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HIP

Arthroscopic correction of femoroacetabular impingement improves athletic performance in male athletes

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Abstract

Purpose To measure the changes in athletic performance in athletes treated arthroscopically for femoroacetabular impingement and compare results to a matched controlled athletic cohort, over a 1-year period.

Methods Male athletes scheduled for arthroscopic correction of symptomatic FAI were recruited and tested (pre-operatively and 1-year postsurgery) for measures of athletic performance which included acceleration (10-m sprint), change of direction speed (CODS), squatting depth, and reactive strength index (RSI). The FAI group was compared to a matched, healthy, control group who were tested at baseline and 1 year later with no disruption to their regular training or competition status; the prevalence of anterior groin pain during testing in either group was recorded. Hip range of motion (ROM) was also measured for both groups at baseline and at 1 year in the FAI group to look for change following intervention.

Results Prior to surgery, the FAI group were slower than the control group ($p < 0.001$) for acceleration (3% slower) and CODS (10% slower). At 1 year, 91% of the FAI group returned to full competition at an average time of 17 weeks, while substantial reductions in pain were also noted during acceleration (51–6%, $p = 0.004$), CODS (62–8%, $p = 0.001$), and squat test (38–8%, $p = 0.003$). Significant improvements were seen in the FAI group for CODS (7%, $p < 0.001$) and squat depth measures (6%, $p = 0.004$) from baseline to 1 year (significant time × group interaction effects were noted for these also). The changes in performance in the control group over time were non-significant across all of the measures (n.s.). At 1-year postsurgery, there were no statistically significant differences between the groups for any of the athletic measures. There was a significant and clinically important improvement in range of hip motion in the FAI group at 1-year postsurgery ($p < 0.05$).

Conclusion Symptomatic FAI causes substantial reductions in athletic performance compared to healthy competitors placing these athletes at a distinct performance disadvantage. The results from the current study demonstrate that arthroscopic correction (including labral repair) in athletes with symptomatic FAI, reduces pain and restores athletic performance to a level which is comparable to healthy athletes, at 1 year.

Level of evidence II.

Keywords Femoroacetabular impingement · FAI · Arthroscopy · Hip injury · Athletes · Sports injury · Athletic performance

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Introduction

Femoroacetabular impingement (FAI) is a pathological hip condition common among the athletic population [1–7, 11] characterised by the development of abnormal bony hip morphology leading to activity-related pain and stiffness [15, 16, 43]. Two types of bony deformities have been described; a cam deformity occurs when excessive bone growth develops on the femoral head/neck junction and a pincer deformity results from a localised or global overgrowth of the acetabular rim. It is common, however, for patients to present with a combination of both. Repetitive abnormal contact between the head/neck junction and the rim of the acetabulum, particularly during hip flexion, adduction and internal rotation, leads to progressive trauma to the labrum and subsequent delamination of the articular cartilage [46, 52]. Progressive symptoms develop including hip/groin pain and stiffness, with increasing restriction of hip motion, decreased functional ability and eventually irreversible chondral damage may lead to osteoarthritis of the hip [10, 16, 43].

The aetiology of the condition is less understood; the role of excessive physical activity during skeletal development has been identified as a possible risk factor for the development of a bony deformity which becomes symptomatic later in the player pathway [1, 34, 42, 51]. The effects of FAI on athletic performance among a cohort of athletes with symptomatic FAI have been previously reported and displayed significantly lower levels of acceleration and agility, increased pain and lower hip range of motion compared to matched controls [35]. This indicates a distinct performance disadvantage to athletes continuing to compete without sufficient treatment, as is often the case among athletes with this condition.

Conservative management is recommended prior to more invasive treatments [39, 53], although there is little evidence supporting physiotherapy as a successful long term treatment option in athletes with symptomatic FAI. The role of surgical intervention for the treatment of FAI has grown substantially in recent years with favourable results among general and athletic populations [6, 7, 18, 44, 45]. Arthroscopy versus targeted conservative treatment protocols have recently been compared in general and military cohorts; both treatment methods improved symptoms [31], although slightly more favourable results among surgery groups have been reported [18, 40].

