Hip Profile in World Elite Junior Badminton Players: Impingement and Range of Motion Data from the World Junior Badminton Championship 2018

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Abstract

Badminton is played with repetitive high loading to the hip with lunging and jumps. In sports like soccer there is a high prevalence of femoroacetabular impingement syndrome in youth populations which may predispose them to osteoarthritis (OA). Internal rotation deficit in the hip of football players is a predictor of hip and groin pain and differences in the range of motion (ROM) of the hip between sex and different ethnicities exist. Early hip replacements in former elite badminton players due to OA seem to be a problem. There are no published values for ROM and impingement of the hip in badminton. The purpose is to report ROM and impingement of the hip in elite junior badminton players and to report any differences between sex and ethnicities. Players at the World Junior Championship 2018 were examined for hip flexion, rotation, and impingement test. Injury history was obtained from a questionnaire. Two hundred and eighty-four players of 433 aged 16 to 18 years were examined. One hundred and forty-three players answered the questionnaire. Females demonstrated greater hip ROM than males. In the dominant side hip flexion was (137.7 degrees [$\pm$9.1] vs. 132.2 degrees [$\pm$11.1], $p < 0.001$), internal rotation range of motion or IROM (60.0 degrees [$\pm$10.9] vs. 49 degrees [$\pm$11.1], $p < 0.001$) and external rotation range of motion or EROM (57.9 degrees [$\pm$9.9] vs. 54.7 degrees [$\pm$8.9], 0.004). Hip flexion was higher in Asian players compared with non-Asian players (139.1 degrees [$\pm$8.4] vs. 130.3 degrees [$\pm$10.7], $p < 0.001$). One hundred (35%) players had at least one positive impingement test. A possible relationship between a positive FADIR and a decrease in hip flexion was found in the dominant hip, OR 1.06 (1.02–1.11) $p = 0.005$. A total of 104 previous injuries lasting over 30 days were reported with five hip-related injuries. No correlation between injury and examinations was found. Females and Asians demonstrated higher ROM in the hip than males and non-Asians. Impingement of the hip is frequent and may be related to low hip flexion.

Keywords
- badminton
- hip
- femoroacetabular impingement
- range of motion

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In badminton, the most common injuries affect the lower extremities, but also the trunk and the shoulder are common injury sites in juniors.[1–3] For sports medicine, sport science, and strength and conditioning professionals it can be valuable to have a musculoskeletal reference profile to compare against when managing the musculoskeletal health of the athletes.[4,5] As an example, Mosler et al found internal rotation deficit to be a predictor of hip and groin pain compared with an asymptomatic population.[6] Sex differences in the range of motion (ROM) of the hip may be a contributing risk factor for differences in lower extremity injuries between women and men.[7,8]

Other racket and overhead sports have ROM profiles available, however, there are no published reference values for ROM and clinical examination findings in the hip in badminton players.[8–11]

In other high demand sports like soccer and ice hockey, there is a high prevalence of femoroacetabular impingement syndrome (FAIS) in youth populations, where FAIS describes the symptomatic abnormal contact of the femur and acetabulum with either pincer and/or cam deformity.[12–15] It is thought that repeated high loading to this region, especially into hip flexion, is a contributing process in the development of FAIS and given the high load repeated lunging and jumping involving significant hip flexion in badminton, the development of FAIS may be an associated phenomenon.[16] It has also been repeatedly suggested that the development of FAIS is a cause of subsequent development of hip osteoarthritis (OA), which makes the early diagnosis of FAIS important.[16–20]

In a study of football players, Asians had less signs of bony morphology associated with FAI on X-rays compared with non-Asians.[8–11] Furthermore, a decreased internal rotation in players with bony abnormalities was reported. In a study on elite adolescent skiers, the presence of cam deformity on MRI correlates with reduced internal rotation in the supine and sitting positions, passive supine hip flexion, and positive impingement tests.[21]

The current study involved a global elite junior badminton playing population. It was conducted at the Badminton World Federation (BWF) World Junior Badminton Championships in Canada during the period November 9 to 17, 2018. Injury epidemiology and training characteristics have previously been reported in another paper with marked differences between Asian and non-Asian players regarding training volume.[22]

The primary objectives of the current study were:

1. To report normative ROM and impingement of the hip and report any differences in ROM and impingement tests between sex and between Asian and non-Asian players.
2. To determine if any correlation exists between ROM, impingement signs, and injury history in badminton players.

