

Early Sport Specialization and Subjective Hip and Groin Dysfunction in Collegiate Ice Hockey Athletes

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Context: Sport specialization is a popular trend among youth athletes that has been associated with an increased risk for developing lower extremity overuse injuries. Early ice hockey specialization may contribute to the high rates of noncontact and overuse hip and groin injuries in collegiate ice hockey athletes.

Objective: To examine the effects of high, moderate, and low levels of sport specialization on subjective hip and groin dysfunction in collegiate ice hockey athletes.

Design: Retrospective cohort study.

Setting: Data were collected during the midseason of the 2018–2019 hockey season at a local ice hockey arena.

Patients or Other Participants: National Collegiate Athletic Association Division III and club ice hockey players from Midwestern college programs ($n = 187$; 81 women, 106 men).

Main Outcome Measure(s): Participants were stratified into high-, moderate-, and low-specialization groups based on ice hockey participation before grade 9 of high school. The 6 subscales of the Hip and Groin Outcome Score questionnaire

were used to assess current subjective hip and groin dysfunction.

Results: The high-specialization group had lower scores than the low-specialization group on the Symptoms ($P = .001$), Pain ($P = .003$), Activities of Daily Living ($P = .001$), Sport and Recreation ($P = .014$), and Quality of Life ($P = .002$) subscales. The moderate-specialization group had lower scores than the low-specialization group on the Symptoms ($P = .015$) and Activities of Daily Living ($P = .006$) subscales.

Conclusions: Collegiate ice hockey athletes who were highly specialized before high school reported greater current hip and groin pain, symptoms, and dysfunction during activities of daily living and sport and recreation and lower current hip- and groin-related quality of life compared with low-specialization ice hockey athletes. Early ice hockey specialization may be detrimental to hip and groin function in collegiate ice hockey athletes.

Key Words: patient reports, overuse injury, lower extremity, pain

Key Points

- Early ice hockey specialization may be detrimental to long-term hip and groin health.
- Collegiate ice hockey athletes who were highly specialized before high school reported greater current hip and groin dysfunction compared with low-specialization ice hockey athletes.
- Female collegiate ice hockey athletes who were highly specialized before high school reported greater current hip and groin dysfunction than their highly specialized male counterparts.

A recent epidemiologic report¹ suggested that women's and men's ice hockey athletes experience some of the highest rates of hip and groin injuries among National Collegiate Athletic Association (NCAA) athletes. Injuries to the hip and groin are considered a greater concern for ice hockey players due to the unique biomechanics of ice hockey skating combined with the anatomical complexity of the hip and groin region.² Evidence³ indicates that the hip and groin region is the most frequently injured body region during NCAA women's and men's ice hockey practices and the second most frequently injured body region during high school boys' ice hockey practices after injuries to the head and face. Among NCAA women's and men's ice hockey athletes, overuse and noncontact mechanisms accounted for 77% and 67% of all hip and groin injuries, respectively.² Interestingly, among overuse hip and groin injuries in collegiate ice hockey players, 46% to 71% were considered non-time-loss injuries²; thus, hip and groin injuries in

collegiate ice hockey may affect patients more off the ice than on the ice.

Some researchers^{2,4} have theorized that the unique biomechanical stresses of ice hockey skating combined with early sport specialization in the sport may explain the higher rates of overuse and noncontact hip and groin injuries in ice hockey athletes. During ice hockey skating, the hip joint and musculature are exposed to repetitive, high-magnitude sagittal-, frontal-, and horizontal-plane motions that may place abnormal stresses on musculoskeletal tissues.⁴ Over time, with repetition, and without opportunity for rest, these abnormal and specific stresses could have deleterious effects on the musculoskeletal tissues of young, developing ice hockey athletes.⁴ For example, investigators⁵ have theorized that high-volume skating and repetitive stresses on the growth plates of skeletally immature youth ice hockey athletes may explain the greater prevalence of asymptomatic femoroacetabular

bony deformities observed in youth ice hockey athletes compared with youth athletes not involved in ice hockey.

