Investigating Strength and Range of Motion of the Hip Complex in Ice Hockey Athletes.

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Previous epidemiological studies investigating injuries in ice hockey have found the hip to be more frequently affected than other body areas, especially via non-contact mechanisms [1-4]. Many studies find strength to be an important risk factor for lower limb injuries and in particular overuse injuries [5-10]. Muscular strength and proprioception are considered key components in joint stability with significant differences in dynamic balance following a strength and proprioception protocol, leading to a reduced risk of injury [11].

Limited range of motion (ROM) has been widely reported to increase the potential risk of injury to athletes in both soccer and ice hockey [7, 12-14] with muscular tightness being a major risk factor for adductor strains in professional soccer [7]. In a prospective study of professional soccer athletes it was found that those who displayed a decrease in hamstring or quadriceps muscle ROM were significantly more likely to sustain a hamstring or quadriceps muscle injury than athletes who did not display tightness, therefore indicating the potential to ascertain injury risk from pre-season data [15].

Tyler and collegues [12] found that ice hockey athletes displaying a decrease in strength of the hip adductor muscles were at a significantly higher risk of receiving a hip adductor muscle strain, with athletes exhibiting hip adductor strength less than 80% of their hip abduction strength being at significantly greater risk of injury [12]. Additionally many studies, particulary in soccer research, have concluded that strength is a more prominent determinant of injury than ROM alone when analysing athletes who subsequently sustained an injury [5-10, 16].

The purpose of this study was to compare the differences in ROM and strength of the hip for both dominant (Dom) and non-dominant (Ndom) legs in ice hockey and soccer athletes. Soccer athletes were chosen for comparison to ice hockey athletes due to similarities between the two sports with regards to the intermittent nature of the sports [17-19] and the similar high number of lower limb injuries observed in soccer[1-4, 15, 20]. A key outcome of this analysis was to determine why the ice hockey athletes' hip is possibly 'at risk' from non-contact injuries.

Methodology

Design

Using a case-control design, participants were required to complete one experimental trial. ROM assessment comprised of one familiarization movement and three experimental movements, strength assessment comprised of one familiarization movement and five experimental movements, with a one minute rest allowed between each movement. Dominance was determined by participants' preferred leg used to kick a ball. For ROM and strength measurement the starting leg (either Dom or Ndom) was alternated by participant and an average of the measured experimental movements were taken for statistical analysis. Participants were asked to refrain from alcohol and strenuous exercise in the 24 hours preceding testing. All testing procedures were approved by a University ethics committee and written informed consent was given. Participants were treated in accordance with the Declaration of Helsinki.

Participants

Twenty-four male participants (mean ± SD: age 21 ± 1.0 yrs; height 182.6 ± 7.2 cm; body mass 81.6 ± 8.4 kg) were recruited from one National Collegiate Athletic Association Division III College within the Minnesota Intercollegiate Athletic Conference during the 2012-13 soccer and ice hockey seasons respectively. Of the 24 participants, eight were soccer athletes (Mean ± SD: Age 20.1 ± 0.99 yrs; Height 181.3 ± 7.3 cm; Body Mass 74.9 ± 5.2 kg) and 16 were ice hockey athletes (Mean ± SD: Age 22.1 ± 1.1 yrs; Height 183.3 ± 7.3 cm; Body Mass 84.9 ± 7.7 kg). Inclusion criteria stipulated that participants were members of either the soccer or ice hockey teams only, having played for at least one season and free from injury for at least three months preceding the date of testing.

Procedures

Prior to all experimental measurement, height (Seca 217, Seca, Hanover, MD, USA) and mass (Seca 700, Seca) were taken as part of the screening process accompanied with total limb length, measured from the anterior superior iliac spine (ASIS) to 2.54 cm above the lateral malleolus, and lower limb length measured from the head of fibula to 2.54 cm above the lateral malleolus and ASIS to one inch above the knee joint line allowing the manual muscle testing results to be converted to Nm/kg [21].

Participants also completed a five minute standardised sub-maximal ergometer warm-up at 50RPM (Monark 824E, Monark Exercise AB, Varberg, Sweden). ROM was measured in degrees (°) using a standard goniometer (Gollehon extendable goniometer, Lafayette Instruments, Lafayette, IN, USA) following the procedures of Reiman and Manske [22] and was completed in the following order: hip abduction, adduction, flexion in sitting (FS) and lying (FL), extension, internal (IR) and external rotation (ER).

Strength testing using the breaking force method [12] was completed using a hand held dynamometer (Datalink DLK900, Biometrics Ltd, Newport, UK), measured in Newtons (N) and was converted into Nm/kg by using participant's limb length and weight. Movement order matched that of ROM testing. After testing strength ratios were calculated both for adduction:abduction of the hip and external/internal rotation of the hip to evaluate any imbalances between opposing muscle groups.

