

# Intra-articular Hip Injuries in National Hockey League Players

## A Descriptive Epidemiological Study

David M. Epstein,<sup>\*†</sup> MD, Malachy McHugh,<sup>‡</sup> PhD, Michael Yorio,<sup>§</sup> MD, and Brian Neri,<sup>§</sup> MD  
*Investigation performed at the Department of Orthopedic Surgery, Lenox Hill Hospital, New York, New York*

**Background:** Intra-articular hip injuries are thought to be common in professional ice hockey; however, injury incidence and missed playing time have not been previously documented. Furthermore, it is not known if injury incidence differs between player positions.

**Hypothesis:** The incidence of symptomatic intra-articular hip injuries in goaltenders is higher than that of other position players.

**Study Design:** Cohort study; Level of evidence, 3.

**Methods:** A database containing the injury surveillance of National Hockey League (NHL) players from the years 2006 to 2010 was used to identify athletes who had sustained a hip or groin injury. From this database, players diagnosed with an intra-articular hip injury were identified. The incidence of intra-articular hip injuries per 1000 player-hours played and per 1000 player-game appearances was compared between goaltenders, defensemen, and forwards.

**Results:** Ninety-four hip injuries, accounting for 10.6% (94/890) of all hip and groin injuries, were identified as intra-articular in nature during the time of the surveillance. Most injuries occurred during the regular season (71.2%; 67/94) and during a game (44.6%; 42/94). Players who sustained intra-articular hip injuries had significantly higher total man-games missed compared with those with all other groin injuries (mean  $\pm$  SD, 8.5  $\pm$  23.0 vs 1.2  $\pm$  4.2 missed games;  $P = .0001$ ). The most frequent intra-articular hip diagnoses made in this cohort were hip labral tear (69.1%), followed by hip osteoarthritis (13.8%), hip loose body (6.3%), and hip femoroacetabular impingement (5.3%). The incidence of intra-articular hip injuries per 1000 player-game hours was not different between goaltenders (1.97) and other on-ice players (defensemen, 1.43; forwards, 1.38) (relative risk [RR], 1.40; 95% CI, 0.86-1.40;  $P = .22$ ). However, injuries per 1000 player-game appearances were significantly higher in goaltenders (1.84) compared with other on-ice players (defensemen, 0.47; forwards, 0.34) (RR, 4.78; 95% CI, 2.94-7.76;  $P < .0001$ ).

**Conclusion:** Hip labral tears are the most frequently encountered intra-articular hip injury in the NHL player and can lead to an average of 8 man-games missed per injury. Goaltenders were not at higher risk when measuring injuries per hours played but were at significantly greater risk of an intra-articular hip injury than other on-ice players (RR, 4.7) when measured per game played.

**Keywords:** intra-articular; hip injury; hockey; goaltenders

There have been several reports in the published literature regarding intra-articular hip disorders in hockey players; however, the incidence of intra-articular hip injuries in this population has not been defined.<sup>4,14,21,23,26</sup> Hip and groin injuries in the United States National Hockey League (NHL) are a major cause of morbidity, with a cumulative incidence rate of 19.87 injuries per 100 players per

year.<sup>6</sup> As the popularity of ice hockey continues to grow, an increasing number of young athletes will be at risk for intra-articular hip injuries, which can affect the quality and duration of their playing career.<sup>1</sup>

Complex forces across the soft tissue and bony structures of the hip joint are responsible for the acceleration and deceleration phases of skating.<sup>27,29</sup> Skating requires hip extension and abduction of the lower extremity, with the hip flexors and adductors stabilizing the hip and decelerating the limb.<sup>31</sup> This combination of factors can result in a significant increase in injuries in particular positions within hockey.<sup>35</sup> Position players (forwards and defensemen), during the skating stride and with starting and stopping, place repetitive stresses on the hip. This ranges from an abducted and externally rotated position to a flexed and internally rotated position, both of which can place the hip at risk for femoroacetabular impingement (FAI).<sup>23,28</sup> Contrary to position players, goaltenders often require extreme hip flexion and internal rotation, particularly when using a butterfly-type technique. Goaltending is a highly

\*Address correspondence to David M. Epstein, MD, Tri-County Orthopedics & Sports Medicine, 160 East Hanover Avenue, Morristown, NJ 07962 (e-mail: drdeps@gmail.com).

