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Szukics, Patrick F; Otlans, Peters T; Arevalo, Alfonso; Meade, Matthew; DeLuca, Peter; and Salvo, John P, "A Scoping Review of Injuries in Amateur and Professional Men's Ice Hockey." (2022). *Orthopedic Surgery Resident Research*. 62.

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A Scoping Review of Injuries in Amateur and Professional Men's Ice Hockey

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Investigation performed at Rowan University School of Osteopathic Medicine, Stratford, New Jersey, USA

Background: Orthopaedic injuries are common in ice hockey at all levels and can result in physical and psychological adverse effects on these athletes.

Purpose: Primarily, to summarize published data on orthopaedic hockey injuries at the junior through professional level. Secondly, to characterize the literature based on anatomic site injured, return-to-play rates, cause/mechanism of injury, time lost, and treatments used.

Study Design: Scoping review; Level of evidence, 4.

Methods: PubMed, EMBASE, Cochrane library, and SCOPUS were searched using the terms “hockey” and “injuries” using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, and 4163 studies involving orthopaedic injuries were identified. Our inclusion criteria consisted of accessible full-text articles that evaluated orthopaedic injuries in men's ice hockey athletes of all levels. We excluded case reports and articles evaluating women's ice hockey injuries, as well as those evaluating nonorthopaedic injuries, such as concussions; traumatic brain injuries; and facial, dental, and vascular injuries, among others. Studies were divided based on level of play and anatomic site of injury. Level of evidence, year published, country of corresponding author, method of data collection, incidence of injury per athlete-exposure, and time lost were extracted from each article.

Results: A total of 92 articles met the inclusion criteria and were performed between 1975 and 2020, with the majority published between 2015 and 2020. These were divided into 8 anatomic sites: nonanatomic-specific (37%), intra-articular hip (20.7%), shoulder (9.8%), knee (8.7%), trunk/pelvis (7.6%), spine (7.6%), foot/ankle (6.5%), and hand/wrist (2.2%). Of these studies, 71% were level 4 evidence. Data were obtained mostly via surveillance programs and searches of publicly available information (eg, injury reports, player profiles, and press releases).

Conclusion: This scoping review provides men's hockey players and physicians taking care of elite ice hockey athletes of all levels with a single source of the most current literature regarding orthopaedic injuries. Most research focused on nonanatomic-specific injuries, intra-articular hip injuries, knee injuries, and shoulder injuries, with the majority having level 4 evidence.

Keywords: athletic training; epidemiology; ice hockey; injury prevention

Hockey is a popular international sport, and injuries occur commonly due to high speed of play, hard ice surface, and contact nature of the sport. Any injury has the potential to be detrimental to a player's physical and mental health.⁸ Having a succinct compilation of the most common injuries and associated games missed can help players, coaches, athletic trainers, and management (in the case of professional leagues) have a more well-rounded understanding of prognosis for an athlete's return to play. In addition, this study stands to highlight certain anatomic areas where novel protective equipment can be researched and

developed to protect players from the most common injuries, such as bony injuries in the foot and ankle. Despite the international popularity of ice hockey, orthopaedic literature regarding competitive hockey players is lacking. In the United States, there has been some examination using the National Collegiate Athletics Association (NCAA) Injury Surveillance Program to assess injury rates and anatomic location in collegiate hockey athletes, as well as the National Hockey League (NHL) Injury Surveillance System to examine similar outcomes in professional athletes.[¶] However, this study serves to broaden the population studied outside of solely collegiate and professional

The Orthopaedic Journal of Sports Medicine, 10(4), 23259671221085968
DOI: 10.1177/23259671221085968
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[¶]References 1, 2, 11–13, 18–21, 27, 32, 33, 40, 41, 46, 52, 55, 57, 59, 66, 73, 81, 93

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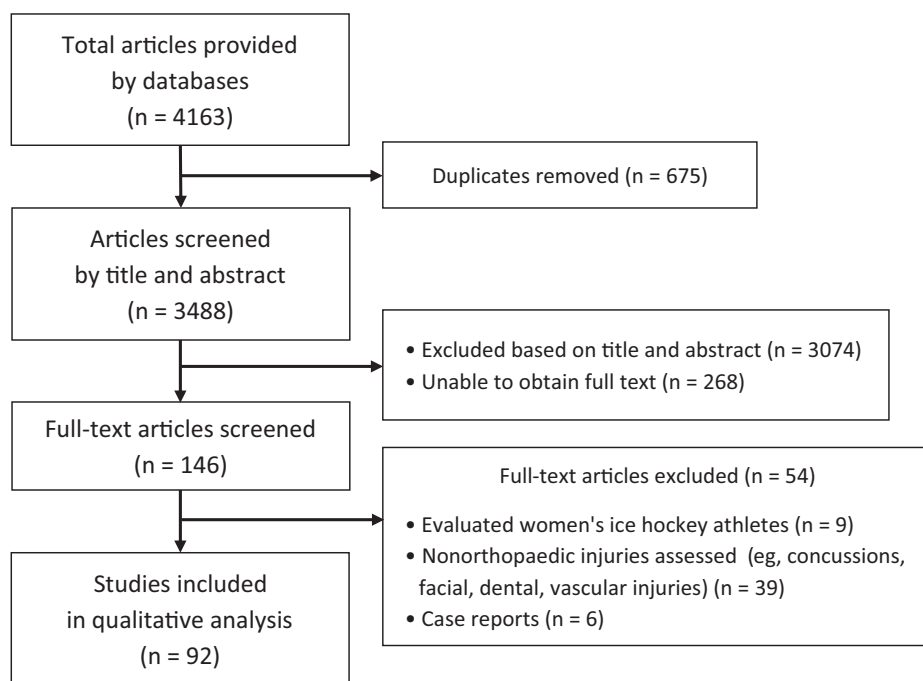


Figure 1. Flowchart of article screening process.

athletes to provide a more well-rounded summary of hockey injuries and how they vary based on level of play.

