 1. Etiological factors of femoroacetabular impingement. Dotted lines represent the normal anatomic bony shape. (A) Normal femoral head-neck junction. (B) Cam impingement: abnormal bone growth at the femoral head-neck junction. (C) Pincer impingement: abnormal bone growth of the acetabular rim. (D) Combination of both cam and pincer causes.

season (according to governing bodies Canada Hockey and USA Hockey), there is a large base of individual hockey participants who may have FAI or be at increased risk of developing FAI. A recent study demonstrated a high prevalence of hip pathological changes in asymptomatic collegiate and professional hockey players.[27]

The purpose of this study was to determine the prevalence of cam impingement, as determined by the α angle, in youth ice hockey players and compare this to the prevalence in youth non–hockey players. Our hypotheses were that the prevalence of cam impingement would be higher in ice hockey players than in a skier (control) group and that α angles would increase with age in ice hockey players.

MATERIALS AND METHODS

Over the 2010-2011 and 2011-2012 seasons, 61 asymptomatic male youth ice hockey players and, from 2011-2012, 27 male youth skiers were recruited to participate in a hip joint screening program. All study participants were between 10 and 18 years old. All athletes underwent a clinical examination and limited-sequence magnetic resonance imaging (MRI) for the measurement of α angles. The testing protocol was approved by the Institutional Review Board at the Vail Valley Medical Center, and parents or guardians provided informed consent for all athletes younger than 18 years of age, while athletes aged 18 years and older provided their own informed consent. The exclusion criterion was a history of hip pain or hip surgery.

To determine if progressive play contributed to the development of FAI, the hockey players were grouped according to their USA Hockey classification as peewees (ages 10-12 years), bantams (ages 13-15 years), and midgets (ages 16-19 years). The peewee cohort consisted of preadolescent youth ice hockey players participating at a competitive level with the introduction of body checking and was typified by increased on-ice time[26] from the prior developmental level of competition. As an in-between age group, the 8 bantam hockey players could have open or closed growth plates. The bantam cohort was defined by their age (usually representing eighth grade and freshman high school players) and an intermediate level of play. The midget cohort was composed of physically mature players, who played at a higher level of competition. The classification of a preadolescent player or physically mature player was based on MRI analysis of the femoral neck physis.[8]

Youth skiers were considered to be an adequate control group based on differences in the use of the hip in each sport. This group of youth skiers dedicated similar time to their sport as the hockey players and advanced through the sport at similar age ranges. Hockey players perform the skating motion with hip flexion and internal rotation repetition,[28] while skiers do not have repetitive hip motions that place their hips at risk of impingement in the presence of FAI.[15]

Each player underwent a physical examination screening by a sports medicine fellow, who was not blinded to their sport, and MRI, which has been reported to have the sensitivity to accurately diagnose acetabular labral tears through noninvasive means.[17] The physical examination screening consisted of the flexion/abduction/external rotation (FABER) distance test, anterior and posterior impingement tests, dial (log roll) test, assessment for a Trendelenburg gait, and hip range of motion measured with a goniometer (flexion, abduction, and adduction in supine position; extension, internal rotation, and external rotation in prone position).[21]

For this study, a positive clinical result for an impingement test was defined as a positive impingement test finding, an increase in the FABER distance, or decreased hip internal rotation as tested in the prone position with neutral hip flexion and 90° of knee flexion. A positive impingement test result was based on a positive player response of pain with anterior or posterior hip impingement testing. A positive FABER distance test finding was identified as a difference of $\geq$3 cm between the distance of the knee on the affected side and the contralateral knee from the examination table while under examination.[16] Decreased internal rotation was considered to be a reduction of $\geq$5° of motion in the examined hip as compared with the contralateral side. After physical screening, each participant underwent a limited, nonarthrogram, 3-T MRI of the dominant hip, as identified by each individual participant, with an oblique axial proton-density (PD) turbo spin echo (TSE) with fat suppression (FS) sequence (repetition time [TR], 2750 ms; echo time [TE], 33 ms; number of excitations [NEX], 2; field of view [FOV], 16 $\times$ 16 cm; matrix, 640 $\times$ 640) oriented along the axis of the femoral neck and head of the hip. This MRI sequence included the anterosuperior region (12-3 o'clock as viewed on the right hip, and 9-12 o'clock as viewed on the left hip),[23] the most common area for an anterolateral labral tear or detachment as a result of cam FAI,[2,7,12] with the acetabular rim and labrum evaluated for possible pathological lesions. The hip α angle was subsequently measured. The participants also had a limited axial gradient echo scout sequence of the knee performed immediately after the hip MRI examination, with the participants in the same unmoved position within the scanner to determine the angle of the femoral head-neck axis relative to the intercondylar line tangential along the posterior margins of the femoral condyles at the knee, to measure femoral anteversion. Each participant was subjected to approximately 5 minutes of total imaging time. All MRI scans were reviewed by a board-certified radiologist with a specialty in sports medicine imaging. The same radiologist measured all angles and determined the presence of pathological abnormalities for all participants. The radiologist was not blinded to the sport of the athlete.

