



Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: www.elsevier.com/locate/jsams



Original research

In-season monitoring of hip and groin strength, health and function in elite youth soccer: Implementing an early detection and management strategy over two consecutive seasons

Martin Wollin^{a,b,*}, Kristian Thorborg^{c,d}, Marijke Welvaert^{a,e}, Tania Pizzari^b

^a Department of Physical Therapies, Australian Institute of Sport, Australia

^b La Trobe Sport and Exercise Medicine Research Centre, La Trobe University, Australia

^c Department of Orthopaedic Surgery, Sports Orthopaedic Research Center, Amager-Hvidovre Hospital, Faculty of Health Sciences, University of Copenhagen, Denmark

^d Physical Medicine and Rehabilitation—Copenhagen (PMR-C), Amager-Hvidovre Hospital, Copenhagen University Hospital, Denmark

^e Research Institute for Sport and Exercise, University of Canberra, Australia

ARTICLE INFO

Article history:

Received 6 October 2016
Received in revised form 15 January 2018
Accepted 7 March 2018
Available online xxx

Keywords:

Injury
Prevention
Football
Athlete monitoring

ABSTRACT

Objectives: The primary purpose of this study was to describe an early detection and management strategy when monitoring in-season hip and groin strength, health and function in soccer. Secondly to compare pre-season to in-season test results.

Design: Longitudinal cohort study.

Methods: Twenty-seven elite male youth soccer players (age: 15.07 ± 0.73 years) volunteered to participate in the study. Monitoring tests included: adductor strength, adductor/abductor strength ratio and hip and groin outcome scores (HAGOS). Data were recorded at pre-season and at 22 monthly intervals in-season. Thresholds for alerts to initiate further investigations were defined as any of the following: adductor strength reductions >15%, adductor/abductor strength ratio <0.90, and HAGOS subscale scores <75 out of 100 in any of the six subscales.

Results: Overall, 105 alerts were detected involving 70% of players. Strength related alerts comprised 40% and remaining 60% of alerts were related to HAGOS. Hip adductor strength and adductor/abductor strength ratio were lowest at pre-season testing and had increased significantly by month two ($p < 0.01$, mean difference 0.26, CI95%: 0.12, 0.41 N/kg and $p < 0.01$, mean difference 0.09, CI95%: 0.04, 0.13 respectively). HAGOS subscale scores were lowest at baseline with all, except Physical Activity, showing significant improvements at time-point one ($p < 0.01$). Most (87%) time-loss were classified minimal or mild.

Conclusions: In-season monitoring aimed at early detection and management of hip and groin strength, health and function appears promising. Hip and groin strength, health and function improved quickly from pre-season to in-season in a high-risk population for ongoing hip and groin problems.

© 2018 Sports Medicine Australia. Published by Elsevier Ltd. All rights reserved.

1. Introduction

Groin injuries affect both youth and senior soccer players at various levels of the sport.^{1–3} On average, professional men's teams sustain seven time-loss injuries per season with most resulting in moderate to severe time-loss³ and when non-time-loss injuries are included the injury rates may be even higher.¹ Most groin problems in soccer appear to be of gradual onset¹ and they seem to deteri-

orate over time.⁴ This has prompted close monitoring of players in-season to facilitate early detection and management of groin problems.⁴

The demands of soccer impacts on hip adductor strength in elite male youth players.⁵ Kicking and change of direction loads in soccer require substantial hip adductor activity and strength.^{6–8} It is therefore not surprising that playing soccer with hip adductor strength deficits increases the risk of groin injury² and that lower hip adduction/abduction strength ratios and eccentric adduction strength are present in players with groin problems.^{9,10} Additionally, adductor strength reductions have been shown to precede the onset of groin pain.¹¹ This demonstrates a latent period, a subclinical state, from

* Corresponding author.

