

The Effectiveness of a Preseason Exercise Program to Prevent Adductor Muscle Strains in Professional Ice Hockey Players*

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Background: Adductor strains are among the most common injuries in ice hockey. Hip adductor weakness has been identified as a strong risk factor.

Hypothesis: An intervention program including muscle strengthening can reduce the incidence of adductor strains in professional ice hockey players.

Study Design: Prospective risk factor prevention study.

Methods: Thirty-three of 58 players from the same National Hockey League team were identified as “at risk” on the basis of preseason hip adductor strength and participated in an intervention program. The program consisted of 6 weeks of exercises aimed at functional strengthening of the adductor muscles. Injury and individual exposure data were recorded for all players.

Results: There were 3 adductor strains in the 2 seasons subsequent to the intervention, compared with 11 in the previous 2 seasons (0.71 versus 3.2 per 1000 player-game exposures). All adductor strains were first-degree strains and occurred during games.

Conclusions: A therapeutic intervention of strengthening the adductor muscle group appears to be an effective method for preventing adductor strains in professional ice hockey players.

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An effective strategy for injury prevention is to 1) identify the incidence of a specific injury, 2) identify risk factors for that injury, 3) design interventions to address the risk factors, and 4) test the effectiveness of the intervention at reducing the incidence of that specific injury. Adductor muscle strains are recognized as a significant problem in professional ice hockey players.^{6,10} Therefore, we initially sought to identify the incidence of adductor muscle strains in professional ice hockey players and to examine whether deficits in muscle strength or flexibility were risk factors.¹⁷ In that study, adductor muscle weakness was identified as a strong risk factor for adductor muscle strain, but lack of flexibility was not identified as a significant risk factor. The ratio of adductor-to-abductor muscle strength was the best predictor of subsequent injury. Therefore, the purpose of the current study was to examine whether having players classified as “at risk” partici-

pate in an intervention program could reduce the incidence of adductor muscle strains.

MATERIALS AND METHODS

Before the 1999 to 2000 and 2000 to 2001 seasons, all players under contract with one National Hockey League professional ice hockey team participated in a preseason screening examination to identify preexisting injuries and to obtain hip muscle strength scores. 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.^{10,11} An adductor muscle strain was defined as pain on palpation of the adductor tendons or the insertion on the pubic bone with or without pain during resisted adduction.^{3,7,9} Adductor muscle 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 compromised the strength of the muscle, but did not include complete loss of strength and function. A third-degree strain denoted complete disruption of the muscle-tendon unit, including complete loss of function of the muscle.¹⁶ A thorough history and a clinical examination were performed on all players to differentiate adductor muscle

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strains from athletic pubalgia, osteitis pubis, hernia, hip joint osteoarthritis, rectal or testicular referred pain, piri-formis syndrome, or the presence of a coexisting fracture of the pelvis or the lower extremities.^{3, 7, 9, 13, 15}

Fifty players were tested before the 1999 to 2000 season and 45 players were tested before the 2000 to 2001 season. Of these players, 12 were tested on consecutive years, giving a total of 83 different players. During the 1999 to 2000 season there were 136 practices and 88 games. During the 2000 to 2001 season there were 139 practices and 86 games. The number of practices and games each individual player participated in was recorded each season. An exposure was defined as any participation in a practice or game (total number of exposures, 10,294).

Hip abduction and adduction muscle strengths were measured with an instrumented manual muscle-testing device (Nicholas Manual Muscle Tester, Lafayette Instruments, Lafayette, Indiana). A force was manually applied with the muscle-testing device in the examiner's hand to break the muscle contraction.⁸ The 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. A break test technique was used for abduction and adduction by using the positions delineated by Kendall and McCreary.⁴ Abduction muscle strength was tested with the subject in the side-lying position. The player was asked to abduct his top 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 his bottom leg and then lift the straight leg 12 inches off the table and a breaking force was applied 1 inch above the medial malleolus. Muscle strength assessment with a handheld dynamometer has been shown to be a valid and reliable method of measuring strength.^{1, 8, 18} Bohannon¹ demonstrated test-retest correlation coefficients of 0.84 to 0.99 for hip strength measurements, indicating good-to-high reproducibility. The same investigator performed all strength measurements for the study.

