The Association of Hip Strength and Flexibility With the Incidence of Adductor Muscle Strains in Professional Ice Hockey Players*

Timothy F. Tyler,†‡ PT, ATC, Stephen J. Nicholas,† MD, Richard J. Campbell,§ ATC, CSCS, and Malachy P. McHugh,† PhD

From the †Nicholas Institute of Sports Medicine and Athletic Trauma, Department of Orthopaedics, Lenox Hill Hospital, New York, and the §New York Islanders Ice Hockey Club, Uniondale, New York

ABSTRACT

This prospective study was conducted to determine whether hip muscle strength and flexibility play a role in the incidence of adductor and hip flexor strains in National Hockey League ice hockey team players. Hip flexion, abduction, and adduction strength were measured in 81 players before two consecutive seasons. Thirty-four players were cut, traded, or sent to the minor league before the beginning of the season. Injury and individual exposure data were recorded for the remaining 47 players. Eight players experienced 11 adductor muscle strains, and there were 4 hip flexor strains. Preseason hip adduction strength was 18% lower in the players who subsequently sustained an adductor muscle strain compared with that of uninjured players. Adduction strength was 95% of abduction strength in the uninjured players but only 78% of abduction strength in the injured players. Preseason hip adductor flexibility was not different between players who sustained adductor muscle strains and those who did not. These results indicate that preseason hip strength testing of professional ice hockey players can identify players at risk of developing adductor muscle strains. A player was 17 times more likely to sustain an adductor muscle strain if his adductor strength was less than 80% of his abductor strength.

Adductor muscle strains are among the most common injuries seen in ice hockey. Lorentzon et al.[10] reported that adductor strains accounted for 10% of all injuries (10 of 95) in elite Swedish ice hockey players. Mölsä et al.[14] reported that adductor strains accounted for 43% of all muscle strains (20 of 47) in elite Finnish ice hockey players. Sim et al.[20] reported that ice hockey players are at high risk for noncontact musculoskeletal injuries because of the excessive force generated during the acceleration and deceleration phases of skating. During the powerful skating stride the hip extensors and abductors are the prime movers, while the hip flexors and adductors act to stabilize the hip and decelerate the limb. In ice hockey players, adductor strains may be caused by the eccentric force of the adductors attempting to decelerate the leg during a stride.[19] A strength imbalance between the propulsive muscles and stabilizing muscles has been proposed as a mechanism for adductor muscle strains in athletes.[4]

Strength and flexibility imbalances have been associated with injuries in various sports.[3,9,16] Preseason hamstring muscle weakness was identified as a risk factor for hamstring muscle strains in Australian rules football players,[16] while musculoskeletal tightness was identified as a risk factor for adductor strains in professional soccer players.[3] Both strength and flexibility imbalances are associated with lower extremity injuries in female collegiate athletes.[9] Strength and flexibility imbalances may manifest as differences between sides or abnormal ratios between agonist and antagonist muscle groups. The association between strength and flexibility and adductor muscle strains has not been previously studied in ice hockey players.

The purpose of this prospective study was to determine whether hip muscle strength and flexibility play a role in the incidence of adductor and hip flexor muscle strains in a National Hockey League (NHL) professional ice hockey team.

MATERIALS AND METHODS

Before the 1997–1998 and 1998–1999 seasons, all players under contract with one NHL professional ice hockey team participated in a preseason screening examination to identify preexisting injuries and to obtain hip flexibility and strength measurements. During the season, the team's physician documented all injuries. Injury was defined as any event that kept a player out of a practice or a game or required the attention of the team physician.[14, 15] An adductor muscle strain was defined as pain on palpation of the adductor tendons or the insertion on the pubic bone, or both, and groin pain during adduction against resistance.[6, 11, 13] Adductor strains were graded as a first-degree strain if there was pain but minimal loss of strength and minimal restriction of motion. A second-degree strain was defined as tissue damage that compromises the strength of the muscle but does not include complete loss of strength and function. A third-degree strain was defined as complete disruption of the muscle tendon unit and complete loss of function of the muscle.[22] A thorough history was taken and a clinical examination performed in all players to differentiate adductor muscle strains from athletic pubalgia, osteitis pubis, hernia, hip joint osteoarthrosis, rectal or testicular referred pain, piriformis syndrome, or the presence of a coexisting fracture of the pelvis or the lower extremities.[6, 11, 13, 17, 21]

Forty-six players were tested before the 1997–1998 season and 55 players were tested before the 1998–1999 season. Twenty of these players were tested on consecutive years (total of 81 players). During the 1997–1998 season there were 131 practices and 88 games and during the 1998–1999 season there were 135 practices and 85 games. The number of practices and games each player participated in was recorded for each season. An exposure was defined as any participation in a practice or game. The team consisted of a total of 25 skaters and 2 goalies during each season.