E-mail address: martin.wollin@ausport.gov.au (M. Wollin).

onset of adductor strength reductions to development of clinical symptoms. Further, players with current groin problems and those with a groin injury in the previous season demonstrate significantly lower scores on all six subscales of the hip and groin outcome score (HAGOS).^{4,12} The HAGOS is a patient reported outcome measure that has been validated in soccer players and can differentiate between those with and without hip and groin problems.^{13,14} Its use has been supported to capture minor and/or overuse injuries.¹⁵

To date, primary groin injury prevention protocols have failed to demonstrate a significant effect, possibly due to challenges around implementation and compliance.^{16,17} Secondary prevention strategies may provide an alternative and/or complement primary prevention approaches in reducing the groin injury burden by limiting time-loss. Secondary prevention aims to identify signs of hip and groin health problems early, to allow for timely management in the subclinical phase to prevent deterioration of the problem by implementing indicated preventative measures.¹⁸ Indicated preventative measures are applied to individual players and includes load management and regular re-testing.¹⁸ This approach may enable clinicians to detect groin problems prior to players recognising or reporting them as an injury. Secondary prevention strategies require valid and reliable clinical screening tests that can detect players with or at risk of developing injury. Available evidence suggests that hip adductor strength, adductor/abductor strength ratio and HAGOS are appropriate to include in a secondary groin injury prevention strategy.^{2,10,19}

The primary purpose of this study was to describe an early detection and management strategy when monitoring in-season hip adductor strength, adductor/abductor (add/abd) strength ratio and HAGOS, against thresholds related to groin problems in soccer. Secondly to compare pre-season (baseline) data with in-season results.

2. Methods

Twenty-seven male U17 Australian soccer players and their parents or legal guardian provided written informed consent to participate in the study. The players were selected from part-time training centres to commence full-time training at the football association's centre of excellence program. All players volunteered to participate in this study, which was approved by the Australian Institute of Sport and La Trobe University Human Ethics Committees.

Prior to commencing training, players completed standardised screening including pre-season testing of hip adductor strength, add/abd strength ratio and HAGOS. Furthermore, anthropometric data and a record of past injury and training history were collected. Monthly in-season testing occurred, across 22 time-points, on the morning of the first regular training day back after a rest day (generally 40 h post-match). Each time-point involved testing ten criteria: hip adductor and add/abd strength ratio on each leg and HAGOS (6 subscales), meaning that a maximum of ten alerts could be triggered per player. Unilateral adductor and abductor strength was tested in supine based on a previous report.²⁰ A 'break' test was used to introduce an eccentric component, since this can better identify players with current groin problems compared to isometric strength testing.¹⁰ Warm-up consisted of two repetitions (five seconds) separated by ten second rest. A twenty second rest period prior to a single maximal test was applied to realistically allow testing of a squad in an acceptable time. Reliability of strength testing was investigated in ten players without a history of groin injury. The inter-rater intra-class coefficient two-way random model results were: adduction 0.86, abduction 0.87 and add/abd strength ratio 0.76. Minimal detectable change (MDC = SEM × 1.96 × $\sqrt{2}$)²¹ results were: adduction 13.9%, abduction 14.6% and add/abd strength ratio

21%. Strength was recorded with a hand-held dynamometer (Micro FET2, Hoggan Health West Jordan UT, USA). Data were captured in Newtons and converted to N/Kg (peak force/body mass). Testing was performed by two male physiotherapists. A strength related alert included at least one of adductor strength reductions >15% and hip ratio <0.90. Mean (SD) hip ratio of 0.80 (± 0.14) and 0.92 (± 0.23) has been reported in soccer players with groin problems^{9,10} and recent normative eccentric add/abd strength ratio data in professional players ranged from 0.9 to 1.4.²²

Players completed an electronic version of the HAGOS including all subscales at each time point. All questionnaires were answered in full. The HAGOS has six subscales; Pain, Symptoms, Activities of daily living (ADL), Sport & recreational activities (Sport), Participation in physical activity (PA) and Quality of living (QOL).¹³ Each subscale is scored 0–100 where higher scores indicate better hip and groin health.¹³ In this study HAGOS alerts were defined by a score <75 out of 100 in any of the subscales since it best fits the 95% reference range, across all subscales, in differentiating soccer players with or without groin problems.²³ Clinical examination was conducted in accordance with the Doha consensus statement.²⁴ Unrestored strength reductions at re-testing and after multi-modal interventions were considered subclinical presentations requiring load management as an indicated preventative measure. Time-loss was calculated for detected injuries and subclinical presentations requiring load management. Time-loss was classified as: minimal (1–3 days), mild (4–7 days), moderate (8–28 days) and severe (>28 days).³ The early detection and management process is outlined in Fig. 1.

Players declared themselves fit to commence training at pre-season testing. During the 22-month study period, the team played 87 matches involving two domestic competitions annually and international tournaments. The team completed 336 days of soccer training during the study period and there were no extended season breaks. Due to team logistics players were not available for strength testing in months 11, 12, 16 and 21.