Any player whose adductor-to-abductor muscle strength ratio was less than 80% participated in a therapeutic exercise program emphasizing hip adductor muscle strengthening. The program consisted of concentric, eccentric, and functional strengthening of the adductor muscles (Table 1). Each player enrolled in the intervention program completed three sessions per week for 6 weeks during the preseason.

Data Analysis

Injury incidence was calculated by dividing the total number of injuries by the sum of the total number of games for each player and dividing by 1000 (per 1000 exposures). Chi-square analysis was used to compare the preintervention and intervention seasons with respect to the overall injury incidence, the incidence of adductor muscle strains, the number of adductor muscle strains in all players, and the number of adductor muscle strains in at risk players.

TABLE 1
Adductor Muscle Strain Injury Prevention Program

Warm-up
Bike
Adductor muscle stretching
Sumo squats
Side lunges
Kneeling pelvic tilts
Strengthening program
Ball squeezes (legs bent to legs straight)
Different ball sizes
Concentric adduction with weight against gravity
Adduction while standing with a cable column or elastic resistance
Seated adduction machine
Standing with involved foot on sliding board and moving in the sagittal plane
Bilateral adduction on sliding board and moving in the frontal plane (that is, bilateral adduction simultaneously)
Unilateral lunges with reciprocal arm movements
Sports-specific training
On ice kneeling adductor pull togethers
Standing resisted stride lengths with a cable column to simulate skating
Slide skating
Cable column crossover pulls
Clinical Goal: Adduction strength at least 80% of the adduction strength

RESULTS

Of the 83 players who had preseason testing, 25 were cut, traded, or sent to the minor league before the beginning of the season. Injury and exposure data were recorded for the remaining 58 players, 12 of whom were followed over both seasons. The mean age, height, and weight of the players were 24 ± 4.5 years, 187 ± 7 cm, 91 ± 8 kg, respectively. There were 140 injuries of different types during the two seasons, giving an incidence of 13.6 injuries per 1000 player exposures (practice or game). This was not different from the injury incidence for the previous two seasons (17 per 1000 player exposures; $P = 0.08$).

On the basis of the preseason strength testing, 33 of these 58 players were classified as at risk and were included in the intervention program. Seventeen players participated in the intervention program in the 1st year and 21 players in the 2nd year. Five players participated in the program both years and two players who participated in the program the 1st year were not on the program the next season.

There were only three adductor muscle strains during the course of the study; one in the first season and two in the second season. All strains were first-degree strains and occurred during games. All three injured players were in the intervention group; however, one of the players sustained his injury in a preseason game before completion of the adductor muscle training program. This player had completed only five strengthening sessions before the adductor muscle strain occurred. One of the injured players was subsequently found to have a coexisting sports hernia that was treated surgically, resulting in 50 games missed. The other two injured players missed one and two games, respectively. None of these players had previously sustained an adductor muscle strain.

TABLE 2
Comparison of Adductor Muscle Strains between the
Preintervention Seasons and the Intervention Seasons

Variable	Preintervention seasons	Intervention seasons	<i>P</i> Value
Number of players	47	58	
Overall injury incidence (per 1000 player-exposures)	17	13.6	0.08
Number of adductor strains	11	3	<0.01
Incidence of adductor strains (per 1000 player-games)	3.2	0.71	<0.05
Number of at risk players with adductor strains	8 of 21	3 of 33	<0.05

The previously reported incidence of adductor muscle strains for the two seasons before this intervention was 3.2 strains per 1000 player-game exposures.¹⁷ The incidence of adductor strains for the two seasons in the present study was reduced to 0.71 strains per 1000 player-game exposures ($P < 0.05$). Furthermore, in the previous 2 years 8 of 21 players with preseason adduction-to-abduction muscle strength ratios of less than 80% sustained a subsequent adductor muscle strain. In the present study, the 33 players with preseason adduction-to-abduc-

tion muscle strength ratios of less than 80% participated in the intervention program, and only 3 sustained a subsequent adductor strain. This represents a significant reduction in risk ($P < 0.05$) achieved by implementing the intervention for players identified as at risk (Table 2).

Adductor-to-abductor muscle strength ratios were not retested at the completion of the intervention program because the tester (TFT) did not have access to players immediately before the first game of the season. Given the high interrater variability of the handheld dynamometer, use of another tester was not thought to be appropriate. However, seven players who participated in the intervention program in the 1st year were retested in the following preseason. They demonstrated a significant improvement in adduction-to-abduction muscle strength ratios ($70.5\% \pm 8.7\%$ versus $82.3\% \pm 7.4\%$; $P < 0.001$).