†Tri-County Orthopedics & Sports Medicine, Morristown, New Jersey.

‡Nicholas Institute of Sports Medicine and Athletic Trauma, New York, New York.

§ProHealth Care Associates, Lake Success, New York.

The authors declared that they have no conflicts of interest in the authorship and publication of this contribution.

specialized position, with most goaltenders using 1 of 2 different types of goaltending techniques. The oldest goaltending technique, used widely in the NHL until the late 1960s, is known as the stand-up style, where the majority of saves are made standing up. In the modern era, the majority of goaltenders have adopted a variation of the butterfly technique known as the proflly technique or a hybrid style of play. This technique maximizes the amount of body blocking the net, with goalies adopting a wide and low stance. Goaltenders using the butterfly technique drop to the knee and internally rotate the hip 90° so that the lower extremity padding is parallel to the ice. This can result in repetitive internal rotation of the hip with axial loading as padding over the knee makes contact with the ice. This style requires technical agility and quick reaction times and allows for a greater coverage of the bottom half of the net when making saves.

When the clinician is faced with hip and groin injuries in the skating athlete, the differential diagnosis is broad and includes hip flexor or adductor sprain, osteitis pubis, sports hernia, FAI, labral tear, femoral neck stress fracture, degenerative arthritis, hernia, and referred pain from testicular or genitourinary abnormalities.<sup>2,15</sup> Femoroacetabular impingement, abnormal bony morphology of the hip joint resulting in abutment of the femoral head-neck junction against the acetabular rim, is thought to be the primary underlying cause of intra-articular hip lesions in the professional ice hockey player.<sup>23</sup> These bony lesions, referred to as cam or pincer lesions, can develop secondary to repetitive hip stresses and are a major cause of chondrolabral dysfunction.<sup>3</sup> Labral tears may result from FAI or from other causes such as traumatic injury, hip instability, or structural derangement.<sup>16,22</sup> The near-term implications of FAI in the athlete are pain, disability, and missed participation in sport, while long-term implications include possible progression to osteoarthritis of the hip.<sup>3,7,13,23,25,33</sup> Recently, the arthroscopic treatment of intra-articular lesions has allowed both improved diagnosis and treatment of these injuries.<sup>21,23</sup> After surgical management of FAI, 60% to 100% of professional hockey players will return to their previous level of competition, with those undergoing arthroscopic treatment more likely to return.<sup>4,21,23</sup> Philippon and colleagues<sup>23</sup> recently showed that the treatment of FAI and labral lesions in professional hockey players resulted in successful outcomes, with high patient satisfaction and a prompt return to sport. Another, less common, cause of intra-articular hip injuries is structural instability, which is often associated with acetabular dysplasia. This subtle instability is thought to result in excessive shearing forces placed on the acetabular cartilage and labrum, which can lead to chondrolabral dysfunction.<sup>17</sup>

Radiographic studies have demonstrated a high prevalence of hip and groin abnormalities even in asymptomatic college and professional hockey players, with up to 64% of players having evidence of intra-articular hip lesions on magnetic resonance imaging (MRI).<sup>26</sup> Although these players were not found to have any symptomatic injuries, this study suggests that the true incidence of injuries in this patient population, as well as other athletic patient populations, may be underappreciated.<sup>8-11</sup> To identify certain

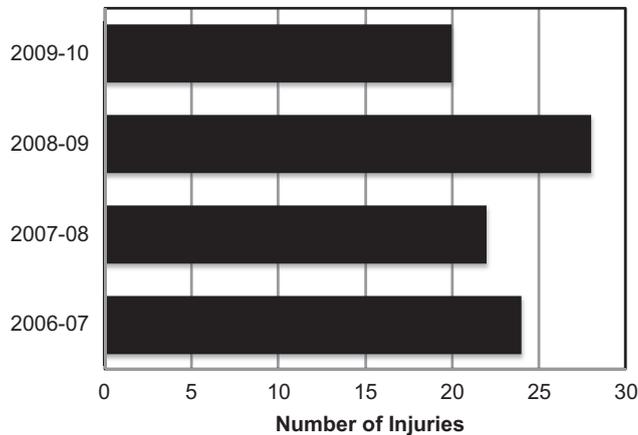
players at risk for symptomatic injuries, it is important to first determine the incidence of intra-articular hip injuries in NHL players. Thus, the purpose of this study was to document the incidence of intra-articular hip injuries in the NHL and compare the injury incidence between players at different positions. This study was undertaken to determine the incidence of intra-articular hip injuries in NHL players. We hypothesized that the incidence of symptomatic intra-articular hip injuries in goaltenders is higher than that of other position players secondary to the technical demands of the position and increased time on the ice during games.