Due to the study being performed in the applied soccer setting it required managing player findings and did not allow for a 'wait and see' approach. Consequently, players identified with alerts at pre-season and in-season testing proceeded per the outlined monitoring and clinical process (Fig. 1). Individual multi-modal management plans incorporated manual therapy, hip muscle activation and strength exercise programs to complete until strength reductions were restored. Exercise programs focused on simple, traditional weighted and elastic band resisted hip adduction and abduction that incorporated isometric, concentric and eccentric contraction modes known to activate the main hip muscle groups²⁵ and improve adductor strength in soccer players.²⁶ Injury rehabilitation comprised of contemporary groin management²⁷ and aforementioned exercises.^{25,26} Additionally, the team performed 20 min of hip muscle activation, balance and pelvic stability exercises prior to training 1–2 times per week supervised by a physiotherapist. Exercises included lateral band walks, star excursion lunges with ball movement, banded hip bridging, isometric adduction, balance with football skills and jump/landing practices.

A linear mixed model was used to investigate if the outcome measures changed from baseline at any of the 22 time-points. Normality of the strength data was confirmed by visually assessing the Q–Q plots of the residuals. The HAGOS variables demonstrated some deviation of normality in the tails of the distribution, however fixed effects estimates are known to be robust under heavy-tailed conditions.²⁸ The dependent variables (HAGOS and strength) were treated as fixed variables and random intercept for subjects were included in the model to allow baseline values of the fixed variables to vary between subjects. The Welch's t-test was used to investigate if there were any differences in time-loss between groin problems detected at pre-season screening compared to those identified in-