Methods

Eligibility Criteria and Setting

The study was commissioned by the BWF. All participants competing in the 2018 BWF World Junior Badminton Championships, Markham, Canada, were invited to take part. Participants were excluded if written consent was not obtained and if they were under 16 years of age. Due to the age limit of the Junior Championships, no participants were over 18 years of age. All physical assessments were undertaken at championship venues.

Study Design

This study was cross-sectional involving a physical assessment of the ROM of the hip and impingement tests for the hip.

Data Collection and Management

The study methods conformed to the Helsinki declaration and was approved by the Danish Data Protection Agency. According to the rules of the Capitol Region Committee on Health Research Ethics in Denmark, no formal ethical approval was needed. Furthermore, as the study was global in nature, the BWF Legal Team evaluated, informed, and approved the study design.

The physical examination was primarily undertaken by the lead investigator, an orthopaedic surgeon specialized in hip arthroscopy. Basic height and weight measurements were collected by an assisting medical doctor, hip ROM, and hip impingement tests by first author.[23,24] The dominant hip was defined as the same side as the racket arm.

The data collected were entered directly into REDCap electronic data capture tools hosted at the Capital Region of Copenhagen and stored for future analysis.[25]

Injury history was obtained from a questionnaire modified from the World Olympic Association Musculoskeletal Health Global Questionnaire[26] with three main components:

1. Significant injuries defined as an injury lasting 30 days or more and causing a reduction in training capacity or which led to absence from competition.
2. Recurrent injuries defined as an injury occurring in the same body part and causing a reduction in training intensity and/or absence from competition for at least 7 days.
3. Current symptoms of pain and/or stiffness in most days of the last 30 days.

The questionnaire was available electronically online in English and paper versions were available in English, Spanish, Indonesian, Korean, Chinese, and French. Questionnaire data was securely stored directly on REDCap. The non-English questionnaires were coded making them easily convertible to the English version in REDCap. BWF approved translators converted the non-English questionnaires into English.

Physical Assessment Protocols

The full physical assessment methodological protocol can be seen in the **Appendix**.

Hip ROM

Hip ROM was measured in supine using a goniometer, with IROM and EROM measurement and hip flexion ROM according to Gradoz et al and Ratzlaff et al with good reliability.[24]

Hip Impingement

The FADIR and FABER impingement tests were performed in supine according to Ratzlaff et al and Bagwell et al with good reliability.[24] Additionally a reliable set square method was used for a modified FABER test to measure the distance between the couch and the lateral epicondyle on the femur.[27]

Statistics

Continuous variables are presented as mean with standard deviation (SD), comparison between groups were done using *t*-test or, if data could not be assumed normally distributed, Wilcoxon rank-sum test. Categorical variables as count, comparison between groups were done using Chi-squared test or, in case with less than five observation for events, Fisher's exact test. ROM measures and differences in the number of positive impingement tests of the hip were compared between female/male, Asian/non-Asian, significant injury (yes/no), knee injury (yes/no), and stress fractures (yes/no).

To evaluate potential selection bias in the study data, a comparison of participants that only finished the clinical examination (non-responders) with those who additionally finished the questionnaire (responders) was undertaken. The groups were compared on age, gender, height, weight, representative region (Asian vs. non-Asian), hip flexion, IROM, and EROM. Likewise, a comparison on age, gender, and representative region was undertaken between participants who finished the clinical examination with those who did not.

To reduce the potential of type I errors from multiple testing, a Bonferroni correction of the *p*-values was used, and specific critical *p*-values with Bonferroni correction are listed in the tables.

All analysis was done in R 3.6.0 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Two hundred and eighty-four players of 433 competing athletes completed the clinical examination and 164 players (164/433) completed the questionnaire (►**Table 1**). One hundred and forty-three players completed both the clinical examination and the questionnaire. Of the tested players, 144 players were male and 140 players were female. One hundred and fifty players represented Asian countries and 134 players were from non-Asian countries. Players from 32 countries from Asia, Europe, Africa, America, and Oceania participated. The tested players did not differ from non-tested players in regards to age and gender, but there were a higher proportion of Asian players in the non-tested group versus the tested group (70 vs. 38%), $p < 0.001$. Comparison of responders and non-responders of the questionnaire in the group that completed clinical examination showed that the responders were taller (mean: 2.7 cm, CI: 0.62–4.8), had a higher weight (mean 2.5 kg. CI: 0.56–4.41), included more males (15.9% CI: 4.8–27%) ,and had fewer players from Asian countries represented (27.2%, CI: 16.6–37.9%), all with *p*-values ≤ 0.011. There were no significant differences between the two groups regarding hip flexion, IROM, and EROM.