The primary goal of this scoping review was to summarize published data on orthopaedic hockey injuries at the junior through professional level, providing team physicians and clinicians with a comprehensive single source of the most current literature regarding the frequency and outcomes of orthopaedic injuries in these athletes, allowing physicians and clinicians to quickly and accurately gather the most up-to-date information regarding treatment. The secondary objective was to characterize the literature based on the anatomic site injured, return-to-play rates, mechanism of injury, time lost, and treatments used. It was hypothesized that most injuries would occur during game-play rather than practice and those competing at the international level would be most likely to get injured.

METHODS

PubMed, EMBASE, Cochrane library, and SCOPUS were searched using the search terms “hockey” and “injuries” to identify all studies of orthopaedic injuries. Three authors

(P.F.S., P.T.O., and M.M.) independently conducted the search and compared findings. Disagreements among reviewers were brought to the attention of the senior author (J.P.S.) who ultimately made the final decision regarding article inclusion. Our inclusion criteria consisted of accessible full-text articles that evaluated orthopaedic injuries in men’s ice hockey athletes of all levels. We excluded case reports and articles evaluating women’s ice hockey injuries, as well as those evaluating nonorthopaedic injuries, such as concussions; traumatic brain injuries; and facial, dental, and vascular injuries. Duplicate studies were consolidated into a single article.

The studies were divided based on level of play and anatomic site of injury. Level of evidence, year published, country of corresponding author, method of data collection, incidence of injury per athlete-exposure (AE; a unit of susceptibility to injury defined as 1 athlete participating in 1 practice or game where the athlete is exposed to the possibility of injury, reported as a rate per 1000 AEs), and time lost were extracted from each article. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart of the search strategies is presented in

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Final revision submitted December 14, 2021; accepted December 31, 2021.

One or more of the authors has declared the following potential conflict of interest or source of funding: P.T.O. has received education payments from Liberty Surgical, Summit Surgical, and Smith & Nephew. P.D. has received education payments from Liberty Surgical. J.P.S. has received education payments from Liberty Surgical and consulting fees from Stryker. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

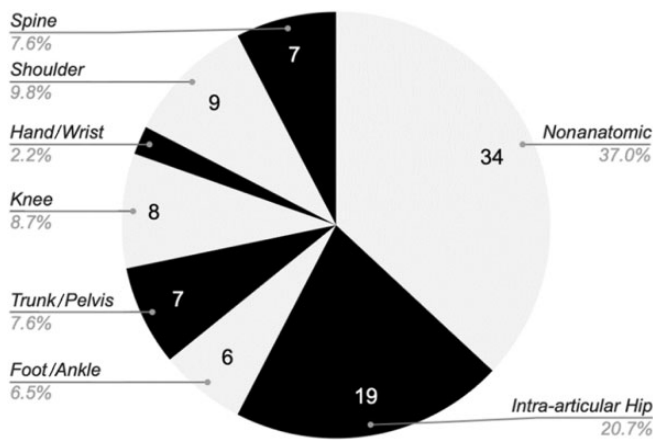


Figure 2. Number of studies based on anatomic site. No. of hand/wrist studies is 2.

Figure 1. We identified 3488 studies via a database search, of which 92 articles met inclusion criteria. Figure 2 summarizes the articles based on anatomic site.

RESULTS

No evidence level 1 or 2 studies met our inclusion criteria (Figure 3A). The majority of studies were published between 2015 and 2020 (Figure 3B), and 62% of the studies were published in the United States (Figure 3C). Most studies obtained their data via surveillance programs (Table 1).

Nonanatomic-Specific Injuries

The overall injury rate for all levels of play was 19.68 per 1000 AEs (range, 4.9-68.5 per 1000 AEs) (Table 2).[#] Professional European players had the highest overall injury rate with 68.5 per 1000 AEs, whereas collegiate athletes had the lowest at 4.9 per 1000 AEs.^{25,41,56,62} Junior players were the most likely to get injured in games, while professional players outside of the United States were most likely to get injured in training.^{16,30,38,42,47,67,84} Overall, players were more likely to get injured during games compared with training, and forwards were more likely to get injured compared with defenseman and goalkeepers.^{**} Anterior Cruciate Ligament (ACL) injuries were found to have the most game-time missed in professional ice hockey players (Table 3).^{22,46,50,79,81}

Donaldson et al¹⁴ reviewed all NHL players between 2009 and 2012 and found that 50.9% of players missed at least 1 game, with most sustaining a leg/foot injury with salary loss of \$68.2 million. Lubbe et al⁴⁹ found the number of games played in the first season after injury by NHL players was reduced significantly after hip arthroscopy (HA), noninstability shoulder arthroscopy, knee

arthroscopy, and core muscle injury repair ($P = .002$, $P = .009$, $P = .03$, and $P = .01$, respectively).