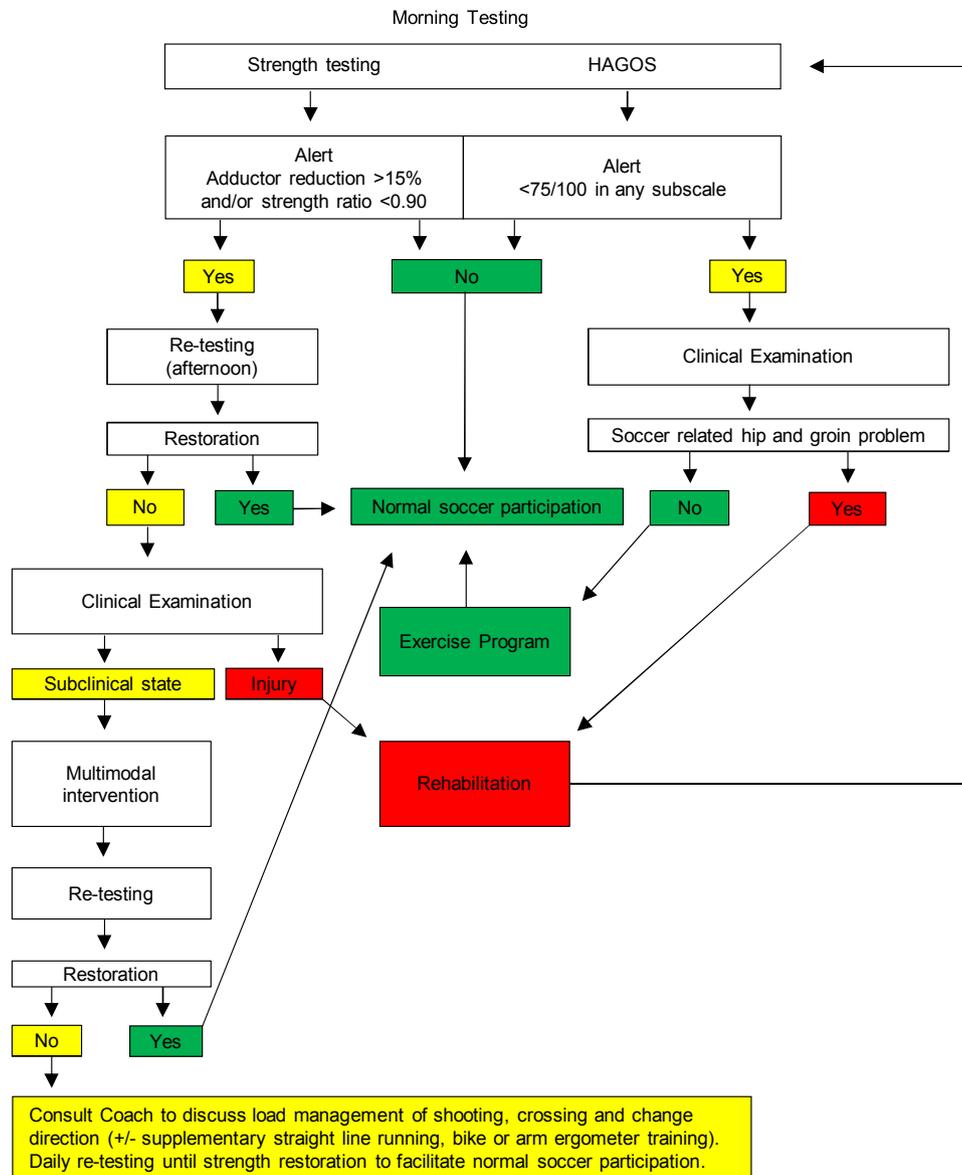


Fig. 1. In-season monitoring and clinical process of hip and groin strength, health and function in soccer. HAGOS = hip and groin outcome score.

season. Effect size is reported as Hedges' *g*. Descriptive data are reported as mean and standard deviation (SD) with significance level $p < 0.05$.

3. Results

Twenty-seven elite male youth soccer players (age: 15.07 ± 0.73 years, height: 174.52 ± 6.28 cm, weight: 66.44 ± 8.13 kg, soccer years: 9.22 ± 2.19 , pre-entry weekly training sessions: 4.44 ± 1.53 , range: 3–10) volunteered to participate in the study as they transitioned into a full-time national program from part-time centres. The prevalence of a reported previous time-loss groin injury at pre-season screening were 52%. All reported past groin injuries had occurred within the previous three years and 64% in the season prior. Five players were released early from the program to join professional teams or return to state programs. Two players exited after five months, one each after 9, 19 and 20 months respectively. One of these player's had a past history of groin injury. A new player entered the program at the 8-month mark and another two players commenced at the start of the 11th month. One player in this group reported a previous

groin injury. Their respective data are included for the period in the program.

Overall, 105 alerts were detected involving 19 players (70% of cohort). Forty-two alerts (40%) were strength related (adductor and/or add/abd ratio) involving 19 players. Strength alerts were triggered on 14 of the time-points tested. The remaining 63 alerts (60%) were HAGOS related. They involved 16 players with alerts triggered on 19 of the time-points. The highest number of HAGOS alerts ($n = 17$, 27%) at any time-point were found at pre-season screening. Over half (56%) of the players who triggered a HAGOS alert were identified at pre-season screening prior to commencing training. None of the players with HAGOS scores < 75 out of 100 at baseline demonstrated a hip strength ratio < 0.90 .

Based on strength related alerts, time-loss was recorded on 11 occasions involving eight players. This resulted in 34 days lost (3.09 ± 5.05 : range 1–18 days), classified as minimal (82%), mild (9%) and moderate (9%). In-season HAGOS soccer related problems requiring rehabilitation were detected on four player occasions resulting in 31 time-loss days (7.75 ± 12.84 : range 1–27 days). In these four cases, time-loss was minimal (75%) and moderate (25%). In contrast, all HAGOS soccer related problems ($n = 6$) detected