Sport specialization, defined as “intense, year-round training in a single sport at the exclusion of others,”⁶ has become common practice in youth sports, with athletes believing that sport specialization will improve athletic performance, playing time, and scholarship opportunities.⁷ However, concern is growing among numerous youth health advocate organizations that early sport specialization may expose youth athletes to injuries.^{8–11} Previous authors¹² have defined a *high level of sport specialization* as (1) considering 1 sport more important than others, (2) quitting other sports to focus on 1 sport, and (3) training in 1 sport for greater than 8 months of the year. This high-volume sport training with minimal diversity in movement patterns and activities during adolescence may expose musculoskeletal tissues to specific and repetitive mechanical stresses and minimal rest and may limit the development of appropriate neuromuscular skills for injury prevention.¹³ In a recent meta-analysis,¹⁴ highly specialized and moderately specialized youth athletes were at greater risk for sustaining overuse injuries than youth athletes with a low level of sport specialization. Additionally, high school athletes who reported participating in a single sport for greater than 8 months of the year were more likely to give a history of hip injuries, but this study did not include ice hockey athletes.¹⁵ In a small sample of NCAA Division I and III men’s ice hockey athletes, approximately 46% (22/48) stated that they had specialized in ice hockey by the age of 14 years,¹⁶ suggesting that a large proportion of ice hockey athletes may already be specialized by the time they reach high school.

Theoretically, early sport specialization could play a role in the high rates of overuse and noncontact hip and groin injuries in collegiate ice hockey athletes; however, this relationship has not been investigated. An improved understanding of this possible relationship could be critical to addressing these common injuries in collegiate ice hockey athletes. Given evidence that the majority of overuse hip and groin injuries are non-time-loss injuries, it may be most appropriate to examine chronic, overuse hip and groin injuries using a subjective, patient-reported outcome questionnaire on hip and groin dysfunction. Therefore, the primary purpose of our study was to examine the effects of ice hockey specialization before high school on current subjective hip and groin dysfunction in collegiate ice hockey athletes. We hypothesized that collegiate ice hockey athletes who were highly specialized before high school would report greater current hip and groin dysfunction than those classified as having a low level of specialization. Our secondary purposes were to explore the relationship between years of ice hockey participation and subjective hip and groin dysfunction and whether subjective hip and groin dysfunction was different between female and male ice hockey athletes who specialized early. We hypothesized that years of ice hockey participation alone would not be strongly associated with subjective hip and groin dysfunction and that highly specialized females would report greater hip and groin dysfunction than their male counterparts based on the higher rates of noncontact and overuse hip injuries that have been observed in female ice hockey athletes versus males.

METHODS

Design

Our study used a retrospective cohort design. Our independent variable was the participant’s self-reported level of hockey specialization (low, moderate, or high) before grade 9 of high school, as determined by a 3-point sport specialization questionnaire.¹² Our dependent variables were the 6 subscales of the Copenhagen Hip and Groin Outcome Score (HAGOS),¹⁷ a patient-reported outcome questionnaire that evaluates hip and groin symptoms and dysfunction during the previous week. Our investigation was approved by our institutional review board, and all participants provided written informed consent.

Participants

We recruited 205 (89 female, 116 male) collegiate hockey athletes between the ages of 18 and 30 years from women’s and men’s NCAA Division III ice hockey teams and American Collegiate Hockey Association Divisions I, II, and III club ice hockey teams at midwestern US colleges. We excluded 13 individuals (6 women, 7 men) who reported that they did not participate in hockey-related activities during the week before data collection and 5 (2 women, 3 men) who reported a history of hip-joint surgery. Individuals with a history of surgery were excluded in an effort to eliminate the possible confounding effect on a participant’s subjective hip and groin dysfunction. Data from a total of 187 participants (81 women, 106 men) were included in the final analyses (Table 1).

Procedures

We collected all data during the midseason of the 2018–2019 hockey season at a formal team gathering. After providing informed consent, participants completed 3 questionnaires: a demographics questionnaire, a 3-point sport specialization questionnaire, and the HAGOS questionnaire.