Mölsä et al,⁶² studying players in the Finnish Hockey League, found the injury rate per game increased from 54 per 1000 player-hours in the 1970s to 83 per 1000 player-hours in the 1990s, with an increasing risk as players aged. In the Superisligaen, Jørgensen and Smasal^{38,68} found the head to be most commonly injured, followed by the lower extremity (LE). The majority of LE injuries were ligamentous sprains seen most commonly in the ankle and muscular strains seen most commonly in the thigh.⁶⁸ In the Swedish Hockey League, most injuries occurred to the LE due to in-game trauma, with shoulder injuries being the most common upper extremity (UE) injury.^{3,4,48,67,85} One study examined injuries in the Asian Ice Hockey League and found players were 6.6 times more likely to sustain serious injuries in a game compared with in practice.⁴²

Between 2006 and 2013 in international competitions, Tuominen et al⁸⁶ found the most commonly injured body part was the face, the knee for the LE, and the shoulder for the UE. Arenas with flexible boards and glass reduced the risk of injury by 29%.⁸⁶ In the 2008 Olympic Games in Beijing, 20.4% of hockey athletes sustained an injury, with the majority occurring during gameplay due to contact with a stick/puck.³⁹

When examining collegiate athletes, researchers have reported most injuries occurred with collisions resulting in concussions followed by knee injuries.^{1,25,56,66} This population had a lower rate of facial injuries compared with professional hockey players, which authors have hypothesized was due to the face shields required in college.⁵⁶

For junior level hockey athletes, the most prevalent injuries were facial lacerations, acromioclavicular (AC) sprains, and knee injuries, most often due to collisions.^{30,65,76,77,84,87}

Intra-articular Hip Injuries

The rate of intra-articular hip injuries was 2.63 per 1000 AEs, with most occurring in a regular season game.^{12,13,21,40} Goalkeepers and older players were significantly more likely to have intra-articular hip pathology ($P < .0001$).²¹ The most frequent intra-articular hip pathology was labral tearing, followed by osteoarthritis, loose body, and femoroacetabular impingement (FAI).²¹

Asymptomatic Screening. Multiple studies found high rates of asymptomatic hip labral tears, acetabular retroversion, and cam-type morphology in NHL players, with cam-type morphology correlating with decreased hip range of motion and positive anterior impingement.^{26,43,44} Goalkeepers had the highest prevalence of cam-type deformity and the least acetabular coverage.⁴⁴ Wörner et al⁹¹ found that over one-half of Swedish professional hockey players reported hip and groin problems. Silvis et al⁸² found that 64% of asymptomatic American Hockey League players had magnetic resonance imaging (MRI) findings of hip pathology. Dalton et al¹³ analyzed NCAA hockey athletes between 2009 and 2015 and found the most common diagnosis was a muscular strain in 1 of the 24 muscles that act on the hip/groin region. Multiple

[#]References 16, 25, 30, 38, 41, 42, 47, 48, 55, 56, 62, 66, 67, 84-87

^{**}References 1, 5, 16, 25, 30, 38, 41, 42, 47, 48, 55, 56, 62, 65-67, 71, 84-87

