Physical Therapy in Sport 52 (2021) 263–271

Contents lists available at ScienceDirect

Physical Therapy in Sport

journal homepage: www.elsevier.com/ptsp

Hip and groin function and strength in male ice hockey players with and without hip and groin problems in the previous season- a prospective cohort study

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ARTICLE INFO

Article history:
Received 16 June 2021
Received in revised form
8 October 2021
Accepted 10 October 2021

Keywords:
Groin pain
Hip pain
Hip muscle strength
Self-reported function

ABSTRACT

Objective: To describe and compare hip and groin strength and function of male ice hockey players over one season in players with and without hip and groin problems in the previous season.
Design: Prospective cohort study.
Setting: Swedish male ice hockey.
Participants: We followed 193 players from 10 teams during the 2017/2018 season.
Main outcome measures: Hip adduction and abduction strength, 5 s squeeze test (5SST), and self-reported hip and groin function (Hip and Groin Outcome Score). Changes over the season and differences between players with and without problems in the previous season were analyzed by linear mixed models.
Results: Adduction strength decreased slightly from pre-to mid-season and abduction strength increased slightly over the full season. However, self-reported function or pain did not change. Players with hip and groin problems in the previous season had significantly worse self-reported function, and more groin pain during the 5SST compared to players without. Strength measurments did not differ between groups.
Conclusions: Hip muscle strength, groin pain, and self-reported function appear to remain stable throughout the season in male ice hockey players. Remaining impairments in players with problems in the previous season suggest that function does not recover by ice hockey participation alone.

1. Introduction

Hip and groin injuries are common in ice hockey (Brunner et al., 2020; Nordstrom et al., 2020; Worner et al., 2021). Among collegiate sports in the USA, ice hockey has the highest proportion of hip and groin injuries among all injuries, and it is the sport with the second highest incidence rate of hip and groin injuries (Orchard, 2015). In professional ice hockey, about half of all players report hip and groin problems over the course of a season (Worner et al., 2019b, 2021). Hip muscle strength, self-reported function, and groin pain during an adductor squeeze are considered to be indicators of hip and groin health in athletes and are therefore recommended to be measured regularly (Thorborg et al., 2017a; Wollin et al., 2018a). A recent study on football players, assessing adduction and abduction strength in the start, middle, and end of the season, reported strength to remain stable over time (van Klij et al., 2021). However, little is known about how these factors change over the course of an ice hockey season.

To reduce injury risk for their athletes, clinicians need knowledge about modifiable risk factors for injury, including how to measure and modify them appropriately (Finch, 2006; van Mechelen et al., 1992). In sports with high prevalence of hip and groin problems (Haroy et al., 2017a; Worner et al., 2019a, 2019b), practitioners have been advised to measure hip muscle strength, groin pain, and self-reported hip and groin function (Wollin et al., 2018a). Isometric and eccentric adduction strength is associated

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https://doi.org/10.1016/j.ptsp.2021.10.005

with subsequent groin injuries in football codes (Bourne et al., 2020; Delahunt et al., 2017; Mosler et al., 2018). In ice hockey, decreased eccentric adduction strength during the pre-season has found to be associated with subsequent groin injury in professional players (Tyler et al., 2001), while isometric adductor strength has not (Worner et al., 2021). Groin pain during a maximal 5 s isometric adduction squeeze test (5-s squeeze test) can indicate impairments in hip muscle strength and self-reported function in ice hockey players (Worner et al., 2019c). Self-reported hip and groin function, as measured by the Copenhagen Hip and Groin Outcome Score (HAGOS), is associated with subsequent groin injury among Association football (soccer) and Gaelic football players (Bourne et al., 2020; Delahunt et al., 2017) but the association has not been investigated in a prospective study of ice hockey players.

As in other sports (Whittaker et al., 2015), a previous hip and groin injury is the most consistently reported risk factor for new hip and groin injuries in ice hockey (Worner et al., 2021). A relatively high prevalence in relation to a relatively low incidence of these problems (Worner et al., 2019a, 2021) as well as the long-lasting functional impairments after reported injuries, (Worner et al., 2019b), suggest that many players end up having chronic hip and groin problems. Therefore, it is of clinical interest to focus on previously injured players to see if their hip and groin impairments persist throughout the season. Throughout a competitive season, prevalence of self-reported hip and groin problems appears to vary (Clarsen et al., 2015; Haroy et al., 2017a; Worner et al., 2019a, 2021). It is hence reasonable to believe that clinical indicators of hip and groin health such as strength, groin pain, and self-reported function also change throughout the season. In youth football players, adduction strength has shown to decrease under periods of intense match congestion (Wollin et al., 2018b). In ice hockey, the seasonal variation of strength, groin pain, and self-reported function has not been investigated.

The aim of this study was (1) to investigate potential changes in indicators for hip and groin health such as hip adduction and abduction strength, pain during the 5SST, and self-reported hip and groin function in male ice hockey players over the course of one season, and (2) to compare the level and seasonal pattern of hip and groin strength, pain, and function between players with and without hip and groin problems in the previous season.

2. Methods

2.1. Study design

We conducted a prospective cohort study of 193 male Swedish ice hockey players. At the beginning, middle, and end of the 2017–2018 season, we measured the 5 s squeeze test (5SST) and isometric hip adduction and abduction strength, and during the same occasion asked players to report their hip and groin function using the HAGOS questionnaire. Our study was approved by the Ethics Committee at Lund University (Dnr 2017/483).

2.2. Participants and recruitment

We invited professional and semi-professional male ice hockey teams in the greater Stockholm area to participate in the study. Players received written information about the study and provided written informed consent before the first assessment. All players that were at least 18 years of age, free from other musculoskeletal injuries or illnesses that could impair or prevent participation in training at the day of the measurement were eligible for inclusion into the study. Of 12 invited teams, 10 agreed to participate and 252 players participated in the first of the three measurement occasions during pre-season. We included all players who still played for the club during follow up measurements and participated in at least two measurement occasions (n = 193) (Fig. 1). Player characteristics (n = 163) are summarized in Table 1. Thirty players did not provide demographic information in the online survey.