Demographics Questionnaire. The demographics questionnaire consisted of questions about the participant’s age, mass, height, sex, years of organized ice hockey participation, current ice hockey position (forward, defense, or goalie), and whether he or she had a history of a *severe hip or groin injury*, defined as a hip or groin injury that resulted in at least 1 week of missed activity.

Three-Point Sport Specialization Questionnaire. Individuals completed the 3-point sport specialization questionnaire¹² that asked whether they had met 3 ice hockey participation criteria at any point before grade 9 of high school.¹⁸ The questions for each criterion were as follows: (1) Before grade 9 of high school, did you quit other sports to focus on ice hockey? (2) Before grade 9 of high school, did you train for more than 8 months out of the year in ice hockey? (3) Before grade 9 of high school, did you consider ice hockey more important than other sports? We scored all *yes* responses with 1 point; *no* responses were scored with 0 points. We stratified participants into high- (3 points), moderate- (2 points), and low- (0–1 points) specialization groups based on their total scores.¹²

Hip and Groin Outcome Score. The HAGOS questionnaire consists of 37 questions categorized into 6 subscales:

Table 1. Participant Demographics by Specialization Groups

Characteristic	Specialization Group			Total (n = 187)
	Low (n = 59)	Moderate (n = 64)	High (n = 64)	
Sex (women/men)	24/35	32/32	25/39	81/106
	Mean \pm SD			
Age, y	20.8 \pm 1.8	20.5 \pm 2.0	20.9 \pm 1.9	20.8 \pm 1.9
Height, m	1.75 \pm .09	1.74 \pm .10	1.76 \pm .10	1.75 \pm 0.10
Mass, kg	76.3 \pm 11.1	78.4 \pm 12.7	78.6 \pm 13.9	77.8 \pm 12.6
Years of ice hockey participation	13.8 \pm 4.0	15.2 \pm 3.2 ^a	15.3 \pm 3.5 ^a	14.8 \pm 3.6
	No. (%)			
History of a severe hip or groin injury	18/59 (31)	23/64 (36)	23/64 (36)	64/187 (34)
Ice hockey position				
Forward	33/59 (56)	31/64 (48)	34/64 (53)	98/187 (52)
Defense	22/59 (37)	25/64 (39)	22/64 (34)	69/187 (37)
Goalie	4/59 (7)	8/64 (13)	8/64 (13)	20/187 (11)

^a More years of ice hockey participation than the low-specialization group (all P values < .03).

Symptoms (7 questions), Pain (10 questions), Activities of Daily Living (5 questions), Sport and Recreation (8 questions), Physical Activity (2 questions), and Quality of Life (5 questions). Each question asks about a specific aspect of the participant's hip and groin symptoms and function during the past week, with answer options provided on a 5-point Likert scale and scored from 0 to 4. Each subscale was scored on a normalized 0% to 100% scale, with a score of 100% indicating no hip and groin dysfunction and lower scores indicating greater hip and groin dysfunction.

Statistical Analyses

We compared the high-, moderate-, and low-specialization groups' age, mass, height, and years of ice hockey participation using 1-way analysis of variance with post hoc least significant difference tests and compared the groups' sex, ice hockey position, and history of severe hip or groin injury using χ^2 tests.

Initial Shapiro-Wilk tests confirmed that all HAGOS subscale data were nonnormally distributed (all P values < .02) within the specialization groups, with data skewed toward the 100% scores; therefore, nonparametric statistics were used for comparisons. Kruskal-Wallis tests were performed to compare each of the HAGOS subscale scores among the high-, moderate-, and low-specialization groups. All significant Kruskal-Wallis tests (α = .05) were followed up with post hoc Mann-Whitney U tests to examine specific comparisons among the 3 specialization groups with Bonferroni adjustments (α = .05/3 = .017). For exploratory purposes, we calculated Spearman ρ correlation coefficients between the years of ice hockey participation and each HAGOS subscale.

