

# Elite Ice Hockey Goalkeepers Have a High Prevalence of Hip and Groin Problems Associated With Decreased Sporting Function

## A Single-Season Prospective Cohort Study

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*Investigation performed at Lund University, Lund, Sweden*

**Background:** The modern style of goalkeeping in ice hockey is thought to predispose athletes to hip and groin problems. However, little is known about the magnitude of these problems in elite goalkeepers.

**Purpose:** To describe the incidence, prevalence, and severity of hip and groin problems in elite ice hockey goalkeepers over the course of a single season.

**Study Design:** Descriptive epidemiology study.

**Methods:** We invited all elite Swedish ice hockey goalkeepers ( $n = 128$ ) to participate in this prospective cohort study. Every second week, players reported hip and groin problems experienced within the past 14 days on the Oslo Sports Trauma Research Center Overuse Injury Questionnaire (OSTRC-O), classifying problems into “all” and “substantial” hip and groin problems. Three times during the season (pre-, mid-, and end-season), players reported hip and groin function on the Hip and Groin Outcome Score (HAGOS) as well as on the OSTRC-O.

**Results:** A total of 101 goalkeepers participated in the study (83.3% male [seniors, 44.1%; juniors, 39.2%], 16.7% female). The cumulative incidences of all hip and groin problems and substantial hip and groin problems were 69% (95% CI, 59%-79%) and 36% (95% CI, 26%-46%), respectively. The average biweekly prevalence for all hip and groin problems and substantial hip and groin problems was 28.1% (95% CI, 25.0%-31.3%) and 10% (95% CI, 8.7%-11.4%), respectively. Among all the reported hip and groin problems, 16.9% ( $n = 70$ ) were acute, 83.1% ( $n = 343$ ) were because of overuse, and 15.5% ( $n = 64$ ) led to time loss. HAGOS did not differ in the pre-, mid-, or end-season. Players reporting hip and groin problems on the OSTRC-O had significantly worse HAGOS scores than players without problems ( $P < .01$ ).

**Conclusion:** Hip and groin problems are highly prevalent in elite ice hockey goalkeepers. During a competitive season, 69% of players experienced hip and groin problems and 36% of players suffered from substantial problems. The vast majority of problems were because of overuse, not leading to time loss but related to reduced self-reported hip and groin function.

**Keywords:** ice hockey; epidemiology; groin pain; hip pain

Bernie Parent, one of the last great stand-up ice hockey goalkeepers in the National Hockey League (NHL), once said: “You don’t have to be crazy to be a goalie—but it helps.” Little did he know, ice hockey goalkeeping would be revolutionized by the next generation of goalkeepers, led by Patrick Roy who brought the goalie game to its knees by introducing a new, more effective way of goalkeeping. This revolution in style may, however, have a toll on players’ hip

and groin health.<sup>11,30</sup> Hip and groin problems are common in ice hockey players, regardless of the position,<sup>8-10,17,25</sup> but especially when watching goalkeepers in action, one cannot help wondering how their hips and groins are affected by the extremes of motion they are going through.

Modern goalkeeping involves frequent dropping down to the knees, using extremes of hip range of motion (ROM) to quickly push from post to post, covering as much of the net as possible using variations of the butterfly technique (Figure 1).<sup>3</sup>

This style of play exposes the hip joint to levels of internal rotation close to or beyond the passive end ROM

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**Figure 1.** Goalkeeper in butterfly position. Standing on the knees, the player internally rotates the hips 90° so the padding is parallel to the ice.

otherwise seen during extreme movements in other sports, such as the side splits in ballet or kicking in martial arts.<sup>13,30,31</sup> During a regular NHL game, a goalkeeper makes about 45 saves in a full or half butterfly<sup>3</sup> and drops down in that position many more times during each game and daily practices. The unique athletic demand appears to place goalkeepers in a susceptible position for the development of hip and groin problems.<sup>11</sup> The available research that specifically focuses on ice hockey goalkeepers describes management of either femoroacetabular impingement syndrome (FAI)<sup>20,22,24</sup> or hip kinematics.<sup>13,30,31</sup> Besides that, little research has attempted to shed light on the magnitude of hip and groin problems in goalkeepers in a sport in which these problems are very common for every athlete.<sup>8,11,25</sup>

Ice hockey is one of the sports topping the list of collegiate sports with high incidence of hip and groin problems.<sup>8,9,17</sup> Our current understanding of these problems in ice hockey is mainly based on collegiate athletes, and research on elite-level players is sparse. In the NHL, a team can expect to have a player on the bench or in the stands because of hip and groin problems for a total of 25 games each season.<sup>10</sup> One thing all existing research on hip and groin problems in ice hockey has in common is that injuries

are recorded once a player cannot participate (time-loss injury) or an injury is reported to the team physician, physical therapist, or athletic trainer (medical attention injury).<sup>8,10,11,25</sup> However, considering the nature of hip and groin problems, defining them as time-loss or medical attention injuries only provides a limited picture of their extent and magnitude.