2.3. Assessment procedure

We assessed players before training sessions in the beginning (July 2017), middle (October 2017), and end (February 2018) of the regular season. At baseline, demographic characteristics, level of play, playing position and history of hip and groin injuries (yes/no) were assessed via an online survey. Prior to the physical assessments, consisting of the 5SST, and isometric adduction and abduction strength (Worner et al., 2019c), players responded to the HAGOS questionnaire (Thorborg et al., 2011) online. At baseline, the online survey also asked about demographics, level of ice hockey participation, playing position, and hip and groin injury history.

2.3.1. Injury history and self-reported hip and groin function

At baseline, we asked players whether they, during the previous season, had experienced hip and groin pain or - injury that a) affected their performance during training or match play (non-time-loss problem) or b) prevented them from participation in training or match play (time-loss problem) and c) the duration of these problems. Self-reported function was assessed through

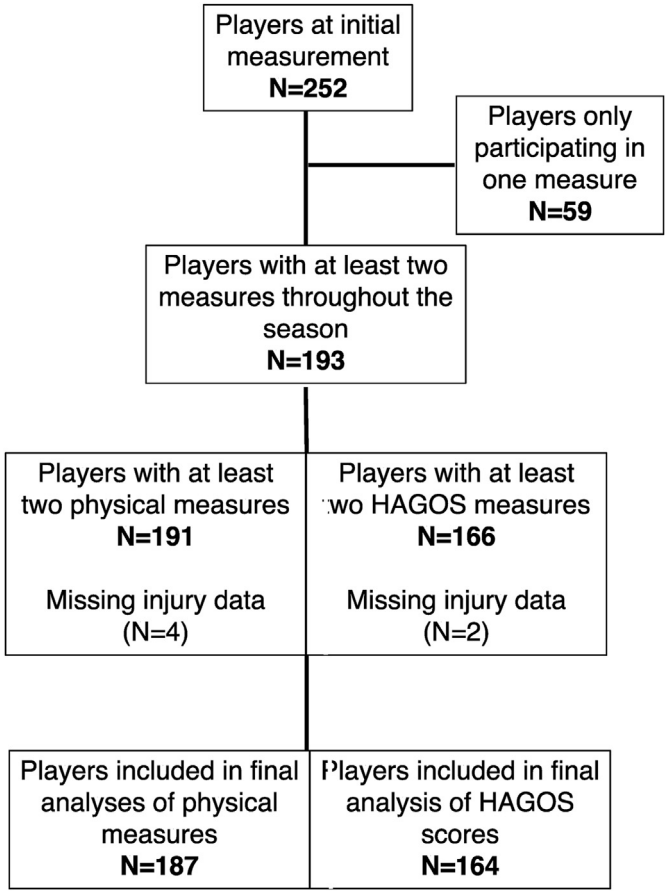

Fig. 1. Flow of players into the study.

Table 1
Player demographics and injury history in the previous season (n = 163).

Age in years [Mean (SD)][a]	23.1 (3.5)
Height in cm [Mean (SD)]	181.7 (13.2)
Weight (kg) [Mean (SD)]	84.8 (7.1)
Years of ice hockey experience [mean (SD)]	17.5 (3.6)
Playing level [a]	
Swedish Hockey League [N (%)]	18 (11)
Hockey Allsvenska [N (%)]	35 (21.5)
Division 1 [N (%)]	109 (66.9)
Playing position	
Goaltender [N (%)]	16 (9.8)
Defender [N (%)]	58 (35.6)
Forward [N (%)]	89 (54,6)
Hip and groin problems during previous season	
Non-time loss n=184 [N (%)]	75 (39,9)
Symptom duration in weeks [Median (IQR)]	2 (1; 4)
Time-loss n=188 [N (%)]	39 (23.9)
Duration of time-loss in weeks [Median (IQR)]	2 (1; 3,25)

SD = Standard deviation; IQR = Interquartal range (25th and 75th percentiles).
[a] Information only available for 162 players.

HAGOS, a valid and reliable tool to assess hip and groin function in athletes (Thorborg et al., 2011) that has previously been used on high level ice hockey players (Worner et al., 2019a,b,c). HAGOS assesses hip and groin function across 6 dimensions – symptoms, pain, function in daily living, function in sport and recreation, participation in physical activities, and hip- and groin related quality of life. Scores for each subscale are transformed to a percentage of the maximal possible score (100) where 0 represents extreme hip and groin problems and 100 represents no hip and groin problems.

2.3.2. Five-second squeeze test and hip muscle strength

The 5SST assesses groin pain during an isometric adduction and is a valid indicator of hip and groin related sporting function (Thorborg et al., 2017a; Worner et al., 2019c). During the 5SST the assessor places a forearm between the players ankle and asks them to perform a maximal 5 s isometric adduction (Fig. 2). Players then rate the level of groin pain during the maximal 5-s adduction on a numeric pain rating scale from 0 to 10 (0 = no groin pain; 10 maximal groin pain). No specific warm up was performed before the test but players performed at least one familiarization trial before executing one maximal test trial. During the test, hip adduction force was measured with a handheld dynamometer (Micro-FET2; Hoggan Health Industries). Hip abduction strength was measured in the same position and according to the same procedure as adduction strength, but resistance was applied via a rigid fixation belt (Fig. 2). All strength measures were performed by a single, trained assessor using a handheld dynamometer according to a standardized, reliable procedure (ICC adduction and abduction strength: 0.95) (Worner et al., 2019c).

2.4. Data management

Players who reported to have experienced either a time loss and/or a non-time loss hip or groin problem during the previous season were categorized as having “previous TL or NTL problem”. Adduction and abduction force (N) were transformed into torque [force * lever arm (distance between anterior superior iliac spine and placement of hand-held dynamometer) = Nm) and then expressed in relation to the players body weight (NM/kg). Adduction-to abduction strength ratio was computed as the ratio between adduction and abduction strength. Changes in adduction- and abduction strength and HAGOS subscales from pre-to mid-season, and from mid-to end season, were categorized into positive or negative changes exceeding minimal detectable change (MDC), or “no change” (below MDC). Proportions of players presenting with increases or decreases > MDC, or no change (<MDC) between measurement points is presented for players with and without problems as well as for the whole group. Limits of MDC for relative change in adduction (16.46%) and abduction (18.50%) strength were based on a reliability study not yet published (L.Ishøi, written communication, December 4, 2020). Limits of MDC for HAGOS were defined according to Thomee et al. (Thomee et al., 2014).