DISCUSSION

In this study, we describe an effective strategy for injury prevention by first determining the incidence of adductor muscle strains in professional ice hockey players and, after that, identifying the risk factors for a future adduc-

TABLE 3
Groin Strain Postinjury Program

Phase I (Acute)
RICE (rest, ice, compression, and elevation) for first \approx 48 hours after injury
Nonsteroidal antiinflammatory drugs
Massage
Electrical stimulation
Ultrasound
Submaximal isometric adduction with knees bent \rightarrow with knees straight progressing to maximal isometric adduction, pain-free
Hip passive range of motion (PROM) in pain-free range
Nonweightbearing hip progressive resistive exercises (PREs) without weight in antigravity position (all except abduction), pain-free, low-load, high-repetition exercise
Upper body and trunk strengthening
Contralateral lower extremity strengthening
Flexibility program for noninvolved muscles
Bilateral balance board
Clinical Milestone: Concentric adduction against gravity without pain.
Phase II (Subacute)
Bicycling/swimming
Sumo squats
Single limb stance
Concentric adduction with weight against gravity
Standing with involved foot on sliding board moving in frontal plane
Adduction in standing on cable column or elastic resistance
Seated adduction machine
Bilateral adduction on sliding board moving in frontal plane (that is, bilateral adduction simultaneously)
Unilateral lunges (sagittal) with reciprocal arm movements
Multiplane trunk tilting
Balance board squats with throwbacks
General flexibility program
Clinical Milestone: Involved lower extremity PROM equal to that of the uninvolved side and involved adductor strength at least 75% that of the ipsilateral abductors
Phase III (Sport-specific training)
Phase II exercises with increase in load, intensity, speed, and volume
Standing resisted stride lengths on cable column to simulate skating
Slide board
On ice kneeling adductor pull together
Lunges (in all planes)
Correct or modify ice skating technique
Clinical Milestone: Adduction strength at least 90% to 100% of the abduction strength and involved muscle strength equal to that of the contralateral side

tor muscle strain. The best predictor of a future groin strain was an adductor-to-abductor muscle strength ratio of less than 80%.¹⁷ The next step was to design an adductor muscle-strengthening program to address the risk factor. Last, we performed the intervention program to demonstrate that strengthening the adductor muscle group can be an effective method for preventing adductor muscle strains in professional ice hockey players.

Previous studies have shown an association between strength and musculoskeletal strains in various athletic populations.^{2,5,12,14} Orchard et al.¹² reported that hamstring muscle weakness was associated with an increased risk of hamstring muscle strains in Australian Rules footballers. In the players who subsequently sustained an injury, preseason hamstring muscle strength in the injured leg was 16% lower than in the uninjured leg. The best predictor of a muscle strain injury was the strength ratio of the agonist-to-antagonist muscle group. Hamstring muscle strength was 55% of quadriceps muscle strength in the injured group, compared with 66% in the uninjured group. These authors did not provide an intervention and test the effectiveness of a strengthening program at reducing the incidence of hamstring muscle strains. However, Holmich et al.³ were able to demonstrate the effectiveness of a muscle-strengthening program as treatment for chronic adductor muscle pain in athletes. Although adductor muscle strength was never measured, the authors were able to show significant improvement in pain in a group of patients actively training the adductor muscle group compared with a group treated passively with stretching, massage, and electric stimulation. In the present study, we also successfully implemented an active training program similar to the program described to prevent future adductor muscle strains.

In the present study there were three adductor strains that all occurred in game situations. This gives an incidence of 0.71 adductor muscle strains per 1000 player-game exposures. Adductor muscle strains accounted for approximately 2% of all injuries. In contrast, there were 11 adductor muscle strains and an incidence of 3.2 adductor strains per 1000 player-game exposures for the two seasons before the intervention.¹⁷ In those two seasons, adductor muscle strains accounted for approximately 8% of all injuries. This was also significantly lower than the incidence reported by Lorentzon et al.,⁶ who found adductor muscle strains to account for 10% of all injuries. Of the three players who sustained adductor strains, none had sustained a previous adductor muscle strain on the same side. One player had bilateral adductor muscle strains at different times during the first season.