Hip and groin problems in ice hockey often are longstanding, characterized by a gradual onset of symptoms, and they do not necessarily lead to time-loss or medical attention.<sup>17</sup> Therefore, current methods of reporting these injuries may underestimate their true burden on players. According to elite athletes, coaches, and physical therapists, the main indications of a sports injury are limited performance and participation in training, while time loss is just one aspect of injury severity.<sup>4</sup> Therefore, if we rely on time loss and medical attention to describe injuries, we neglect the players' own experience of when a problem starts to impair performance and participation. In other sports, such as soccer, researchers have adapted their methods to capture the magnitude of hip and groin problems more appropriately. By reporting the prevalence of players that experience problems instead of incidence of

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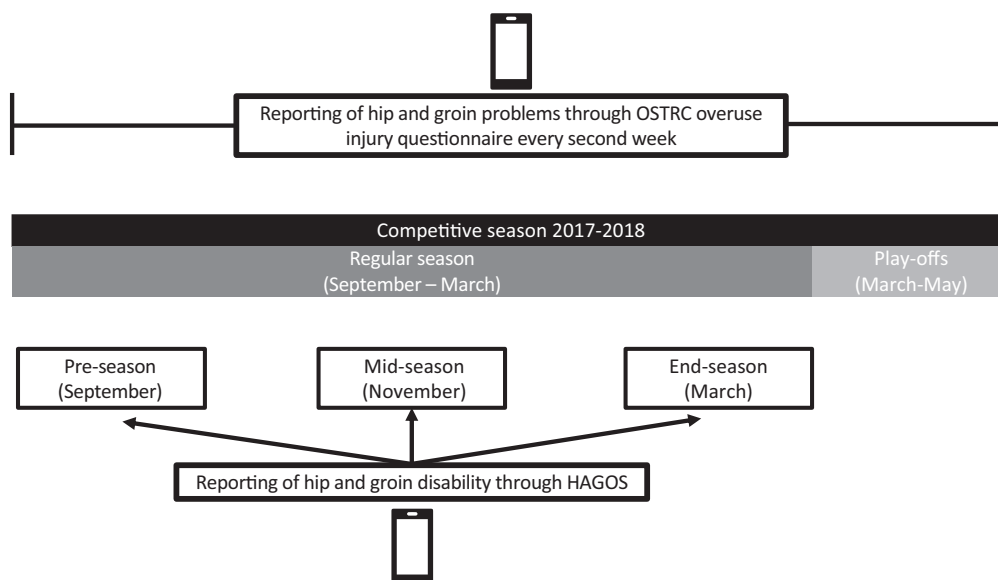
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**Figure 2.** Distribution of surveys throughout the season. HAGOS, Hip and Groin Outcome Score; OSTRC, Oslo Sports Trauma Research Center.

new time-loss or medical attention injuries, Harøy et al<sup>14</sup> showed that 30% of players had groin problems and that traditional surveillance methods would have only captured one-third of these problems. Consequently, expressing severity of hip and groin problems by the number of days a player is sidelined also seems inappropriate. Instead, severity of hip and groin problems expressed by the functional impairments experienced by the players themselves may be a suitable indication of severity.<sup>2</sup> The prevalence of hip and groin problems in ice hockey goalkeepers as well as their functional consequences is unknown, and, surprisingly, no study has investigated hip and groin problems in ice hockey players from the perspective of those affected by it—the players themselves.

In this study, we aimed to describe the incidence, prevalence, and severity of hip and groin problems in elite male and female ice hockey goalkeepers over the course of a single season. We also explored the potential changes in self-reported hip and groin function throughout the season and to what extent affected players differed from nonaffected in terms of self-reported hip and groin function.

## METHODS

### Study Design

This ethics committee–approved prospective cohort study of elite ice hockey goalkeepers describes a comprehensive overview of the prevalence and consequences of hip and groin problems over the course of a competitive season from 2017 to 2018. We measured the prevalence of hip and groin problems through the Oslo Sports Trauma Research Center Overuse Injury Questionnaire (OSTRC-O)<sup>7</sup> and hip and groin–related disability through the Copenhagen Hip and Groin Outcome Score (HAGOS).<sup>23</sup> Every second Sunday

throughout the season, players reported hip and groin problems on OSTRC-O, and 3 times during the season (pre-, mid-, and end-season) players also reported hip and groin function on HAGOS (Figure 2).

### Participants and Recruitment

We aimed to include all elite goalkeepers playing at the highest level of Swedish ice hockey [female: Swedish Women's Hockey League; male (senior): Swedish Hockey League, HockeyAllsvenskan (Allsvenskan); male (junior): J20 SuperElit]. We invited all goalkeepers in the respective leagues ( $n = 128$ ) to participate in the study. Invited goalkeepers received written information about the study by goalkeeper coaches of the respective clubs and provided their contact information and informed consent.