The α angle of the hip as measured on MRI was defined as the angle of 2 intersecting lines at the center of the femoral head as previously described.[19] With use of a best-fit circle digitized around the femoral head, the first line extended from the center of the femoral head to the midpoint of the femoral neck, and the second line extended from the center of the femoral head to the deviation of the femoral neck from the circle drawn around the femoral head[11] (Figure 2). For this study, we operationally defined cam impingement as an α angle of $\geq$55° based on previous reports.[11,19] This was for analysis only because a diagnosis of cam impingement is based on symptoms, clinical examination findings, and imaging results.

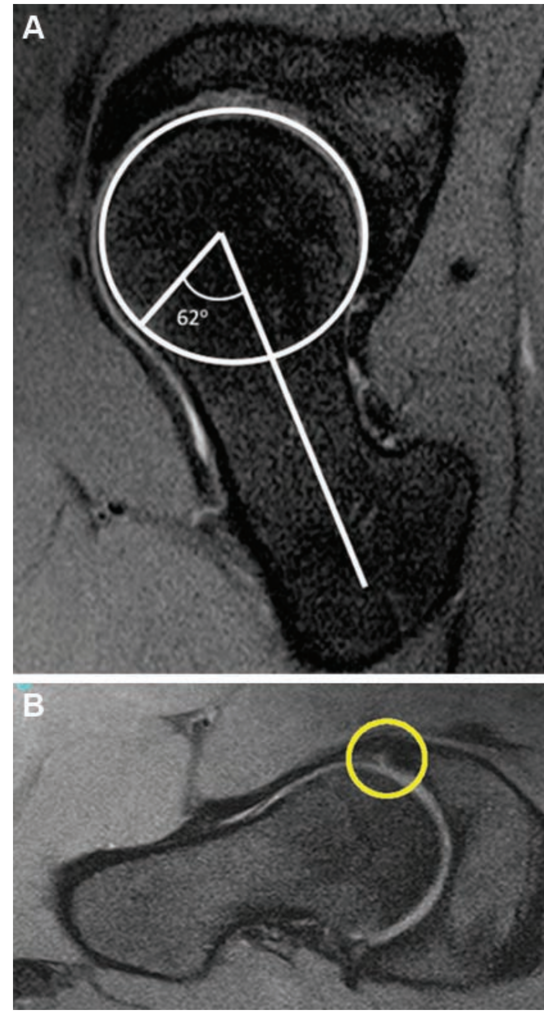

Figure 2. Magnetic resonance imaging scans of cam femoroacetabular impingement. (A) Depiction of an α angle. The α angle, shown here, was defined as an objective measure of the cam lesion. (B) Acetabular labral tear with partial detachment (circle).

The acetabular labrum was observed for possible pathological abnormalities by MRI and was categorized as torn or not torn. Acetabular labral tears were defined by a high signal (similar to fluid on the PD TSE FS scans) undermining and separation of the chondrolabral junction from the underlying acetabulum (Figure 2).

Descriptive statistics (arithmetic mean, standard deviation, range) were calculated using standard formulae.

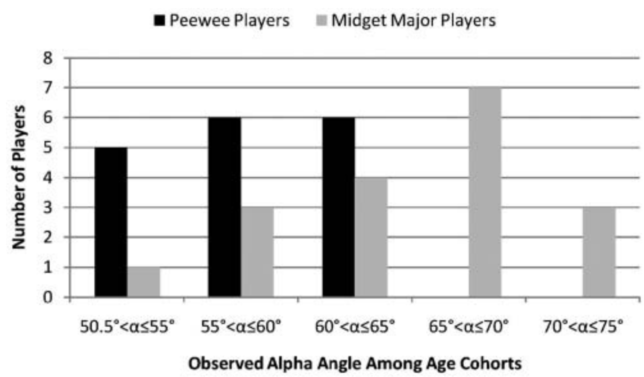

Figure 3. Distribution of α angles of peewee, bantam, and midget ice hockey cohorts.

Univariate comparisons were performed using the independent-samples *t* test for comparison of continuous variables and the Fisher exact test for comparison of proportions. Comparison of 2 continuous variables was performed using the Pearson correlation coefficient.

