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Published in:
The Orthopaedic Journal of Sports Medicine

DOI (link to publication from Publisher):
10.1177/2325967117747275

Publication date:
2018

Document Version
Publisher's PDF, also known as Version of record

Original Research

Preseason Adductor Squeeze Strength in 303 Spanish Male Soccer Athletes

A Cross-sectional Study

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Background: Hip adductor muscle weakness and a history of groin injury both have been identified as strong risk factors for sustaining a new groin injury. Current groin pain and age have been associated with hip adductor strength. These factors could be related, but this has never been investigated.

Purpose: To investigate whether soccer athletes with past-season groin pain and with different durations of past-season groin pain had lower preseason hip adductor squeeze strength compared with those without past-season groin pain. We also investigated whether differences in preseason hip adductor squeeze strength in relation to past-season groin pain and duration were influenced by current groin pain and age.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: In total, 303 male soccer athletes (mean age, 23 ± 4 years; mean weight, 74.0 ± 7.9 kg; mean height, 178.1 ± 6.3 cm) were included in this study. Self-reported data regarding current groin pain, past-season groin pain, and duration were collected. Hip adductor squeeze strength was obtained using 2 different reliable testing procedures: (1) the short-lever (resistance placed between the knees, feet at the examination bed, and 45° of hip flexion) and (2) the long-lever (resistance placed between the ankles and 0° of hip flexion) squeeze tests.

Results: There was no difference between those with (n = 123) and without (n = 180) past-season groin pain for hip adductor squeeze strength when adjusting for current groin pain and age. However, athletes with past-season groin pain lasting longer than 6 weeks (n = 27) showed 11.5% and 15.3% lower values on the short-lever ($P = .006$) and long-lever ($P < .001$) hip adductor squeeze strength tests, respectively, compared with those without past-season groin pain.

Conclusion: Male soccer athletes with past-season groin pain lasting longer than 6 weeks are likely to begin the next season with a high-risk groin injury profile, including a history of groin pain and hip adduction weakness.

Keywords: groin pain; soccer; injury prevention; epidemiology; muscle strength; sports

Nearly 1 in every 2 players is affected by groin pain during a single soccer season, and 1 in 3 will start the new soccer season with groin pain.[15,26] Importantly, among players starting the new soccer season with groin pain, one-third suffer from the same groin pain problem as they did in the previous season.[26] This suggests that the interseason break is not sufficient for a full recovery from a past-season groin pain episode.

A history of groin injury is the strongest risk factor for sustaining a new groin injury among male soccer athletes.[30] Male soccer athletes with a previous groin injury have a 2.4 to 7.3 times higher risk of a new groin injury.[1,5,8] However, previous studies investigating risk factors for groin pain have failed to take into account the duration of pain and symptoms of the previous groin injury.[1,5,8] This hampers any firm conclusion about how the duration of groin pain in the previous season affects the current season. Specific information about past-season hip and/or groin pain and its duration has recently been related to sports function in the beginning of a new soccer season.[26] Soccer athletes with different past-season hip and/or groin pain durations (1-2, 3-6, and >6 weeks) showed an almost dose-response relationship with hip- and/or groin-related sports function and pain,[26] with preseason HAGOS (Copenhagen Hip and Groin Outcome Score) values being lower when the duration of pain in the past season was longer. This indicates that not only a history of groin injury but also the duration of a previous groin injury could be related to future hip and/or groin injury events in soccer[26] and also

The Orthopaedic Journal of Sports Medicine, 6(1), 2325967117747275
DOI: 10.1177/2325967117747275

highlights the importance of obtaining specific information on duration in relation to past-season groin pain at the beginning of a new preseason.

There is consistent evidence that low hip adductor strength is a strong risk factor for a new groin injury in soccer.[24] In European soccer, players with weak hip adductors were found to have a more than 4 times higher risk of sustaining a new groin injury compared with players without weak hip adductors.[5] However, when investigating hip adductor strength as a risk factor for a new groin injury in soccer, various types of hip adductor strength measurements of unknown precision and reliability have been used,[5,22] which makes it difficult to compare across studies. Additionally, current groin pain and age have been associated with hip adductor strength in soccer, in which both the presence of groin pain[18,21,25] and older player age[20] have a negative effect on hip adductor strength and consequently need consideration when screening soccer athletes using strength measurements to detect high-risk groin injury profiles. Furthermore, it is at present unknown how past-season groin pain and its duration may affect preseason hip adductor squeeze strength and if these 2 risk factors are related. This is important, as soccer athletes who suffered from past-season groin pain could be prone to start the new soccer preseason with a high-risk profile that includes both a history of groin pain and hip adductor squeeze strength weakness.