ROM

Females in general demonstrated greater hip ROM than males (►**Table 2**). In the dominant side hip flexion (137.7 [±9.1] degrees vs. 132.2 [±11.1] degrees, $p < 0.001$), IROM (60.0 [±10.9] degrees vs. 49 [±11.1] degrees, $p < 0.001$) and EROM (57.9 [±9.9] degrees vs. 54.7 [±8.9] degrees, $p < 0.004$) were all higher among females. Also, on the non-dominant side females had a significantly higher ROM compared with males (►**Table 2**). Females had a small loss of EROM in the dominant hip/gain in the non-dominant hip which was significantly different from the males who had a small gain in EROM in the dominant hip/loss in EROM in the non-dominant hip, $p = 0.003$.

When comparing the dominant with the non-dominant hip in all players, there was a significantly higher ROM in the dominant hip (IROM 4.8 [±11] degrees, $p < 0.001$, [CI 3.5: 6.0]; EROM 1.0 [±8.5] degrees, $p = 0.04$, [CI 0.3:2.2]; and total rotational range of movement (TRROM) 5.8 [±13.0] degrees, $p < 0.001$, [CI 4.3:7.3]).

Hip flexion was significantly higher in players representing Asian countries compared with non-Asian countries (139.1 [±8.4] degrees vs. 130.3 [±10.7] degrees, $p < 0.001$). Players representing Asian countries had higher measures in the modified FABER test compared with players from non-Asian countries in the dominant and non-dominant hip, respectively (21.6 [±5.4] cm vs. 23.9 [±5.2] cm, $p < 0.001$) and 20.4 (±5.2) cm. vs. 22.1 (±5.0) cm., $p = 0.004$. Hip IROM,

Table 1 Anthropometrics of study participants

	Males	Females	*p*	Asians	Non-Asians	*p*	Total
Participants	144	140	0.812	150	134	0.342	284
Mean age (years ± SD[a])	17.1 ± 0.9	16.9 ± 1.2	0.05	17 ± 1.0	17 ± 1.0	1	17.0 ± 1.0
Mean weight (kg ± SD[a])	71.0 ± 8.0	60.9 ± 6.1	< 0.001	64.3 ± 7.6	68.0 ± 9.5	< 0.001	66.0 ± 8.7
Mean height (cm ± SD[a])	179.2 ± 6.9	166.1 ± 6.9	< 0.001	170.1 ± 9.1	174.7 ± 9.4	< 0.001	172.6 ± 9.4
Right-handed players	129	128	0.74	135	122	0.92	257
Left-handed players	15	12		15	12		27

[a]Standard deviation.
Note: Significant level with Bonferroni correction: *p*-value = 0.008 (0.05/6).