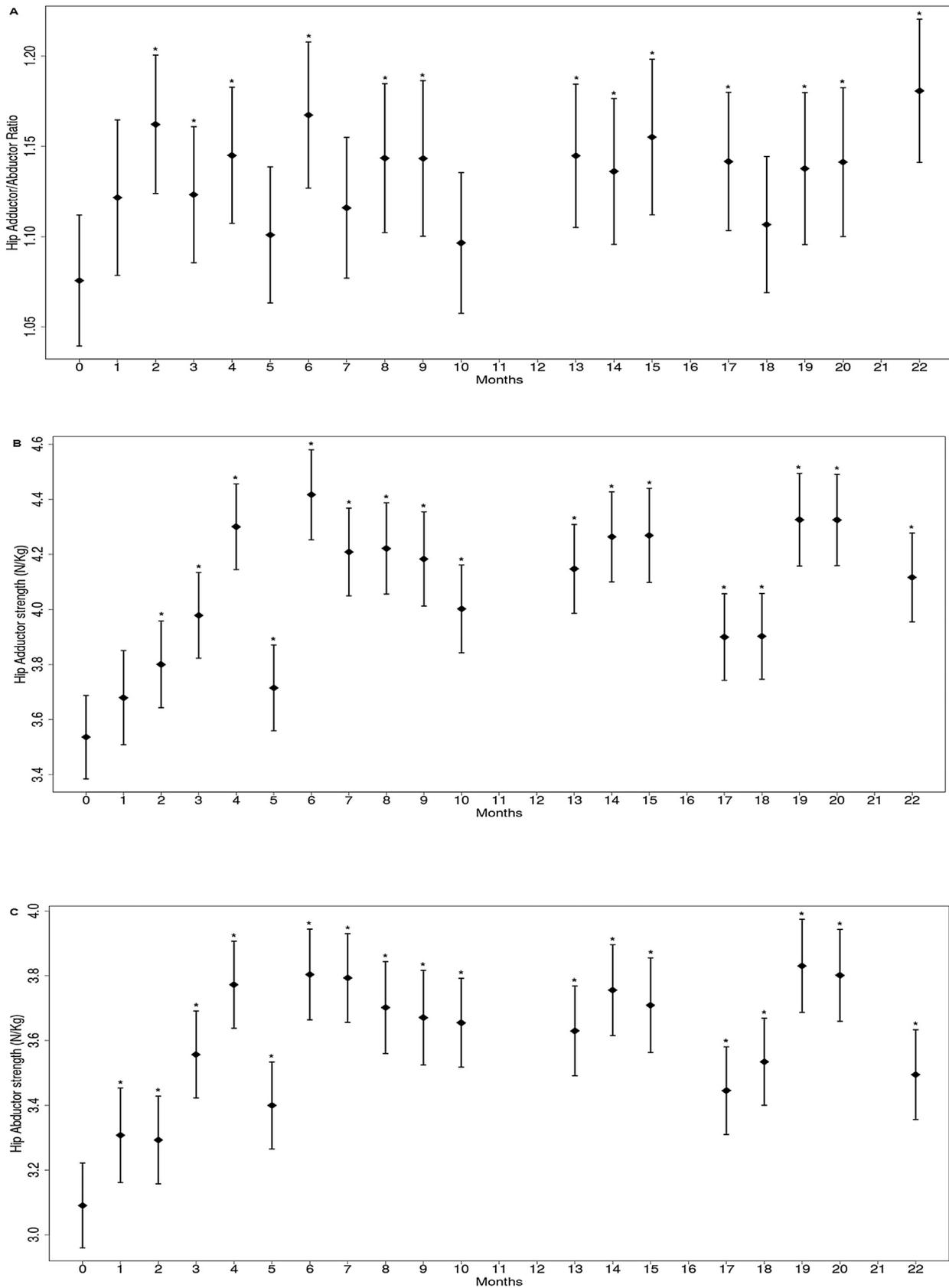


Fig. 2. Hip strength outcome measures (mean and 95%CI) from baseline pre-season testing with monthly follow up over two consecutive seasons in elite male youth soccer players. A: Hip adductor/abductor strength ratio, B: hip adductor strength and C: hip abductor strength. 0= baseline pre-season, 1–22 = follow up months. N = newton, kg = kilogram. *p < 0.05.