2.5. Statistical analysis

For each analysis of the repeated measures, players were included if they participated in at least two measurement occasions and provided information regarding injury in the previous season (time-loss or non-time-loss injuries). For the physical outcomes (strength and 5SST pain), 187 players were included. For the self-reported function (survey), 164 players were included. A linear mixed model was used to specify a repeated measures model, solved using the restricted maximum likelihood (REML) method. Categorical predictors were injury group (two groups; previous time loss or non-time-loss injury during preceding season, or no such injuries during the previous season) and time (three levels; pre-season, in-season and end-season). Separate analyses were performed for each outcome variable: 5SST (pain), adduction and abduction strength, adduction-to-abduction strength ratio, and HAGOS (sub scales pain, symptoms, ADL, sport, physical activity, QoL). In the case of significant main effect of time, we performed Bonferroni corrected post-hoc comparisons between time points. The statistical modeling also included the two-way interactions of group by time to explore possible differential patterns of outcomes

Fig. 2. Isometric adduction (left) and abduction measure (right).

between the groups. For all analyses, a first-order autoregressive (AR-1) covariance structure was applied. All analyses were performed in IBM Statistical Package for Social Sciences SPSS (version 26). Significance level was set to 0.05.

3. Results

Adduction strength decreased slightly from the beginning of the season to mid-season (−0.09 nm/kg [95% CI -0.02; −0.16], $p = 0.015$) while abduction strength was slightly higher at end season compared with both beginning of season (0.07 nm/kg [95% CI 0.02; 0.12] $p = 0.01$) and mid-season (0.07 nm/kg [0.03–0.11] $p < 0.001$). We did not identify any significant changes in the adduction/abduction strength ratio, ($p = 0.12$), 5SST (pain) ($p = 0.33$) or HAGOS scores ($p > 0.09$) over the season (Table 2). More than 25% of players showed changes (increase or decrease) in adduction strength exceeding MDC between the measurement points. Less than 10% of all players showed changes exceeding MDC in abduction strength (Fig. 3). Approximately 40% of players showed changes exceeding MDC in HAGOS scales symptoms and quality of life during the season. For quality of life, the largest share of change exceeding MDC was observed among players that had hip and groin problems in the previous season. Only a small share of players showed changes exceeding MDC in the other subscales of HAGOS (Figs. 4 and 5).

3.1. Differences between players with and without problems in the previous season

No significant differences in hip muscle strength were found between players with previous hip and groin problems and players without previous problems ($p \geq 0.15$). Players with previous problems reported significantly more groin pain during the 5SST [Mean difference: 1.0 (95%CI 0.6–1.4); $p < 0.01$] than players without previous problems. Players with previous problems also reported significantly worse function (HAGOS scores pain [Mean difference: 6.0 (95%CI 3.9–8.1); $p < 0.01$]; Symptom [Mean difference: 6.0 (95%CI 32.7–9.3); $p < 0.01$]; ADL [Mean difference: 4.9 (95%CI 3.2–6.6); $p < 0.01$]; Sport [Mean difference: 11.5 (95%CI 8.2–14.7); $p < 0.01$]; PA [Mean difference: 7.5 (95%CI 4.8–10.1); $p < 0.01$]; QoL [Mean difference: 12.0 (95%CI 8.3–15.8); $p < 0.01$]. There were no significant interaction effects between time and group ($p \geq 0.27$) indicating similar seasonal patterns for the outcomes in players with and without problems in the previous season (Figs. 5-8).

4. Discussion

In this prospective cohort study, we investigated potential patterns of change in hip and groin function over the course of a competitive ice hockey season, and explored potential differences in function between players with and without hip and groin problems in the previous season. Our main findings were that levels of hip muscle strength, groin pain and self-reported hip and groin function remained relatively stable throughout the season. Players with previous hip and groin problems had similar strength levels but had more groin pain and more impaired self-reported hip and groin function than players without previous problems.

We found a small decrease in adduction strength in the first half of the season and small increase of abduction strength in the end of the season. However, changes in adduction strength where small and of questionable clinical relevance. In soccer players, eccentric adduction strength has been found to be stable over the course of the season (van Klij et al., 2021) but clinically meaningful decreases in isometric adduction strength have been reported during a tournament with high match congestion (Wollin et al., 2018b). In our study we also measured adduction strength isometricaly. In ice hockey however, the adductors are mainly loaded eccentrically. Skating exposed the adductors to high eccentric load, which increases with higher velocities (Chang et al., 2009). Ice hockey players, therefore, expose their adductors to repetitive eccentric contractions, which has been speculated to contribute to the high incidence of adductor strains in these athletes (Tyler et al., 2001). While it also can be argued that this repetitive loading of the adductors during skating may lead to gains in adduction strength, our results indicate that playing a season of ice hockey is not associated with meaningful strength changes. Hence, clinicians seeking to increase adductor strength in players need to implement targeted interventions to achieve this goal.

Levels of groin pain during the 5SST did not change with more training sessions and more matches played over the season. Players with problems in the previous season had significantly more groin pain during the 5SST than players without previous problems. Despite being statistically significant, the absolute difference in groin pain, measured on an 11-point NRS, was smaller than the minimal clinical important difference for this type of measurement (Farrar et al., 2001). However, the 5SST categorizes players into a traffic light system according to groin pain intensity (NRS 0–2 = green, 3–5 = yellow, 6–10 = red) (Thorborg et al., 2017a). According to the traffic light system, players without hip and groin problems in the previous season had an average value

Table 2
Hip and groin function over the course of the season (N = 163).