Statistical Analyses

Data were analysed using SPSS version 19 (Chicago, IL, USA). A mixed model ANOVA was used to investigate interactions (sport (ice hockey/soccer) x leg (Dom/Ndom)) and main effects (leg differences or sport differences) for the ROM variables: abduction, adduction, FS, FL, extension, IR, ER and for the strength variables: abduction, adduction, FS, FL, extension, IR and ER. In the instance of a significant interaction (accepted at $p \leq 0.05$) post-hoc analysis was completed using least significance difference (LSD). Only significant findings were reported with their associated F values and effect size.

Results

Mean hip ROM for both ice hockey and soccer athletes are displayed in Table 1. There was a significant interaction for sport and leg dominance for ROM in adduction ($F(1,21) = 7.850$, $p = 0.011$, $Peta^2 = 0.272$). Ice hockey athletes had greater hip adduction on their Dom leg and also greater ROM than soccer athletes on their Dom leg (both $p = 0.002$) (Table 1). Ice hockey athletes also had greater ROM in adduction ($F(1,21) = 8.033$, $p = 0.010$, $Peta^2 = 0.277$) and less ROM in ER ($F(1,21) = 4.709$, $p = 0.042$, $Peta^2 = 0.183$) than soccer athletes (Figure 1).

There were also main effect differences between the legs of athletes regardless of sport. The Dom leg always displayed greater ROM in FS ($F(1,21) = 7.030$, $p<0.015$, $Peta^2 = 0.251$) (Figure 2). The Ndom leg displayed greater ROM in FL ($F(1,21) = 6.786$, $p = 0.017$, $Peta^2 = 0.244$) and IR ($F(1,21) = 6.940$, $p = 0.015$, $Peta^2 = 0.248$) (Figure 2). There were no other significant interactions between sport and leg, nor main effect differences between sport or leg for the remaining ROM variables measured.

Strength

Mean strength for both ice hockey and soccer athletes is displayed in Table 2. There was a significant interaction effect for sport and leg dominance for strength in adduction ($F(1,21) = 15.267$, $p = 0.001$, $Peta^2 = 0.421$). Ice hockey athletes had less adduction strength on their Ndom leg compared to their Dom leg (p = 0.02) as well as less strength in adduction than soccer athletes on their Ndom leg (p = 0.40) (Table 2). Similar to ice hockey athletes, soccer athletes had greater strength in adduction in their Dom leg compared to their Ndom leg (p = 0.033) (Table 2).

There were main effect differences for strength between the sports. Ice hockey athletes had less hip adduction strength (F (1,21) = 5.415, p = 0.030, Peta^2 = 0.205), FS (F (1,21) = 6.066, p = 0.023, Peta^2 = 0.224) and FL (F (1,21) = 5.411, p = 0.030, Peta^2 = 0.205) than soccer athletes (Figure 3). There was a main effect difference for the adduction:abduction ratio between the legs of all athletes, regardless of sport, with the Dom leg showing a higher ratio (more equal) than the Ndom leg (F (1,22) = 8.439, p = 0.008, Peta^2 = 0.277) (Figure 4). There were no other significant interactions between sport and leg, nor main effect differences between sport or leg for the variables measured.

Discussion

This study aimed to investigate the differences between ice hockey and soccer athletes hips with regards to ROM and strength. The main findings were that ice hockey athletes had greater hip adduction ROM compared to soccer athletes, along with greater ROM on their Dom leg compared to their Ndom leg. Ice hockey athletes also exhibited less strength in hip adduction when compared to soccer athletes, with all athletes showing decreased strength in hip adduction in their Ndom leg compared to their Dom leg. Another major finding is that ice hockey players presented with a decrease in ROM of their ER which has previously been suggested to increase an athlete's risk of developing a femoroacetabular impingement (FAI) injury. These findings may mean that ice hockey athletes are at an increased risk of injury due to their weakness in strength around the hip.

Although direct comparisons between the current study and that of the work of Tyler and colleagues [12] cannot be made due to the lack of injury data in the current study and the lack of strength measures given by Tyler and colleagues [12], some similarities can clearly be seen.

Tyler and colleagues [12] found that ice hockey athletes who subsequently went on to sustain a hip injury had a decrease in pre injury hip adduction strength compared to athletes who did not sustain an injury. When this information is considered alongside our finding that ice hockey athletes had an adduction strength deficit when compared to soccer athletes (Figure 3; ice hockey 2.51 Nm/kg vs. soccer 2.79 Nm/kg) it may suggest that ice hockey athletes are at an increased risk of injury. Hip adduction weakness is of also of particular importance as ice hockey athletes have previously been reported to be at a greater risk of injury with the existence of hip adductor weakness limiting the eccentric control needed for successful skating, along with a compromise of stability throughout the skating pattern [12, 23, 24]. This finding may hold interest for coaches, clinicians and trainers with an interest in performance enhancement and injury risk mitigation.