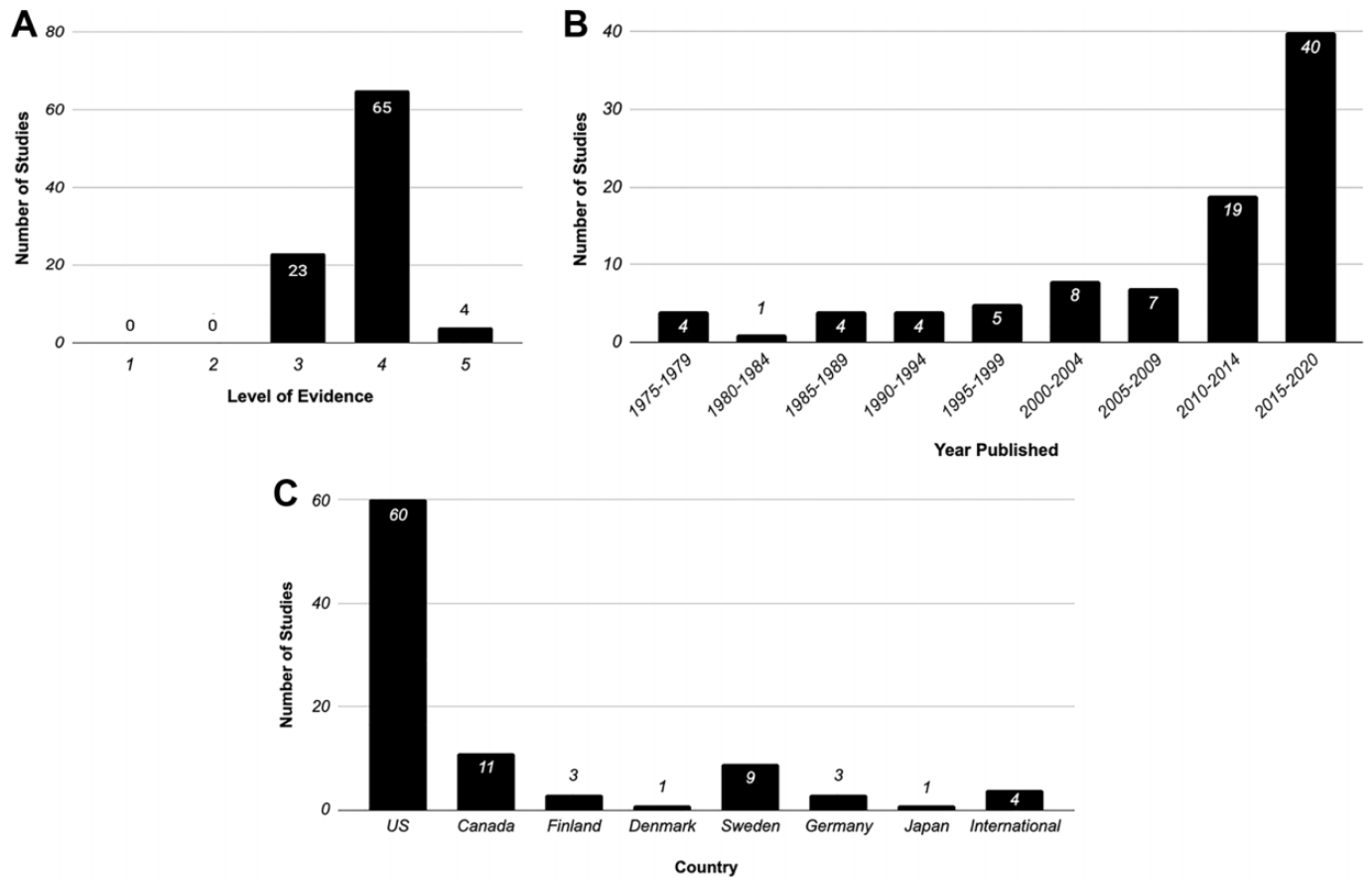


Figure 3. Number of studies based on (A) level of evidence, (B) year of publication, and (C) country of publication. US, United States.

TABLE 1
Number of Studies Based on Method of Data Collection^a

Method of Data Collection	No. of Studies	References
Surveillance programs (NHL ISS, NCAA ISP, and CAIRS)	23	1, 2, 11-13, 18-21, 27, 32, 33, 40, 41, 46, 52, 55, 57, 59, 66, 73, 81, 93
League data	21	3, 4, 15, 23, 34, 38, 42, 45, 47, 54, 60-62, 64, 67, 68, 74, 75, 82, 85, 90, 91
Individual team data	18	9, 22, 24, 25, 30, 35, 37, 48, 50, 51, 56, 65, 71, 79, 80, 84, 87
Institutional data	15	7, 10, 26, 28, 29, 31, 36, 43, 44, 53, 69, 70, 88, 89, 92
Internet	7	5, 14, 16, 49, 58, 78, 83
Literature review	4	6, 17, 63, 72
Olympic data	4	39, 76, 77, 86

^aCAIRS, Canadian Athletic Injuries/Illness Reporting System; NCAA ISP, National Collegiate Athletic Association Injury Surveillance Program; NHL ISS, National Hockey League Injury Surveillance System.

studies have demonstrated that most collegiate injuries were noncontact, causing <24 hours of time lost.^{12,40} Ayeni et al⁶ found that junior hockey athletes were more likely to have radiographic findings of cam but not pincer impingement compared with nonathletes.

Hip Arthroscopy. Schallmo et al⁷⁸ found that NHL players returned to sport at a significantly greater rate

compared with National Basketball Association, National Football League, and Major League Baseball (MLB) athletes after HA ($P = .048$). NHL players had a significant decrease in performance 1 season after surgery as compared with their baseline ($P = .002$).⁷⁸ Sochacki et al⁸³ studied 70 NHL players who underwent HA for FAI between 2000 and 2016 and found 90% of athletes returned to sport

TABLE 2
Overall Injury Rate by Anatomic Site and Level of Play^a

Lead Author (Year)	Player Cohort	No. of Injuries		
		Per 1000 AEs	Per 1000 Game-Hours	Per 1000 Training-Hours
Nonanatomic Specific				
McKay (2014) ⁵⁵	NHL	15.6	49.4	
Donskov (2019) ¹⁶	NHL		64.5	
Mölsä (2000) ⁶²	Professional European	68.5		
Jørgensen (1986) ³⁸	Professional European		38	1.5
Tegner (1991) ⁸⁵	Professional European		53	
Lorentzon (1988) ⁴⁸	Professional European		78.4	1.4
Pettersson (1993) ⁶⁷	Professional European		74.1	2.6
Kuzuhara (2009) ⁴²	Professional Asian		74.3	11.2
Tuominen (2015) ⁸⁶	International		52.1	
Lorentzon (1988) ⁴⁷	International		79.2	
Donskov (2019) ¹⁶	Collegiate (Canada and US)		16.85	
Kerr (2015) ⁴¹	Collegiate (Canada and US)	9.5		
Flik (2005) ²⁵	Collegiate (Canada and US)	4.9	13.8	2.2
Agel (2010) ¹	Collegiate (Canada and US)		18.7	2.2
McKnight (1992) ⁵⁶	Collegiate (Canada and US)	10.2	14.2	2.52
Pelletier (1993) ⁶⁶	Collegiate (Canada and US)		19.95	
Donskov (2019) ¹⁶	Junior		80.4	
Stuart (1995) ⁸⁴	Junior	9.4	96.1	3.9
Tuominen (2015) ⁸⁶	Junior		39.8	
Gröger (2001) ³⁰	Junior		46.8	
Intra-articular Hip				
Epstein (2013) ²¹	NHL		1.81	
Dalton (2016) ¹³	Collegiate (Canada and US)	1.03		
Kerbel (2018) ⁴⁰	Collegiate (Canada and US)	3.43		
Cruz (2019) ¹²	Collegiate (Canada and US)	3.43		
Trunk/Pelvis				
Tyler (2002) ⁸⁸	NHL		3.2	
Knee				
Longstaffe (2020) ⁴⁶	NHL		0.2	
Agel (2016) ²	Collegiate (Canada and US)	0.03		
Grant (2013) ²⁸	Collegiate (Canada and US)	0.44		
Foot/Ankle				
Roos (2017) ⁷³	Collegiate (Canada and US)	0.15		
Mauntel (2017) ⁵²	Collegiate (Canada and US)	0.11		
Shoulder				
Hibberd (2016) ³³	Collegiate (Canada and US)	0.64		
Melvin (2018) ⁵⁷	Collegiate (Canada and US)		7.33	0.83
Gil (2018) ²⁷	Collegiate (Canada and US)	0.06		
Spine				
Zupon (2018) ⁹³	Collegiate (Canada and US)	0.56		