Much of the existing research, which has included athletes specifically, has used self-reported measures, timing of return to play, or internet sources to determine player appearances following surgery [3, 26] and have indicated positive results. A small number of studies assessing the effect of surgery on more functional movements including gait, strength, and squatting have also shown improvements following treatment [22, 24, 49] However, there is a paucity of research which examines the effect of corrective surgery on measures of athletic performance [47].

The aim of the study was to determine the effect of symptomatic FAI on athletic performance in athletes compared to healthy controls and measure changes in performance following arthroscopic FAI correction. "Athletic performance" for the purpose of this study was classified as the ability to carry out functional aspects of sporting performance and differs slightly from previous investigations. Athletic performance would be reduced prior to surgery, but would improve following treatment, allowing athletes to return to play at a level required to compete with their healthier counterparts.

Materials and methods

Ethical approval was granted by the research ethics committee at Waterford Institute of Technology (Reference number 13/HSES/09) prior to commencement. Forty-seven male athletes with symptomatic FAI (FAI group) between the ages of 18 and 35 were recruited for the study (Table 1). All athletes in the FAI group presented with symptoms (activity-related pain/stiffness), clinical signs (including a positive impingement test), and radiological findings (cam/pincer) in keeping with a diagnosis of FAI. A cam deformity was considered to be present when the alpha angle was > 55° (Dunn view) or > 65° (AP view). A pincer deformity was identified if the lateral centre edge angle (CEA) measured > 35° or a "crossover sign" was observed on a standardised AP view, or an obvious anterolateral rim deformity was observed on the false profile view. Athletes were excluded if treated for FAI previously (Fig. 1), had a secondary lower limb injury at the time or had evidence of osteoarthritis on radiograph (Tonnis Grade 2 or 3). A control group ($n=32$) was also recruited for the study consisting of athletes that were matched to the FAI group for age and activity level and were excluded from the study if, they had a lower limb injury, were treated for or reported signs and symptoms in keeping with FAI prior to or during the study.

Twenty-three FAI athletes were diagnosed with bilateral FAI (46 hips) and 24 with unilateral FAI; in total, 70 hips were included in the study. Seven hips (10%) were diagnosed with an isolated pincer impingement, 12 with pure cam impingement (17%), and 51 with a combination of both (73%). The FAI group primarily consisted of athletes from Gaelic (GAA) games including hurling ($n=13$),

Table 1 Participant demographics

	Age (years)	Height (cm)	Body mass (kg)	Centre edge angle (°)	Alpha angle; Dunn view (°)	Alpha angle; AP view (°)
FAI group ($n=47$)	24.6 ± 4.8	179.0 ± 5.3	80.6 ± 8.4	35.7 ± 6.5	58.9 ± 11.8	65.0 ± 18.9
Control group ($n=32$)	24.3 ± 4.3	179.4 ± 7.4	83.1 ± 7.1	N/A	N/A	N/A

No significant differences between groups (n.s.)

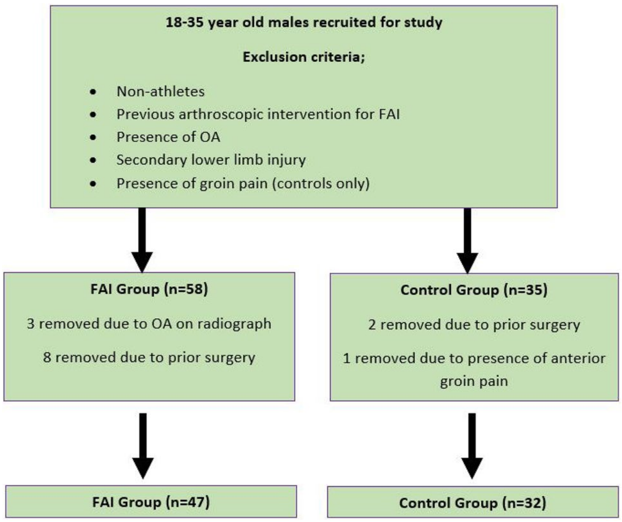

Fig. 1 Recruitment of FAI and control groups

gaelic football ($n=16$), and both hurling and gaelic football ($n=12$). Rugby players ($n=2$), soccer players ($n=2$), hockey ($n=1$), and gym/weights ($n=1$) athletes were also included. The control group ($n=32$) consisted of athletes from hurling ($n=12$), Gaelic football ($n=7$), both GAA codes ($n=11$) and rugby ($n=2$).

