Associations between Adductor Strength; Flexibility and Self-Reported Symptoms in Elite Professional Footballers: A case series

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**Objectives**: Measures of adductor strength, flexibility and self-reported symptoms offer insights into athlete hip/groin pain and function. Understanding the relationship between these measures, may determine their suitability for use within football medicine.

**Design**: Prospective clinical case series study

**Method**: Eighteen youth professional footballers (18.8 ±1.18 years) from an English Premier League club completed two adductor squeeze tests (short and long-lever), the HAGOS (sport) and Bent Knee Fall Out; two days post game-day, during a period of four months.

**Results:** Adductor strength reduced beyond the minimal detectable change (MDC) on 16 occasions for the long-lever squeeze test (MDC=7%) and 7 occasions for short-lever squeeze test (MDC=15%). On 17 occasions, participant BKFO scores reduced beyond the MDC (21%). A relationship between both squeeze tests and HAGOS (sport) was observed explaining 12% variance for the short-lever (R2 = 0.121, p=0.006) and 7% for the long-lever (R2 = 0.065, p=0.046). Changes in these measures appear to occur simultaneously. The bent knee fall out showed no statistically significant (P= >0.05) correlation to either squeeze test (rp =0.153 / 0.193) or HAGOS (sport) (rp = 0.182).

**Conclusion:** This study adds to the literature surrounding objective and subjective measures of hip/groin pain in professional youth footballers. The long-lever adductor squeeze test detected meaningful changes more frequently than the short-lever. Both tests shared a weak, albeit statistically significant relationship with HAGOS (sport), whilst the bent knee fall out did not. A larger prospective study is warranted to increase confidence in selecting these measures for monitoring footballer hip/groin pain.

**Keywords:** football; soccer; groin; hip; adductor; strength; screening

**Introduction**

Hip/groin injury is common in football contributing to 12-16% of all injuries per playing season (Werner et al. 2009). Such injuries often result in extensive periods of absence from play and a common feature of footballer hip/groin pain is longstanding symptoms - limiting function and performance for months or potentially years (Fricker et al. 1991). Indeed, many players continue to play with symptoms (Haroy et al. 2017), which often persist from one season to the next (Thorborg et al. 2014).

A systematic review by Ryan, De Burca and McCreesh (2014) identifies key ‘modifiable’ risk factors associated with hip/groin injuries in field-based sports, including adductor muscle strength. where deficits have been found to precede groin pain (Crow et al. 2009) and low pre-season scores may predict subsequent injury (Delahunt et al. 2017).

Reduced hip range of motion (ROM) is also considered as a modifiable risk factor (Ryan, De Burca and McCreesh, 2014), and measures of hip internal ROM and performance on the bent knee fall out test (a combined movement of hip flexion, abduction and external rotation) have been found to have discriminative ability in identifying athletes with hip/groin pain (Mosler et al. 2015). Commonly used in the professional football setting, the Bent Knee Fall Out (BKFO) test is considered a reliable measure of hip adductor flexibility (Paul et al. 2014), where deficits of around 3.6cm (1.3–5.8) can be observed in symptomatic athletes (Mosler et al. 2015).

It appears important then, that monitoring adductor strength and/or flexibility on a regular basis should be incorporated by football medicine clinicians as a pro-active approach to detecting potential hip/groin problems. In order to gain useful information from player monitoring, clinicians should consider the minimal detectable change (MDC) value for any given clinical test, facilitating clinicians to gauge whether score fluctuations are meaningful and thus inform clinical decisions (Hachana et al. 2013). Ultimately, interpreting a test score in relation to its MDC, may offer preventative value - serving to ‘yellow’ flag players prior to activity.

It is not only objective clinical measures that provide an insight into an athletes groin function / health. The HAGOS (Copenhagen Hip and Groin Outcome Score) is a patient reported outcome (PRO) measure also strongly evidenced to support its use in identifying athlete hip/groin pain (Mosler et al. 2015). The ‘sport, recreation and function’ subscale of the HAGOS has been shown to predict groin injury, albeit in a small amateur Gaelic footballer cohort (Delahunt et al. 2017) potentially presenting an opportunity for subjective symptoms and functional deficits to be monitored in a timely, non-invasive manner.