## MATERIALS AND METHODS

The NHL conducts injury surveillance using Sutton Medical Systems' Athlete Health Management System (AHMS). This system contains injury data regarding players on all NHL member clubs. All injuries requiring evaluation and treatment, regardless of whether the player missed time in practice or game participation, are entered into the database by each team's athletic trainer or physician. These data are available in deidentified form for analysis by the league office and club representatives (including club physicians). Before undertaking this study, Institutional Review Board approval was granted by Hofstra University's Human Subjects Committee. Additionally, the NHL Team Physicians Society formed a working group to investigate intra-articular hip injuries in NHL players that was chaired by the senior author (B.N.).

The data extracted from the AHMS included deidentified data for all NHL player hip and groin injuries from all NHL teams from the 2006-2010 seasons. From this database, those players who sustained an intra-articular hip injury were further classified based on the diagnosis of a hip labral tear, FAI, osteoarthritis, chondromalacia, loose body, or other hip injury. Diagnoses were made in conjunction with team physicians based on a thorough history and physical examination along with appropriate imaging when necessary. Player demographic data, including player position and player age, were documented. Additionally, injury-related data, such as side of injury, session (practice vs game) during injury, time of season when injury occurred, regular-season games missed, total man-games missed, and days missed to injury, were analyzed.

Using publicly available data from the NHL website (<http://www.NHL.com>), total time on ice and total game-hours played by each position player (goaltenders/forwards/defensemen) per season were calculated. The NHL records time on ice for all players in all games for each season. Data for the last 14 seasons are available on the NHL website and can be sorted by player position. We determined the injury incidence per 1000 player-game hours that was specific to each position played. This was calculated as a cumulative incidence over the 4 years during which we had injury data. Additionally, to account for goaltenders' longer periods of low-intensity (relative inactivity compared with other position players) on-ice time per game than other position players, injury incidence was calculated per 1000 player-game appearances.



**Figure 1.** The number of intra-articular hip injuries each year.

Differences in the incidences between groups were tested by the  $\chi^2$  test. Injury incidence is reported as injuries per 1000 player-game hours and per 1000 player-game appearances with 95% confidence intervals (CIs).

## RESULTS

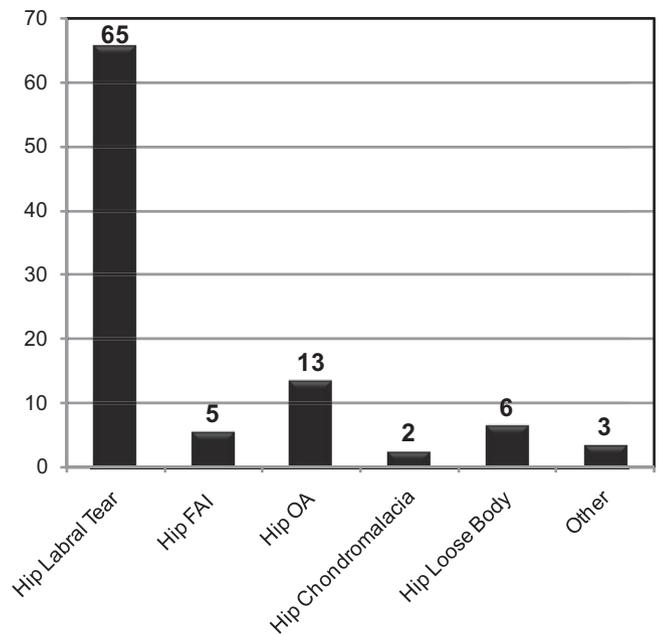
From 2006 to 2010, a total of 1441 players participated in at least 1 game (138 goaltenders, 859 forwards, 444 defensemen). A total of 890 hip or groin injuries were sustained over the 4 seasons analyzed. Ninety-four of these athletes were identified as sustaining an intra-articular hip injury during the time of our surveillance (incidence proportion, 6.5% over 4 seasons), accounting for 10.6% (94/890) of all hip and groin injuries.