### Baseline Assessment

In the beginning of the 2017-2018 season, we sent a link for an electronic baseline questionnaire to all participants. The baseline questionnaire collected characteristic information such as anthropometrics, playing level, playing position, years of ice hockey experience, and history of hip and groin problems. Furthermore, participants reported their hip and groin function during the past week on HAGOS.

### In-Season Monitoring of Hip and Groin Problems and Disability

Participating players reported existing hip and groin problems on the OSTRC-O, a valid instrument for the registration of overuse injuries,<sup>6,7</sup> by answering questions specifically referring to their hip and groin status during the 2 previous weeks. The survey consists of 4 questions,

**Question 1**

Have you had any difficulties participating in normal training and competition due to hip and groin problems during the past two weeks?

- Full participation without problems
- Full participation but with problems
- Reduced participation due to problems
- Cannot participate due to problems

**Question 3**

To what extent have hip and groin problems affected your performance during the past two weeks?

- No reduction
- To a minor extent
- To a moderate extent
- To a major extent
- Cannot participate at all

**Question 2**

To what extent have you reduced your training volume due to hip and groin problems during the past two weeks?

- No reduction
- To a minor extent
- To a moderate extent
- To a major extent
- Cannot participate at all

**Question 4**

To what extent have you experienced hip and groin pain related to your sport during the past two weeks?

- No pain
- Mild pain
- Moderate pain
- Severe pain

**Figure 3.** Oslo Sports Trauma Research Center Overuse Injury Questionnaire for hip and groin problems.

assessing (1) the effect of hip and groin pain on the ability to participate in training and match play, (2) potential reduction in training volume, (3) performance, and (4) pain experience during sport participation<sup>7</sup> (Figure 3). In case of reported problems, we further asked about the onset of hip and groin problems (gradual/sudden; training/match) as well as missed matches or training because of these problems. Finally, we asked players about their exposure to match play and training (including strength training). We distributed the OSTRC-O every second Sunday over the course of the competitive season (17 questionnaires distributed over 34 weeks from September 2017 to May 2018) by text messages (SMS) via a web-platform (Briteback AB). After the regular season, we removed players of teams that did not continue the competitive season from the distribution list, while players participating in relegation or playoff matches as well as the final series kept receiving invitations until their season ended.

The players self-reported any hip and groin disability on the HAGOS. The HAGOS is a reliable and valid instrument for the assessment of hip and groin problems in physically active populations and consists of 37 items, assessing self-reported hip and groin function across 6 subscales: symptoms, pain, function in daily living, function in sport and recreation, participation in physical activity, and quality of life.<sup>23</sup> We administered the HAGOS during the pre-season (September), mid-season (November), and end-season (March). We choose these 3 points in time to reflect the changes in load on players from pre-season, over increased match congestion during mid-season, to the maximal amount of played games toward the end of the regular season.

We defined “all hip and groin problems” by the reporting of at least 1 of the following on the 4 OSTRC-O questions:

(1) full participation or less, but with hip and groin problems; (2) reduction in training volume to any extent; (3) affected performance to any extent; and (4) hip and groin pain experienced in relation to sport participation. “Substantial hip and groin problems” were defined by the reporting of at least 1 of the following answer options to the OSTRC-O questions: (1) moderate or severe reduction in training volume; (2) moderate or severe affected performance; and (3) inability to participate.

We defined hip and groin problems causing at least 1 day of missed participation as “time-loss problems” and those not causing any day(s) of missed training or matches as “non-time-loss problems.” Multiple time-loss problems for the same individual were recorded if these events were separated by at least 2 weeks of full ice hockey participation.

We defined hip and groin problems with gradual onset as “overuse” and problems starting with sudden onset during a single injury event as “acute.” Multiple acute problems in the same location were treated as separate cases if they were separated by at least 2 symptom-free weeks. For acute problems, we asked participants to report whether the problem occurred during training or match play.

### Statistical Analysis

For each 2-week period, we calculated the biweekly prevalence of all, as well as substantial, hip and groin problems. The 95% CIs for proportions ( $p$ ) were computed according to the asymptotic (Wald) method based on a normal approximation as  $p \pm 1.96 \times (p(1-p)/n)$ . The average biweekly prevalence with the corresponding 95% CI was calculated for the first 15 measurement points (because of few participants in the final 2 measurement points).

TABLE 1  
Player Characteristics (N = 101)<sup>a</sup>

	Female (n = 17)	Male (n = 84)
Age, y, mean (SD)	21 (3.9)	22 (4.9)
Height, cm, mean (SD)	170 (6.1)	186 (5.2)
Weight, kg, mean (SD)	68 (5.6)	84 (10.9)
Years of elite ice hockey, median (IQR)	3 (1-7.25)	
Playing level (n = 102)		
Swedish Hockey League, n (%)	22 (21.8)	
Hockey Allsvenskan, n (%)	23 (22.5)	
J20 SuperElit, n (%)	39 (38.6)	
Swedish Women's Hockey League, n (%)	17 (16.8)	
Hip and groin problems during previous season		
Nontime loss, n (%)	55 (54.5)	
Symptom duration, wk, median (IQR)	2 (1-3.5)	
Time loss, n (%)	28 (27.7)	
Duration of time loss, wk, median (IQR)	1.75 (1-3)	

<sup>a</sup>IQR, interquartile range.