The need for prospective investigation of multiple risk factors for hip/groin injuries over a period of time, is highly evident (Mosler et al. 2015) and with a dearth of such data (particularly using high-level youth football players), the aim of this study was to add to the current lack of data surrounding two commonly utilised adductor strength measures, the BKFO test and the HAGOS (sport) in young professional footballers. Furthermore, we wanted to examine the relationship between these subjective and objective measures.

**Methods**

A convenience sample of eighteen male Professional Footballers (18.8 ± 1.18 years (range 17-21); mass = 75.5 ± 4.6 kg) from an English Premier league club participated. All participating players were full-time professionals, who played a minimum of one competitive match per week and trained for approximately 15 hours per week. All participants were outfield players representing the under-18 or under-23 squads. Player inclusion criteria required them to be “fully fit”, defined as being able to wholly participate in training or match play (Ekstrand et al. 2011). Participants were excluded from partaking if they had a confirmed time-loss hip/groin injury in the 3 months prior to testing. All participants maintained their regular training routines throughout the investigation period. The University of Chichester (UK) Ethics Committee granted ethical approval for the study.

Participants performed a series of clinical tests including adductor squeeze tests (AST) using a Commander Hand-held dynamometer (HHD) (JTECH Medical, Utah, USA); flexibility via the BKFO test and self-reporting of symptoms / function via the HAGOS (sport). All testing was undertaken at the club training ground in a designated medical room. All tests were completed two-days post-match, in line with the clubs normal player monitoring processes. Testing lasted approximately 5-10 minutes per player. The adductor squeeze measures were completed last, due to potentially being stressful / pain provocative (Verrall et al. 2007); which may alter other test results. All tests were performed on the same weekday and at the same approximate time of day (prior to training). Test day’s (n=8) occurred between the months of November 2016 and February 2017.

Adductor strength was measured using two different AST positions as described by Light and Thorborg (2016); long-lever at 0° hip flexion and short-lever at 45° hip flexion. The long-lever squeeze applied resistance by placing the HHD 5cm superior to the medial malleoli whilst the participant’s legs were abducted to the length of the tester’s forearm. The short-lever squeeze was measured placing the HHD between the knees (flexed to 90°) on the bulk of the Vastus Medialis Oblique (VMO). Participant positioning was standardised during all trials; lying in a supine position with no cervical or trunk flexion allowed and forearms supinated, with arms fully extended by their sides. The participants performed three maximal voluntary contractions (MVC’s) lasting 5-sec each in both test positions. The command “go ahead-push-push-push-push relax” was used (Thorborg et al. 2010) instructing the participants to give an increasing effort leading up to a maximum effort. A 5-sec rest period between reps was allowed. Testing lasted approximately 3 minutes per participant with the mean of 3 reps initially recorded in Newtons. Body weight (kg) and lever-length (cm) was measured (Anterior Superior Iliac Spine (ASIS) to the point of force application) for both test positions; allowing for torque calculation, relative to body-weight (Nm/kg). The reported minimal detectable change (MDC%) of a mean of 3 reps of the long-lever and short-lever squeeze tests in elite footballers is 6.6% and 13.2% respectively (Light & Thorborg, 2016). Based on these findings, a strength reduction >7% (long-lever) and >15% (short-lever) was considered clinically meaningful.

For the BKFO test, participants were instructed to position themselves in crook lying with knees flexed to 90° and feet placed together (Malliaris et al. 2009).The participant then allowed their knees to fall outwards as far as they could manage whilst keeping their feet together. The distance between the most distal point of the head of the fibula and the level of the plinth was measured (cm) using an inflexible ruler for both right and left legs. Participants performed one trial. The MDC for the BKFO was based on a study by Paul et al. (2014) using youth trained footballers; where a change of >21% was considered clinically meaningful.