^aAEs, athlete-exposures; NHL, National Hockey League; US, United States.

at an average of 6.8 months, with 1-year NHL career survival rate being 84.4%. Matched control players had significantly longer careers compared with those who had

surgery ($P = .00002$).⁸³ Menge et al⁵⁸ found that, in 60 NHL players undergoing HA for FAI, 67% continued to play professionally a minimum of 5 years after HA, with career

TABLE 3
Average Game Time Missed by Anatomic Site and Level of Play^a

Injury	Lead Author (Year)	Player Cohort	Average Game-Time Missed, wk
Intra-articular Hip			
General intra-articular hip injuries	Epstein (2013) ²¹	NHL	6.17
	Wörner (2020) ⁹¹	Other professional leagues (Swedish)	2
Hip arthroscopy for FAI	Schallmo (2018) ⁷⁸	NHL	23.4
	Sochacki (2019) ⁸³	NHL	29.1
	Philippon (2007) ⁶⁹	NHL	23.8
	Bizzini (2007) ⁹	International/Olympics	47
Knee			
ACL	Longstaffe (2020) ⁴⁶	NHL	58.1
	Erickson (2014) ²²	NHL	54.6
	Mai (2017) ⁵⁰	NHL	60.2
	Sikka (2016) ⁸¹	NHL	68.6
Arthroscopic microfracture	Schallmo (2018) ⁷⁹	NHL	60.2
Foot/Ankle			
High ankle sprains	Mollon (2019) ⁵⁹	NHL	6.4
	Wright (2004) ⁹²	NHL	3.1
Shoulder			
Clavicle fractures	Hebert-Davies (2018) ³²	NHL	15.2
Labral tears	Rangavajjula (2016) ⁷²	NHL	30.1
Spine			
ACDF	Watkins (2018) ⁹⁰	NHL	66.5
Spondylolysis	Mai (2018) ⁵¹	NHL	31.7
	Donaldson (2014) ¹⁵	Juniors	8

^aACDF, anterior cervical discectomy and fusion; ACL, anterior cruciate ligament; FAI, femoroacetabular impingement; NCAA, National Collegiate Athletic Association; NHL, National Hockey League.

length correlating with age at time of surgery. Philippon et al⁶⁹ studied 24 professional hockey players who underwent HA for FAI and found that 23 returned to sport. The average time to return to training was 3.4 months, with the average modified Harris Hip Score improving from 70 to 95.⁷⁰ McDonald et al^{53,54} reviewed 17 NHL athletes who underwent arthroscopic microfracture of the hip and found 82% of athletes returned to play with no change in performance measures.

Bizzini et al⁹ followed 5 Swiss national athletes who underwent open surgery for FAI and found average return to gameplay was 9.6 months, with 2 athletes unable to return to their previous level of play.

Trunk and Pelvic Injuries

Groin and Abdominal Strains. Emery et al²⁰ found an increasing injury rate of groin and abdominal strains in NHL players from 12.99 per 100 players per year in the 1991 season to 19.87 per 100 players in the 1997 season.

The majority of injuries were noncontact adductor strains, with a 23.5% recurrence rate.²⁰ The mean time lost from abdominal injuries was significantly greater compared with groin injuries, which the authors hypothesized was due to abdominal injuries requiring surgery more often compared with groin injuries ($P = .0058$).²⁰ Groin injuries were more common in those who completed <18 offseason training sessions and those with an adductor strength <80% of their abductor strength.^{19,88,89} Eckard et al¹⁸ found, via the NCAA Injury Surveillance Program, that both hip flexor and adductor strains were often from non-contact injuries, resulting in <24 hours of gametime loss, with hip flexor strains more likely to be recurrent.