Athletic performance assessment

Both the FAI and control groups were tested for acceleration, change of direction speed (CODS), squatting depth, reactive strength index (RSI) at baseline, and 1-year postintervention. The exact protocols for each individual test utilised have been published by the current research team previously [35]. Acceleration and CODS were assessed using a 10-m sprint and modified agility *t* test, respectively, using dual-beam timing gates (Microgate, Italy). Squatting was assessed for depth using 2D video analysis, with RSI calculated using an Optojump system (Microgate, Italy). Dual-beam timing gates where chosen for the increased accuracy that they provide during sprinting assessments [20] and times were recorded to 100th of a second. Three trials of each test were carried out with 45 s of seated recovery between trials and an average of the fastest two results was recorded. The Optojump system has been shown previously to be a valid and reliable assessment tool for jump height when compared to force plates [17] and other portable jump assessment systems [8]. An average RSI of both limbs was determined using flight time/contact time, from three trials of a single leg drop jump protocol with a 30 cm box. Camera positioning for the squat evaluation was carefully considered to reduce the potential for prospective error [41]. Actual squat depth was measured using Dartfish software which has been cited previously as a valid and accurate method for the determination of movement patterns in clinical fields [37]. Depth was calculated by subtracting the distance of the greater trochanter (reflective marker placed on the outside of tight fitting clothing) to the floor at the base of the squat from the distance of the greater trochanter to the floor in a standing position and recorded in centimetres. Five trials were recorded for this measure. All participants were also asked to report the presence of any anterior groin pain/stiffness during each of the tests (pain: yes/no).

The control group underwent individual hip ROM testing (maximal flexion, abduction, and internal rotation in the supine position) at baseline only with a single operator, using a hand-held goniometer, the intra-relater reliability (Intraclass correlation coefficients >0.75) for this measure was published in an earlier manuscript [34, 35]. These measurements were compared with ROM assessment recorded in the FAI group undertaken as part of their routine preop and 1-year postop consultation using a similar dual-operator technique. In the clinic, measures of flexion, adduction, abduction, and external and internal rotation are recorded.

Surgical intervention

All 47 athletes (70 hips) with symptomatic FAI underwent arthroscopic bony correction (Fig. 2) and labral repair under the care of one experienced hip surgeon (PC). Athletes were anaesthetised and placed on a distraction table in the supine position. The hip was placed on traction and an antero-lateral and modified mid-anterior portal were established safely under X-ray guidance and an inter-portal capsulotomy was performed. If a pincer deformity was present, a labral 'reflection' technique was utilised for 'takedown' preserving the chondrolabral junction where possible. A 4-mm mechanical burr was used to resect pathological acetabular bone to a pre-planned depth establishing a lateral Centre Edge Angle of 30°. A labral cuff repair was utilised where possible for reattachment to acetabular rim; in some cases, a looped repair was used [7]. The labrum was then probed to assess stability of the fixation. Distraction was released, and the peripheral compartment examined. Femoro-osteoplasty was subsequently undertaken to remove excessive bone on the femoral head neck junction in cases, where a cam deformity was also present. The hip joint was dynamically assessed to ensure appropriate impingement-free movement. The capsulotomy was repaired using three non-absorbable sutures. Post-operation, athletes were encouraged to mobilise the joint 4 h following the procedure with use of a stationary bike on day 1. Crutches were used for 5 days following the treatment, with hydrotherapy initiated as soon as the incision wounds had healed, usually around 10 day postsurgery. Bilateral patients underwent bilateral surgery, 1 week apart.