The cumulative incidence for all, as well as substantial, hip and groin problems was calculated for a closed cohort of players who participated in at least 13 of 17 measurement points (n = 83). The injury incidence rate (IR) of acute groin injuries, as well as for “time-loss events,” in relation to 1000 athlete-exposures (number of matches and training sessions) was calculated, with 95% CIs computed by normal approximation to the Poisson distribution.

We used univariate analyses of variance (ANOVAs) to analyze differences in HAGOS results between affected and nonaffected players, at the 3 time points over the season. Age was included as covariate in the model, but since it had no independent effect ( $P \geq .25$ ) or effect on the estimated difference between affected and nonaffected players, it was not included in the final and reported models. Changes in HAGOS results over the season (between pre-, mid-, and end-season) was analyzed through repeated-measures ANOVA. All data were analyzed using SPSS Statistics 23 (IBM). Significance level was set at  $P < .05$ .

## RESULTS

### Response Rate

Of the 128 goalkeepers providing their contact information, 101 (79%) responded to the baseline survey and 118 (92%) responded to the OSTRC-O at least once during the season. Player characteristics are presented in Table 1. The mean response rate to the OSTRC-O sent out every second week was 76% (minimum, 45%; maximum, 89%). During the regular season (September to March [survey distributions 1-13]), the survey was sent to all 128 participating players. In the postseason (March to April), the last 4 survey distributions were sent to players remaining in the competitive play (distribution 14: n = 126, distribution 15: n = 62, distribution 16: n = 29; distribution 17: n = 4). HAGOS

results in pre-, mid-, and end-season was obtained from 87 (68%), 88 (69%), and 81 (63%) players, respectively.

### Hip and Groin Problems

Over the course of the season, a total of 413 problem reports were recorded, among which 145 were reports of “substantial hip and groin problems.” The mean biweekly prevalence of “all hip and groin problems” among elite goalkeepers in Sweden was 28.1% (95% CI, 25.0%-31.3%). The mean biweekly prevalence of “substantial hip and groin problems” was 10% (95% CI, 8.7%-11.4%) (Figure 4). Hip and groin problems were prevalent from the beginning of the season (all problems: 27%; substantial problems: 11%). The cumulative incidence was 69% (95% CI, 59%-79%) for all hip and groin problems and 36% (95% CI, 26%-46%) for substantial hip and groin problems.

### Time-Loss Problems

Over the course of the season, 30 separate time-loss events (IR, 1.2 [95% CI 0.8%-1.7%]/1000 athlete-exposures) occurred. Time loss was reported for 15.5% of reports of “all hip and groin problems” and 40.7% of reports of “substantial hip and groin problems.”

### Acute and Overuse Problems

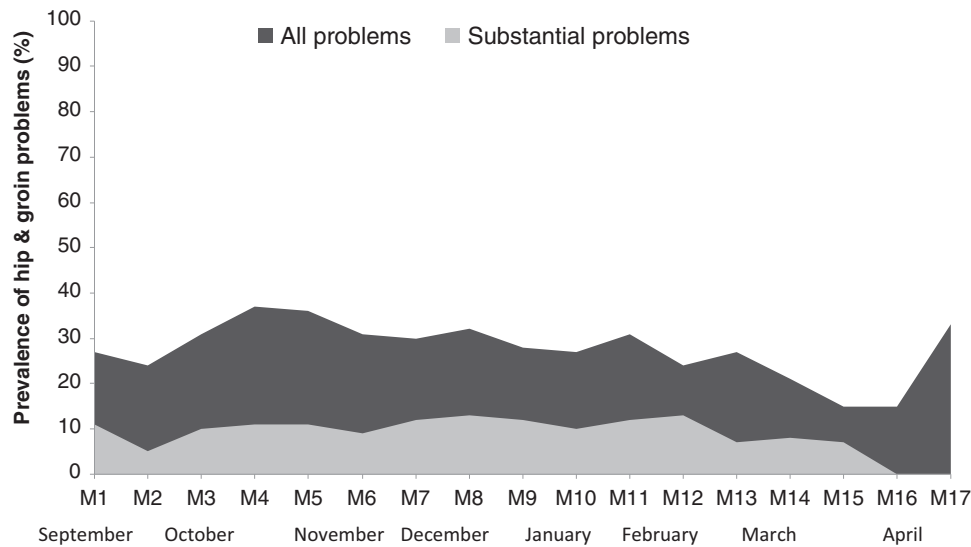
A total of 51 separate acute problems (IR, 2.1 [95% CI, 1.5%-2.7%]/1000 athlete-exposures) and 80 separate overuse problems were reported. Among reports of “all hip and groin problems,” 16.9% were acute and 83.1% were overuse, whereas among reports of “substantial hip and groin problems,” 17.9% were acute and 82.1% were overuse. In total, 43% of the acute problems occurred during match play (IR, 7.2 [95% CI, 4.2%-10.3%]/1000 match exposures) and 57% occurred during training (IR, 1.4 [95% CI, 0.9%-1.9%]/1000 training exposures).