The number of reported intra-articular injuries varied from year to year over the study period, with an average prevalence of 23.5 injuries per year (Figure 1). The majority of injuries occurred during the regular season (71.2%), followed by the postseason (13.8%), offseason (7.5%), and pre-season (7.5%). The majority of injuries were sustained during a game (44.6%) or practice (41.4%), with the remainder occurring during off-ice or non-hockey-related activity.

The most frequent intra-articular hip diagnosis made in this cohort was hip labral tear (69.1%), followed by hip osteoarthritis (13.8%), hip loose body (6.3%), hip FAI (5.3%), other hip injury (3.1%), and hip chondromalacia (2.12%) (Figure 2).

During the 4 seasons reviewed, 21 injuries occurred among 138 goaltenders (15.2%) compared with 30 injuries among 444 defensemen (6.8%) and 43 injuries among 859 forwards (5.0%). This was a significantly higher proportion for goaltenders versus other players ( $P < .0001$ ).

The overall incidence rate for intra-articular hip injuries among all positions was 1.81 per 1000 player-game hours. The incidence of intra-articular hip injuries per 1000 player-game hours was not different between goaltenders (1.97; 95% CI, 1.30-3.02) and other on-ice players (defensemen: 1.43; 95% CI, 1.00-2.03; forwards: 1.38; 95% CI, 1.04-1.88) ( $P = .22$ ). However, because goaltenders are typically on ice for the full duration of a game while other players



**Figure 2.** The number of intra-articular hip injuries by diagnosis. FAI, femoroacetabular impingement; OA, osteoarthritis.

are only on ice for a proportion of the game, we chose to also examine injury incidence per game exposure. For example, a goaltender who is on the ice for a whole game will be recorded as having the same exposure (1 game) as a forward who was on ice for only 5 minutes of the same game. Injuries per 1000 player-game appearances were significantly higher in goaltenders (1.84; 95% CI, 1.21-2.82) compared with other on-ice players (defensemen: 0.47; 95% CI, 0.33-0.67; forwards: 0.34; 95% CI, 0.26-0.46) ( $P < .0001$ ).

There was a significant difference in age between players with an intra-articular hip injury compared with those with all other groin injuries (mean  $\pm$  standard deviation, 32.0  $\pm$  5.1 vs 30.6  $\pm$  4.8 y;  $P = .008$ ). Those players who sustained intra-articular hip injuries had significantly higher total man-games missed compared with those with all other groin injuries (8.5  $\pm$  23.0 vs 1.2  $\pm$  4.2 man-games lost;  $P = .0001$ ). Additionally, there was a significant difference in overall days missed between players with an intra-articular hip injury and those with all other groin injuries (43.2  $\pm$  16.5 vs 7.0  $\pm$  27.7 days missed;  $P = .0001$ ) (Table 1).

## DISCUSSION

The purpose of our study was to determine if hockey player position is a risk factor for intra-articular hip injuries. Several studies looking at the overall injury rate in elite-level hockey players found that the forward position was the most frequently injured. Molsa and colleagues,<sup>18</sup> in a prospective study of ice hockey injuries in elite Finnish hockey teams, found that there was an overall risk of injury of 66 injuries per 1000 player-game hours. The authors also found that forwards accounted for 54.5% of players injured, followed by defenders (31.2%) and goaltenders (5.8%). Agel

TABLE 1  
Relative Risk for Sustaining Intra-articular Hip  
Injuries in Goaltenders Versus Other Position Players  
(Forwards and Defensemen Combined)<sup>a</sup>

	Injuries/ 1000 Hours	Injuries/ 1000 Games
Relative risk	1.40	4.78
95% confidence interval	0.86-2.28	2.94-7.76
P value	.22	.0001

<sup>a</sup>Relative risks and 95% confidence intervals are reported for injuries per 1000 player-hours on ice in National Hockey League games and per 1000 player-game appearances.

et al,<sup>1</sup> in a descriptive epidemiological study of United States National Collegiate Athletic Association men's ice hockey injuries over a 16-year period, used a weighted average to calculate athlete exposures to injury. Similarly, they found that forwards accounted for 48.3% of overall injuries, followed by defensemen (40.8%) and goaltenders (9.6%).<sup>1</sup> These studies, while informative, did not examine the incidence of intra-articular hip injuries, nor did they account for the amount of time spent on ice by each position player. The amount of time spent by each player on the ice is important, as the more time the player is on the ice, the more likely he is exposed to the potential for injury.