In this study, we aimed to investigate if soccer athletes with past-season groin pain had lower preseason hip adductor squeeze strength compared with soccer athletes without past-season groin pain. Secondly we also investigated if soccer athletes with different durations of past-season groin pain had lower preseason hip adductor squeeze strength compared with soccer athletes without past-season groin pain. Additionally, we investigated if the possible differences in preseason hip adductor squeeze strength, in relation to past-season groin pain and its duration, could be influenced by current groin pain and age, as these are factors associated with hip adductor squeeze strength.

METHODS

Design and Participants

The reporting of the present cross-sectional study follows the STROBE (Strengthening the Reporting of Observational studies in Epidemiology) statement.[29] This study is based on data from a large cohort study investigating the incidence, prevalence, and risk factors of groin pain in Spanish male soccer athletes. Under the corresponding approval of a local ethics committee, 17 male amateur soccer teams from the northeastern region of Spain, competing in the third national and the first and second regional divisions, were invited to participate. All 17 teams accepted the invitation, and none of their respective players refused to be recruited. In total, 363 players from these teams were screened for eligibility and were tested during the preseason (July-August 2015). To be included in the study, soccer athletes had to be present at baseline testing and available to fully participate in the following training session. Athletes not able to perform the test because of an injury, sickness, or any physical complaint were excluded. Also, soccer athletes not able to understand the Catalan, Spanish, or English language and players younger than 18 years were not included. Before entering the study, all soccer athletes were informed verbally about the purpose of the study and gave written informed consent to participate.

Testing Procedure

Baseline measurements were performed at the respective team facilities by 3 members of the research team: 1 physical therapist and 2 physical trainers with a sports science background. All players were asked to arrive 90 minutes before the start of a preseason regular training session to complete the test battery. Team physical therapists, physical trainers, and members of the technical staff of the respective teams collaborated in the assessments, providing questionnaires and forms and conducting the standardized warm-up, which consisted of low-intensity shuttle runs and active lower limb mobility exercises.

Using a standardized form, soccer athletes were asked about personal information (identification number, date of birth, and telephone number) and history of groin pain. Data on current groin pain (yes or no), past-season groin pain (yes or no), and duration of past-season groin pain (0 weeks, $\leq$3 weeks, >3 to $\leq$6 weeks, or >6 weeks) were collected for each athlete.

Hip adductor squeeze strength values were obtained using a handheld dynamometer (MicroFet2; Hoggan Health Industries) with 2 different testing procedures: (1) the short-lever (resistance placed between the knees, feet at the examination bed, and 45° of hip flexion) and (2) the

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The authors declared that they have no conflicts of interest in the authorship and publication of this contribution.
Ethical approval for this study was obtained from the Comitè d'Ètica d'Investigacions Clíniques de l'Administració Esportiva de Catalunya, Generalitat de Catalunya (reference No. 8/2015/CEICEGC).

long-lever (resistance placed between the ankles and 0° of hip flexion) squeeze tests. Isometric peak force (N) was obtained from 1 maximal repetition for both tests, as this method has shown to be reliable for both tests in soccer athletes (minimal detectable change: long-lever test = 13.6%-13.7%, short-lever test = 15.2%-18.6%).[17] Body weight, as well as short- and long-lever lengths, was measured in each athlete, and all strength values were normalized to body weight and lever and reported as N·m/kg. A single physical therapist collected all hip adductor strength values, and the dynamometer was calibrated before each testing session to ensure valid data.

Statistical Analysis

All statistical analyses and assumption testing were performed using SPSS version 22.0.0.1 (IBM). For descriptive statistics, means ± SDs were used for continuous variables, while numbers (percentages) were used for categorical variables. Differences in preseason hip adductor squeeze strength between soccer athletes without past-season groin pain compared with (1) all soccer athletes with past-season groin pain (model 1) and (2) soccer athletes with ≤3 weeks, >3 to ≤6 weeks, and >6 weeks of past-season groin pain (model 2) were obtained using linear regression models. Preseason hip adductor squeeze strength values (short lever and long lever) were included as the dependent variables, while past-season groin pain (model 1) and duration of past-season groin pain (model 2) were included as the independent variables of interest. Furthermore, adjusted estimates were obtained using linear multiple regression models by including current groin pain and age as covariates into the respective models. Corresponding 95% CIs were also obtained for all estimates derived from these models. All assumptions for all regression models were tested. A significance level of .05 was used. Estimates of differences in hip adductor squeeze strength values were presented as absolute mean differences (N·m/kg) and as a percentage, by dividing the absolute mean difference by the estimated mean of the reference group, for each variable.