Core Muscle Injuries. All NHL players who underwent repair of the external oblique aponeurosis returned to play without complications, although most had decreased assists and games played versus a control group.^{10,36,37} Players with ≤6 seasons played were likely to play significantly fewer games in the following 2 seasons postoperatively compared with controls ($P = .01$).³⁷ However, players

with \geq seasons had significantly decreased games played and performance in the following 2 seasons postoperatively compared with controls ($P = .03$).³⁷

Foot and Ankle Injuries

Fractures. Baker et al⁷ found 27 bony injuries in 31 NHL athletes via MRI, with 10 being occult fractures. Direct impact injury was more likely to cause a bony injury, usually occurring in the medial foot or ankle.⁷

Sprains. Mollon et al⁵⁹ prospectively evaluated high ankle sprains in NHL athletes between 2006 and 2012 and found 81% of these injuries caused an average of 8 games missed. A retrospective review of MRI scans revealed that 62% had complete tears to the anterior inferior tibiofibular ligament, 24% had high-grade partial tears of the anterior inferior tibiofibular ligament, and 43% had a partially torn posterior inferior tibiofibular ligament.⁵⁹ Wright et al⁹² evaluated 2 NHL teams over a 10-year period and found 14 players were diagnosed with syndesmosis sprains and 5 players were diagnosed with lateral ankle sprains with a mean time to return to games of 45 and 1.4 days, respectively. In NCAA athletes, Roos et al⁷³ found most lateral ligament ankle sprains occurred during gametime due to contact. Crowley et al¹¹ examined foot and ankle injuries in NCAA athletes and found that 87% occurred during the regular season, with the most common injury being foot contusions. High ankle sprains accounted for the most severe time loss (>14 days), while foot contusions accounted for the most moderate time lost (<14 days).¹¹ Mauntel et al⁵² examined high ankle sprains in collegiate hockey athletes and found that 69% of injuries occurred during competition.

Knee Injuries

Anterior Cruciate Ligament Injuries. Longstaffe et al⁴⁶ reviewed the NHL database between the 2006 and 2016 seasons and found 67 ACL tears among NHL players, with forwards being most susceptible. Compared with controls, NHL athletes with ACL tears had a significant decrease in performance, with no difference in games/seasons played after injury ($P = .001$).⁴⁶ Erickson et al²² examined 36 NHL athletes undergoing ACL reconstruction (ACLR) between 1990 and 2013 and found a 97% return to the NHL at a mean of 7.8 months. Length of career after ACLR was 4.47 years, with a 2.5% revision rate.²² There was no significant difference in performance after ACLR when compared with preinjury performance ($P = .056$).²² Sikka et al⁸¹ examined ACL injuries in 47 NHL players between 2006 and 2010 and found the average postoperative performance/career length after ACLR was significantly less compared with controls (players without ACL tears matched via those who entered the league within 2 years and were drafted within 2 rounds with similar performance, years of experience, age, height, and weight; 2.8 vs 4.4 years; $P = .004$); 8.5% of players had a failure of ACLR with an overall 20% reoperation rate, 10.6% of players did not return to play, and 8.5% of players were unable to return to play for a full season.⁸¹ Mai et al⁵⁰ examined professional athletes

in the NHL, National Football League, National Basketball Association, and MLB and found NHL players had higher return to play (95.8% vs 83.4%), shorter average recovery time (258 days vs 367 days), and smallest decrease in performance the season after ACLR compared with all other athletes.

Other Knee Injuries. Schallmo et al⁷⁹ examined professional athletes in multiple American sports who underwent knee microfracture and found only NHL and MLB players to have 100% return-to-play rates. Lian et al⁴⁵ evaluated the prevalence of patellar tendinitis in Norwegian professional athletes and found an overall prevalence of 13% in hockey athletes. Hockey players were least symptomatic of all athletes, owing to the lack of jumping required in hockey.⁴⁵ Grant et al²⁸ followed a single varsity NCAA hockey team between 2003 and 2011 and found 13 MCL injuries in 10 athletes, with an overall injury rate of 0.44 per 1000 AEs. The majority were Grade 2 sprains due to contact, and the grade of injury correlated with time lost from play.²⁸

Hand and Wrist Injuries

Greditzer et al²⁹ reported a prevalence of 81% of os styloideum in NHL players, which was significantly increased when compared with the other population ($P < .001$). Rovere et al⁷⁵ examined "gamekeeper's thumb" sustained from fighting in minor league players between 1973 and 1975 and found all hockey players were treated successfully with a thumb spica cast, resulting in no residual thumb-index pinch instability or time lost secondary to injury.

Shoulder Injuries

Screening via MRI. Hacken et al³¹ reported MRI findings on 25 asymptomatic hockey players and demonstrated labral tears in 25%, with 75% found in the nondominant stick hand. The authors reported 8% of AC joint abnormalities without separation, with 75% of these abnormalities in the dominant shoulders; 6% of athletes had rotator cuff tears.³¹ Shoulder pathology overall was significantly more common in the dominant shoulder ($P = .021$).³¹ In contrast, Dwyer et al¹⁷ reported MRI findings of 24 NHL players who sustained traumatic injury with description of acute subluxation or dislocation. They found 75% of players had Bankart lesions, 54.2% had a Hill-Sachs lesion, 20.8% had a Type 2 superior labrum anterior to posterior tear, and 8.3% had isolated posterior labral tears; 12.5% of players had a glenoid bony defect, all of which were $<25\%$ of the anteroinferior glenoid.¹⁷

Nonspecific Shoulder Injuries. Gil et al²⁷ reported an incidence of 0.60 per 10,000 AEs for operative UE injuries in collegiate athletes. Similarly, Melvin et al⁵⁷ found the most commonly injured positions were forward (55.1%) and defenseman (29.7%). The shoulder was the most common site injured (54.4%), followed by the hand and wrist (18.9% and 13.8%, respectively).⁵⁷ The most common injuries were sprains (40.4%), contusions (19.9%), and fractures (9.5%).⁵⁷