Patient reported symptoms were measured using the HAGOS (sport). This sub-scale of the HAGOS is of particular importance to sports physiotherapists (Delahunt et al., 2017). Consisting of eight questions relating to activities such as kicking, pivoting and sprinting, the participants completed the test in paper form by applying a ‘tick’ in boxes that are allocated a pre-determined score; None = 0, Mild = 1, Moderate = 2, Severe = 3 and Extreme = 4. The total score was calculated using the following equation: 100 – ((Total score of questions 1 to 8 x 100) / 32) (Thorborg et al. 2011).

Data was recorded on Microsoft Excel (2013) with further statistical analysis carried out using SPSS software (version 23, IBM). The AST scores were weight adjusted (Nm/kg) using the following calculation: (N) x Leg lever length (m) / body mass (Kg). This calculation was used to compare the torque output between the two AST’s. Independent samples t-tests were performed to determine any significant differences between the under-18s and under-23s squads. Data was analysed as means ± standard deviations (m ± SD) to indicate centrality and spread of results, to examine squad and individual performance and allow for the number of occasions individual scores fluctuated beyond the stated MDC values. Linear regressions were performed to determine whether one variable could significantly predict the results of the other. Pearson correlations were used to determine the strength of the association between two variables being related, with values set as <0.3 (weak), 0.3-0.5 (moderate) and >0.5 (strong) (Cohen, 1988).

**Results**

Results of the independent t-tests showed no statistically significant difference between the under-18 and under-23 squad scores for any of the tests resulting in a range of p values greater than 0.05 (p=0.310-0.914) and therefore both squads’ results were combined for further analysis. Means ± SD for all outcome measures, in all participants are reported in Table 1. The long-lever test yielded 56% more mean torque (1.39 ± 0.29 Nm/kg) than the short-lever test position (0.89 ± 0.23) which was statistically significant with t(61) = 17.7, *p* <0.001, 95% CI [0.44, 0.55].

\*\*\*Table 1 near here\*\*\*

Figure 1 shows the mean scores for all participants across the testing period. The mean squeeze scores ranged from 1.27 – 1.48 (Nm/kg) and 0.75 – 1.00 (Nm/kg) for the long-lever and short-lever positions respectively. The mean BKFO test scores ranged from 12.4-18.8 (cm) and the mean HAGOS (sport) scores ranged from 95.8 - 98.1.

\*\*\*\* Figure 1 near here \*\*\*\*

Analysis of individual participant long-lever squeeze data showed that there were 16 occasions when a participant squeeze output reduced beyond 7% MDC from their previous recorded score, whilst there were 6 occasions where a participant’s short-lever output reduced beyond 15% MDC. Individual BKFO scores showed that 12 participants recorded a reduction beyond 20.7% MDC from their previous recorded score, which occurred on seventeen occasions. For the HAGOS (sport), individual scores demonstrated six players recording a score <95 (on fourteen occasions), whilst three players recorded a score < 85 (on five occasions) and one participant recording a score <75 (once).

A total of eight players reported groin pain / symptoms through the HAGOS (sport) (range 62.5 - 96.9). Those whose HAGOS score reduced from the first day of testing (range 100-62.5), simultaneously presented with a deficit in squeeze test scores in both AST positions (range for long 2.00-1.10; range for short 1.13-0.56) (Figure 2). Table 2 shows the linear regressions found that the short-lever AST poorly predicted low HAGOS scores thus explaining 12% of the variance (p=<0.05). The long-lever AST also poorly predicted low HAGOS scores, thus explaining the lower explanation of variance at 6% (p = <0.05). The BKFO did not show a statistically significant association at 3% (p = >0.05).

\*\*\* Figure 2 near here \*\*\*

Pearson correlations between all variables (Table 2) showed that short-lever and long-lever AST output correlated to each other with moderate statistical significance *(rp* = 0.556, *p* = <0.01) and individually to HAGOS (long-lever = *rp* = 0.255, *p* = < 0.046 and short-lever = *rp* = 0.348, *p* = 0.006) considered weak and moderate correlations respectively. The BKFO did not correlate with any other variables with statistical significance (p = >0.05).