Table 2 Range of motion (ROM) and impingement of the hip

	Overall $n=284$	Male $n=144$	Female $n=140$	p-Value	Asian $n=150$	Non-Asian $n=134$	p-Value
Flexion (D[a])	135 (±10.5)	132.2 (±11.1)	137.7 (±9.1)	< 0.001	139.1 (±8.4)	130.3 (±10.7)	< 0.001
Flexion (ND[b])	136 (±11.4)	133.6 (±10.8)	138.6 (±11.4)	< 0.001	140 (±10.3)	131.5 (±10.8)	< 0.001
Flexion difference	−1.1 (±6.9)	−1.3 (±5.1)	−0.8 (±8.4)	0.53	−0.9 (±8.3)	−1.3 (±4.9)	0.63
IROM[c] (D[a])	54.2 (±12.4)	48.6 (±11.1)	60.0 (±10.9)	< 0.001	57.8 (±11.6)	50.2 (±12.0)	< 0.001
IROM[c] (ND[b])	49.4 (±13.3)	43.5 (±11.7)	55.6 (±12.1)	< 0.001	53.1 (±13.0)	45.3 (±12.4)	< 0.001
IROM[c] difference	4.8 (±11.0)	5.1 (±11.2)	4.4 (±10.9)	0.40	4.6 (±11.0)	4.9 (±11.1)	0.60
EROM[d] (D[a])	56.3 (±9.5)	54.7 (±8.9)	57.9 (±9.9)	0.004	58.7 (±8.9)	53.5 (±9.4)	< 0.001
EROM[d] (ND[b])	55.3 (±10.0)	52.2 (±9.3)	58.4 (±9.8)	< 0.001	58.8 (±9.3)	51.2 (±9.3)	< 0.001
EROM[d] difference	1.0 (±8.5)	2.5 (±8.5)	−0.5 (±8.2)	0.003	−0.1 (±8.3)	2.3 (±8.5)	0.12
TRROM[e] (D[a])	110.5 (±16.7)	103.3 (±15.2)	117.9 (±15.0)	< 0.001	116.5 (±15.1)	103.7 (±15.9)	< 0.001
TRROM[e] (ND[b])	104.7 (±18.5)	95.7 (±15.4)	114.0 (±16.8)	< 0.001	112.0 (±17.2)	96.6 (±16.4)	< 0.001
TRROM[e] Difference	5.8 (±13.0)	7.6 (±13.2)	3.9 (±12.5)	0.11	4.5 (±12.2)	7.2 (±13.7)	0.62
FADIR pain[f] (D[a])	63 (22.2%)	31 (21,5%)	32 (22.9%)	0.62	28 (18.7%)	35 (26.1%)	0.11
FADIR pain[f] (ND[b])	68 (23.9%)	32 (22,2%)	36 (25.7%)	0.40	33 (22.0%)	35 (26.1%)	0.35
FABER pain[g] (D[a])	21 (7.4%)	13 (9,0%)	8 (5.7%)	0.28	9 (6.0%)	12 (9.0%)	0.47
FABER pain[g] (ND[b])	13 (4.6%)	10 (6,9%)	3 (2.1%)	0.68	7 (4.7%)	6 (4.5%)	1
FABER in cm[h] (D[a])	22.7 (±5.5)	23,0 (±5,4)	22,3 (±5,4)	0.17	21.6 (±5.4)	23.9 (±5.2)	< 0.001
FABER in cm[h] (ND[b])	21.2 (±5.2)	21.7 (±5.8)	20.7 (±4.4)	0.08	20.4 (±5.2)	22.1 (±5.0)	0.004

Abbreviations: EROM, external rotation range of motion; FABER, flexion abduction external rotation; FADIR, flexion, adduction, internal, rotation; IROM, internal rotation range of motion; TRROM, total rotational range of movement.
[a]Dominant side.
[b]Non-dominant side.
[c]External rotational ROM.
[d]Internal rotational ROM.
[e]Total rotational ROM.
[f]Flexion adduction internal rotation test.
[g]Flexion abduction external rotation test.
[h]Length in cm. between the lateral epicondyle of the femur and the couch when performing the FABER test.
Note: Mean value in degrees with SD. Significant level with Bonferroni correction: p-value $= 0.003$ (0.05/18).

EROM, and TRROM were all significantly different between players representing Asian and non-Asian countries with $p < 0.001$ (►**Table 2**).

Impingement of the Hip

The distribution of positive impingement tests can be found in ►**Table 2**. One hundred (35%) players had at least one positive impingement test in the dominant or the non-dominant hip. There were no differences between players from Asian and non-Asian countries or between males and females regarding the number of positive impingement tests. A positive FADIR and a positive FABER were present in the same hip in 20 (7%) of the cases.

A possible relationship between a positive FADIR and a decrease in hip flexion was found in the dominant hip, OR 1.06 (1.02–1.11) $p = 0.005$. Likewise, a possible relationship was found between FADIR and non-dominant hip flexion, OR 1.05 (1.00–1.09), non-dominant EROM, OR 1.03 (1.00–1.06) and between FABER, and non-dominant EROM, OR 1.06 (1.00–1.13) with p-values < 0.05. However, with a Bonferroni correction the relationships were not significant.

Clinical Examination and Correlation with Injury

A total of 104 significant injuries earlier in the players career were reported with knee ($n = 28$), ankle ($n = 19$), and lower back ($n = 10$) being the most frequently affected locations. Eleven stress fractures were reported of which eight were in the lower extremities and three in the pelvis or lower back. No correlation between any significant injury and clinical examinations of the hip was found.

Five players reported a significant injury in the hip lasting more than 30 days and four players reported a recurrent injury in the hip. Only one player reported a diagnosis of hip impingement. Nine players had current symptoms of either stiffness or pain in the hip at the time of the world championship, six of them had pain. No uniform findings or correlations concerning symptoms, injury history, and tests were found.