### Self-Reported Disability Throughout the Season and Relation to Reported Problems

Changes in the HAGOS between pre-, mid-, and end-season were observed to be minimal and insignificant (mean difference, 0.3-2.5 points;  $P \geq .053$ ) except for the subscale pain between mid- and end-season where a statistically significant reduction in pain was observed (mean difference, 2.4 points;  $P = .004$ ) (Figure 5). At all the 3 measurement points, players reporting “all hip and groin problems” or “substantial hip and groin problems” on the OSTRC-O had significantly worse HAGOS results than players without such problems ( $P < .01$ ) (Figure 4).

## DISCUSSION

Over the course of a competitive season, 69% of elite goalkeepers in this study experienced at least 1 episode of hip and groin problems and 36% experienced at least 1 episode of substantial problems affecting their performance,



**Figure 4.** Prevalence of all hip and groin problems (dark gray) and substantial hip and groin problems (light gray) at all 17 surveillance measurement (M) points.

training volume, or ability to play ice hockey. During any given 2-week interval, an average of 28% reported suffering from hip and groin problems and 10% reported suffering from substantial problems. Overuse problems represented 83% of all reported problems. Players reporting to have problems on the OSTRC-O also reported reduced hip and groin function on the HAGOS.

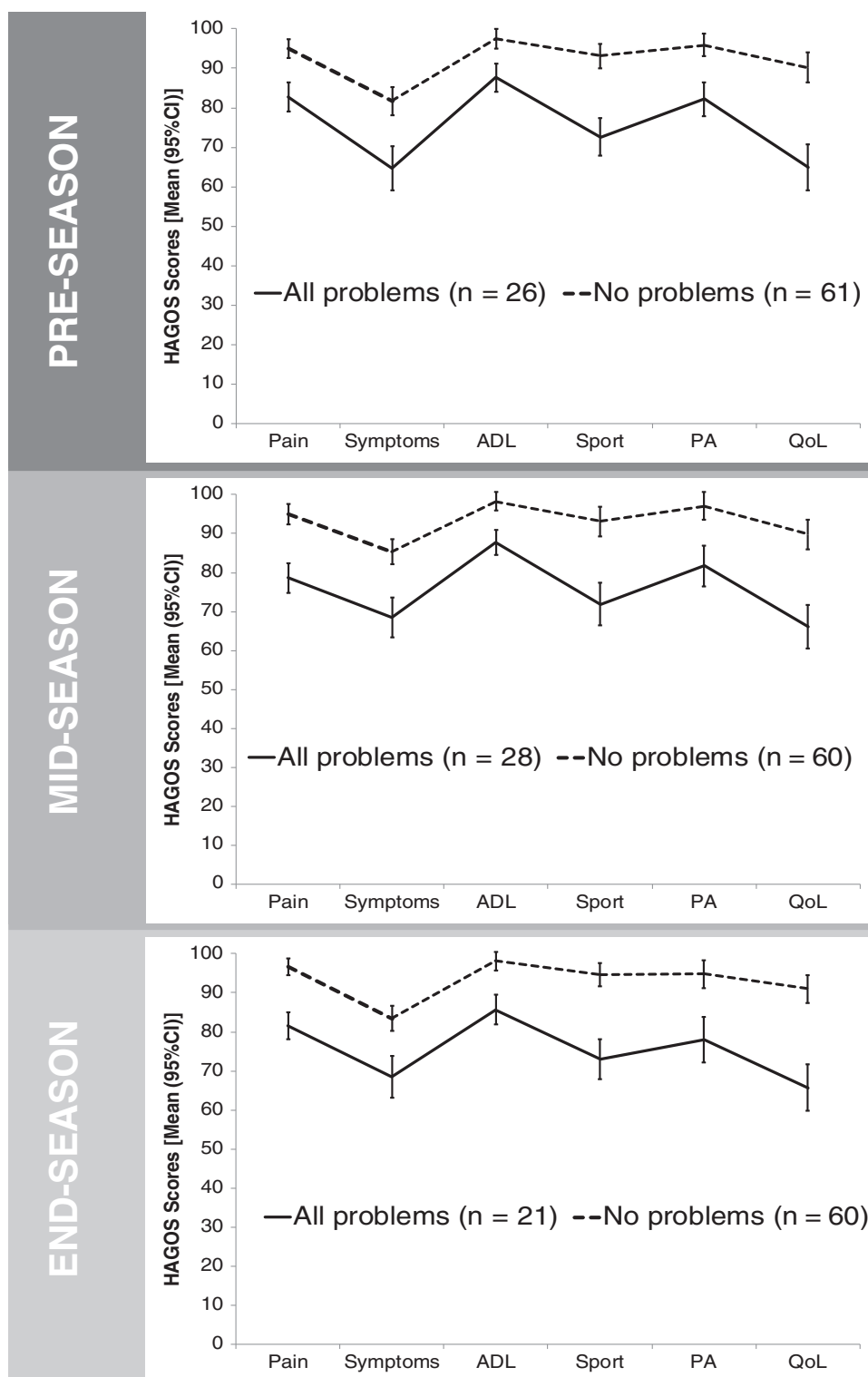
An elite ice hockey team can expect about 2 hip and groin time-loss injuries per season.<sup>10</sup> According to our data, a full squad of goalkeepers (25 players) could expect more than 9 players to experience substantial hip and groin problems per season. The reason for this marked difference likely lies within the definition of an injury or problem. Considering only acute injuries, goalkeepers in our study were hurt at similar rates to those of goalkeepers in previous reports.<sup>11</sup> Once we looked beyond acute problems and considered all reported complaints relevant, the gap widened between our results and those of previous studies. In contrast to previous research, which counts time-loss and medical attention injuries,<sup>8,10,11,25</sup> we counted all problems reported by the players, thereby capturing a broader range of problems.<sup>5</sup> Besides observing our players longitudinally and counting problems along the way, we also provide another perspective of the injury landscape by reporting the average prevalence of problems, including functional consequences (OSTRC-O) for the players.