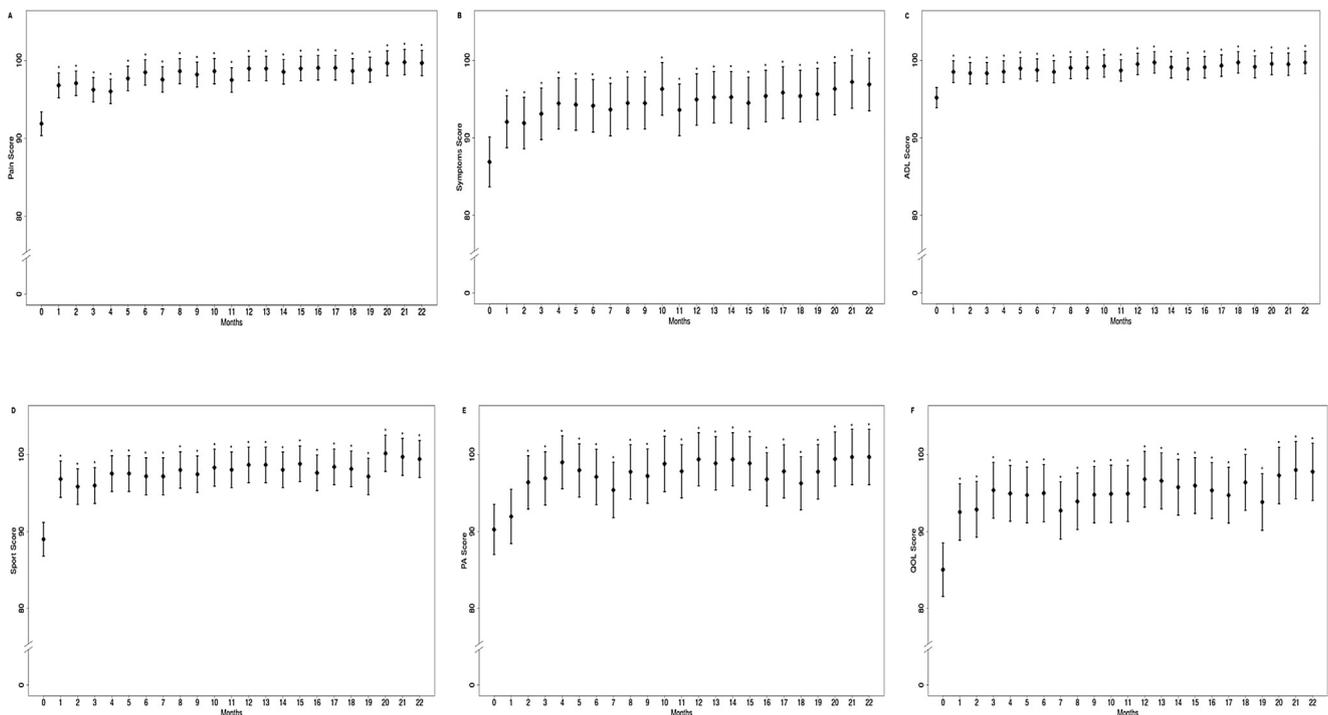


Fig. 3. HAGOS subscale scores (mean and 95%CI) from baseline pre-season screening with monthly follow up over two consecutive seasons in elite male youth soccer players. A: Pain, B: Symptoms, C: Activities of Daily Living (ADL), D: Sport & Recreation (Sport), E: Physical Activity (PA) and F: Quality of Life (QOL). * $p < 0.05$.

at pre-season testing where of moderate time-loss (8–28 days) resulting in a total of 85 days lost (14 ± 3 ; range 9–18 days). No severe time-loss events were detected in this study. The days lost in-season due to indicated preventative measures and rehabilitation were significantly less when compared to those detected at pre-season testing prior to commencing training ($t(19) = -2.353$, $p = 0.03$, mean difference -5.97 , 95%CI $-11.27, -0.66$, $g = 0.80$).

In-season strength results compared to pre-season are based on grouped (left and right) data and are presented in Fig. 2. Hip adductor strength changed significantly during the seasons ($F(18, 759.551) = 19.105$, $p < 0.001$) and demonstrated significant improvements by month two compared to pre-season ($p < 0.01$, mean difference 0.26, CI95%: 0.12, 0.41 N/kg). The add/abd strength ratio also demonstrated significant in-season change compared to pre-season results ($F(18, 760.666) = 2.512$, $p < 0.01$). It was smallest at the start of pre-season and had increased significantly ($p < 0.01$, mean difference 0.09, CI95%: 0.04, 0.13) at test-point two, mainly due to increased adductor strength. Similarly, HAGOS subscale scores changed significantly compared to pre-season and demonstrated significant improvements in all subscales within the first two months (Pain: $F(22, 516) = 4.140$, $p < 0.001$, Symptoms: $F(22, 470.760) = 3.266$, $p < 0.001$, ADL: $F(22, 516) = 1.725$, $p < 0.05$, Sport: $F(22, 516) = 3.334$, $p < 0.001$, PA: $F(22, 516) = 1.876$, $p < 0.05$, QOL: $F(22, 516) = 1.816$, $p < 0.05$). HAGOS results are outlined in Fig. 3.

4. Discussion

The main aim of this study was to describe an early detection and management strategy when monitoring elite male youth soccer players for hip adductor strength reductions $>15\%$, adductor/abductor strength ratio <0.90 and HAGOS subscale scores <75 out of 100 in-season. Secondly to compare pre-season hip and groin strength, health and function with in-season results.