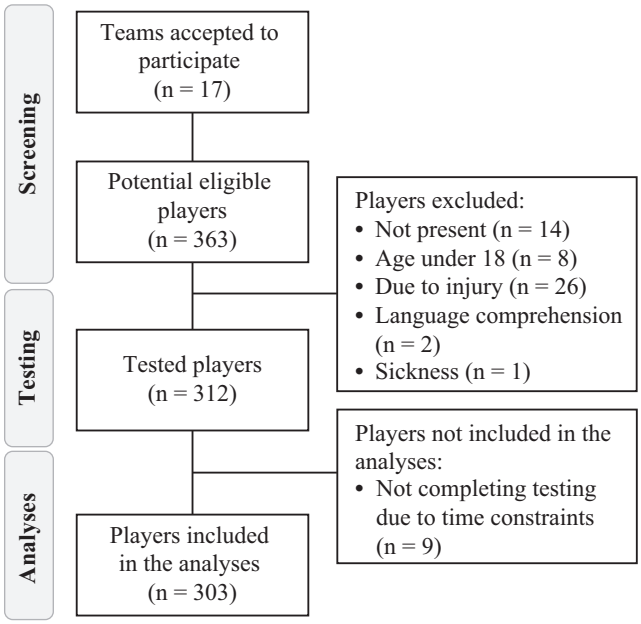

Figure 1. Flow chart of participants.

RESULTS

In total, 303 soccer athletes were included in the analyses (mean age, 23 ± 4 years; mean weight, 74.0 ± 7.9 kg; mean height, 178.1 ± 6.3 cm). From the 363 potentially eligible athletes, 51 did not meet the inclusion criteria and were excluded. Nine athletes did not complete all relevant tests and were therefore not included in the analyses (Figure 1). Preseason hip adductor strength values are shown in Table 1.

Past-Season Groin Pain

Soccer athletes with past-season groin pain showed 5.4% lower strength on the long-lever squeeze test compared with soccer athletes without past-season groin pain (P =

TABLE 1
Hip Adductor Strength Values[a]

	n (%)	Short-Lever Squeeze Test, N·m/kg	Long-Lever Squeeze Test, N·m/kg
Past-season GP			
No	180 (59.4)	1.818 ± 0.346 (0.98-2.77)	2.816 ± 0.482 (1.67-3.87)
Yes	123 (40.6)	1.770 ± 0.400 (0.67-2.55)	2.664 ± 0.572 (1.31-4.30)
Duration of past-season GP			
≤3 wk	74 (24.4)	1.856 ± 0.351 (1.18-2.55)	2.768 ± 0.493 (1.56-3.82)
>3 to ≤6 wk	22 (7.3)	1.713 ± 0.458 (0.67-2.37)	2.783 ± 0.654 (1.38-4.30)
>6 wk	27 (8.9)	1.580 ± 0.416 (0.71-2.26)	2.280 ± 0.556 (1.31-3.31)
Current GP			
No	257 (84.8)	1.814 ± 0.359 (0.67-2.77)	2.797 ± 0.505 (1.38-4.30)
Yes	46 (15.2)	1.713 ± 0.412 (0.71-2.60)	2.515 ± 0.576 (1.31-3.70)
Overall	303 (100.0)	1.798 ± 0.369 (0.67-2.77)	2.754 ± 0.525 (1.31-4.30)

[a]Values are shown as mean ± SD (range) unless otherwise indicated. GP, groin pain.