We also explored differences in hip and groin dysfunction between sexes within the specialization groups. To limit the multiple comparisons that would be involved in performing sex comparisons for each subscale, we calculated a HAGOS total score using all questions across all subscales. We then conducted Mann-Whitney U tests to compare the HAGOS total score between women and men in the high-, moderate-, and low-specialization groups and across the total sample.

Effect sizes with 95% confidence intervals were determined for all statistically significant HAGOS comparisons.

Because these data were nonnormally distributed, we calculated a robust effect size (d_r)¹⁹ that uses 20% trimmed means (\bar{Y}_t), pooled 20% Winsorized standard deviations (S_w), and the formula $d_r = 0.642 (\bar{Y}_{t1} - \bar{Y}_{t2} / S_w)$. The d_r effect size is considered more robust for nonnormally distributed data than traditional Cohen d effect sizes but can still be interpreted on the traditional *small* (0.2–0.5), *moderate* (0.5–0.8), or *large* (>0.80) effect-size scale.^{19,20}

RESULTS

We observed a relatively even distribution of participants in the high- (34%), moderate- (34%), and low- (32%) specialization groups (Table 1). Age (P = .47), sex (P = .41), mass (P = .53), height (P = .51), ice hockey position (P = .78), and history of severe hip or groin injuries (P = .77) did not differ among the high-, moderate-, and low-specialization groups (Table 1). The high- (P = .02) and moderate- (P = .03) specialization groups reported a greater number of years of ice hockey played compared with the low-specialization group, with no difference between the high and moderate groups (P = .86; Table 1).

We observed differences among specialization groups for all HAGOS subscale scores except for Physical Activity (P = .26). The high-specialization group reported greater dysfunction than the low-specialization group on the Symptoms (P = .001), Pain (P = .003), Activities of Daily Living (P = .001), Sport and Recreation (P = .014), and Quality of Life (P = .002) subscales (Table 2). The moderate-specialization group reported greater dysfunction than the low-specialization group on the Symptoms (P = .015) and Activities of Daily Living (P = .006) subscales but not on the Pain (P = .02), Sport and Recreation (P = .11), or Quality of Life (P = .04; Table 2) subscales. Reported dysfunction did not differ between the high- and moderate-specialization groups for any of the subscales (all P values > .16). Years of ice hockey played and scores on any of the HAGOS subscales were not related (P values = 0.28 to 0.98, r = −0.02 to 0.08), suggesting that years of ice hockey participation alone was not associated with a participant's current hip and groin dysfunction.

Highly specialized female ice hockey athletes had a lower HAGOS total score (P = .03) than highly specialized male ice hockey athletes (Table 3), suggesting that the females experienced greater hip and groin dysfunction than

Table 2. Hip and Groin Outcome Score (HAGOS) Subscale Scores in the Low-, Moderate-, and High-Specialization Groups and Effect Sizes for Significant Group Comparison

Subscale	Specialization Group			Effect-Size Comparison, d_r (95% Confidence Interval)	
	Low (n = 59)	Moderate (n = 64)	High (n = 64)	Low Versus Moderate	Low Versus High
	Median Score (Lower Quartile, Upper Quartile)				
Symptoms	85.7 (67.9, 96.4)	75.0 ^a (57.1, 88.4)	71.4 ^a (53.6, 85.70)	0.43 (0.07, 0.79)	0.61 (0.24, 0.97)
Pain	95.0 (85.0, 100)	91.3 (75.0, 97.5)	88.8 ^a (66.9, 97.5)	NS	0.52 (0.16, 0.88)
Activities of Daily Living	100.0 (90.0, 100)	95.0 ^a (80.0, 100)	95.0 ^a (75.0, 100)	0.48 (0.12, 0.83)	0.57 (0.21, 0.93)
Sport and Recreation	93.8 (81.3, 100)	87.5 (64.1, 100)	84.4 ^a (62.5, 96.9)	NS	0.42 (0.06, 0.78)
Physical Activity	100.0 (87.5, 100)	100.0 (78.1, 100)	100.0 (78.1, 100)	NS	NS
Quality of Life	95.0 (80.0, 100)	85.0 (70.0, 100)	80.0 ^a (56.3, 100)	NS	0.56 (0.19, 0.92)

Abbreviation: NS, effect size not calculated due to no difference among groups.