RESULTS

The demographics of each group are shown in Table 1. Preadolescents were categorized based on MRI scans by open proximal femoral physes, and physically mature athletes were observed to have a closed physis. All 27 of the peewee hockey players were preadolescents. Bantam hockey players had open and closed physes. All 26 of the midget hockey players were determined to be physically mature.

A total of 27 peewee-level (mean age, 11.7 years; range, 10-12 years), 8 bantam-level (mean age, 14.6 years; range, 13-15 years), and 26 midget-level (mean age, 17.4 years; range, 16-18 years) ice hockey players were screened. Hip examination findings are detailed in Table 2, and MRI findings are detailed in Table 3. Of the 5 players with chondral defects identified on MRI, 2 players had femoral head defects only, and 3 had defects on both the acetabulum and the femoral head.

For the peewee-matched control group, 7 skiers aged 10 to 12 years were screened. For the bantam control group, 8 skiers were screened who were all 15 years of age, and for the midget control group, 12 skiers were screened with a mean age of 17.6 years (range, 16-18 years) (see Tables 2 and 3 for details).

Overall, the ice hockey group had significantly higher α angles ($P < .005$) than skiers. For the hockey players, there was a significant correlation between age and α angle ($r = 0.421$; $P < .001$); however, there was no significant correlation between age and α angle in the skier group ($r = –0.258$; $P = .254$). In the ice hockey group, 75% had an α angle of ≥55° compared with 42% in the skier group ($P < .006$). Hockey players were 4.46 times more likely to have an α angle of ≥55° than were skiers (95% confidence interval [CI], 1.5-13.2).

When the athletes were divided into age groups, there were no differences in clinical examination findings based on age and sport (Table 2). In the peewee and bantam age-matched groups, there were no differences in MRI findings (Table 3). In the midget age-matched group, significantly more hockey players had an α angle of ≥55° (24/27) compared with skiers of the same age (3/12). In this age group, hockey players were 36 times more likely to have an α angle of ≥55° compared with skiers (95% CI, 4.0-462.8). There was no significant difference in the presence of acetabular labral tears between ice hockey players (23/26) compared with skiers (10/12) in the midget group.

DISCUSSION

We confirmed our primary hypothesis demonstrating that cam impingement affected 79% of ice hockey players versus 40% of skiers. This difference became most evident in the midget groups. The α angles significantly increased with age in hockey players but did not increase with age in skiers. In comparing these 2 groups, we found that in the young athlete, ice hockey players have a high prevalence of α angles greater than 55°. As hockey players reached the midget level, in conjunction with increased age and cumulative participation in ice hockey, this prevalence increased. The finding that ice hockey players had an increased risk for α angles greater than 55° compared with skiers suggests a biomechanical cause. One feasible reason for the increase in α angles with age is repeated subclinical physeal injury due to the unique stress placed on the hip as a result of the ice hockey skating motion.[28]

Alarmingly, we identified labral tears in 93% of asymptomatic midget hockey athletes, who were previously unrecognized as a group at particular risk of suffering the deleterious effects of FAI, such as acetabular labral tears and/or damage to articular cartilage. We also found labral tears in 75% of skiers of the same age range. While the percentage of labral tears was high in both groups, more labral tears were seen in hockey players, and more hockey players had α angles of ≥55°. In a surgical study, the average α angle observed with labral tears was 56°, and the average α angle observed with articular cartilage damage was 55°.[11] In this study, we found that 37% of peewee players, 63% of bantam players, and 93% of midget players had α angles of ≥55°. The likelihood of having high α angles increased with increasing age group and increasing level of hockey play. In the control group of skiers, we did not see increasing numbers of athletes with α angles of ≥55° with increasing age and skill level. This suggests that with increasing play and skill levels, α angles increased in a youth ice hockey cohort. This may help answer the questions about the age or developmental stage of cam formation in young ice hockey players. Hack et al[9] reported that a normal α angle was ≤50.5° and that observed cam FAI was most prevalent among asymptomatic male patients (24.7%); however, we identified that an α angle of ≥55° was present in much higher numbers within all cohorts.

Clinical examination findings in this study did not differ between the control group and ice hockey group. The diagnosis of FAI is usually based on symptoms, physical examination results, and radiographic findings. In this group of

TABLE 1
Demographic Information for All Groups Screened[a]

Group	n	Age, y	Participating in Sport, wk/y	Age Started Sport, y	α Angle, deg	Femoral Anteversion, deg
Hockey players	61	14.5 ± 2.7	38.1 ± 12.5	5.0 ± 2.0	60.1[b] ± 7.4	4.8 ± 10.0
Skiers	27	15.2 ± 2.7	34.1 ± 12.3	4.0 ± 2.6	55.2 ± 7.0	4.5 ± 8.8

[a]Values are expressed as mean ± standard deviation.
[b]P = .05 when comparing hockey players to skiers.