The most common UE injury was partial or complete AC joint sprains, most frequently from in-game contact.⁵⁷

Clavicle and AC Joint Pathology. Norfray et al⁶³ analyzed clavicle radiographs of 77 NHL players and found 8 ligamentous injuries, with 6 AC joint subluxations and 2 AC joint dislocations, and 2 players with distal clavicle fractures. Follow-up radiographs demonstrated coracoclavicular ligament calcifications in 2 players with dislocation, 1 player after distal clavicle surgical excision after failed non-operative treatment of AC joint subluxation, and 1 player with posttraumatic osteoarthritis.⁶³ Hebert-Davies and Agel³² reported average time from injury to return to play after clavicle fracture was 65.0 and 97.6 days for operative and nonoperative treatment, respectively, although this finding was not found to be statistically significant. Hibberd et al³³ examined AC joint sprains in collegiate athletes and found the most commonly injured positions were forwards (57.5%) and defenseman (29.1%), with 37.9% of these sprains resulting in no time lost, whereas 11.1% of these sprains were diagnosed as severe (defined as >3 weeks' time lost or season ending).

Glenohumeral Instability. Hovelius³⁴ examined 63 Swedish hockey players with shoulder dislocations and found all players were <30 years of age at the first dislocation, with recurrence rates of 90% in players <20 years of age and 50% in players >25 years of age. Rangavajjula et al⁷² reported on 11 NHL players who returned to play at an average of 4.3 months after arthroscopic labral repair. No significant difference was found regarding hand dominance or performance after return to play ($P = .632$).⁷²

Spine Injuries

Other Injury Characteristics. Zupon et al⁹³ found most spine injuries in NCAA athletes occurred in competition, and 65.9% resulted in no time lost from play. In games, 39.2% of injuries occurred in the cervical spine, and 40.0% occurred in the lumbar spine, with the majority of the injuries being classified as pain or spasms.⁹³ The most common injury mechanism in games was contact and in training was noncontact (33.3%) or overuse (21.9%).⁹³ Fett et al²⁴ showed a significantly higher prevalence of back pain in German hockey players compared with all other German athletes ($P = .018$).

Cervical Spine. Mai et al⁵¹ reported on NHL players treated operatively for cervical disc herniation and showed no significant decrease in performance postoperatively ($P = .41$). For NHL players undergoing anterior cervical discectomy and fusion (ACDF), Watkins et al⁹⁰ reported radiographic union at an average of 7.3 months.

Lumbar Spine. NHL players with lumbar disc herniations had a >80% return-to-play rate at an average of 2.9 years after diagnosis, with a significant decrease in games played and performance ($P < .05$).^{35,80} Those treated non-operatively returned to sport at a greater rate and played more games, but they had a significant decrease in performance compared with those treated surgically ($P < .02$).⁸⁰ Donaldson¹⁵ examined junior hockey players with low back pain and found 44% of players had evidence of lumbar spondylolysis. The level of spondylolysis occurred

predominantly at L5 (55%), followed by L4 (36%).¹⁵ Spondylolysis occurred on the same side as the player's shooting side in 73% of cases and most commonly in forwards (67%).¹⁵ Return to play averaged 8 weeks, with 96% of athletes continuing to play at an elite level ranging from juniors to professional.¹⁵

DISCUSSION

To the best of the authors' knowledge, this is the first scoping review to examine the range of hockey injuries from all levels of elite athletes, from junior through professional level. Not only were most injuries sustained during game play, but there was also an increased risk of facial or head/neck injuries in the professional leagues. Most studies focused on nonanatomic-specific injuries, followed by intra-articular hip injuries, with the majority having level 4 evidence.

Based on injury rates seen per AE, most injuries occurred in games compared with training.^{††} Gameplay, regardless of level, lends itself to producing more injuries due to the higher speed of play and increased rates of body checking as compared with practice, where portions of play are often dedicated to skill-specific training and installation of offensive and defensive sets. The highest injury rates were seen in athletes at the international or junior level, while the lowest rates were seen in collegiate athletes.^{‡‡} This low rate of injuries among collegiate athletes is likely related to the rules regarding allowable contact. In collegiate hockey, body checking, or the act of the player physically using the body first to deliberately cause collisions, is strictly forbidden. Contrarily, there are more liberal rules in professional leagues with respect to body checking and player-to-player contact, yielding higher injury rates.

The highest injury rates seen in training were in those competing in professional Asian leagues, followed by those at the junior level, likely due to the demanding and rigorous training schedules these athletes must endure to stay competitive at such a high level.^{42,84} Athletes in professional European leagues were least likely to get injured during practice.^{38,48,67} The majority of studies reported that the most common injuries were facial injuries, followed by LE injuries, especially in professional players.^{§§} Collegiate athletes had comparatively lower rates of facial injuries, likely due to the required use of face shields.⁵⁶ This disparity in facial injuries when comparing collegiate athletes with others does obviate the question of whether or not protective shields (full or half) should be required among the professional leagues. However, most facial injuries (nonconcussion injuries) sustained are minor in nature and do not account for missed games.⁴⁷ In addition, there would likely be player opposition to such a proposed change because of some athletes' perceived decrease in visibility with either a half or full shield as compared with no shield.