This study involved a young cohort of elite male soccer players progressing to higher levels of play with a 52% prevalence of previous time-loss groin injury and HAGOS scores suggestive of ongoing

problems when presenting for pre-season. This could be considered a high-risk population for ongoing hip and groin problems.^{19,29} The natural progression for such a cohort is likely to involve further deterioration of groin health and function, potentially leading to severe time-loss.^{4,19,27} Despite this, no severe time-loss were detected in this study and in-season hip strength and HAGOS scores improved significantly from pre-season scores. It is possible that the described secondary prevention approach contributed to these improvements and limited groin health deterioration commonly seen in soccer.^{4,12} In-season monitoring aims to identify groin problems early, in the subclinical phase, to initiate a cascade of clinical interventions aimed at restoring individual player's strength, health and function to limit deterioration and time-loss. This study highlights the potential of in-season monitoring as a promising alternative and/or complement to primary prevention of groin problems in elite male youth soccer.

Hip strength was lowest at pre-season testing and gradually increased as players adapted to the new and higher training demands, with appropriate loading, management and modifications guided by results of in-season monitoring. The hip strength findings are similar to data from Danish sub-elite male football players that demonstrated lower hip strength after a mid-season break compared to results after two months of soccer training.²⁶ This is in keeping with reports that soccer specific fitness, including strength and power, deteriorates after an off-season break³⁰ and can improve with appropriate sports-specific loading. Regular monitoring of hip and groin strength, health and function may help to determine individual player's response and readiness to loading.

The HAGOS scores suggests that hip and groin health and function were lowest at pre-season before commencing training. The pre-season HAGOS results in this study are similar to pre-season data in adult soccer players with groin problems in the previous season.^{4,12} Most (56%) of the players who triggered HAGOS alerts were identified at pre-season screening. These players did not demonstrate corresponding add/abd strength ratio issues during testing. This might be explained by the fact that the HAGOS

measures hip and groin health and function over the past week, while strength testing captures the present moment. This may explain why HAGOS and strength did not necessarily correspond. It highlights that clinicians should consider including objective and subjective measures when monitoring groin problems.

An advantage of this study is that it was conducted in the applied soccer setting during consecutive seasons. Conversely, we acknowledge that there are limitations in the present study associated with the inherent challenges of conducting research in this setting where individual management is required and the inclusion of matched control groups is unreasonable. Consequently, the results should be interpreted accordingly. In addition, the HAGOS is a retrospective self-report of an individual's perceived hip and groin health and function over the last week and since scores were collected monthly, three weeks during each month were unaccounted for. Collecting all six subscales weekly may reduce compliance and reliability. Reducing the number of subscales used may allow for more frequent monitoring. Further, hip adductor strength reductions have been found to precede the onset of groin pain by two weeks in elite youth Australian rules football players.¹¹ The optimal frequency of in-season strength testing is not established and it is likely to vary depending on contextual circumstances.

5. Conclusions

Hip and groin strength, health and function improved quickly in a high-risk population for ongoing hip and groin problems. Early detection and management of players groin health status in-season may assist in limiting further deterioration and time-loss. Such a proactive medical model appears a promising secondary injury prevention strategy as an alternative or to complement primary groin injury prevention methods in elite soccer. However, further research is required to confirm its effectiveness to reduce the burden of groin injury in the elite soccer setting.

Practical implications

- In-season monitoring of hip and groin strength, health and function may assist in determining individual player's response and readiness to loading.
- Athlete monitoring as a secondary groin injury prevention strategy appears promising in elite soccer.
- Clinicians should consider implementing both objective and subjective measures when monitoring soccer players groin health and function.

Acknowledgements

This work was supported by an Australian Government Research Training Program Scholarship.