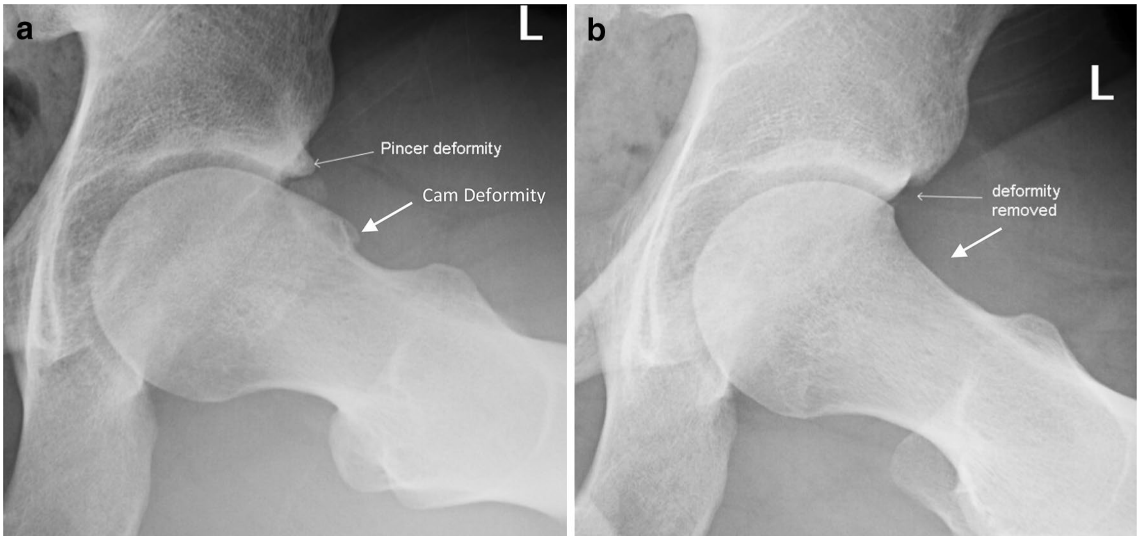

Fig. 2 Pincer and Cam deformities prior to surgery (**a**) with deformities removed during arthroscopy (**b**)

Rehabilitation and return to play

The FAI group were provided with a 12-week standardised rehabilitation program by the resident physiotherapist immediately following surgery and had follow-up examinations with the surgeon and physiotherapist at 6-week and 12-week postsurgery. The rehabilitation protocol consisted of four phases which included exercises to increase mobility in the early stages with gradual progression to more functional tasks and subsequent return to play recommendations. Return to play (RTP) was defined as the ability of the FAI group to participate fully in training and competition without any disruption to these schedules specifically due to prolonged hip pain or discomfort. The time taken for the FAI group to return to pre-injury levels of play and reasons for not returning was recorded at the 1-year assessment. Secondary injuries sustained in the time between follow-ups were also noted.

Statistical analysis

Previous research has not analysed post-FAI surgery changes in the range of key-dependant variables from this study (i.e., speed, agility, RSI, and squat depth). However, effect sizes > 1.0 have been shown in research on these variables comparing patients and controls [35]. Based on a more cautious effect size of 0.7 [12], a minimum of 19 participants per group would be required for within group comparisons with an alpha level of 0.05 and study power of > 0.80 (G*Power 3.0.10). At baseline, an independent samples *t* test or non-parametric equivalent was used to compare differences between the groups for each measure. A mixed methods ANOVA was used to examine time by group interaction effects. If a significant interaction was observed, this was examined using simple main effects by running a repeated measures ANOVA for each group and an independent samples *t* test for between group differences at both timepoints. Alternatively, if no interaction effect was observed, the main effects of time and group were examined using between subject and within subject effects. A *p* value of less than 0.05 was considered significant in all cases, while effect sizes were calculated using Cohen's *d* for between group differences and partial eta squared values (partial η^2) for repeated measures analysis and interaction effects. Differences within the FAI group for hip ROM measures between baseline and 1 year as well as changes in radiological parameters of Centre Edge Engle, and the Alpha Angles (Dunn and AP view) were determined using a paired samples *t* test or non-parametric Wilcoxon signed ranks test. Effect sizes for ROM data were calculated using Cohen's *d* for independent and paired samples tests. A McNemar's test was used to examine whether changes in the proportion of FAI athletes reporting pain prior to and following surgery were statistically significant.

Results

Eleven athletes from the FAI group and nine control athletes did not return for 1-year follow-up, leaving 36 FAI athletes and 23 controls tested at both timepoints. Mean alpha angles (AP and Dunn) improved from 65.0° ± 18.0° to 56.0° ± 14.1° and 58.9° ± 11.8° to 49.8° ± 10.1°, respectively, while the mean lateral CE angle improved 35.7° ± 6.5° to 28.9° ± 5.8°, all of which were statistically significant (Table 2). There were no post-operative complications.