	Beginning of season		Mid-season		End of the season		p[a]
	Mean	95% (CI)	Mean	95% (CI)	Mean	95% (CI)	
5SST (NRS)	1.6	1.3–1.9	1.8	1.5–2.1	1.9	1.6–2.2	0.332
Adduction (Nm/kg)	2.91[a]	2.83–3.00	2.82[a]	2.74–2.91	2.89	2.80–3.00	**0.025**
Abduction (Nm/kg)	2.05[b]	2.00–2.10	2.05[c]	2.00–2.10	2.12[b;c]	2.11–2.20	**0.001**
Add:Abd ratio	1.5	1.4–1.5	1.4	1.4–1.5	1.4	1.3–1.4	0.118
HAGOS Pain	92.2	91.0–94.0	92.8	91.5–94.2	93.2	91.8–94.6	0.498
HAGOS Symptoms	81.3	79.4–83.3	83.0	81.0–85.0	83.6	81.6–85.7	0.093
HAGOS ADL	95.5	94.3–96.6	95.2	94.1–96.5	95.9	94.6–97.1	0.740
HAGOS Sport	87.5	85.4–89.7	87.1	84.8–89.3	88.1	85.8–90.4	0.755
HAGOS PA	92.5	90.6–94.3	92.8	90.8–94.8	94.7	92.7–96.7	0.223
HAGOS QoL	88.1	85.9–90.2	87.3	85.1–89.5	88.4	86.1–90.7	0.473

5SST = Five second squeeze test; NRS = Numeric rating scale; Nm/kg = Newton meter per kilogram; HAGOS = Hip and groin outcome score; Add:Abd ratio = Adduction:Abduction ratio; ADL = Activities of daily living; Sport = Sport and recreation; PA = Physical activity; QoL = Quality of life.
Main effect of time.
[a] Significant difference between beginning of season and mid-season ($p < 0.05$).
[b] Significant difference between beginning of season and end season ($p < 0.05$).
[c] Significant difference between mid-season and end season ($p < 0.05$).

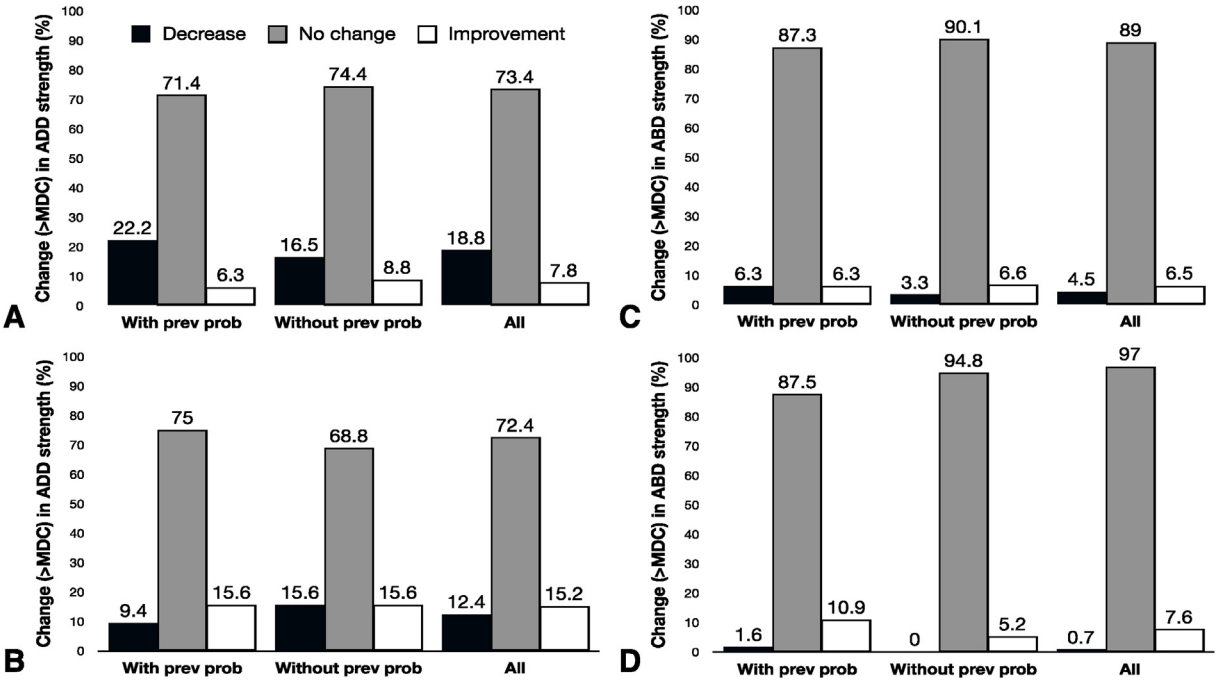

Fig. 3. A) Changes (>%MDC) in adduction strength from **preseason to midseason**; B) Changes (>%MDC) in adduction strength from **mid-season to end season**; C) Changes (>%MDC) in abduction strength from **preseason to midseason**; D) Changes (>%MDC) in abduction strength from **mid-season to end season**; Data is displayed for players with previous hip and groin problems, without previous hip and groin problems, and all players.