TABLE 2
Unadjusted Estimates From Linear Regression[a]

	Short-Lever Squeeze Test, N·m/kg		Long-Lever Squeeze Test, N·m/kg	
	Estimated Mean (95% CI)	Mean Difference (95% CI)	Estimated Mean (95% CI)	Mean Difference (95% CI)
Past-season GP				
No	1.818 (1.764 to 1.872)[b]	Reference	2.816 (2.739 to 2.892)[b]	Reference
Yes		–0.048 (–0.133 to 0.037)		–0.152 (–0.272 to –0.032)[c]
Duration of past-season GP				
≤3 wk		0.039 (–0.060 to 0.137)		–0.048 (–0.185 to 0.090)
>3 to ≤6 wk		–0.105 (–0.266 to 0.057)		–0.033 (–0.257 to 0.192)
>6 wk		–0.237 (–0.385 to –0.090)[c]		–0.536 (–0.741 to –0.331)[b]
Current GP				
No	1.814 (1.769 to 1.859)[b]	Reference	2.797 (2.733 to 2.860)[b]	Reference
Yes		–0.100 (–0.216 to 0.015)		–0.282 (–0.445 to –0.119)[c]
Age				
Current	2.058 (1.813 to 2.304)[b]	Reference	2.956 (2.605 to 3.307)[b]	Reference
Per-year increase in player's age		–0.011 (–0.022 to –0.001)[c]		–0.009 (–0.024 to 0.006)

[a]N = 303. GP, groin pain.
[b]$P < .001$.
[c]$P < .05$.

TABLE 3
Adjusted Estimates From Multiple Regression Models 1 and 2[a]

	Short-Lever Squeeze Test, N·m/kg		Long-Lever Squeeze Test, N·m/kg	
	Estimated Mean (95% CI)	Mean Difference (95% CI)	Estimated Mean (95% CI)	Mean Difference (95% CI)
Model 1				
Past-season GP				
No	2.067 (1.819 to 2.315)[b]	Reference	2.987 (2.638 to 3.336)[b]	Reference
Yes		–0.024 (–0.117 to 0.069)		–0.082 (–0.213 to 0.049)
Current GP (yes)		–0.078 (–0.205 to 0.050)		–0.229 (–0.408 to –0.049)[c]
Per-year increase in player's age		–0.011 (–0.021 to 0.000)[c]		–0.007 (–0.022 to 0.008)
Model 2				
Past-season GP (no)	2.062 (1.817 to 2.307)[b]	Reference	3.001 (2.658 to 3.343)[b]	Reference
Duration of past-season GP				
≤3 wk		0.035 (–0.065 to 0.136)		–0.030 (–0.170 to 0.111)
>3 to ≤6 wk		–0.096 (–0.266 to 0.075)		0.028 (–0.210 to 0.266)
>6 wk		–0.237 (–0.404 to –0.069)[c]		–0.459 (–0.694 to –0.225)[b]
Current GP (yes)		0.001 (–0.134 to 0.136)		–0.126 (–0.314 to 0.062)
Per-year increase in player's age		–0.011 (–0.021 to 0.000)[c]		–0.008 (–0.022 to 0.007)

[a]N = 303. GP, groin pain.
[b]$P < .001$.
[c]$P < .05$.

.013), whereas there was no difference on the short-lever test (Table 2). When adjusted for current groin pain and age, no significant differences were seen in squeeze strength between soccer athletes with and without past-season groin pain (Table 3).

Duration of Past-Season Groin Pain

Soccer athletes with a duration of past-season groin pain of more than 6 weeks showed 13% and 19% lower strength, respectively, on the short-lever ($P = .002$) and long-lever ($P < .001$) squeeze tests compared with players without past-season groin pain. When adjusting for current groin pain and age, differences remained significant, and soccer athletes with a duration of past-season groin pain of more than 6 weeks showed 11.5% and 15.3% lower strength on the short-lever ($P = .006$) and long-lever ($P < .001$) squeeze tests, respectively, compared with soccer athletes without past-season groin pain. There were no differences between soccer athletes without past-season groin pain and the 2 other subgroups of athletes with past-season groin pain durations of ≤3 weeks or >3 to ≤6 weeks.

Current Groin Pain and Age

Soccer athletes with current groin pain showed 10.1% lower strength on the long-lever squeeze test ($P = .001$) compared with soccer athletes without current groin pain. There was no difference between athletes with and without current groin pain on the short-lever test. Current groin pain also negatively influenced the difference on the long-lever test between athletes with and without past-season groin pain ($P = .013$). Soccer athletes with current groin pain showed a 7.7% mean reduction in squeeze strength, irrespective of having had past-season groin pain. No influence was detected for current groin pain in relation to the different durations of past-season groin pain and preseason hip adductor squeeze strength values.