Discussion

This is the first available dataset on normative values for hip ROM in badminton and the first of its kind to look at clinical signs of impingement in the hip. As associations of ROM and radiological signs of FAI in athletes have been reported,[6,21,28,29] knowledge of sports-specific normative data would be helpful in guiding the interpretation of the clinical hip examination when making decisions for the prevention, further diagnosis, and treatment of hip- and groin-related problems. Furthermore, normative ROM and hip impingement values can be used to inform athlete screening programs and physical performance measures in response to training programs. This dataset is therefore of multidisciplinary interest for health and fitness professionals working in badminton.

ROM

The IROM and EROM values reported in this study are similar to results reported by Tainaka et al also using supine measurements.[30] However, studies which used a prone position while measuring IROM and EROM generally reported lower values.[7] Therefore, the present results are only generalizable to a population measured in supine.

Hip flexion results must be interpreted with caution due to the known issues with the reliability in goniometric measurement of hip flexion where this method is known to overestimate true hip ROM, however, since hip flexion examination measurement was conducted by the same experienced examiner, it may improve the reliability of between-group observations.[31]

Females demonstrated a larger hip flexion, IROM, and EROM than males. The difference was more than 10% in IROM on both sides and in non-dominant EROM. This is in line with tennis studies which demonstrated clinical differences in hip ROM between genders.[8] Higher ROM in hip flexion and in rotation among females may be related to several factors that might differ from males such as pelvic anatomy, passive muscular stiffness, collagen distributions, and levels of estrogen.[32]

Hip flexion was significantly higher in players representing Asian countries. Cultural differences in training methods, genetic differences, or cultural differences in daily activities could all contribute to the observed difference in hip flexion between Asian and non-Asian players.

Badminton differs substantially in terms of movement from soccer, basketball, tennis and other sports. In badminton, players lunge repetitively with terminal range flexion in the dominant hip and with various abduction/adduction and external/internal rotation movements of the hip to cover the entire court.[33] The difference in ROM between the dominant and non-dominant hip found in these badminton players may reflect the asymmetrical loading of the lower extremities due to the repetitive lunges on the dominant leg.[33] In the study by Mosler et al, pain in the hip and groin was associated with IROM deficit which differed from our study where no statistical correlation between ROM and a history of significant injury and present pain was observed.[6] It is also possible that due to the multifactorial etiology of injuries, no association with single ROM measures can be found. However, given the small number of specific injuries in this study, this lack of correlation should be interpreted cautiously and a correlation in adult players may still exist.

Hip Injuries and Hip Impingement

To diagnose FAIS, a history of pain in the hip region has to be present at the same time as a positive impingement test and radiological findings with bony abnormalities on the acetabulum or head–neck junction of the femur. It was not possible in the competition setting of the current study to obtain radiological imaging of the players. It was therefore not possible to diagnose players with FAIS.

In this cohort, 100 players (35%) had a minimum of one positive hip impingement test in either their dominant or non-dominant hip. The FADIR test was the most frequently positive hip impingement test. There may be a high rate of false positive hip impingement tests as seen in other studies owing to the moderate specificity of the FADIR test.[34,35] There is a proposed relationship between FAIS and the development of OA and we know from other sports that FAIS is more prevalent in sporting populations than in the general population.[16–20] Furthermore, through personal communications, the authors are aware of a high number of former elite badminton players who have had hip replacements at an early age due to OA. This gives rise to concern since badminton has evolved physically over the past 40 years and the load on the hip joint may be even greater in the current badminton generation.[36,37] Newer studies of arthroscopic treatment after failed conservative treatment of athletes with FAI syndrome have shown unsatisfying results of return to the same level of sport.[38,39] FAIS may be underdiagnosed and symptoms may not become present prior to the age of 20 years in badminton players. If an early diagnosis is made, management can be optimized which may delay or prevent the development of OA and maintain their level of badminton participation. It follows that positive hip impingement tests in this population should be given appropriate consideration.

Despite the high number of players with positive impingement tests, relatively few players reported either previous significant injury or current stiffness or pain in the hip or groin. There are several pathologies other than FAI which can create pain in the hip and groin and the diagnosis of FAIS also depends on the clinical suspicion of the health care professional. It is therefore possible that players either have another condition causing the painful impingement tests or that they have pre-symptomatic FAIS (signs before symptoms) which could both contribute to the lack of correlation in this study. We recommend that health care professionals working with badminton players refer those with hip complaints and positive impingement tests to a hip specialist so that accurate and early diagnosis can be made and appropriate care be provided.