During any given 2-week interval throughout the season, 28% of elite goalkeepers experienced hip and groin problems and 10% experienced substantial problems. Of all reported problems, 4 in 5 were because of overuse and just 15% led to time loss. Thus, a large proportion of ice hockey goalkeepers are playing despite hip and groin pain. Harøy et al<sup>14</sup> found a similar prevalence of self-reported hip and groin problems in a cohort of soccer players. In a follow-up study, performing a simple strengthening exercise for the adductors<sup>16</sup> decreased this prevalence by 41%.<sup>15</sup> Therefore, similar primary prevention strategies, aiming to increase

adduction strength in all ice hockey goalkeepers, may be appropriate. However, prevention of groin injuries in ice hockey players has only been tested after identifying certain “at-risk” players. Tyler et al<sup>26</sup> selected players with reduced adduction strength to implement targeted strengthening during the pre-season, which was associated with reduced groin injury risk. Strength training interventions often aim to increase strength during the pre-season and maintain strength gains in-season.<sup>15,28</sup> Our data indicated that the highest prevalence of problems occurs early in the season, as did previous research using the OSTRC-O.<sup>6</sup> The ice hockey year in Sweden is interrupted by a long summer break during which most teams do not practice on ice. It is reasonable to assume that the high prevalence of problems during the pre-season is because of the rapid increase in on-ice practices and matches after a summer without ice hockey. However, the prevalence of hip and groin problems remained high throughout the season, and continuous problems may require continuous attention.

As suggested by Wollin et al<sup>33</sup> in their study on youth soccer players, hip muscle strength and self-reported hip and groin function can be continuously monitored and thereby help clinicians to identify at-risk players early and manage them accordingly. Assessment of strength and self-reported function is time consuming but can be indicated by a rapid field test, recently tested on high-level ice hockey players.<sup>34</sup> This rapid field test, called the “5-second squeeze test,” could serve as a quick initial screen for players who may need hip muscle strengthening or load management.<sup>34</sup>

While it is likely that the effect of hip muscle strengthening on groin problems in soccer players is similar to that in ice hockey players, it is unknown whether it will have the same effect on goalkeepers, who may be more prone to hip problems. Ice hockey goalkeepers repetitively force their hip joints into extreme ROMs,<sup>3,13,30,31</sup> which in many ways resembles loads on the shoulder joints of baseball players. As with ice hockey goalkeepers, baseball pitchers are



**Figure 5.** Differences in self-reported hip and groin function (HAGOS [Hip and Groin Outcome Score]) in pre-, mid-, and end-season between players reporting hip and groin problems on the Oslo Sports Trauma Research Center Overuse Injury Questionnaire and players not reporting hip and groin problems. ADL, activities of daily living; PA, physical activity; QoL, quality of life.

unique athletes because of their highly specialized movement patterns. Because of the association between pitching and shoulder pain in youth players,<sup>19</sup> pitch counts are now quantified and restricted to reduce the total load and risk of overuse injuries.<sup>12</sup> Considering the association between specialized athletic activity in adolescence and development of cam morphology,<sup>1,21</sup> it may be worth applying the same principles in youth ice hockey goalkeepers and keep track on the amount of load their hips are regularly exposed to. Even though the majority of athletes with cam morphology never develop FAI,<sup>18</sup> ice hockey goalkeepers might be more likely to develop symptoms if a hip with cam morphology is repetitively forced into end ROM. Therefore, accounting for total load on a goalkeeper's hip and potential restrictions in specific actions on ice may also be appropriate for adult athletes. Future research should quantify potentially hip compromising movements in ice hockey goalkeepers and investigate their association with hip pain.