Hip flexion, abduction, and adduction strength were measured with an instrumented manual muscle-testing device (Nicholas Manual Muscle Tester, Lafayette Instruments, Lafayette, Indiana). Hip flexion was tested with the subject in a sitting position, where he was asked to raise his thigh 8 inches from the surface and to maintain the position. A force was manually applied with the manual muscle-testing device in hand to break the muscle contraction.[12] The required force to break the muscle contraction was then recorded in newtons. The average of two maximum effort tests for each action was taken on both legs for each player. The same instrumented break test technique was used for abduction and adduction strength using the positions delineated by Kendall and McCreary.[8] Abduction strength was tested with the subject in the side-lying position. The player was asked to abduct the leg

above horizontal, and a breaking force was applied distally, 1 inch above the lateral malleolus. The side-lying position was also used for testing adduction muscle strength. The player was asked to straighten the lower leg and then lift the straight leg 12 inches off the table, then a breaking force was applied 1 inch above the medial malleolus. Muscle strength assessment using a handheld dynamometer has been shown to be a valid and reliable method of measuring strength.[2, 12, 25] Bohannon[2] demonstrated test-retest correlation coefficients of 0.84 to 0.99 for hip strength measurements, indicating good-to-high reproducibility.

Hip adductor flexibility was measured with the player supine on a plinth. The moving arm of a goniometer was aligned with the long axis of the femur, and the stationary arm was parallel to a line between the anterior superior iliac spines. The starting position was with the legs adducted together. The leg being tested was passively moved away from midline until rotation of the femur occurred, indicating the end of adductor flexibility.[1] The Thomas test position was used to measure hip flexor flexibility. The subject was asked to lie supine on the table with the gluteal folds at the edge of the table. The subject held the contralateral limb in a knee-to-chest position. Subjects were instructed to push their lower back into the table. An assistant then lowered the subject's test leg to the point where motion ceased or there was external rotation of the femur. At this point the tester took a goniometric measurement at the hip. The fulcrum of the goniometer was aligned with the greater trochanter. The moving arm was aligned with the lateral femoral condyle, and the stationary arm was parallel to the table.[24] The range of motion was quantified as a negative number if the measurement was above horizontal and positive if below horizontal.[5] The same investigator performed all flexibility and strength measurements for the study.

Data Analysis

Mixed model analysis of variance was used to determine whether preseason strength and flexibility differed between players who sustained subsequent adductor and hip flexor strains and those who were uninjured. The between-subjects factor was group (injured or uninjured) and the within-subjects factor was side (injured versus uninjured in the injured group and left versus right in the uninjured group). Bonferroni corrections were applied to all post hoc pair-wise comparisons. Discriminant analysis was used to determine which variables were the best predictors of muscle strains. Values in the text are reported as mean $\pm$ standard deviation, and values in the figures are mean $\pm$ standard error.

RESULTS

Of the 81 players who had preseason testing, 34 were cut, traded, or sent to the minor league before the beginning of the season. Injury and exposure data were recorded for the remaining 47 players, 17 of whom were followed over both seasons. The mean age, height, and weight of the players were 23 ± 4.3 years, 175 ± 5 cm, and 89 ± 7 kg,

respectively. There were 141 injuries during the two seasons, giving an injury rate of 17 injuries per 1000 player-exposures.

There were 11 adductor muscle strains in 8 players. Two players who had adductor strains during the initial season had recurrences during the second season. One player had bilateral adductor strains at different times during the first season. There were two second-degree strains and nine first-degree strains. Twenty-seven games were missed because of adductor muscle strains. All adductor strains occurred during the 173 game situations, giving an incidence of 3.2 adductor strains per 1000 player-game exposures. The players who sustained an adductor strain participated in a similar number of games as the uninjured players (97 ± 70 versus 71 ± 48, $P = 0.19$). Two of the players who sustained adductor strains had sustained a previous adductor strain, and one of the uninjured players had sustained a previous adductor strain. Only three players sustained hip flexor strains (all first-degree), resulting in only two missed games. Limited sample size precluded analysis of the role of strength or flexibility in the incidence of hip flexor strains.