Since it has been shown in other sports that decreased internal rotation with measures below 10 degrees was associated with degenerative changes on MRI, early progression of radiological signs of OA and positive impingement tests, it is advisable to suspect hip pathology when players present with low IROM.[28] It is the authors own clinical experience that small deficiencies in ROM are not correlated with hip pathology but patients with advanced hip pathology often present with marked decrease in hip flexion and IROM. This study furthermore showed a possible relationship between a decreased hip flexion and a positive FADIR test. There was no relationship between a positive impingement test and IROM. No players had IROM less than 10 degrees.

Limitations

Internal reliability tests were not performed and since especially rotational ROMs were higher than previously reported the results can be questioned. However, measurement methods with high reliability were selected for this study and performed by an experienced orthopaedic surgeon with a hip arthroscopy specialty.

Even though there was a high attendance from Asian players in the tests, there were proportionally more Asians who were not tested. Furthermore, in the group of tested players the responders of the questionnaire were significantly taller, had a greater weight, were predominantly males, and were more likely to represent non-Asian countries. There was a high representation from all continents, however, some countries chose not to volunteer for the study. This may be due to cultural differences between nations, less experience of research participation, and for some players it may have been a disturbing factor to undergo examination during the championships and therefore chose not to participate.

We did not find any significant correlation between injuries and clinical findings. This may be due to a low number of regional injuries and the large number of variables included which required a Bonferroni correction lowering the level of significant *p*-values. The study population may be healthier than a matched cohort of badminton players not qualifying for the World Championship since players with present injuries or history of injuries may not have qualified. The retrospective study design may also have caused recall bias in regards to injury reporting.

The time between completing a match and undertaking test varied between participants due to the “in-competition” nature of the study. Therefore, the possibility for transient neuromuscular changes and stiffness in soft tissue in response to playing should be considered when interpreting physical assessment data.

Conclusion

Female players and players representing Asian countries demonstrated clinically and significantly higher ROM in the hip than male players and non-Asian representative players. There was also a side to side difference favoring higher ROM of the dominant hip in flexion, EROM, and IROM.

Clinical impingement of the hip is frequent in this cohort and seems to be positively related to low hip flexion. Players have few complaints of current hip and groin problems. We did not find significant correlation between injury history and ROM or between injury history and impingement in the hip, but acknowledge the relatively low number of injuries reported in the young cohort as a possible confounder.

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Conflict of Interest
N.C.K. and S.K.’s travel costs were paid by Badminton World Federation.

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Appendix

Protocol of ROM and hip impingement tests of the participants at the World Junior Badminton Championship 2018 in Canada

Hip Flexion

- The participant will be positioned supine on the examination table to measure passive hip flexion.
- The examiner will fully flex the participants' hip passively and will use a goniometer to measure knee flexion angle.
- The goniometer will be placed with the central axis of rotation at the hip joint axis of rotation and with the proximal arm placed along a line intersecting the greater trochanter and the glenohumeral joint. The distal arm of the goniometer will be placed along a line intersecting the hip joint axis of rotation and the femoral lateral epicondyle.
- The assistant will record the maximum hip flexion angle determined by the examiner.
- This will be repeated on the other leg.

FADIR

- The participant is placed supine on the examination table.
- The examiner takes the hip into full flexion, adduction and external rotation as a starting position.
- The examiner then extends the hip combined with internal rotation and adduction.
- The examiner will determine a positive test if pain or apprehension is reported in the groin/hip.
- The assistant will be instructed to record either a positive or negative test finding.
- This will be repeated on the other leg.

FABER

- The participant is placed supine on the examination table.
- The examiner will place the foot of the test leg on the contralateral knee.
- A gentle pressure is then placed on the medial aspect of the knee on the test leg.
- The distance from the lateral femoral epicondyle to the examination table is taken on the test leg using a tape measure.
- The presence of pain in the groin/hip is also noted.
- The assistant will record the measurement taken and the presence of pain.
- This will be repeated on the other leg.

Hip Internal and External Rotation

- The participant is placed supine on the examination table.
- The examiner will position the test hip in 90 degrees of flexion.
- The participants hip will then be taken passively into internal rotation maximally.
- The examiner will use a manual goniometer with the distal arm placed along the length of the tibia and the proximal arm perpendicular to the pelvis (as described and illustrated by Gradoz et al 2018).
- The maximum hip internal rotation angle will be determined by the examiner and recorded by the assistant.
- The examiner will then passively take the participants hip into maximum external rotation while maintaining 90 degrees flexion.
- The goniometer will be kept in the same position and the maximum angle is determined by the examiner.
- The assistant will then record this angle.