Despite the identification of risk factors and strengthening intervention for ice hockey players, adductor muscle strains continue to occur throughout the National Hockey League. The results of the present study may provide some insight into avoiding a recurrence or preventing a chronic adductor muscle strain. Although players participating in the intervention program had experienced adductor muscle strains during their careers, no player who participated in the program went on to have another ad-

ductor muscle strain in the two seasons evaluated. The three players who did sustain an adductor muscle strain missed a minimal amount of playing time because of their adductor muscle strain. The emphasis of our rehabilitation program was to restore the adduction-to-abduction muscle strength ratio of the injured leg. This was done by providing a therapeutic exercise program similar to that used by the at risk players once the injured player was past the early healing phase (Table 3). Other authors have stated that an active training program along with complete strengthening of the adductor muscle group is the key to a successful rehabilitation.^{3,7}

SUMMARY

In this prospective study we evaluated the effectiveness of a preseason strength training program at reducing the incidence of adductor muscle strains in players identified as at risk. The results indicate that preseason hip strengthening in professional ice hockey players whose adductor-to-abductor muscle strength ratio was less than 80% can lower the incidence of adductor muscle strains.

REFERENCES

1. Bohannon RW: Test-retest reliability of hand-held dynamometry during a single session of strength assessment. *Phys Ther* 66: 206-209, 1986
2. Ekstrand J, Gillquist J: The avoidability of soccer injuries. *Int J Sports Med* 4: 124-128, 1983
3. Holmich P, Uhrskou P, Ulnits L, et al: Effectiveness of active physical training as treatment for long-standing adductor-related groin pain in athletes: Randomised trial. *Lancet* 353: 439-443, 1999
4. Kendall FP, McCreary EK: *Muscles: Testing and Function*. Third edition. Baltimore, Williams & Wilkins, 1983
5. Knapik JJ, Bauman CL, Jones BH, et al: Preseason strength and flexibility imbalances associated with athletic injuries in female collegiate athletes. *Am J Sports Med* 19: 76-81, 1991
6. Lorentzon R, Wedren H, Pietila T: Incidences, nature, and causes of ice hockey injuries: A three-year prospective study of a Swedish elite ice hockey team. *Am J Sports Med* 16: 392-396, 1988
7. Lynch SA, Renstrom PA: Groin injuries in sport: Treatment strategies. *Sports Med* 28: 137-144, 1999
8. Marino M, Nicholas JA, Gleim GW, et al: The efficacy of manual assessment of muscle strength using a new device. *Am J Sports Med* 10: 360-364, 1982
9. Meyers WC, Ricciardi R, Busconi BD, et al: Adductor pain in athletes, in Arendt EA (ed): *Orthopaedic Knowledge Update, Sports Medicine 2*. Rosemont, IL, American Academy of Orthopaedic Surgeons, 1999, pp 281-289
10. Molsa J, Airaksinen O, Nasman O, et al: Ice hockey injuries in Finland. A prospective epidemiologic study. *Am J Sports Med* 25: 495-499, 1997
11. Noyes FR, Lindenfeld TN, Marshall MT: What determines an athletic injury (definition)? Who determines an injury (occurrence)? *Am J Sports Med* 16: S65-S68, 1988
12. Orchard J, Marsden J, Lord S, et al: Preseason hamstring muscle weakness associated with hamstring muscle injury in Australian footballers. *Am J Sports Med* 25: 81-85, 1997
13. Renstrom P, Peterson L: Groin injuries in athletes. *Br J Sports Med* 14: 30-36, 1980
14. Seward H, Orchard J, Hazard H, et al: Football injuries in Australia at the elite level. *Med J Austr* 159: 298-301, 1993
15. Simonet WT, Saylor HL III, Sim L: Abdominal wall muscle tears in hockey players. *Int J Sports Med* 16: 126-128, 1998
16. Speer KP, Lohnes J, Garrett WE Jr: Radiographic imaging of muscle strain injury. *Am J Sports Med* 21: 89-96, 1993
17. Tyler TF, Nicholas SJ, Campbell RJ, et al: The association of hip strength and flexibility with the incidence of adductor muscle strains in professional ice hockey players. *Am J Sports Med* 29: 124-128, 2001
18. Wadsworth CT, Krishnan R, Sear M, et al: Intrarater reliability of manual muscle testing and hand-held dynamic muscle testing. *Phys Ther* 67: 1342-1347, 1987