Age had a negative effect on the short-lever test ($P = .035$), with a mean reduction in squeeze strength of 0.5% per 1-year increase in player's age. Age was also shown to negatively influence the differences on the short-lever test in relation to past-season groin pain and its duration, with identical estimates in both models (Table 3), with a mean reduction in squeeze strength of 0.5% per 1-year increase in player's age ($P = .046$). The results of the long-lever squeeze test were not significantly related to player age.

Details on multiple regression models 1 and 2 can be found in Appendix Tables A1 and A2.

DISCUSSION

This study investigated if soccer athletes with past-season groin pain, and with different durations of past-season groin pain, had lower preseason hip adductor squeeze strength compared with soccer athletes without past-season groin pain. The most important finding of the present study was that soccer athletes with past-season groin pain of longer than 6 weeks showed 12% and 15% lower preseason hip adductor strength on the short- and long-lever squeeze tests, respectively, compared with soccer athletes without past-season groin pain, independently of current groin pain and player age.

This finding is in line with a previous study in subelite Danish male soccer in which players who suffered from past-season groin pain for more than 6 weeks showed the lowest scores in sports function and participation compared with groups of players with a shorter duration of groin pain symptoms.[26] This supports the finding of the present study, indicating that having had past-season groin pain for more than 6 weeks seems to induce objective muscle impairment in addition to self-reported hip and groin–related sporting limitations.[26] The present study also found that, compared with soccer athletes without past-season groin pain, athletes who reported suffering from past-season groin pain but who were free of groin pain at the time of testing did not show lower values on preseason hip adductor squeeze tests. Similarly, a recent study conducted on male professional soccer athletes playing in the Qatar Stars League found that past-season hip and/or groin time-loss injuries had no effect on hip strength profiles at the beginning of a new season.[20] Although these 2 studies are not completely comparable because of the differences in injury definitions, it seems that the negative effect of previous groin injury on preseason hip adductor strength is more related to the duration of pain and symptoms during the past season than to a history of groin injuries alone.

The findings of the study suggest that players who suffered from past-season groin pain for more than 6 weeks are likely to start the new soccer season with a high-risk groin injury profile. This high-risk profile includes both a history of groin pain and hip adductor weakness,[1,5] which place these soccer athletes at a higher risk for sustaining a new groin injury in the new season. Thus, to intervene in this subgroup of soccer athletes at the beginning of a new season, with secondary preventative measures, focusing on hip adductor weakness, seems important, as hip adductor strength is an intrinsic and modifiable risk factor.[24] However, the efficacy of groin injury preventative programs that include hip adductor strengthening exercises in soccer remains uncertain.[6] It has been suggested that one of the explanations for the lack of certainty from this approach could be compliance and the insufficient intensity related to these exercises.[10] A progression from static isometric to high-intensity dynamic exercises, especially those with eccentric muscle contractions, has been recommended when aiming at strength gains for injury prevention and athletic performance.[3] Full-range hip adduction exercises using elastic bands or the Copenhagen adduction exercise have both led to significant increases in eccentric hip adduction strength after 8 weeks of progressive training.[12,13] Both hip adduction with an elastic band and the Copenhagen adduction exercise require no or minimal equipment, which make them easy to implement during soccer training routines and which could provide an effective, supervised strengthening program.

The results from the present study also indicate that, in Spanish subelite male soccer athletes with past-season groin pain lasting longer than 6 weeks, the current activity regimen during the interseason break may not be sufficient to restore normal values in hip adductor strength. It has been outlined that the lack of sufficient sport-specific training during the interseason break increases the risk of a new groin injury.[30] Additionally, soccer athletes traditionally face high training loads with rapidly increasing spikes during the preseason,[14] which could be particularly challenging for athletes with a history of groin injury and hip adductor weakness. Improving hip adductor muscle strength requires repeated sessions and relatively large time frames that would inevitably require several weeks.[12,13] Thus, starting a hip adductor strengthening exercise program at the beginning of the preseason could be too late for soccer athletes with large strength deficits, and consequently, these athletes may still remain at a high risk until hip adduction strength values have been increased. The interseason break would be a better opportunity to provide such athletes with a more substantial strengthening program, including more exercises and higher loads, than what would normally be feasible during the soccer preseason, although it seems difficult to implement at this time point. However, implementing a more comprehensive strengthening program than a single exercise has been shown possible in a prospective

study in elite ice hockey players.[28] In this study, a 6-week preseason preventative program, including up to 7 strengthening exercises targeting hip adductor muscles, decreased the risk for adductor injuries during the season in a group of players identified as having weak hip adductors and thus at a high risk for sustaining a groin injury.[28]