Preseason hip adduction strength was a mean of 18% lower in the eight players who subsequently sustained adductor strains compared with the mean for uninjured players ($P = 0.021$) (Fig. 1). This effect was similar for absolute ($P = 0.021$) and weight-corrected strength ($P = 0.039$) values. In the players who sustained adductor strains, there was no difference in hip adduction strength between the injured and uninjured sides ($P = 0.18$). The hip adduction-to-abduction strength ratio was significantly different between the two groups ($P = 0.038$). Adduction strength was 95% of abduction strength in the uninjured players but only 78% of mean abduction strength in the injured players (Fig. 2). In the players who sustained an adductor strain, the preseason adduction-to-abduction strength ratio was lower on the side that was subsequently injured compared with the uninjured side ($P = 0.011$). Adduction strength was 86% of abduction
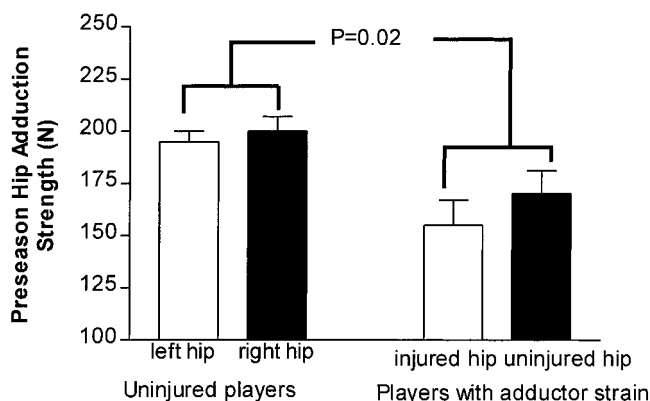
Figure 1. Mean ($\pm$SE) preseason hip strength in each hip for ice hockey players who did not experience an adductor strain ($N = 39$) compared with players who subsequently sustained an adductor strain ($N = 8$).
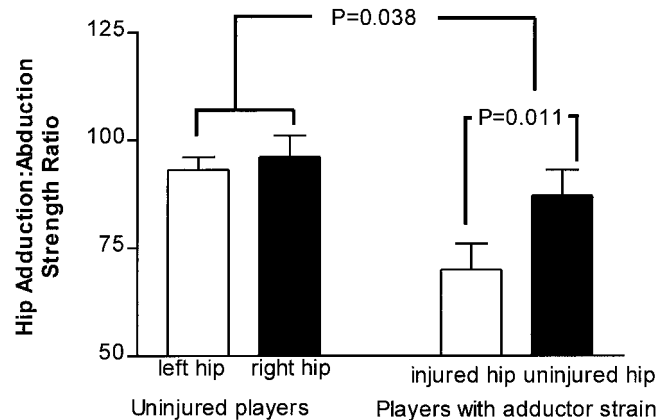
Figure 2. Mean hip adduction-to-abduction strength ratio in each hip for ice hockey players who did not experience an adductor strain ($N = 39$) compared with players who subsequently sustained an adductor strain ($N = 8$).

strength on the uninjured side but only 70% of mean abduction strength on the injured side.

There was no significant difference in preseason hip adductor flexibility between the players who subsequently sustained adductor strains ($46.3° \pm 10.3°$) and the uninjured players ($45.8° \pm 11.0°$) ($P = 0.92$). Similarly, of the eight players who sustained injuries to the groin, there was no significant difference in preseason adductor flexibility between the injured side ($46.3° \pm 10.3°$) and the uninjured side ($46.3° \pm 9.2°$) ($P = 0.69$).

Discriminant analysis indicated that the hip adduction-to-abduction strength ratio was the best predictor of a future adductor strain ($P = 0.003$). Adduction-to-abduction strength ratios were calculated for 94 hips (47 players). Of these hips, 9 sustained adductor strains (one player sustained bilateral strains and two players had a recurrence during the second season) and 85 were uninjured. Injury risk was 1 per 3.75 in hips that had tested hip adduction strength less than 80% of abduction strength (8 strains among 30 hips with 80% strength). Therefore, the relative risk for an adductor strain was 17:1 based on a hip adduction of less than 80% of abduction strength.