Our study is the first that attempts to take into account the total amount of time spent on the ice (and thus exposed to potential injury) by each player position. It was hypothesized that goaltenders would be at increased risk for intra-articular hip injuries because of the extreme demands, forceful hip flexion and internal rotation, that the position requires. Our study found that injuries per 1000 player-game appearances were significantly higher in goaltenders compared with other on-ice players while the incidence of intra-articular hip injuries per 1000 player-game hours was not different between goaltenders and other on-ice players.

We calculated the time on ice statistics using publicly available data published by the NHL and then used those data to calculate injury incidence per 1000 player-game hours. This allowed us to calculate the time on ice data for all players, by position, for each of the 4 seasons studied. This was then combined with our AHMS injury database so that a cumulative incidence of injury for each player position (forward, defense, and goaltender) could be calculated. We thought that to account for the goaltenders' substantially longer on-ice time per game than other players, injury incidence per 1000 player-game appearances would also be useful. This statistic takes into account the relative inactivity (short bursts of high-intensity activity, followed by longer periods of low-intensity activity) of goaltenders as compared with defensemen and forwards. The statistic of injury incidence per 1000 player-game hours in both forwards and defensemen may be comparatively increased because while on the ice, these position players are undergoing constant high-intensity activity. This is in contradistinction to goaltenders, who are relatively idle for longer periods of time on the ice, with intermittent periods of high-intensity activity. The statistic of

injury incidence per 1000 player-game appearances accommodates for this distinction between positions.

Philippon et al,<sup>23</sup> in a review of NHL players undergoing arthroscopic intervention for chondrolabral dysfunction, found that 43% of players in their series were forwards, 32% were defensemen, and 25% were goaltenders. Indeed, our series found that 45.7% of players with intra-articular hip injuries were forwards, 31.9% were defensemen, and 22.3% were goaltenders. This parallels the results found by others in the literature for overall injuries as well as intra-articular injuries.<sup>1,18,23</sup> This confirms that forwards are the most commonly injured players, likely because at any point during the game there are more forwards (n = 3) than defensemen (n = 2) and goalies (n = 1), hence highlighting the importance of determining actual injury incidence to determine true injury risk.

Our results are difficult to compare to the current literature because there does not exist a standard method of calculating the risk of hip injury in the athlete. One common method of measuring the incidence of athletic injury in the hockey population is to calculate the incidence as the number of injuries per 1000 athlete-exposures.<sup>34</sup> For example, in the NHL, the number of athlete-exposures per year would be calculated as the following: the number of games (82) during the regular season × the number of teams in the league (30) × the number of players on each team (20). This method does not take into account any practice exposure to injury. Additionally, it fails to account for the vast differences in on-ice time per game by position. Alternatively, other authors have reported injury incidence as the number of injuries per 100 players per year.<sup>5,6</sup>

Surgical intervention for nonarthritic conditions of the hip in athletes has increased over the past decade, with favorable outcomes allowing the return to the previous level of athletic activity.<sup>12,24</sup> The results of arthroscopic intervention for the treatment of intra-articular hip abnormalities in elite hockey players have been reported. Philippon et al<sup>23</sup> followed 28 professional NHL players over an average of 24 months who underwent arthroscopic labral repair for the treatment of FAI. The authors found that the average time to skating/hockey drills was 3.4 months, with an improvement of the modified Harris hip score from 75 to 95. Two players were reinjured and required additional arthroscopic procedures. It was also noted that the longer the players waited for surgical intervention, the more chondral damage they were noted to have and the longer it took them to return to hockey. Those players who waited more than 1 year after injury to have surgery returned to sport on average 1.1 months later than those who had surgery less than 1 year after injury. This highlights the need for early intervention after injury in the professional hockey player.