Soccer athletes with past-season groin pain lasting longer than 6 weeks showed lower preseason hip adductor strength on both the short- and long-lever squeeze tests compared with athletes without past-season groin pain. Both the short- and long-lever (45° and 0° of hip flexion, respectively) squeeze tests used in this study are the most common bilateral examinations used in the literature.[16,18,20,21] The differences were largest on the long-lever squeeze test, which also provides a larger hip adductor moment and consequently is more demanding on the hip adductor muscle group.[4,23] It is important to note that adductor-related groin pain is the primary clinical entity in groin pain cases among male soccer athletes,[9,11] and it therefore seems reasonable to expect larger differences when testing hip adductor muscles using long levers. It is also important to note that in a bilateral adduction squeeze test, the output will be determined by the weaker side.[27] Although a bilateral test provides a quick and precise assessment to determine weaker players,[17] to determine the weaker side using a unilateral test could be highly relevant in a secondary assessment. A unilateral test should also include testing in different muscle activation modalities, which would have been unfeasible when testing full soccer squads in this primary assessment, when time efficiency was important.

In the present study, soccer athletes with current groin pain showed 10% lower strength on the long-lever squeeze test compared with players without current groin pain, whereas there was no difference on the short-lever test. A recent systematic review has shown that the presence of hip/groin pain is associated with lower hip adductor strength in the sporting population.[19] Studies in soccer have shown that players with current groin pain have lower hip adductor strength compared with asymptomatic players.[18,21,25] In the present study, having current groin pain also influenced the differences between soccer athletes with and without past-season groin pain on the preseason hip adductor long-lever squeeze test. Soccer athletes with current groin pain showed almost 8% lower values on the preseason hip adductor long-lever test compared with soccer athletes with no current groin pain, independent of past-season groin pain. Thus, the differences in preseason hip adductor squeeze strength between soccer athletes with and without past-season groin pain seem to be a consequence of having current groin pain symptoms and are not related to past-season groin pain as such. Conversely, having current groin pain did not influence the differences on preseason hip adductor squeeze strength values between soccer athletes with different durations of past-season groin pain compared with athletes without past-season groin pain.

Finally, this study also identified that age had a negative effect on the short-lever squeeze test. Estimates revealed that per 1-year increase in player's age, a 0.5% decrease could be expected in short-lever hip adductor squeeze strength. This is a small but important effect, considering that in 10 years, strength values could be reduced by 5%. A similar small but statistically significant negative influence of age on short-lever hip adductor squeeze strength (9% decrease per 10-year increase in player's age) was also found in a previous study looking at normative values on muscles around the hip in professional Qatari soccer athletes.[20] Thus, it seems relevant to address specific attention to older soccer athletes with a duration of past-season groin pain for more than 6 weeks, as they are likely to show even lower short-lever hip adductor strength compared with younger soccer athletes with past-season groin pain.

A potential limitation of the present study is recall bias, concerning the use of a self-reported past-season injury form. To minimize recall bias, the past-season injury form contained a small number of simple questions and included a clear definition of injury and details in relation to anatomic regions, which has shown to result in better recall.[2] Importantly, we also limited the extent of time over which participants were asked to recall to a 12-month time frame, as this has been shown to reduce the impact of recall bias.[7] Another potential limitation of this study is selection bias. This study was conducted in a convenience sample, and consequently, generalization of the results must always be taken with caution. Nevertheless, we were able to include a relatively large cohort of soccer athletes from similar levels of play, equally exposed to soccer, in which none refused to participate, and therefore, we have little reason to believe that using a random sample of the same population would have yielded different results.

CONCLUSION

Preseason hip adductor squeeze strength is lower in male soccer athletes who have had past-season groin pain for more than 6 weeks compared with soccer athletes without past-season groin pain, independent of current groin pain status and age. Differences in preseason hip adductor squeeze strength previously observed between soccer athletes with and without past-season groin pain seem to be associated with current groin pain and not to a history of groin pain alone. Age negatively influenced short-lever hip adductor squeeze strength and should be considered when using the short-lever squeeze test in soccer athletes with wide age ranges.