Our study included more than 90% of all elite ice hockey goalkeepers in Sweden. We therefore believe our results to be generalizable to goalkeepers at the highest international level of play. There may be some differences in the prevalence of hip and groin problems between the sexes,<sup>8</sup> but because of the low number of female athletes included in this study, no subgroup analysis was performed. With an average response rate of 76% to the OSTRC-O throughout the season, it has to be acknowledged that the accuracy of our prevalence estimates may have been affected. It is possible that players with hip problems were more likely to complete the survey or vice versa. Hip and groin problems often have gradual onset without leading to time loss,<sup>17</sup> and an "all complaint" definition of problems captures these problems.<sup>5,14</sup> Such a definition has, however, been found prone to bias if reporting is performed by third parties.<sup>5,32</sup> Nevertheless, our data are based on self-reports from players on the OSTRC-O. The OSTRC-O describes the effect of groin problems on players' ice hockey participation, training volume, performance, and symptoms, but it can be argued that the threshold for considering a report to be a problem may be too low. However, we found that players reporting "any problem" on the OSTRC-O had significantly more hip and groin disability according to the HAGOS than nonaffected players ( $P < .01$ ). Therefore, even though a player may report full participation with minor effect on training volume, performance, and mild pain, hip and groin function may be significantly impaired.

We chose to administer the OSTRC-O every other week instead of every week to keep the administrative load on players as low as possible and thereby maintain high response rates. Sports injuries have shown to be accurately reported by patients even over recall periods of 4 weeks,<sup>27</sup> so we consider 2 weeks to be short enough to allow for an accurate recall of physical complaints. The recall of hip and groin problems during the previous season may be less accurate. Our definition of exposure did not include actual time on ice, which may reduce specificity of the IR estimates. Prevalence and measures of functional limitations are, however, not directly affected by specific exposure. We cannot make any conclusions about the potential anatomic sources of the players' complaints, as logistical constraints

precluded us from classifying reported symptoms according to the Doha agreement.<sup>29</sup> Future studies should aim to use consensus classification to describe the nature of hip and groin problems in ice hockey players and thereby improve our understanding of the underlying causes and aid specific targeting of appropriate intervention strategies.

## CONCLUSION

Hip and groin problems are highly prevalent in elite ice hockey goalkeepers. During a competitive season, 69% of players experienced hip and groin problems and 36% of players suffered from substantial problems. During any given 2-week interval, an average of 28% reported suffering from hip and groin problems and 10% reported suffering from substantial problems. More than 80% of all reported problems were because of overuse, and time loss was uncommon. Reporting of hip and groin problems on the OSTRC-O was associated with significant reporting of hip and groin disability on the HAGOS.

## ACKNOWLEDGMENT

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## REFERENCES

1. Agricola R, Heijboer MP, Ginai AZ, et al. A cam deformity is gradually acquired during skeletal maturation in adolescent and young male soccer players: a prospective study with minimum 2-year follow-up. *Am J Sports Med.* 2014;42(4):798-806.
2. Bahr R. No injuries, but plenty of pain? On the methodology for recording overuse symptoms in sports. *Br J Sports Med.* 2009; 43(13):966-972.
3. Bell GJ, Snyder Miller GD, Game AB. An investigation of the type and frequency of movement patterns of National Hockey League goaltenders. *Int J Sports Physiol Perform.* 2008;3(1):80-87.
4. Bolling C, Delfino Barboza S, van Mechelen W, Pasman H. How elite athletes, coaches, and physiotherapists perceive a sports injury. *Translational Sports Medicine.* 2019;2(1):17-23.
5. Clarsen B, Bahr R. Matching the choice of injury/illness definition to study setting, purpose and design: one size does not fit all! *Br J Sports Med.* 2014;48(7):510-512.
6. Clarsen B, Bahr R, Heymans MW, et al. The prevalence and impact of overuse injuries in five Norwegian sports: application of a new surveillance method. *Scand J Med Sci Sports.* 2015;25(3):323-330.
7. Clarsen B, Myklebust G, Bahr R. Development and validation of a new method for the registration of overuse injuries in sports injury epidemiology: the Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire. *Br J Sports Med.* 2013;47(8):495-502.
8. Dalton SL, Zupon AB, Gardner EC, Djoko A, Dompier TP, Kerr ZY. The epidemiology of hip/groin injuries in National Collegiate Athletic Association men's and women's ice hockey: 2009-2010 through 2014-2015 academic years. *Orthop J Sports Med.* 2016;4(3): 2325967116632692.
9. Eckard TG, Padua DA, Dompier TP, Dalton SL, Thorborg K, Kerr ZY. Epidemiology of hip flexor and hip adductor strains in National Collegiate Athletic Association athletes, 2009/2010-2014/2015. *Am J Sports Med.* 2017;45(12):2713-2722.