\*\*\* Table 2 near here \*\*\*

## **Discussion**

In the present study, we investigated the scores of two adductor squeeze tests, the BKFO test and the HAGOS (sport) in young professional footballers. Furthermore, we examined the relationship between the HAGOS, AST and BKFO. Our findings demonstrate how both adductor squeeze positions scores appear to simultaneously fluctuate, yet the long-lever test may be more effective in detecting meaningful changes when compared to the short-lever test. Interestingly, only a moderate correlation was observed between the two adductor squeeze tests *(rp* = 0.556), which may be due to each test challenging different anatomical structures due to the positioning of the hips during testing (hip flexion vs hips neutral). Further investigation into the differences between the tests, may facilitate clinicians in selecting either test to target specific anatomical structures. We found a weak yet statistically significant relationship between the adductor squeeze tests and the HAGOS (sport), but not with the BKFO.

Detecting clinically meaningful changes in adductor strength requires squeeze tests to be reliable and precise (Light & Thorborg, 2016). Our findings demonstrate that recording a mean of 3 repetitions on the long-lever AST (with a corresponding MDC threshold of 7% as reported by Light & Thorborg, 2016), resulted in 16 occurrences of meaningful deficits in strength (out of 144 data points relating to 11%), compared to the short-lever test (MDC=15%) where 6 occurrences (out of 144 data points relating to 4%). A recent paper by Wollin et al (2017) shows how deficits in long-lever AST scores recorded using one measure (as opposed to a mean of 3) during a tournament period, demonstrated a negative relationship with match sessional rate of perceived exertion, suggestive that even just one test repetition is clinically useful. However, it is important to note that when recording just one measure of the long-lever AST, the MDC is increased to 15% and for our findings this would have resulted in a detection of meaningful deficits on just 6 occasions, which represents approximately 60% less sensitivity. Subsequently, it is arguable that a long lever AST appears more efficacious than the short-lever option and most precise when recording the mean of 3 measures. Unfortunately, this increases time of testing to approximately 2-min per player (Light & Thorborg, 2016), which in some sporting contexts may prove too long.

The mean torque values yielded for both AST’s in this study are much lower than previous findings; long-lever mean 1.39 Nm/kg vs 2.41 Nm/kg (Light & Thorborg, 2016) vs 3.43 (Wollin et al. 2017). This may be explained in part by the presence of neuromuscular fatigue when testing two-days post-match play (Nedelec et al. 2014) and the differing body-weights and lever-lengths of players tested yielding significantly different calculated AST torque values. This highlights how such variables can negatively impact a clinician’s ability to compare AST performance between player cohorts.

Both AST positions measured correlated to HAGOS (sport) scores with the short-lever position explaining a higher variance (12%) than the long-lever position. We acknowledge however, that 88% (short-lever AST) and 94% (long-lever AST) of the variance remains unexplained. This is possibly due to factors such as training load; states of fatigue or previous injury history. However, it may simply reflect the low number of participants observed with *very* low HAGOS (sport) scores in the current study. Indeed, HAGOS (sport) scores as low as 71 have been found in injury free soccer players (Thorborg et al. 2014) yet only one player in our study recorded a value <75.

It must be stressed therefore, that despite statistical significance, the associations we observed between the BKFO, AST’s and the HAGOS (sport) are only weak to moderate, with pearson correlation r-values ranging from just 0.255 to 0.55. Subsequently, interpreting these findings is difficult and may render them clinically meaningless. A longer prospective study with more symptomatic participants is warranted to better explore this association. This in turn, may offer higher clinical utility to clinicians by facilitating the choice of what and/or how to monitor depending on their player cohort, the testing environment or situation (e.g daily monitoring before training or during tournament periods). Notably, the HAGOS (sport) is free of cost, far less invasive or time consuming and could be considered as a first level screen identifying players who may then need to be assessed with an AST.