ACKNOWLEDGMENT

The authors sincerely thank all players, physical therapists, and members of the technical staff from teams who participated in the present study.

REFERENCES

1. Arnason A, Sigurdsson SB, Gudmundsson A, Holme I, Engebretsen L, Bahr R. Risk factors for injuries in football. *Am J Sports Med*. 2004; 32(suppl 1):5S-16S.
2. Askling C, Lund H, Saartok T, Thorstensson A. Self-reported hamstring injuries in student-dancers. *Scand J Med Sci Sports*. 2002; 12(4):230-235.

3. Brughelli M, Cronin J. Altering the length-tension relationship with eccentric exercise: implications for performance and injury. *Sports Med*. 2007;37(9):807-826.
4. Drew MK, Palsson TS, Izumi M, et al. Resisted adduction in hip neutral is a superior provocation test to assess adductor longus pain: an experimental pain study. *Scand J Med Sci Sports*. 2016;26(8):967-974.
5. Engebretsen AH, Myklebust G, Holme I, Engebretsen L, Bahr R. Intrinsic risk factors for groin injuries among male soccer players: a prospective cohort study. *Am J Sports Med*. 2010;38(10):2051-2057.
6. Esteve E, Rathleff MS, Bagur-Calafat C, Urrutia G, Thorborg K. Prevention of groin injuries in sports: a systematic review with meta-analysis of randomised controlled trials. *Br J Sports Med*. 2015; 49(12):785-791.
7. Gabbe BJ, Finch CF, Bennell KL, Wajswelner H. How valid is a self reported 12 month sports injury history? *Br J Sports Med*. 2003;37(6): 545-547.
8. Hagglund M, Walden M, Ekstrand J. Previous injury as a risk factor for injury in elite football: a prospective study over two consecutive seasons. *Br J Sports Med*. 2006;40(9):767-772.
9. Holmich P. Long-standing groin pain in sportspeople falls into three primary patterns, a "clinical entity" approach: a prospective study of 207 patients. *Br J Sports Med*. 2007;41(4):247-252, discussion 252.
10. Holmich P, Larsen K, Krogsgaard K, Gluud C. Exercise program for prevention of groin pain in football players: a cluster-randomized trial. *Scand J Med Sci Sports*. 2010;20(6):814-821.
11. Holmich P, Thorborg K, Dehlendorff C, Krogsgaard K, Gluud C. Incidence and clinical presentation of groin injuries in sub-elite male soccer. *Br J Sports Med*. 2014;48(16):1245-1250.
12. Ishoi L, Sorensen CN, Kaae NM, Jorgensen LB, Holmich P, Serner A. Large eccentric strength increase using the Copenhagen adduction exercise in football: a randomized controlled trial. *Scand J Med Sci Sports*. 2016;26(11):1334-1342.
13. Jensen J, Holmich P, Bandholm T, Zebis MK, Andersen LL, Thorborg K. Eccentric strengthening effect of hip-adductor training with elastic bands in soccer players: a randomised controlled trial. *Br J Sports Med*. 2014;48(4):332-338.
14. Junge A, Dvorak J, Rosch D, Graf-Baumann T, Chomiak J, Peterson L. Psychological and sport-specific characteristics of football players. *Am J Sports Med*. 2000;28(suppl 5):S22-S28.
15. Karlsson MK, Dahan R, Magnusson H, Nyquist F, Rosengren BE. Groin pain and soccer players: male versus female occurrence. *J Sports Med Phys Fitness*. 2014;54(4):487-493.
16. Krause DA, Schlagel SJ, Stember BM, Zoetewey JE, Hollman JH. Influence of lever arm and stabilization on measures of hip abduction and adduction torque obtained by hand-held dynamometry. *Arch Phys Med Rehabil*. 2007;88(1):37-42.
17. Light N, Thorborg K. The precision and torque production of common hip adductor squeeze tests used in elite football. *J Sci Med Sport*. 2016;19(11):888-892.
18. Malliaras P, Hogan A, Nawrocki A, Crossley K, Schache A. Hip flexibility and strength measures: reliability and association with athletic groin pain. *Br J Sports Med*. 2009;43(10):739-744.
19. Mosler AB, Agricola R, Weir A, Holmich P, Crossley KM. Which factors differentiate athletes with hip/groin pain from those without? A systematic review with meta-analysis. *Br J Sports Med*. 2015;49(12):810.
20. Mosler AB, Crossley KM, Thorborg K, et al. Hip strength and range of motion: normal values from a professional football league. *J Sci Med Sport*. 2017;20(4):339-343.
21. Nevin F, Delahunt E. Adductor squeeze test values and hip joint range of motion in Gaelic football athletes with longstanding groin pain. *J Sci Med Sport*. 2014;17(2):155-159.
22. O'Connor D. Groin injuries in professional rugby league players: a prospective study. *J Sports Sci*. 2004;22(7):629-636.
23. Robertson BA, Barker PJ, Fahrer M, Schache AG. The anatomy of the pubic region revisited: implications for the pathogenesis and clinical management of chronic groin pain in athletes. *Sports Med*. 2009; 39(3):225-234.
24. Ryan J, DeBurca N, McCreesh K. Risk factors for groin/hip injuries in field-based sports: a systematic review. *Br J Sports Med*. 2014; 48(14):1089-1096.
25. Thorborg K, Branci S, Nielsen MP, Tang L, Nielsen MB, Holmich P. Eccentric and isometric hip adduction strength in male soccer players with and without adductor-related groin pain: an assessor-blinded comparison. *Orthop J Sports Med*. 2014;2(2):2325967114521778.
26. Thorborg K, Rathleff MS, Petersen P, Branci S, Holmich P. Prevalence and severity of hip and groin pain in sub-elite male football: a cross-sectional cohort study of 695 players. *Scand J Med Sci Sports*. 2017; 27(1):107-114.
27. Thorborg K, Serner A, Petersen J, Madsen TM, Magnusson P, Holmich P. Hip adduction and abduction strength profiles in elite soccer players: implications for clinical evaluation of hip adductor muscle recovery after injury. *Am J Sports Med*. 2011;39(1):121-126.
28. Tyler TF, Nicholas SJ, Campbell RJ, Donellan S, McHugh MP. The effectiveness of a preseason exercise program to prevent adductor muscle strains in professional ice hockey players. *Am J Sports Med*. 2002;30(5):680-683.
29. von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Lancet*. 2007;370(9596):1453-1457.
30. Whittaker JL, Small C, Maffey L, Emery CA. Risk factors for groin injury in sport: an updated systematic review. *Br J Sports Med*. 2015;49(12):803-809.