DISCUSSION

This is the first study to prospectively examine the association of strength and flexibility with the incidence of adductor strains in NHL players. Our results demonstrate that players with weaker adductor muscles were more likely to experience an adductor strain during the season. Furthermore, players whose adductors were markedly weaker than their abductors were more likely to experience an adductor strain. By contrast, adductor flexibility was not associated with adductor strains.

Previous studies have shown an association between strength and flexibility and musculoskeletal strains in various athletic populations.[3,9,16] Knapik et al.[9] reported that strength and flexibility imbalances in female colle-

giate athletes were associated with lower extremity injuries in general, but not specifically with the muscle group in which the imbalance was found. Ekstrand and Gillquist[3] found that preseason hip abduction range of motion was less in soccer players who subsequently sustained adductor strains compared with that of uninjured players. Recently, Orchard et al.[16] reported that hamstring muscle weakness was associated with an increased risk of hamstring muscle strains in Australian rules football players, while hamstring muscle flexibility was not a significant risk factor. Preseason strength was 16% lower in the hamstring muscles that subsequently sustained an injury compared with those that were uninjured. The best predictor of a muscle strain injury was the strength ratio of the agonist to antagonist muscle groups. Hamstring muscle strength was 55% of quadriceps muscle strength in the injured group, compared with 66% in the uninjured group. These findings are comparable with our results for adductor strains in professional ice hockey players. Preseason hip adduction strength was 18% lower in the injured players compared with the uninjured players, and adduction strength was only 78% of abduction strength in the injured players compared with 95% in the uninjured players.

The incidence of injury was 17 injuries per 1000 player-exposures in our study. This value is not directly comparable with previously reported injury incidences of between 30 and 80 injuries per 1000 player-game hours.[10, 14, 23] Unlike the present study, which documented the actual number of practices and games each player participated in, previous studies estimated exposure based on team size and average participation.[7, 10, 14, 23] Additionally, in our study, the incidence of injury was reported for game and practice exposures combined. However, the incidence of injury was probably much higher in games than in practices. Lorentzon et al.[10] reported an incidence of 1.4 injuries per 1000 player-practice exposures compared with 78.4 injuries per 1000 player-game exposures. The purpose of the present study was to examine factors that contribute to adductor muscle strains in professional ice hockey rather than to report on the incidence of all injuries.

There were 11 adductor muscle strains, all occurring in game situations, giving an incidence of 3.2 injuries per 1000 player-game exposures in our study. Adductor strains accounted for approximately 8% of all injuries. This finding is similar to that of Lorentzon et al.,[10] who reported that adductor strains make up 10% of all injuries. Of the eight players who sustained adductor strains, two had sustained previous strains on the same side. Additionally, two other players reinjured the same side in the second season of the study. One player had bilateral adductor muscle strains at different times during the first season. Therefore, four of nine adductor strains (44%) were recurrent injuries. This is consistent with the results of Seward et al.,[18] who reported a 32% recurrence rate for adductor strains in players of Australian rules football.

The high incidence of recurrent strains could be due to incomplete rehabilitation or inadequate time for complete tissue repair. Hölmich et al.[6] demonstrated that a conventional physical therapy program of massage, stretching, and modalities was ineffective in treating chronic adductor strains. By contrast, an 8- to 12-week active strengthening program consisting of progressive resistive adduction and abduction exercises, balance training, abdominal strengthening, and skating movements on a slide board proved more effective in treating chronic adductor strains. An increased emphasis on strengthening exercises may reduce the recurrence rate of adductor strains.

SUMMARY

Our results indicate that preseason hip strength testing of professional ice hockey players can identify players at risk of developing adductor strains. Hip adduction strength was 18% lower in players who subsequently sustained an adductor strain compared with that of uninjured players. Moreover, a player was 17 times more likely to sustain an adductor strain if his adductor strength was less than 80% of his abductor strength. Future studies should prospectively evaluate whether preseason strength training is effective at reducing the incidence of adductor strains in players identified at risk.

ACKNOWLEDGMENTS

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