10. Emery CA, Meeuwisse WH, Powell JW. Groin and abdominal strain injuries in the National Hockey League. *Clin J Sport Med.* 1999;9(3):151-156.
11. Epstein DM, McHugh M, Yorio M, Neri B. Intra-articular hip injuries in National Hockey League players: a descriptive epidemiological study. *Am J Sports Med.* 2013;41(2):343-348.
12. Feeley BT, Schisel J, Agel J. Pitch counts in youth baseball and softball: a historical review. *Clin J Sport Med.* 2018;28(4):401-405.
13. Frayne RJ, Kelleher LK, Wegscheider PK, Dickey JP. Development and verification of a protocol to quantify hip joint kinematics: an evaluation of ice hockey goaltender pads on hip motion. *Am J Sports Med.* 2015;43(9):2157-2163.
14. Harøy J, Clarsen B, Thorborg K, Holmich P, Bahr R, Andersen TE. Groin problems in male soccer players are more common than previously reported. *Am J Sports Med.* 2017;45(6):1304-1308.
15. Harøy J, Clarsen B, Wiger EG, et al. The adductor strengthening programme prevents groin problems among male football players: a cluster-randomised controlled trial. *Br J Sports Med.* 2019;53(3):150-157.
16. 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.
17. Kerbel YE, Smith CM, Prodrogo JP, Nzeogu MI, Mulcahey MK. Epidemiology of hip and groin injuries in collegiate athletes in the United States. *Orthop J Sports Med.* 2018;6(5):2325967118771676.
18. Lerebours F, Robertson W, Neri B, Schulz B, Youm T, Limpisvasti O. Prevalence of cam-type morphology in elite ice hockey players. *Am J Sports Med.* 2016;44(4):1024-1030.
19. Lyman S, Fleisig GS, Andrews JR, Osinski ED. Effect of pitch type, pitch count, and pitching mechanics on risk of elbow and shoulder pain in youth baseball pitchers. *Am J Sports Med.* 2002;30(4):463-468.
20. MacIntyre K, Gomes B, MacKenzie S, D'Angelo K. Conservative management of an elite ice hockey goaltender with femoroacetabular impingement (FAI): a case report. *J Can Chiropr Assoc.* 2015;59(4):398-409.
21. Palmer A, Fernquest S, Gimpel M, et al. Physical activity during adolescence and the development of cam morphology: a cross-sectional cohort study of 210 individuals. *Br J Sports Med.* 2018;52(9):601-610.
22. Pierce CM, LaPrade RF, Wahoff M, O'Brien L, Philippon MJ. Ice hockey goaltender rehabilitation, including on-ice progression, after arthroscopic hip surgery for femoroacetabular impingement. *J Orthop Sports Phys Ther.* 2013;43(3):129-141.
23. Thorborg K, Holmich P, Christensen R, Petersen J, Roos EM. 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.
24. Tramer JS, Deneweth JM, Whiteside D, Ross JR, Bedi A, Goulet GC. On-ice functional assessment of an elite ice hockey goaltender after treatment for femoroacetabular impingement. *Sports Health.* 2015;7(6):542-547.
25. Tuominen M, Stuart MJ, Aubry M, Kannus P, Parkkari J. Injuries in men's international ice hockey: a 7-year study of the International Ice Hockey Federation Adult World Championship Tournaments and Olympic Winter Games. *Br J Sports Med.* 2015;49(1):30-36.
26. 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.
27. Valuri G, Stevenson M, Finch C, Hamer P, Elliott B. The validity of a four week self-recall of sports injuries. *Inj Prev.* 2005;11(3):135-137.
28. van der Horst N, Smits DW, Petersen J, Goedhart EA, Backx FJ. The preventive effect of the Nordic hamstring exercise on hamstring injuries in amateur soccer players: a randomized controlled trial. *Am J Sports Med.* 2015;43(6):1316-1323.
29. 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.
30. Whiteside D, Deneweth JM, Bedi A, Zernicke RF, Goulet GC. Femoroacetabular impingement in elite ice hockey goaltenders: etiological implications of on-ice hip mechanics. *Am J Sports Med.* 2015;43(7):1689-1697.
31. Wijdicks CA, Philippon MJ, Civitarese DM, LaPrade RF. A mandated change in goalie pad width has no effect on ice hockey goaltender hip kinematics. *Clin J Sport Med.* 2014;24(5):403-408.
32. Wik EH, Materne O, Chamari K, et al. Involving research-invested clinicians in data collection affects injury incidence in youth football. *Scand J Med Sci Sports.* 2019;29(7):1031-1039.
33. Wollin M, Thorborg K, Welvaert M, Pizzari T. 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. *J Sci Med Sport.* 2018;21(10):988-993.
34. Worner T, Thorborg K, Eek F. 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.* 2019;7(2):2325967119825858.