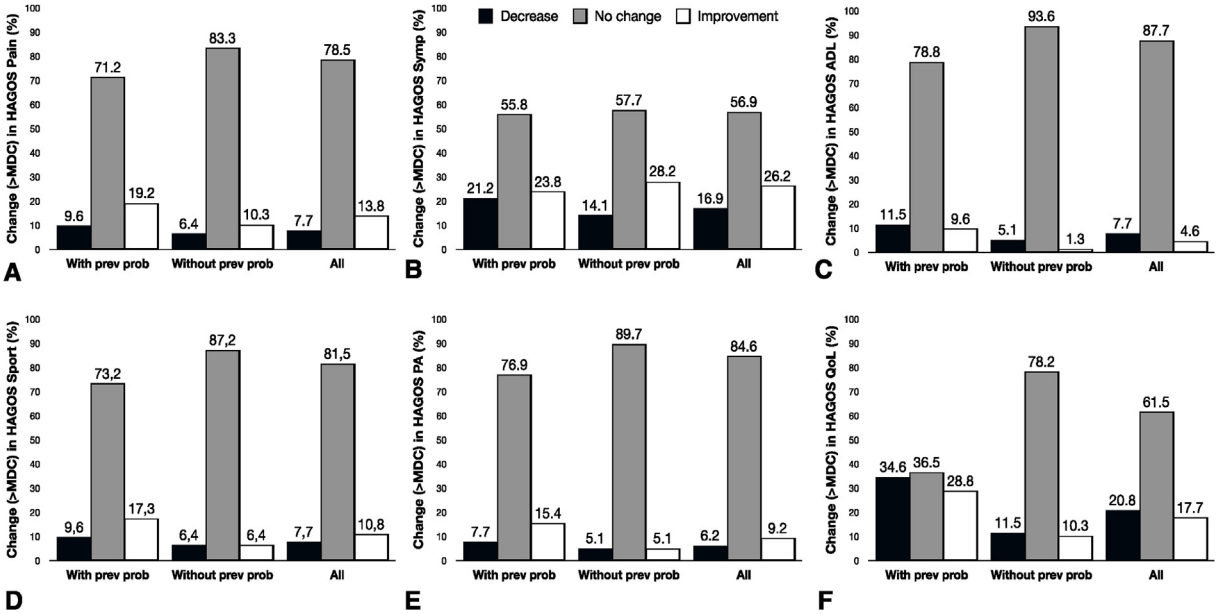

Fig. 4. Changes (>%MDC) in HAGOS scores from pre-season to mid-season. Data is displayed for players with previous hip and groin problems, without previous hip and groin problems, and all players. A) HAGOS subscale Pain; B) HAGOS subscale Symptoms; C) HAGOS subscale Activities of daily living (ADL); D) HAGOS subscale Sport; E) HAGOS subscale Physical Activity (PA); F) HAGOS subscale Quality of Life (QoL).

corresponding with green light throughout the season while the average among players with previous problems fell within yellow lights. We have previously found that ice hockey players with yellow light have similar impairments in self-reported hip muscle strength and sporting function as players with red light (Worner et al., 2019c).

Self-reported hip and groin function also remained relatively stable throughout the season; however, it was significantly impaired in players with hip and groin problems in the previous season, compared to those without. Despite being statistically significant, differences in HAGOS scores between players with and without previous problems were small and below the minimal detecable difference (Thomee et al., 2014) for most of the subscales. Clinically meaningful differences between these groups of players were found for the subscales sport and qualify of life. Clinical populations with hip and groin problems typically have lowest ratings in subscales sport, physical activities, and quality of life (Thorborg et al., 2018) and regard questions related to sports and

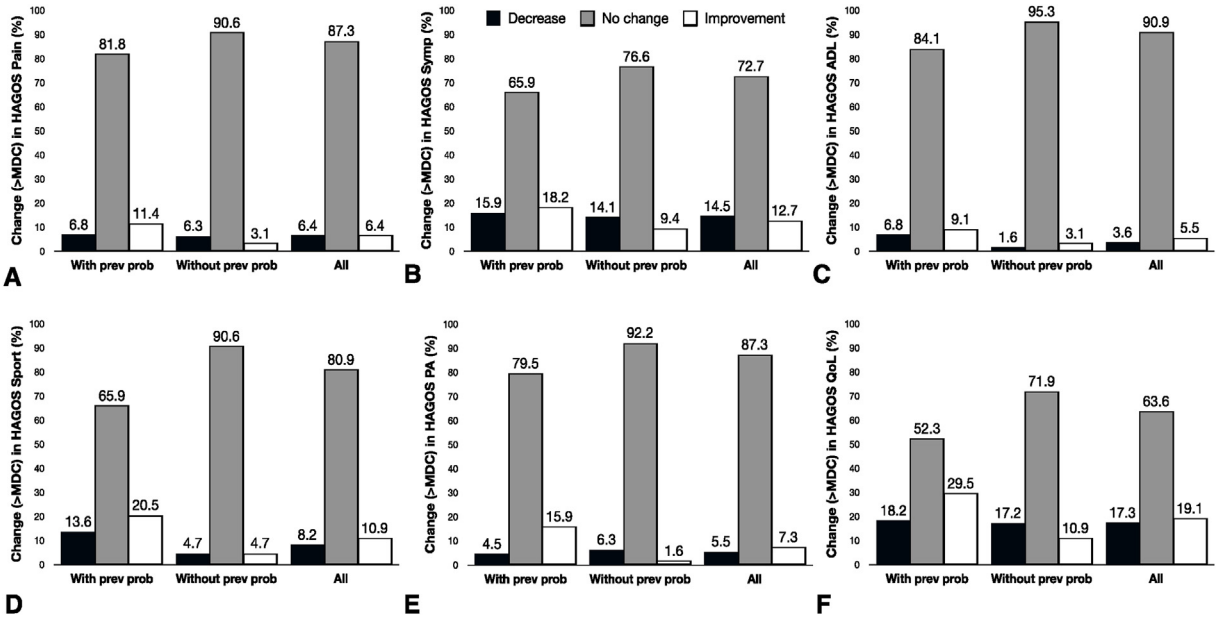

Fig. 5. Changes (>%MDC) in HAGOS scores from mid-season to end-season. Data is displayed for players with previous hip and groin problems, without previous hip and groin problems, and all players. A) HAGOS subscale Pain; B) HAGOS subscale Symptoms; C) HAGOS subscale Activities of daily living (ADL); D) HAGOS subscale Sport; E) HAGOS subscale Physical Activity (PA); F) HAGOS subscale Quality of Life (QoL).