^a Lower HAGOS subscale score than the low-specialization group ($P < .017$).

the males. The HAGOS total scores of female and male ice hockey athletes did not differ in the moderate- ($P = .70$) and low- ($P = .51$) specialization groups (Table 3). Also, HAGOS total scores between women and men across the total sample were not different regardless of specialization level ($P = .57$; Table 3).

DISCUSSION

Our findings suggest that early ice hockey specialization before high school may contribute to long-term hip and groin dysfunction in collegiate ice hockey athletes. We observed that collegiate ice hockey athletes who were highly specialized before high school reported greater current hip- and groin-related pain, symptoms, and dysfunction during activities of daily living and sport and recreation and lower current hip- and groin-related quality of life when compared with ice hockey athletes who were in the low-specialization group. Additionally, moderately specialized ice hockey athletes described greater hip and groin symptoms and less hip- and groin-related quality of life than low-specialization ice hockey athletes. Although this was the first study to specifically examine differences in sport specialization and musculoskeletal injuries among ice hockey athletes, our results align with those of a recent meta-analysis¹⁴ that suggested highly and moderately specialized athletes across a variety of sports were at greater risk of developing lower extremity overuse injuries compared with athletes with a low level of specialization.

Our findings are consistent with the theory that early ice hockey specialization, which combines the unique biomechanical stresses of ice hockey skating with year-round, intensive training and skeletally immature joint tissues, could contribute to the high rates of overuse and noncontact hip and groin injuries that have been reported in collegiate ice hockey athletes.^{2,4} Ice hockey skating requires excessive hip flexion, abduction, and rotation, which can lead to

impingement and excessive stress on tissues such as the femur, acetabulum, labrum, articular cartilage, and adductor and iliopsoas muscle groups.^{4,21} Cumulative stress on these tissues over ≥ 8 months of training per year combined with minimal rest and movement diversity may lead to chronic inflammation, tissue degeneration, or malformation of developing musculoskeletal tissues (or all of these). In agreement with this theory, we observed differences among specialization groups in subjective hip and groin dysfunction but not in the proportion of participants with hip or groin injuries that caused them to miss at least 1 week of activity, suggesting that specialization may be more related to chronic hip and groin stress than to a severe hip or groin injury. Additionally, the lack of correlation between the number of years that participants played ice hockey and their HAGOS subscale scores indicates that the observed differences among the levels of specialization were driven by the specificity of early ice hockey participation rather than prolonged participation in organized ice hockey.

We used the HAGOS subjective questionnaire to capture the potential deleterious effects of early sport specialization on hip and groin function based on evidence suggesting that most overuse and noncontact hip and groin injuries in collegiate ice hockey athletes do not affect sport participation and therefore may not always be reported and captured in medical records maintained by athletic trainers and other sports medicine providers. To our knowledge, this was the first study to measure subjective hip and groin dysfunction in “healthy” collegiate ice hockey athletes and may indicate that a large proportion of these athletes experience hip and groin dysfunction both on and off the ice. Interestingly, the largest-magnitude effect-size (moderate) differences between the high- and low-specialization groups were on the Symptoms, Pain, Activities of Daily Living, and Quality of Life subscales, which all focus on questions regarding hip and groin function unrelated to sport and physical activity; for the 2 subscales that do focus

Table 3. Hip and Groin Outcome Score (HAGOS) Total Scores by Sex and Specialization Groups

Sport Specialization Group	Median Score (Lower Quartile, Upper Quartile)		Effect Size, Women Versus Men, d_r (95% Confidence Interval)
	Women	Men	
Low	90.2 (82.9, 99.3)	91.9 (84.5, 97.3)	NS
Moderate	89.9 (70.3, 95.0)	82.8 (72.5, 95.3)	NS
High	70.3 ^a (52.1, 93.3)	86.5 (76.4, 93.9)	0.61 (0.10, 1.12)
Total	87.2 (67.9, 95.6)	87.2 (76.9, 96.6)	NS

Abbreviation: NS, effect size not calculated due to no difference among groups.