^{††}References 1, 5, 25, 38, 41, 42, 47, 56, 67, 71, 84, 87

^{‡‡}References 1, 16, 25, 30, 41, 47, 56, 66, 84, 86, 87

^{§§}References 3, 4, 38, 42, 47, 68, 74, 85–87

Another significant difference in professional leagues that can result in an increase in facial injuries is fighting. Although fighting is met with subsequent penalization for both parties in professional leagues, the act of fisticuffs is neither forbidden nor immediately stopped by the referees.

The most common LE injury was the knee, whereas in the UE, it was the shoulder.^{57,86} Players' shoulders are often the first thing that is contacted by either another player or when up against the boards, resulting in a high rate of injury to this anatomic area. In addition, older players were more likely to get injured, likely due to loss of conditioning/reduced peak performance or from years of prolonged exposure to physical contact due to the nature of the sport.^{19,21,61}

The most commonly injured position was forwards, followed by defenseman then goalkeepers.^{38,42,46,48,56,65,66,71} Forwards are injured most commonly due to the elevated speed with which they play, and they are also commonly of smaller stature as compared with the defenseman against whom they are competing. Also, forwards are more commonly the position that receives a body check to disengage them from the puck as opposed to the defensive player who typically initiates contact. Interestingly, arenas with flexible boards and glass have reduced the risk of injury by 29%.⁸⁶ This finding is not only interesting but also provides initial evidence that ice hockey rinks should be fitted with flexible boards and glass throughout all of levels of play. This is certainly an area where future research should focus to facilitate injury reduction especially at levels where checking into the boards is allowed.

For hip injuries, hockey athletes had an increased incidence of cam but not pincer deformity, and goalkeepers had the highest prevalence of intra-articular hip pathology.^{6,21,43,44} The most frequent intra-articular hip pathology was a labral tear. Over 90% of athletes returned to sport after arthroscopic hip surgery at an average of 6.8 months with no decrease in postoperative performance.^{21,58,70,78,83} Hip flexor/adductor strains are common injuries, frequently resulting in <24 hours of game time lost, although hip flexor strains were more likely to be recurrent.¹⁸

Trunk/pelvic injuries are a common yet preventable injury, as athletes who performed more off-season training sessions or implemented a preseason exercise program were less likely to sustain trunk injuries.^{20,88,89} Understanding this fact can play a critical role in hockey-specific training programs that focus on core/trunk training. Providing a preseason focus on strengthening this area will serve to limit the incidence of these preventable injuries and thus decrease games/practices missed. However, regardless of preseason training, these injuries will occur due to the contact nature of hockey and the rotational forces present in the trunk/core musculature. It is important to note that, for those athletes with core injuries that did require surgical repair, 80% returned to sport, although their performance overall decreased.^{10,36,37}

We found that ACL injuries occurred with less frequency as compared with other hockey injuries, likely owing to the lack of both jumping and hard pivoting in hockey compared with other sports. Those hockey athletes who did sustain

ACL tears were likely to be forwards because of the increased speed and sudden change of direction necessitated by this position.⁴⁶ ACLR in hockey players is a more successful procedure compared with ACLR in athletes of other sports, with hockey athletes having a higher return to play and shorter recovery rate.^{22,50} However, after ACLR, hockey players had decreased performance with a shorter length of career compared with healthy controls.^{46,50,81} Knee microfracture was also found to be a successful procedure, with hockey athletes returning to play at a higher rate compared with athletes in other sports.⁷⁹

Our results indicated that the most common shoulder injury was an AC joint sprain secondary to direct contact, although studies were conflicted about whether hand dominance is a factor.^{17,31,33,57} For clavicle fractures, hockey athletes treated operatively returned to play sooner compared with those treated nonoperatively, although this finding was not found to be significant (65 vs 97.6 days).³²

We found that lumbar disc herniations were common in hockey players and respond well to both nonoperative and operative treatment, with those treated nonoperatively returning to sport at a higher rate but with lower performance.^{24,35,80,93} Lower back injuries occurred more commonly in gameplay due to contact injuries, while those sustained in practice were more likely to be due to noncontact overuse injuries.⁹³

Limitations

There are limitations to this scoping review. Inherent to the review design, we were reliant on previously published information. Very few studies have been published for thigh, hand, and wrist injuries in hockey athletes probably because of the scarcity of these injuries. Most included studies were of lower-quality evidence (level 3 or 4). However, this seems appropriate, as all studies included examined descriptive data pertaining to injuries in hockey athletes. There were multiple studies included that obtained their data via an internet-based search of publicly available data (eg, injury reports, player profiles, and press releases). Data collected in this manner are not standardized and may not produce reliable estimates. Also, publicly available data are limited and do not provide access to detailed medical records. In addition, we found that 20% of studies collected data from a single team, and therefore, the results of these studies may not be generalizable to all hockey athletes. Multiple studies also collected data via a survey of team physicians and/or athletic trainers and thus were subject to recall bias and nonresponse. Studies captured were performed between 1975 and 2020, and observed changes in injury types, rates, and return to play are likely subject to rule changes/enforcement, training methods, safety equipment advances, and injury treatment methods over time.

CONCLUSION

This scoping review provides men's hockey players and physicians taking care of ice hockey athletes of all levels

with a comprehensive single source of the most current literature regarding the frequency and outcomes of orthopaedic injuries in these athletes, allowing those taking care of these athletes to quickly and accurately gather the most up-to-date information regarding their prognosis and treatment.

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