Table 2 Changes in radiological FAI parameters

Measure	Baseline	1 year	*p* value (ES)
Centre edge angle	35.7 ± 6.5	28.9 ± 5.8	< 0.001 (1.20)
Alpha angle (Dunn view)	58.9 ± 11.8	49.8 ± 10.1	< 0.001 (1.10)
Alpha angle (AP view)	65.0 ± 18.9	56.0 ± 14.1	< 0.001 (0.64)

ES effect size measured using Cohen's *d*

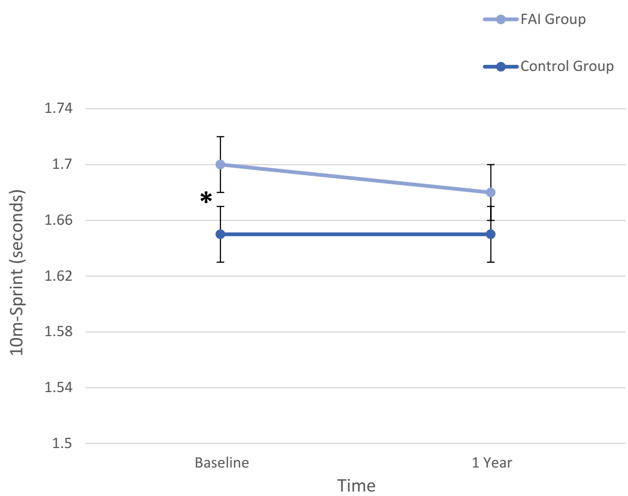

Fig. 3 A line graph indicating changes in 10-m sprint performance for FAI and control group over time. *Significant ($p < 0.05$) difference between the groups. ¥Significant ($p < 0.05$) change between time-points for either group

At 1-year postsurgery, 33 FAI athletes (91%) had returned to their full level of training and competition at an average of 17 weeks (range 9–52 weeks). Prior to surgery, 18 athletes (50%) of the FAI group reported pain for the 10-m sprint, and this reduced to two (6%) at 1 year ($p = 0.004$). Similar significant reductions in pain were recorded for the CODS, and squat depth which reduced from 22 (61%) at baseline, to three (8%) ($p = 0.001$) and 14 (39%) to three (8%) at 1 year, respectively.

Acceleration (10-m sprint)

No time × group interaction effect was observed for the 10-m sprint (n.s., partial $\eta^2 = 0.039$), and therefore, the main effects of group and time were assessed (Fig. 3). The effect of group was not significant (n.s., partial $\eta^2 = 0.052$) with the main effect of time also reported as non-significant (n.s., partial $\eta^2 = 0.018$).

Change of direction speed (CODS)

There was a significant time × group interaction observed for the CODS ($p < 0.001$, partial $\eta^2 = 0.359$). Simple main effects were therefore assessed for the CODS (Fig. 4). Significant differences between the groups for CODS at baseline (7.90 s ± 0.80 versus 7.17 s. ± 0.41, $p < 0.001$, Cohen's $d = 1.15$) were observed, but differences between the groups were no longer significant at 1 year (7.39 s ± 0.68 and 7.29 ± 0.37, n.s., Cohen's $d = 0.18$). Significant improvements among the FAI group were documented from baseline to 1 year ($p < 0.001$, partial $\eta^2 = 0.557$) for this measure, while changes in the control group were non-significant over time.

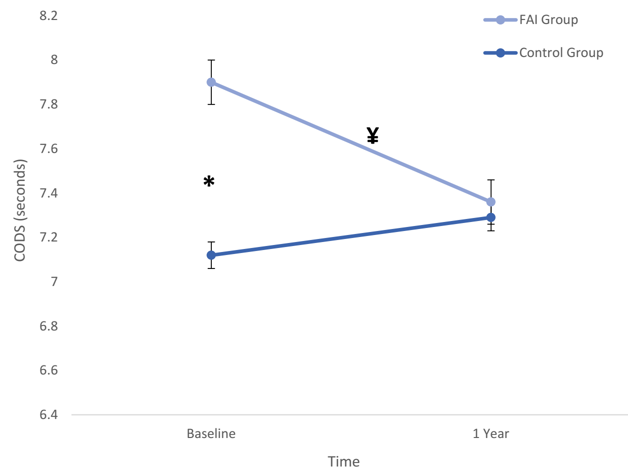

Fig. 4 A line graph indicating changes in CODS performance for FAI and control group over time. *Significant ($p < 0.05$) difference between the groups. ¥Significant ($p < 0.05$) change between time-points for either group