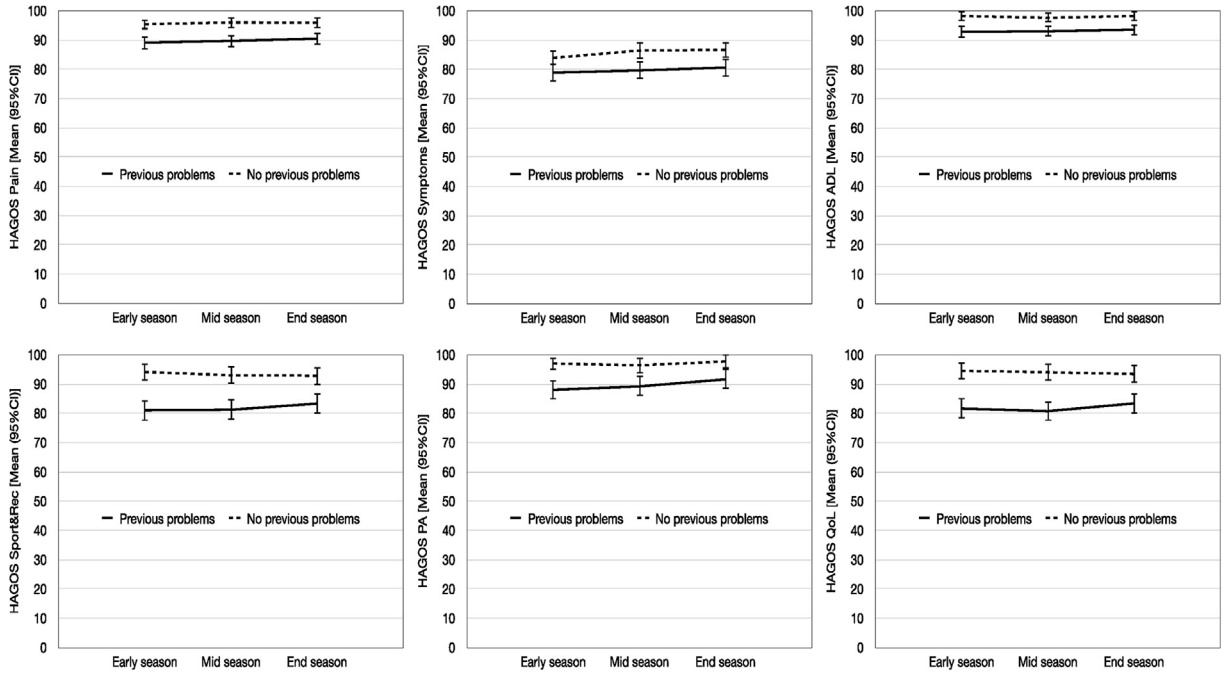

Fig. 6. Changes (>%MDC) in HAGOS scores from mid-season to end-season. Data is displayed for players with previous hip and groin problems, without previous hip and groin problems, and all players. A) HAGOS subscale Pain; B) HAGOS subscale Symptoms; C) HAGOS subscale Activities of daily living (ADL); D) HAGOS subscale Sport; E) HAGOS subscale Physical Activity (PA); F) HAGOS subscale Quality of Life (QoL).

recreation and social-emotional aspects as most important (Martin et al., 2009). This pattern in self-reported function is in line with the pattern observed in players with previous hip and groin problems in this study.

4.1. Clinical relevance

Clinicians working with ice hockey players can expect that players' hip muscle strength, groin pain, and self-reported hip and groin function will be relatively stable throughout the season. However, more than a quarter of the players in a team may change their function beyond the minimal detecable change of these measures. Hence, individual and continuous monitoring of players remains an important aspect of player care (Wollin et al., 2018a). Continuous monitoring does not need to be time consuming. The 5SST e.g. is a rapid clinical tool that provides clinicians with an

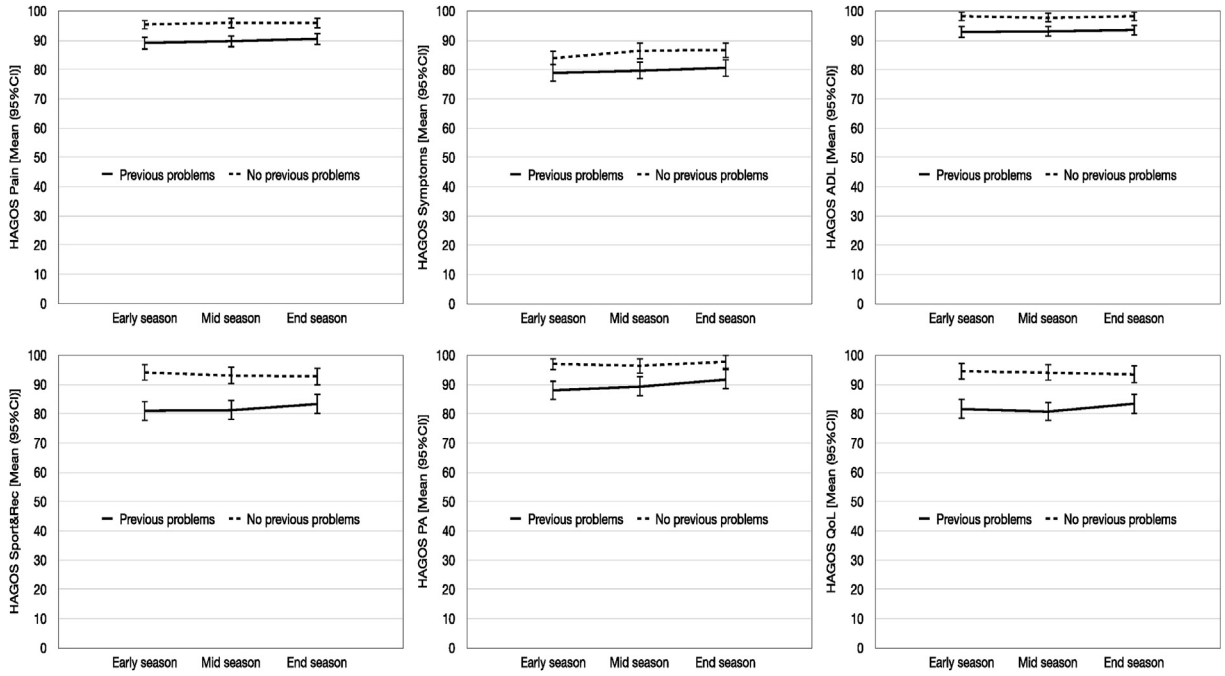

Fig. 7. Hip and Groin Outcome Score (HAGOS) of players with and without previous problems over course of the season.