A prospective study in the NHL population has the potential to uncover risk factors for injury in this cohort of patients. An effective strategy to prevent injury in hockey players is to first identify the incidence of a specific injury, identify the risk factors for the injury, design interventions aimed at decreasing those risk factors, and then test the effectiveness of the proposed intervention at reducing the incidence of injury.<sup>32</sup> For example, Tyler et al,<sup>31</sup> in a prospective study of an NHL team, found that players were 17

times more likely to sustain an adductor muscle strain if adductor strength was less than 80% of abductor strength. This information was then used to employ an effective training regimen that was found to decrease the rate of adductor strains.<sup>30</sup> Screening radiographs could be helpful in identifying NHL players at risk for intra-articular injuries. The anatomy of the femoral head-neck junction is defined as abnormal if the  $\alpha$  angle, as described by Notzli et al,<sup>20</sup> is greater than 50°. Philippon et al,<sup>23</sup> in a study of 28 NHL players requiring arthroscopic hip surgery for intra-articular lesions, found that all players had evidence of cam impingement ( $\alpha$  angle >50°), with an average  $\alpha$  angle of 80° (69°-96°). Additionally, 85% of patients had radiographic evidence of pincer impingement on anteroposterior pelvis radiographs. Nepple and colleagues,<sup>19</sup> using multivariate analysis, found that several clinical and radiographic characteristics such as male sex, increasing age, Tonnis grade 1 or 2, and  $\alpha$  angle >50° were associated with at least a 3 times greater risk of severe intra-articular hip disease (grade 3 or 4 chondromalacia). The vast majority of professional hockey players are male, with the average  $\alpha$  angle in elite hockey players being abnormal.<sup>23,26</sup> These factors, combined with the mechanical repetitive nature of skating, and the high-energy collisions in professional ice hockey, put players at risk for intra-articular hip injuries. A preventative screening program would identify patients with clinical characteristics and radiographic hip morphological parameters that may identify them as being at risk for intra-articular hip injuries.

While screening radiographs may be helpful, an MRI examination may not be effective as a screening tool. Silvis et al<sup>26</sup> found that MRI findings of common adductor-abdominal rectus dysfunction and hip disorders are frequently observed in high-performance hockey players in the absence of clinical symptoms. The possibility exists that these findings could be indicative of cumulative tissue damage that occurs before the onset of symptoms. Furthermore, an MRI examination of each NHL player would impart a tremendous cost on the system.

The average age of players in our cohort who sustained an intra-articular injury was  $32.0 \pm 5.1$  years. This was significantly older than those who sustained other groin injuries. Prior studies in this patient population have found that older age was negatively correlated with the number of games played after surgical intervention for intra-articular hip injuries, although no association between time to return to play and age or functional outcome was identified.<sup>23</sup>

The time missed in sports participation because of this injury is significant, which can be frustrating to athletes, coaches, athletic trainers, and physicians. Emery et al,<sup>6</sup> in a retrospective epidemiological study, reported on a total of 617 groin/abdominal strain injuries in the NHL population over 6 seasons of play. The majority of injuries reported were adductor groin muscle strains. Mean time loss due to injury was significantly greater for abdominal injuries (10.59 sessions) than for groin injuries (6.59 sessions). The authors suggest that a conservative estimate of the effect of groin/abdominal injuries on each NHL team is a game loss of 25 player-games per year. They

did not differentiate between intra-articular and extra-articular hip injuries. We found that those players who sustained intra-articular hip injuries had significantly higher total man-games missed than those with all other groin injuries ( $8.5 \pm 23.0$  vs  $1.2 \pm 4.2$  man-games lost;  $P = .0001$ ). Additionally, we found a significant increase in overall days missed between players with intra-articular hip lesions compared with those with all other groin injuries ( $43.2 \pm 16.5$  vs  $7.0 \pm 27.7$  days missed;  $P = .0001$ ).

With regard to the type of activity (practice vs game) performed when injured, several studies have found that the rate of injury of overall injuries is increased by 6 to 8 times during a game as compared with practice.<sup>1,6</sup> Our study differs from the published literature, with 44.7% of intra-articular hip injuries occurring during a game, 41.5% occurring during practice, and the rest occurring off-ice or during non-hockey-related activity. This is likely because the majority of injuries in the published literature are muscle strains, which are dependent on different risk factors than are intra-articular hip injuries.