TABLE 2
Positive Clinical Examination Findings for Cam-Type Femoroacetabular Impingement for All Study Groups Screened[a]

Group	n	Positive Impingement Sign	Positive FABER Distance	Decreased Internal Rotation	Positive Outcomes in at Least 1 of 3 Tests
Peewee hockey player	27	1 (4)	8 (30)	5 (19)	12 (44)
Skier (control)	7	2 (28)	2 (28)	4 (57)	5 (71)
Bantam hockey player	8	1 (13)	1 (13)	3 (38)	4 (50)
Skier (control)	8	0 (0)	2 (25)	2 (25)	4 (50)
Midget hockey player	26	2 (8)	13 (50)	9 (35)	16 (62)
Skier (control)	12	1 (8)	3 (25)	4 (33)	6 (50)

[a]Values are expressed as n (%). A positive flexion/abduction/external rotation (FABER) distance test result was defined as a difference of ≥3 cm between the distance of the affected knee from the examination table and the contralateral knee from the examination table during the test.

TABLE 3
Findings on Magnetic Resonance Imaging for All Study Groups Screened

Group	n	α Angle, Mean (Range), deg	α Angle ≥55°, n (%)	Mean Femoral Anteversion, deg	Acetabular Labral Tear, n (%)	Chondral Defect, n (%)
Peewee hockey player	27	57 (45-65)	17 (37)	4.6	13 (48)	0 (0)
Skier (control)	7	56 (54-61)	3 (43)	2.0	5 (71)	0 (0)
Bantam hockey player	8	57 (45-70)	5 (63)	5.1	5 (63)	0 (0)
Skier (control)	8	58 (51-80)	5 (63)	4.3	5 (63)	0 (0)
Midget hockey player	26	65 (53-78)	24 (93)[a]	5.0	24 (93)	5 (20)
Skier (control)	12	52 (46-67)	3 (25)	7.3	9 (75)	1 (8)

[a]P = .001 when comparing each hockey group to its respective control group.

patients with no symptoms, the clinical examination may have limited sensitivity in detecting FAI. This demonstrates the importance of a complete assessment of the patient before the clinical diagnosis of FAI.

From this study, we cannot describe why there was a higher prevalence of cam-related α angles in youth ice hockey players. However, our study is in accordance with reports that suggest that FAI is prevalent in athletic young adult male patients,[6,18,27] and based on our observations, it would appear that despite presenting as asymptomatic, increased hip α angles and labral injury both emerge in youth ice hockey players at an earlier age than has previously been reported. This is concerning because of previous suggestions that hips with higher α angles are "at risk" because of an unfavorable mechanical environment that increases the risk of labral tears and chondral damage.[11] Our findings emphasize the need to identify a more specific cause, or causes, that lead to the onset of an increased α angle in youth ice hockey players so that potential interventions can be investigated to arrest or prevent its formation and potential progression.

We acknowledge some limitations to our study. This study examined male ice hockey players and skiers (controls). However, cam-type FAI has been reported to be most commonly associated with young athletic male patients; thus, we believe that investigating mostly male cohorts was appropriate for the aims of this study. The other limitation was that while there was a high prevalence of increased α angles in these youth hockey players, it has also been reported in asymptomatic adults.[9,25] It is unclear which players will develop symptoms and when the symptoms occur. However, identifying the prevalence of high α angles at a young age may help to determine the cause of cam development, which would contribute to preventive recommendations as a result of future research in this arena. An additional limitation is that the radiologist was not blinded to the sport of each athlete. The radiologist was blinded to all other data, including age and years playing sport. Because these factors are also related to MRI findings, we did not believe there was a significant bias based on the radiologist knowing the sport of the athlete.

CONCLUSION

We found a higher prevalence of α angles, commonly associated with cam-type FAI, among hockey players compared with age-matched skiers (controls). Additionally, there was a large majority of labral tears observed in the midget hockey cohort. As young hockey players reach the midget level, they are at significantly higher risk of developing imaging findings commonly seen in patients diagnosed with cam impingement. With these considerations based against a control group without high α angles, and no correlation between age and α angle, we believe that the sport of ice hockey has certain properties that increase the risk of higher α angles. Further study into the cause of the increase in the α angle in ice hockey players is recommended to determine if preventative measures may be adapted to decrease the incidence of hip injuries.

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