APPENDIX

TABLE A1
Estimates From Linear Multiple Regression Model 1[a]

	Unstandardized Coefficients			
	B	Standard Error	95% CI for B	*P* Value
Short-lever squeeze test				
Constant	2.067	0.126	1.819 to 2.315	<.001
Current GP	–0.078	0.065	–0.205 to 0.050	.231
Age	–0.011	0.005	–0.021 to 0.000	.046
Past-season GP	–0.024	0.047	–0.117 to 0.069	.615
Long-lever squeeze test				
Constant	2.987	0.177	2.638 to 3.336	<.001
Current GP	–0.229	0.091	–0.408 to –0.049	.013
Age	–0.007	0.008	–0.022 to 0.008	.343
Past-season GP	–0.082	0.066	–0.213 to 0.049	.217

[a]N = 303. GP values are reported as N·m/kg. GP, groin pain.

TABLE A2
Estimates From Linear Multiple Regression Model 2[a]

	Unstandardized Coefficients			
	B	Standard Error	95% CI for B	*P* Value
Short-lever squeeze test				
Constant	2.062	0.125	1.817 to 2.307	<.001
Current GP	0.001	0.069	–0.134 to 0.136	.992
Age	–0.011	0.005	–0.021 to 0.000	.046
Duration of past-season GP				
≤3 wk	0.035	0.051	–0.065 to 0.136	.489
>3 to ≤6 wk	–0.096	0.087	–0.266 to 0.075	.271
>6 wk	–0.237	0.085	–0.404 to –0.069	.006
Long-lever squeeze test				
Constant	3.001	0.174	2.658 to 3.343	<.001
Current GP	–0.126	0.096	–0.314 to 0.062	.189
Age	–0.008	0.007	–0.022 to 0.007	.287
Duration of past-season GP				
≤3 wk	–0.030	0.071	–0.170 to 0.111	.680
>3 to ≤6 wk	0.028	0.121	–0.210 to 0.266	.817
>6 wk	–0.459	0.119	–0.694 to –0.225	<.001

[a]N = 303. GP values are reported as N·m/kg. GP, groin pain.