There are several limitations to our study. This study is inherently limited by its retrospective design, although the data were collected prospectively, which limits recall bias. Another limitation of our study is that practice-hours were not included as part of our analysis. Time spent on ice during practice is not data that are included in the AHMS database, nor is it information that is made available to the public. We also did not include recurrent injuries as part of our review, which may have affected the number of games missed. Furthermore, there was a lack of uniformity in player treatments and rehabilitation strategies, which clearly could affect our results in terms of man-games missed. Additionally, the AHMS database is dependent on the head team trainers' and team physicians' understanding of the injury, as they are responsible for all data input and collection. It is possible that errors were made with this data entry and that not all injuries were included in this database. The true incidence of intra-articular hip injuries may have been underestimated secondary to a vague or incorrect preliminary diagnosis being input into the database, only to have a diagnosis of intra-articular hip injury manifest itself after further testing. Additionally, there is considerable overlap between our intra-articular hip diagnoses of FAI and hip labral tear, which often coexist. Although the database did allow for more than 1 diagnosis to be input into the system, only the primary diagnosis was used for this analysis, so the actual incidence of FAI may be higher than as reported in the database. It should be noted that the mechanism of injury was not reliably compiled in the database. No imaging or radiographic studies were reviewed because they are not available in the AHMS database. The treatment of these injuries was not available because the extraction of injury surveillance data does not include any information from the players' medical records.

Lastly, the number of man-games lost because of injury may have been underreported for injuries that happened at the end of the season. Injuries that did not result in missed participation in games may underestimate the total man-games missed for each injury.

In conclusion, hip labral tears are the most frequently encountered intra-articular hip injury in the NHL player

and can lead to a significant amount of man-games missed. Goaltenders have a significantly higher risk of intra-articular hip injuries in this player population as compared with forwards and defensemen when measuring injuries per game played but not if measured per hour played. These findings support future research aiming to identify risk factors for developing intra-articular hip injuries and prevention. Additionally, the information contained in this article should allow physicians and athletic trainers to better counsel athletes and coaches regarding the nature and incidence of these injuries.

## ACKNOWLEDGMENT

The authors thank each of the NHL clubs' athletic trainers and physical therapists who are members of the Professional Hockey Athletic Trainers Society (PHATS) for their tireless work in documenting all injuries in the NHL. They also thank the members of the NHL Team Physicians Society.