Squat depth measure (cm)

A significant time × group interaction was observed ($p = 0.028$, partial $\eta^2 = 0.080$). When examining the simple main effects of the squat depth measure (Fig. 5), no significant differences (n.s.) between the FAI group and control group for squat depth at either timepoint (baseline; 49 ± 12 cm and 50 ± 12 cm, and 1 year; 52 ± 10 cm, and 50 ± 14 cm, respectively), but a significant improvement was recorded among the FAI group ($p = 0.004$, partial $\eta^2 = 0.206$). Again, no significant effect of time was noted for the control group (n.s., partial $\eta^2 = 0.011$).

Reactive strength index (RSI)

No time × group interaction effect was recorded for the RSI variable (Fig. 6); the main effects of time and group were subsequently examined. The test of between group effects was non-significant (n.s., partial $\eta^2 = 0.019$), but assessments of within group effects indicated significant improvements in mean scores in the FAI group from baseline to 1 year ($p = 0.030$, partial $\eta^2 = 0.103$).

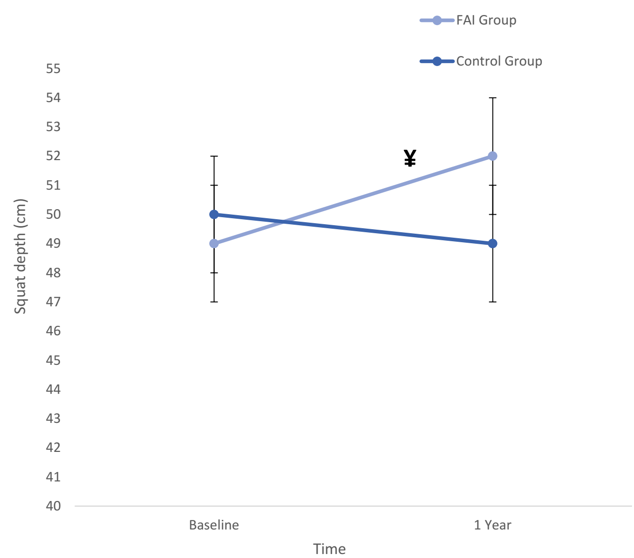

Fig. 5 A line graph indicating changes in Squat depth performance for FAI and control group over time. *Significant ($p<0.05$) difference between the groups. ¥Significant ($p<0.05$) change between time-points for either group

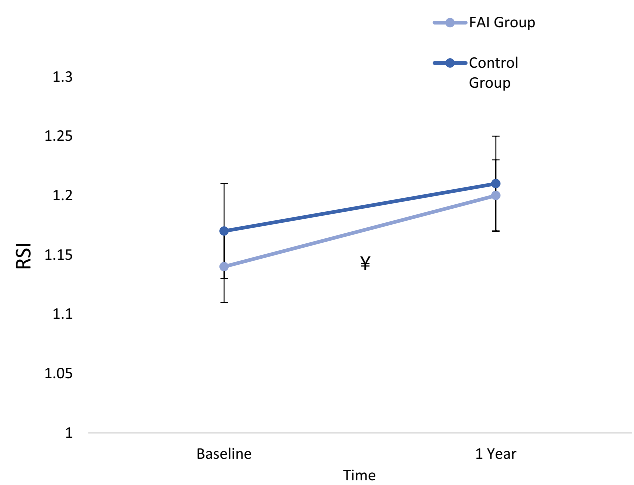

Fig. 6 A line graph indicating changes in reactive strength index for FAI and control group over time. *Significant ($p<0.05$) difference between the groups. ¥Significant ($p<0.05$) change between time-points for either group

Hip range of motion (ROM)

At baseline, no significant differences between the groups for maximal flexion or abduction were noted, although significantly lower internal rotation measures were recorded in the FAI group compared to the control group (see Table 3). Changes in ROM from baseline to 1 year among the FAI group indicate significant improvements in adduction, internal, and external rotation but not flexion or abduction (Table 4).