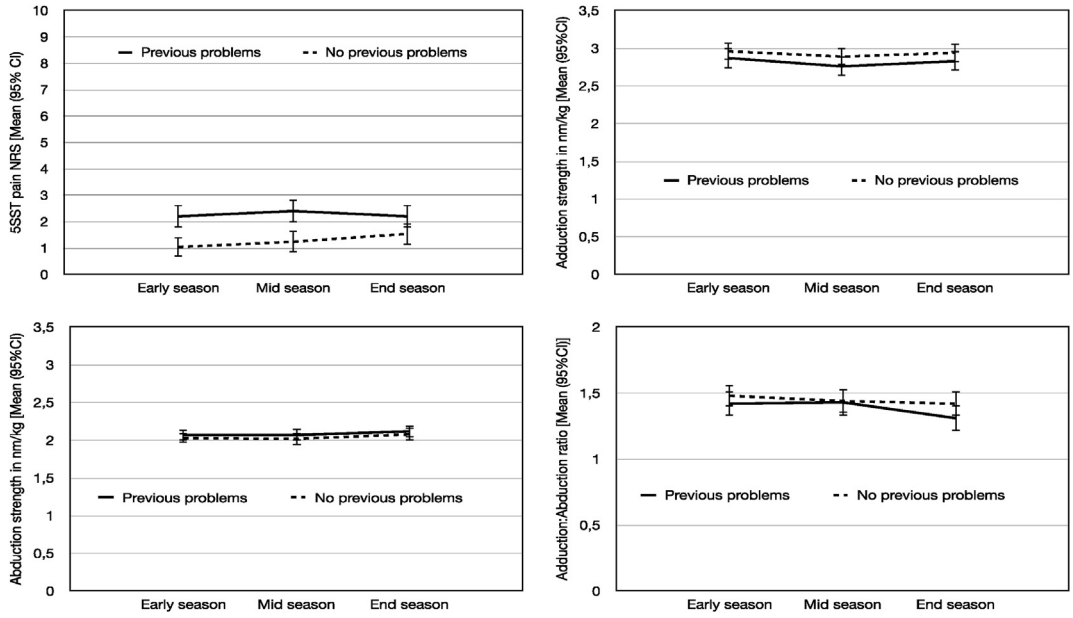

Fig. 8. Physical measures of players with and without previous problems over course of the season.

indication about players' sporting function and hip muscle strength, and can be used to guide management (Worner et al., 2019c). Recently, we learned that hip and groin problems in ice hockey players do not just disappear during the off-season (Worner et al., 2019b, 2021), a finding that has been made in football players previously (Esteve et al., 2018, 2021; Thorborg et al., 2017b). Our study adds to this knowledge by reporting lower functional levels in the previously injured players, and these do not resolve by ice hockey participation alone. In other sports, simple strengthening interventions have shown to improve hip muscle strength (Haroy et al., 2017b) and decrease the risk for hip and groin problems (Haroy et al., 2019). Similar strengthening strategies, implemented in off-season and continued during the competitive season may protect all ice hockey players from developing hip and groin problems. Players with previous problems may need more of these targeted interventions to reach the functional level of their non-injured teammates.

4.2. Methodological considerations

This study had several strengths, including a relatively large sample size and comprehensive measures of hip and groin function through strength measures, clinical provocation testing with the 5SST, and self-reported function. We acknowledge that we had a

drop out rate of 23% from the pre-season measurement to the mid-season measurement. This drop out rate can be explained by the high turn-over of players from pre-season (before final rosters are determined) to the mid-season, when the final squad has been confirmed. Therefore, we do not believe that the drop out had a systematic effect on our outcomes. Even though we did not select the teams for inclusion randomly we don't believe our results are effected by selection bias. We recruited all teams in a relatively large geographical area, which is not different from the rest of the country and 10/12 of these teams agreed to participate. Measuring adduction squeeze strength with flexed knees (90°) and hips (45°) may be seen as more specific to the sport of ice hockey and a recent study provides reference values for clinicians measuring in this position (Oliveras et al., 2020). We measured adduction strength isometricaly, with extended knees and hips since it is the position eliciting highest torque production and allowing highest reliability among squeeze tests (Light & Thorborg, 2016). Furthermore, this position gave us the possibility to combine the 5SST effectively with an objective force output, as previously described in ice hockey players (Worner et al., 2019c). Measuring adduction eccentrically may have been a better reflection of adductor function in ice hockey. We can therefore not draw any conclusions regarding potential changes in eccentric adduction strength in response to ice hockey participation. It is likely that some players in our cohort may have experienced hip and groin problems during the season and that these problems had an impact on our results. However, the aim of this study was not to investigate associations between hip and groin problems and function but to describe potential changes in function over the course of the season in ice hockey players. Hip and groin problems are a part of ice hockey and there will be individuals with these problems in each team (Worner et al., 2019b, 2021). Therefore, we believe that the potential effect of ongoing problems on our results should not be considered as bias but rather a reflection of clinical reality.

5. Conclusion

Hip muscle strength, groin pain, and self-reported hip and groin function remain stable throughout the season in male ice hockey players. Players with problems in the previous season have significantly more groin pain and impaired self-reported sporting function during the season, indicating that function does not recover by ice hockey participation alone.

Ethical approval

This study was approved by the ethical committee of Lund University (Dnr 2017/483)). All participants provided written informed consent.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We would like to thank all participating organizations, coaches, and especially the players for their contribution that helped us to perform this study.

References

Bourne, M. N., Williams, M., Jackson, J., Williams, K. L., Timmins, R. G., & Pizzari, T. (2020). Preseason hip/groin strength and HAGOS scores are associated with subsequent injury in professional male soccer players. *Journal of Orthopaedic & Sports Physical Therapy, 50*(5), 234–242.

Brunner, R., Bizzini, M., Niedermann, K., & Maffiuletti, N. A. (2020). Epidemiology of traumatic and overuse injuries in Swiss professional male ice hockey players. *Orthop J Sports Med, 8*(10), 2325967120964720.

Chang, R., Turcotte, R., & Pearsall, D. (2009). Hip adductor muscle function in forward skating. *Sports Biomechanics, 8*(3), 212–222.

Clarsen, B., Bahr, R., Heymans, M. W., et al. (2015). The prevalence and impact of overuse injuries in five Norwegian sports: Application of a new surveillance method. *Scandinavian Journal of Medicine & Science in Sports, 25*(3), 323–330.

Delahunt, E., Fitzpatrick, H., & Blake, C. (2017). Pre-season adductor squeeze test and HAGOS function sport and recreation subscale scores predict groin injury in Gaelic football players. *Physical Therapy in Sport : Official Journal of the Association of Chartered Physiotherapists in Sports Medicine, 23*, 1–6.

Esteve, E., Casals, M., Saez, M., et al. (2021). Past-season, pre-season and in-season risk assessment of groin problems in male football players: A prospective full-season study. *British Journal of Sports Medicine*.

Esteve, E., Rathleff, M. S., Vicens-Bordas, J., et al. (2018). Preseason adductor squeeze strength in 303 Spanish male soccer athletes: A cross-sectional study. *Orthop J Sports Med, 6*(1), 2325967117747275.

Farrar, J. T., Young, J. P., Jr., LaMoreaux, L., Werth, J. L., & Poole, R. M. (2001). Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. *Pain, 94*(2), 149–158.

Finch, C. (2006). A new framework for research leading to sports injury prevention. *Journal of Science and Medicine in Sport/Sports Medicine Australia, 9*(1–2), 3–9. discussion 10.