## REFERENCES

- Agel J, Dompier TP, Dick R, Marshall SW. Descriptive epidemiology of collegiate men's ice hockey injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train*. 2007;42(2):241-248.
- Anderson K, Strickland SM, Warren R. Hip and groin injuries in athletes. *Am J Sports Med*. 2001;29(4):521-533.
- Beck M, Kalhor M, Leunig M, Ganz R. Hip morphology influences the pattern of damage to the acetabular cartilage: femoroacetabular impingement as a cause of early osteoarthritis of the hip. *J Bone Joint Surg Br*. 2005;87(7):1012-1018.
- Bizzini M, Notzli HP, Maffioletti NA. Femoroacetabular impingement in professional ice hockey players: a case series of 5 athletes after open surgical decompression of the hip. *Am J Sports Med*. 2007;35(11):1955-1959.
- Emery CA, Meeuwisse WH. Risk factors for groin injuries in hockey. *Med Sci Sports Exerc*. 2001;33(9):1423-1433.
- 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.
- Ganz R, Parvizi J, Beck M, Leunig M, Notzli H, Siebenrock KA. Femoroacetabular impingement: a cause for osteoarthritis of the hip. *Clin Orthop Relat Res*. 2003;417:112-120.
- Gerhardt MB, Romero AA, Silvers HJ, Harris DJ, Watanabe D, Mandelbaum BR. The prevalence of radiographic hip abnormalities in elite soccer players. *Am J Sports Med*. 2012;40(3):584-588.
- Hack K, Di Primio G, Rakhra K, Beaulieu PE. Prevalence of cam-type femoroacetabular impingement morphology in asymptomatic volunteers. *J Bone Joint Surg Am*. 2010;92(14):2436-2444.
- Kang AC, Gooding AJ, Coates MH, Goh TD, Armour P, Rietveld J. Computed tomography assessment of hip joints in asymptomatic individuals in relation to femoroacetabular impingement. *Am J Sports Med*. 2010;38(6):1160-1165.
- Kapron AL, Anderson AE, Aoki SK, et al. Radiographic prevalence of femoroacetabular impingement in collegiate football players: AAOS Exhibit Selection. *J Bone Joint Surg Am*. 2011;93(19):e1111(1-10).
- Larson CM, Pierce BR, Giveans MR. Treatment of athletes with symptomatic intra-articular hip pathology and athletic pubalgia/sports hernia: a case series. *Arthroscopy*. 2011;27(6):768-775.
- Leunig M, Ganz R. Femoroacetabular impingement: a common cause of hip complaints leading to arthrosis [in German]. *Unfallchirurg*. 2005;108(1):9-10, 12-17.
- Lorentzon R, Wedren H, Pietila T, Gustavsson B. Injuries in international ice hockey: a prospective, comparative study of injury incidence and injury types in international and Swedish elite ice hockey. *Am J Sports Med*. 1988;16(4):389-391.
- Lynch SA, Renstrom PA. Groin injuries in sport: treatment strategies. *Sports Med*. 1999;28(2):137-144.
- McCarthy J, Barsoum W, Puri L, Lee JA, Murphy S, Cooke P. The role of hip arthroscopy in the elite athlete. *Clin Orthop Relat Res*. 2003;406:71-74.
- McCarthy JC, Lee JA. Acetabular dysplasia: a paradigm of arthroscopic examination of chondral injuries. *Clin Orthop Relat Res*. 2002;405:122-128.
- Molsa J, Airaksinen O, Nasman O, Torstila I. Ice hockey injuries in Finland: a prospective epidemiologic study. *Am J Sports Med*. 1997;25(4):495-499.
- Nepple JJ, Carlisle JC, Nunley RM, Clohisy JC. Clinical and radiographic predictors of intra-articular hip disease in arthroscopy. *Am J Sports Med*. 2011;39(2):296-303.
- Notzli HP, Wyss TF, Stoecklin CH, Schmid MR, Treiber K, Hodler J. The contour of the femoral head-neck junction as a predictor for the risk of anterior impingement. *J Bone Joint Surg Br*. 2002;84(4):556-560.
- Philippon M, Schenker M, Briggs K, Kuppersmith D. Femoroacetabular impingement in 45 professional athletes: associated pathologies and return to sport following arthroscopic decompression. *Knee Surg Sports Traumatol Arthrosc*. 2007;15(7):908-914.
- Philippon MJ, Stubbs AJ, Schenker ML, Maxwell RB, Ganz R, Leunig M. Arthroscopic management of femoroacetabular impingement: osteoplasty technique and literature review. *Am J Sports Med*. 2007;35(9):1571-1580.
- Philippon MJ, Weiss DR, Kuppersmith DA, Briggs KK, Hay CJ. Arthroscopic labral repair and treatment of femoroacetabular impingement in professional hockey players. *Am J Sports Med*. 2010;38(1):99-104.
- Sampson TG. Arthroscopic treatment for chondral lesions of the hip. *Clin Sports Med*. 2011;30(2):331-348.
- Siebenrock KA, Wahab KH, Werlen S, Kalhor M, Leunig M, Ganz R. Abnormal extension of the femoral head epiphysis as a cause of cam impingement. *Clin Orthop Relat Res*. 2004;418:54-60.
- Silvis ML, Mosher TJ, Smetana BS, et al. High prevalence of pelvic and hip magnetic resonance imaging findings in asymptomatic collegiate and professional hockey players. *Am J Sports Med*. 2011;39(4):715-721.
- Sim FH, Chao EY. Injury potential in modern ice hockey. *Am J Sports Med*. 1978;6(6):378-384.
- Stull JD, Philippon MJ, LaPrade RF. "At-risk" positioning and hip biomechanics of the Peewee ice hockey sprint start. *Am J Sports Med*. 2011;39 Suppl:29S-35S.
- Tegner Y, Lorentzon R. Ice hockey injuries: incidence, nature and causes. *Br J Sports Med*. 1991;25(2):87-89.
- 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.
- Tyler TF, Nicholas SJ, Campbell RJ, McHugh MP. The association of hip strength and flexibility with the incidence of adductor muscle strains in professional ice hockey players. *Am J Sports Med*. 2001;29(2):124-128.
- van Mechelen W, Hlobil H, Kemper HC. Incidence, severity, aetiology and prevention of sports injuries: a review of concepts. *Sports Med*. 1992;14(2):82-99.
- Wenger DE, Kendell KR, Miner MR, Trousdale RT. Acetabular labral tears rarely occur in the absence of bony abnormalities. *Clin Orthop Relat Res*. 2004;426:145-150.
- Wennberg RA, Tator CH. National Hockey League reported concussions, 1986-87 to 2001-02. *Can J Neurol Sci*. 2003;30(3):206-209.
- Wright RW, Barile RJ, Surprenant DA, Matava MJ. Ankle syndesmosis sprains in National Hockey League players. *Am J Sports Med*. 2004;32(8):1941-1945.