Table 3 Differences between FAI group and control group at baseline for flexion, abduction and internal rotation (°)

Measure	FAI group	Control group	*p* value (ES)
Flexion	116.5 ± 8.7	117.1 ± 5.9	n.s.
Abduction	50.9 ± 9.8	47.8 ± 9.4	n.s.
Internal rotation	23.8 ± 8.5	52.3 ± 8.7	< 0.001 (3.40)

ES effect size measured using Cohen's *d*

Table 4 Changes in ROM among FAI group from baseline to 1 year

Measure	Baseline	1 year	*p* value (ES)
Flexion	116.5 ± 8.7	117.2 ± 6.9	n.s.
Abduction	50.9 ± 9.8	52.2 ± 6.4	n.s.
Adduction	24.6 ± 6.1	27.8 ± 2.8	0.012 (0.53)
External rotation	38.7 ± 7.6	44.5 ± 5.3	< 0.001(0.93)
Internal rotation	23.8 ± 8.5	27.4 ± 3.9	0.003 (0.39)

ES effect size measured using Cohen's *d*

Discussion

The aim of the current study was to determine the effect of symptomatic FAI on performance and measure changes in athletic performance following surgical treatment. The most important finding of the research included a considerable reduction in pain during athletic performance testing following surgery and an improvement in athletic function in FAI athletes when compared to that of healthy controls at 1 year. Recent studies have focused on comparing arthroscopic surgery with conservative management of FAI; both treatment types have demonstrated improvement in symptoms, albeit to a greater extent in surgical cohorts [18, 40]. In the current study, the phased rehabilitation program following surgery was designed to protect the labral and capsular repair while aiding recovery and strengthening of the hip muscles, in particular those directly affected by the portal entry.

There are currently very few research investigations on FAI which have examined the effect of treatment on athletic performance. Most of these have focused on RTP. We report a 91% RTP at an average of 17 weeks. Three patients did not return to sport (two with significant articular cartilage damage and one recommended to stop playing). Our RTP results are comparable to and in some cases higher than that of the previous literature [3, 26, 38, 44]. A recent systematic review of return to play rates has indicated an average return rate of 74%.

Ishøi et al. [21] reported that only 57% of athletes returned to play at their pre-injury level. The authors included participants who were treated by multiple surgeons, had different follow-up times and patient reported levels of what constitutes optimal sports performance. Patient perception of sporting ability can be influenced by multiple factors including prolonged symptom duration prior to intervention, patient–surgeon interaction, and rehabilitation time. Alternatively, McDonald et al. reported on match performance among ice hockey players following treatment and found a reduction in the number of shots taken on goal following the procedure [32]. While, more recently, Schallmo et al. examined sporting performance based on pre-determined algorithms relative to each sport, with each athlete acting as their own control [50]. Although athletes were able to return to play, the quality of their performance varied depending on sporting type and playing position. Many confounding factors can affect match performance which cannot be controlled for in scientific investigation, including the quality of opposition, overall team performance, or motivation. In a more controlled setting, the results indicate that measures of individual athletic function at 1 year have significantly improved and are comparable to healthy athletes of the same discipline.

Acceleration and CODS (agility) are of paramount importance to on-field performance, especially in Gaelic games which are high intensity, multi-directional, collision field sports similar to rugby and soccer in terms of physiological demands [27–30, 33]. A previous paper from the current research group demonstrated that acceleration and CODS are reduced in athletes with FAI [35]. However, these measures have not been examined following treatment to date. Gait has been examined, however, and shown to be altered in persons with FAI [23, 36, 48] with some improvements reported following surgical intervention [5, 22, 49]. At baseline, both acceleration and CODS were significantly reduced compared to controls; however, significant improvements were observed in CODS at 1 year (significant group × time effect). The multi-planar movements required in the CODS test place a greater overall load on the hip joint than the 10-m straight line sprint test. This may explain the greater improvements seen in the CODS score. The 7% improvement in CODS time following arthroscopic surgery marks a distinct performance improvement among the FAI group.