^a Lower HAGOS total score than in the high-specialization men ($P = .006$).

on sport and recreation and physical activity, we noted a small effect-size difference and no difference between the high- and low-specialization groups, respectively. These findings could suggest that early ice hockey specialization had greater physical effects on the players' hip and groin function during off-ice than on-ice activities. This idea aligns with the evidence that the majority of reported noncontact and overuse hip and groin injuries in collegiate ice hockey athletes are non-time-loss injuries² that are affecting them but not in a way that limits their on-ice activities.

To our knowledge, this was also the first study to examine sport specialization during early adolescence and its relationship with subjective musculoskeletal function during early adulthood. Much of the prior evidence pertaining to the relationship between sport specialization and musculoskeletal injury has focused on adolescent participants' current sport specialization practices and either retrospective injury rates^{15,22,23} or prospective injury rates over the following year of sport involvement during adolescence.²⁴ The possibility that early ice hockey specialization may contribute to impaired physical function during early adulthood shines light on a potential area for education and intervention in youth and collegiate ice hockey athletes. As health advocates for youth ice hockey athletes, parents, coaches, organizations, and health care providers should be aware of this possible relationship. Our results could provide support for recent initiatives by some youth hockey organizations, such as USA Hockey and Hockey Canada, that have recommended development models that include delaying ice hockey specialization and incorporating interseason time off from ice hockey. Additionally, because our findings suggested that early ice hockey specialization could be related to hip and groin dysfunction during collegiate ice hockey, athletic trainers and other sports medicine clinicians could theoretically use the 3-point sport specialization questionnaire as a screening tool to identify athletes who may be predisposed to chronic hip and groin dysfunction. However, further research is needed before evidence-based screening recommendations can be made.

In alignment with previous researchers,^{15,25} we did not note a sex-related difference in the proportion of participants who reported high, moderate, or low specialization. Nevertheless, female collegiate ice hockey athletes who were highly specialized before high school reported greater hip and groin dysfunction (and, therefore, had a worse HAGOS total score) than highly specialized male ice hockey athletes. We did not demonstrate sex differences between the moderate- and low-specialization groups in the HAGOS total score. It is possible that sex differences in hip and groin anatomy and maturation processes could lead to alternative physical effects of early specialization on hip and groin tissues and neuromuscular control in female and male adolescents. Recent evidence²⁶ indicates that adolescent female athletes who are specialized during puberty may develop compromised neuromuscular-control patterns that place them at greater risk for knee injury compared with multisport female athletes. Our observation that highly specialized female ice hockey athletes experienced greater hip and groin dysfunction could help explain the epidemiologic reports that women's ice hockey athletes (77.2%)

experienced higher rates of noncontact and overuse hip and groin injuries than men's ice hockey athletes (67.0%).²

It is important to consider limitations in our methods when interpreting our findings. We used a retrospective cohort design, which makes it difficult to establish a causal relationship between our exposure of interest, sport specialization, and outcome of interest, hip and groin dysfunction. The sport specialization questionnaire used to stratify participants into the high-, moderate-, or low-specialization group relied on participants' memories of their hockey participation practices before high school and may be subject to bias. Our population focused on collegiate-level ice hockey athletes; however, our sample was relatively small and consisted of participants from NCAA Division III and American Collegiate Hockey Association Divisions I through III ice hockey teams only. Although these leagues and divisions represent the majority of the collegiate ice hockey population, our results may not be applicable to collegiate ice hockey athletes in more elite-level leagues and divisions.

CONCLUSIONS

Collegiate ice hockey athletes who were highly specialized before high school reported greater current hip and groin pain, symptoms, and dysfunction during activities of daily living and sport and recreation and lower current hip- and groin-related quality of life compared with low-specialization ice hockey athletes. Early ice hockey specialization may be detrimental to long-term hip and groin function in collegiate ice hockey athletes.

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