References

1. Haroy J, Clarsen B, Thorborg K et al. Groin problems in male soccer players are more common than previously reported. *Am J Sports Med* 2017; 45(6):1304–1308.
2. Engebretsen AH, Myklebust G, Holme I et al. Intrinsic risk factors for groin injuries among male soccer players: a prospective cohort study. *Am J Sports Med* 2010; 38(10):2051–2057.
3. Werner J, Hagglund M, Walden M et al. UEFA injury study: a prospective study of hip and groin injuries in professional football over seven consecutive seasons. *Br J Sports Med* 2009; 43(13):1036–1040.
4. Thorborg K, Rathleff MS, Petersen P et al. 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.
5. Wollin M, Pizzari T, Spagnolo K et al. The effects of football match congestion in an international tournament on hip adductor squeeze strength and pain in elite youth players. *J Sports Sci* 2017:1–6.
6. Charnock BL, Lewis CL, Garrett Jr WE et al. Adductor longus mechanics during the maximal effort soccer kick. *Sports Biomech* 2009; 8(3):223–234.
7. Brophy RH, Backus SI, Pansy BS et al. Lower extremity muscle activation and alignment during the soccer instep and side-foot kicks. *J Orthop Sports Phys Ther* 2007; 37(5):260–268.
8. Thorborg K, Couppe C, Petersen J et al. Eccentric hip adduction and abduction strength in elite soccer players and matched controls: a cross-sectional study. *Br J Sports Med* 2011; 45(1):10–13.
9. Thorborg K, Serner A, Petersen J et al. 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.
10. Thorborg K, Branci S, Nielsen MP et al. 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.
11. Crow JF, Pearce AJ, Veale JP et al. Hip adductor muscle strength is reduced preceding and during the onset of groin pain in elite junior Australian football players. *J Sci Med Sport* 2010; 13(2):202–204.
12. Tak I, Glasgow P, Langhout R et al. Hip range of motion is lower in professional soccer players with hip and groin symptoms or previous injuries, independent of cam deformities. *Am J Sports Med* 2016; 44(3):682–688.
13. Thorborg K, Holmich P, Christensen R et al. The Copenhagen hip and groin outcome score (HAGOS): development and validation according to the COSMIN checklist. *Br J Sports Med* 2011; 45(6):478–491.
14. Mosler AB, Agricola R, Weir A et al. 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.
15. Esteve E, Rathleff MS, Bagur-Calafat C et al. 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.
16. Holmich P, Larsen K, Krogsgaard K et al. Exercise program for prevention of groin pain in football players: a cluster-randomized trial. *Scand J Med Sci Sports* 2010; 20(6):814–821.
17. Engebretsen AH, Myklebust G, Holme I et al. Prevention of injuries among male soccer players: a prospective, randomized intervention study targeting players with previous injuries or reduced function. *Am J Sports Med* 2008; 36(6):1052–1060.
18. Jacobsson J, Timpka T. Classification of prevention in sports medicine and epidemiology. *Sports Med* 2015; 45(11):1483–1487.
19. Delahunt E, Fitzpatrick H, Blake C. Pre-season adductor squeeze test and HAGOS function sport and recreation subscale scores predict groin injury in Gaelic football players. *Phys Ther Sport* 2017; 23:1–6.
20. Thorborg K, Petersen J, Magnusson SP et al. Clinical assessment of hip strength using a hand-held dynamometer is reliable. *Scand J Med Sci Sports* 2010; 20(3):493–501.
21. Weir JP. Quantifying test–retest reliability using the intraclass correlation coefficient and the SEM. *J Strength Cond Res* 2005; 19(1):231–240.
22. Mosler A, Crossley K, Thorborg K et al. Normative profiles for hip strength and flexibility in elite footballers. *J Sci Med Sport* 2016; 18:e32–e33.
23. Thorborg K, Branci S, Stensbirk F et al. Copenhagen hip and groin outcome score (HAGOS) in male soccer: reference values for hip and groin injury-free players. *Br J Sports Med* 2014; 48(7):557–559.
24. Weir A, Brukner P, Delahunt E et al. Doha agreement meeting on terminology and definitions in groin pain in athletes. *Br J Sports Med* 2015; 49(12):768–774.
25. Serner A, Jakobsen MD, Andersen LL et al. EMG evaluation of hip adduction exercises for soccer players: implications for exercise selection in prevention and treatment of groin injuries. *Br J Sports Med* 2014; 48(14):1108–1114.
26. Jensen J, Holmich P, Bandholm T et al. 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.
27. Wollin M, Lovell G. Osteitis pubis in four young football players: a case series demonstrating successful rehabilitation. *Phys Ther Sport* 2006; 7(3):153–160.
28. Jacqmin-Gadda H, Sibillot S, Proust C et al. Robustness of the linear mixed model to misspecified error distribution. *Comput Stat Data Anal* 2007; 51(10):5142–5154.
29. Whittaker JL, Small C, Maffey L et al. Risk factors for groin injury in sport: an updated systematic review. *Br J Sports Med* 2015; 49(12):803–809.
30. Caldwell BP, Peters DM. Seasonal variation in physiological fitness of a semi-professional soccer team. *J Strength Cond Res* 2009; 23(5):1370–1377.