Previous research has indicated that squatting mechanics may be altered in persons with FAI compared to those without [2, 25]. No differences were noted in our study between the FAI and control groups with regard to squat depth at either timepoint, similar to one previous investigation [9]. Of the previous research which examined the ability of FAI patients to squat, only Lamontagne et al. carried out follow-up testing. They found no differences in the squat kinematics. The results of our study indicate greater squatting depths at 1 year among the FAI group compared to baseline, although the 2D nature of the current study does not allow determination of the causes of greater squatting depths. Reductions in hip ROM between those with FAI and those without have been well documented and are generally considered highly indicative of the condition [19, 43]. The effect of surgical intervention on hip ROM has been less reported. Bizzini et al. described increases in hip ROM following an open-surgical procedure among professional ice hockey players [4]. In the present study, there were significant improvements in ROM (adduction, internal rotation, and external rotation) in the FAI group, indicating that removing the bony deformity and restoring natural anatomy to the hip joint permits improvement of ROM.

Reactive strength index is a measure of the ability of an athlete to change from concentric force to eccentric force in as little time as possible and gives an overall indication of lower limb power [13]. Apart from one study which examined RSI between the affected and unaffected limb among ACL rupture athletes [14], currently, there is very little research which includes measurement of RSI, especially those involving injured athletes. Results of our study indicated slight improvements in RSI at 1 year in both groups. No differences were detected between the groups at any time point including baseline for RSI, which could indicate that RSI is perhaps minimally affected by biomechanical alterations to the hip joint and a more reliable indicator of the stretch-shortening cycle.

At the 1-year follow-up, 8% of the FAI group who reported pain on each of the tests included two athletes who had bilateral surgery with partial and complete chondrolabral separation, respectively, and a third athlete who was older in comparison with the others (34 years). Damage to the articular cartilage and increased age have been cited previously as risk factors for poorer outcomes following surgery. Earlier detection of FAI could ensure timely intervention, both conservative and surgical, which may yield more favourable results for these patients.

The inclusion of a control group which was tested both at baseline and at 1-year post-operation is a major strength of this study in comparison with the previous literature available. A small number of similar studies have included a control group, but comparative tests in these studies were only performed at a single timepoint. In this research, the repeated testing of controls allowed for time by group interactions over a 1-year period. While patient reported outcomes are undoubtedly beneficial in clinical practice, the objective nature of the testing is also a considerable advantage of the study and offers a unique, less reported perspective of FAI treatment. The use of dual beam timing gates, the wide-based LED-triggered Optojump system and the consistent running surface used for all testing were also key factors in increasing the accuracy of results.

Limitations

As with any prospective research, a number of participants in both groups did not complete follow-up testing, although all participants were contacted a minimum of three times to arrange testing. The most common reason for the FAI athletes not returning for follow-up was the travel time involved in coming to the clinic. Many of the athletes had to travel substantial distances to clinic and were reluctant to take time from work commitments to travel, especially if there were no further issues with their hip. This could have led to an underestimation of the true improvements among the FAI group. It was also not possible to collect RTP data for this cohort which leads to a degree of research bias. Dropout rates among the control group were largely due to the time taken to complete testing and motivational factors. Two different techniques for the measurement of hip ROM were used (single operator and dual-operator) which could have led to discrepancies between measurements for hip ROM.

The findings of this study highlight that the negative impact symptomatic FAI has on athletic performance and the potential benefits from arthroscopic FAI surgical correction on restoring optimal athletic function. Further studies might assess the use of performance testing in screening for underlying FAI or comparing outcomes between surgical and conservative management of symptomatic FAI.

Conclusion

Symptomatic FAI in male athletes results in reduced acceleration, change of direction speed (agility), decreased hip range of movement, and increased pain during performance testing when compared to a healthy, matched, athletic control group.

Arthroscopic correction of the abnormal bony anatomy and labral repair significantly improves change of direction speed, hip ROM, and squat depth, and results in substantial reductions in activity-related pain, with a high return to play rate at 1-year post-operation.

For male athletes with symptomatic FAI which has not responded to conservative treatment, arthroscopic FAI correction and labral repair should be considered as an early treatment option to maximise restoration of athletic performance and return to play.

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

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Ethical approval Ethical approval was granted by the research ethics committee at Waterford Institute of Technology (Reference number 13/HSES/09) prior to commencement.

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