Haroy, J., Clarsen, B., Thorborg, K., Holmich, P., Bahr, R., & Andersen, T. E. (2017a). Groin problems in male soccer players are more common than previously reported. *The American Journal of Sports Medicine, 45*(6), 1304–1308.

Haroy, J., Clarsen, B., Wiger, E. G., et al. (2019). The adductor strengthening programme prevents groin problems among male football players: A cluster-randomised controlled trial. *British Journal of Sports Medicine, 53*(3), 150–157.

Haroy, J., Thorborg, K., Serner, A., et al. (2017b). Including the copenhagen adduction exercise in the FIFA 11+ provides missing eccentric hip adduction strength effect in male soccer players: A randomized controlled trial. *The American Journal of Sports Medicine, 45*(13), 3052–3059.

van Klij, P., Langhout, R., van Beijsterveldt, A. M. C., et al. (2021). Do hip and groin muscle strength and symptoms change throughout a football season in professional male football players? A prospective cohort study with repeated measures. *Journal of Science and Medicine in Sport/Sports Medicine Australia*.

Light, N., & Thorborg, K. (2016). The precision and torque production of common hip adductor squeeze tests used in elite football. *Journal of Science and Medicine in Sport/Sports Medicine Australia, 19*(11), 888–892.

Martin, R. L., Mohtadi, N. G., Safran, M. R., et al. (2009). Differences in physician and patient ratings of items used to assess hip disorders. *The American Journal of Sports Medicine, 37*(8), 1508–1512.

van Mechelen, W., Hlobil, H., & Kemper, H. C. (1992). Incidence, severity, aetiology and prevention of sports injuries. A review of concepts. *Sports Medicine, 14*(2), 82–99.

Mosler, A. B., Weir, A., Serner, A., et al. (2018). Musculoskeletal screening tests and bony hip morphology cannot identify male professional soccer players at risk of groin injuries: A 2-year prospective cohort study. *The American Journal of Sports Medicine, 46*(6), 1294–1305.

Nordstrom, A., Bahr, R., Talsnes, O., & Clarsen, B. (2020). Prevalence and burden of health problems in male elite ice hockey players: A prospective study in the Norwegian professional league. *Orthop J Sports Med, 8*(2), 7, 232596712090240.

Oliveras, R., Bizzini, M., Brunner, R., & Maffiuletti, N. A. (2020). Field-based evaluation of hip adductor and abductor strength in professional male ice hockey players: Reference values and influencing factors. *Physical Therapy in Sport : Official Journal of the Association of Chartered Physiotherapists in Sports Medicine, 43*, 204–209.

Orchard, J. W. (2015). Men at higher risk of groin injuries in elite team sports: A systematic review. *British Journal of Sports Medicine, 49*(12), 798–802.

Thomee, R., Jonasson, P., Thorborg, K., et al. (2014). Cross-cultural adaptation to Swedish and validation of the Copenhagen Hip and Groin Outcome Score (HAGOS) for pain, symptoms and physical function in patients with hip and groin disability due to femoro-acetabular impingement. *Knee Surgery, Sports Traumatology, Arthroscopy : Official Journal of the ESSKA, 22*(4), 835–842.

Thorborg, K., Branci, S., Nielsen, M. P., Langelund, M. T., & Holmich, P. (2017a). Copenhagen five-second squeeze: A valid indicator of sports-related hip and groin function. *British Journal of Sports Medicine, 51*(7), 594–599.

Thorborg, K., Holmich, P., Christensen, R., Petersen, J., & Roos, E. M. (2011). The copenhagen hip and groin outcome score (HAGOS): Development and validation according to the COSMIN checklist. *British Journal of Sports Medicine, 45*(6), 478–491.

Thorborg, K., Rathleff, M. S., Petersen, P., Branci, S., & Holmich, P. (2017b). Prevalence and severity of hip and groin pain in sub-elite male football: A cross-sectional cohort study of 695 players. *Scandinavian Journal of Medicine & Science in Sports, 27*(1), 107–114.

Thorborg, K., Reiman, M. P., Weir, A., et al. (2018). Clinical examination, diagnostic

imaging, and testing of athletes with groin pain: An evidence-based approach to effective management. *Journal of Orthopaedic & Sports Physical Therapy, 48*(4), 239–249.

Tyler, T. F., Nicholas, S. J., Campbell, R. J., & McHugh, M. P. (2001). The association of hip strength and flexibility with the incidence of adductor muscle strains in professional ice hockey players. *The American Journal of Sports Medicine, 29*(2), 124–128.

Whittaker, J. L., Small, C., Maffey, L., & Emery, C. A. (2015). Risk factors for groin injury in sport: An updated systematic review. *British Journal of Sports Medicine, 49*(12), 803–809.

Wollin, M., Pizzari, T., Spagnolo, K., Welvaert, M., & Thorborg, K. (2018b). The effects of football match congestion in an international tournament on hip adductor squeeze strength and pain in elite youth players. *Journal of Sports Sciences, 36*(10), 1167–1172.

Wollin, M., Thorborg, K., Welvaert, M., & Pizzari, T. (2018a). 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. *Journal of Science and Medicine in Sport/Sports Medicine Australia, 21*(10), 988–993.

Worner, T., Clarsen, B., Thorborg, K., & Eek, F. (2019a). Elite ice hockey goalkeepers have a high prevalence of hip and groin problems associated with decreased sporting function: A single-season prospective cohort study. *Orthop J Sports Med, 7*(12), 2325967119892586.

Worner, T., Thorborg, K., Clarsen, B., & Eek, F. (2021). Incidence, prevalence, severity, and risk factors for hip and groin problems in Swedish male ice hockey - a one-season prospective cohort study. *Journal of Athletic Training*.

Worner, T., Thorborg, K., & Eek, F. (2019b). High prevalence of hip and groin problems in professional ice hockey players, regardless of playing position. *Knee Surgery, Sports Traumatology, Arthroscopy : Official Journal of the ESSKA*.

Worner, T., Thorborg, K., & Eek, F. (2019c). Five-second squeeze testing in 333 professional and semiprofessional male ice hockey players: How are hip and groin symptoms, strength, and sporting function related? *Orthop J Sports Med, 7*(2), 2325967119825858.