Literature regarding hip flexibility as a risk factor for hip/groin pain is inconsistent and we found no association between the BKFO test and AST or HAGOS - questioning its clinical utility in this setting. The BKFO is regarded as a reliable tool in measuring hip adductor flexibility (Malliaris et al. 2009; Paul et al. 2014) and out findings support this with correlation between left and right leg measures. However, its clinical application relating to monitoring footballer hip/groin pain also requires future prospective research. This may also be facilitated by a better understanding of what the BKFO test is actually measuring (muscle flexibility / joint ROM / neuromuscular tone / lumbo-hip dissociation or other). Indeed, adductor muscle flexibility is likely to be closely-related to lumbo-pelvic and femur movement, and whilst the latter was measured in this study – there was no consideration for pelvic movement. Future research examining the relationship between these body segments during the BKFO test is warranted.

A limitation to this study was that no baseline values were taken in the pre-season period, preventing a comparison to which may provide a percentage deficit to be observed. A further limitation was that we did not relate outcomes to injury occurrence. Delahunt et al. (2017) found that a score below 87.5 in the HAGOS predicted groin injury and four of our participants scored below this threshold (62.5-84.4) yet time-loss from activity or medical investigation was not recorded and thus the impact of such scores in our study cannot be reported. Also due to the problems associated with assuming normality for variables used in scatterplots, a linear regression on in-transformed values was undertaken, but the results were no more informative than the correlations already undertaken. Finally, due to the nature of testing players in these ‘development’ phase playing squads; players drifted in and out of the squads (due to senior team or international call-ups) meaning some players were not tested on a regular basis. Researchers should consider using a larger consistent sample of participants over a prolonged period.

Conclusion

This study describes results from three clinical measures related to the assessment of athlete hip/groin pain and function in a young elite professional footballer cohort that adds to the dearth of literature within this area. The long-lever AST elicited significantly higher torque output than the short-lever position and appears more capable at detecting meaningful fluctuations in adductor strength. We found a weak correlation between the AST’s and the HAGOS (sport) but not between these measures and the BKFO. Due to the high level of unexplained variance and weak to moderate correlation values, clinical interpretation of our findings should be met with caution. Future research should assess these measures in a consistent cohort of players, prospectively over a full playing season, whilst further considering the assessment of lumbo-pelvic movement during the BKFO.

**Practical Implications:**

* The long-lever AST appears most suited to regular monitoring of adductor strength, particularly when recording the mean of 3 repetitions.
* The HAGOS (sport) could be used in conjunction with the AST for a more comprehensive assessment of hip/groin health.
* Performance of the BKFO test does not appear to correlate with either adductor strength or self-reported symptoms.

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**Table 1.** Mean ± SD of all outcome measures for all participants (under-18 & under-23 squads combined).

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| --- |
|  Outcome measure Mean ± SD |
| LL AST (Nm/kg) |  1.39 ± 0.29 |
| SL AST (Nm/kg) |  0.89 ± 0.23 |
| HAGOS sport |  96.53 ± 7.18 |
| BKFO |  15.91 ± 4.71 |

SD, standard deviation; AST, Adductor Squeeze test; LL, long-lever; SL, short-lever; Nm/kg, Newton meters per kilogram; HAGOS sport, Copenhagen Hip and Groin Outcome score (function, sport and recreation subscale); BKFO, Bent Knee Fall Out.

**Table 2.** Linear regressions & Pearson Correlations between HAGOS (sport), Adductor Squeeze tests and Bent Knee Fall out.

|  |  |  |
| --- | --- | --- |
| **Regression Variables** | **Linear Regression** | **Pearson Correlation** |
| **HAGOS sport & LL AST** | R2 = 0.065, p=0.046 \* | rp = 0.255, p=0.046  |
| **HAGOS sport & SL AST**  | R2 = 0.121, p=0.006 \* | rp = 0.348, p=0.006 \* |
| **HAGOS sport & BKFO** | R2 = 0.033, p=0.168 | rp = 0.182, p=0.168 |
| **BKFO vs LL AST** |  | rp = 0.193, p=0.133 |
| **BKFO vs SL AST** |  | rp = 0.153, p=0.236 |
| **LL AST & SL AST**  |  | rp = 0.556, p<0.01 \* |

\* = p<0.05; HAGOS sport, Copenhagen Hip and Groin Outcome Score (function sport and recreation subscale); AST, Adductor Squeeze Test; LL, long-lever; SL, short-lever; BKFO, Bent Knee Fall Out.