A further finding of our study was that ice hockey athletes had lower strength than soccer athletes in FS (ice hockey 1.84 Nm/kg vs. soccer 2.06 Nm/kg) and FL (ice hockey 1.44 Nm/kg vs. soccer 1.71 Nm/kg) (Figure 3). This may be important because the hip flexors and adductors act as stabilizers during ice skating [12], thus apparent weakness perhaps suggests some rationale for the incidence of non contact hip musculature injuries in ice hockey. In comparison to soccer specific literature this argument does seem to have merit. Studies such as those conducted by Askling and colleagues [10] and Orchard and colleagues [13] have reported that decreased knee flexor strength predisposes soccer athletes to hamstring muscle injury, theorising that this muscle has a role to stabilise the joint [13]. Conversley, it has also been found that there were no differences between injured and uninjured ice hockey athletes' FS or FL strength which may suggest that hip musculature injury risk is dependent upon a pattern of muscle weakness across multiple movements [12]. Therefore, the demands of the ice hockey skating stride must be discussed in detail alongside our findings to discern areas of possible causation for hip musculature injury.

During the skating stride in ice hockey the hip abductors and extensors are the primary movers whilst the hip flexors and adductors act predominantly as stabilizers of the hip joint and also act to decelerate the lower limb [12]. A weakness in strength of these muscles in the ice hockey athlete (as seen in Figure 3) may therefore lead to an increased risk of injury due to the high loading placed upon the adductors when slowing the limb down across the hip, along with the high external forces placed upon the hip during the skating stride [12, 25, 26]. Since higher calibre athletes generally achieve a faster skating speed whilst maintaining the same stride rate as lower calibre athletes [27] it may be assumed that the aformentioned loading patterns and forces are greater, meaning that strength deficit may be relative but also more damaging and pre-disposing. Indeed, work by Stull and colleagues [23] and Chang and colleagues [24] has suggested that increased skating speed is associated with higher eccentric muscle loading patterns and increased hip musculature injury rates. Additionally, increased skating speed is a desirable factor in ice hockey performance [23, 24] meaning that it will likely be coached and practiced regularly, also possibly driving up predisposition to injury in athletes with strength deficit patterns.

We also presented that the Ndom leg had a decreased adduction/abduction strength ratio compared to that of the Dom leg (Figure 4; Dom 1.18 vs. Ndom 1.08). This finding is similar to the previous work of Tyler and colleagues [12] as they investigated injured versus uninjured athletes, finding that athletes who went on to sustain an injury had a lower ratio compared to uninjured athletes. However, the study by Tyler and Colleagues [12] reported no difference between the Dom and Ndom leg in athletes who went on to sustain a hip injury and although the work of Tyler and colleagues [12] is suggestive that either leg is susceptible to injury, our work suggests that the Ndom leg may be at an increased risk due to the lower strength ratio seen in Figure 4, however as this study did not analyse athletes who went on to sustain a hip injury, further research is necessary to investigate this further.

With regard to ROM, ice hockey athletes displayed significantly less ER when compared to soccer athletes (Figure 1; ice hockey 28.97° vs. soccer 37.00°). This may be important for injury risk because professional soccer athletes with decreased ROM have been shown to be more likely to sustain a muscle injury, suggesting that lack of ROM may be a predictor of injury, particularly with a decrease in ER ROM [15, 28]. Our finding that ice hockey athletes have a decreased ROM, may imply that they are at a greater risk of hip injury compared to soccer athletes, as it has been noted that a decrease in general hip ROM leads to an increased risk of injury as performance of complex ice hockey skills, such as skating, is hindered [14]. This finding may also begin to explain the increasing amount of FAI injuries observed in ice hockey athletes [23, 25, 29] as external rotation has been seen to decrease in athletes with FAI symptoms [30].

All athletes in this study showed greater ROM in Dom hip FL compared to the Ndom leg (Dom 41.42° vs. Ndom 35.46°), but conversely had less than the Ndom in FL (Dom 99.92° vs. Ndom 104.88°) and IR (Dom 25.88° vs. Ndom 29.50°) (Figure 2). However, as previously mentioned measures of strength may be a greater determinant for injury as opposed to ROM alone and therefore both strength and ROM measures should be taken into account [5-10, 16].

Conclusion

Our findings suggest that ice hockey athletes may present an 'at risk' profile for non-contact hip injuries, based on both previous literature and due to weaknesses in strength and ROM around the hip in comparison with soccer athletes. When discussed in relation to the specific demands of the ice hockey stride the results of our study give an insight to hip musculature injury causation which may aid in the recognition of ice hockey athletes who may benefit from strategies for injury prevention and performance enhancement. Future research should employ detailed biomechanical analysis of the loading of the hip in ice hockey, particularly in athletes who display an 'at risk' profile. High quality prospective studies are also required in this population to clarify the usefulness of the 'at risk' profile as a predictor of injury. Additionally, authors should consider the efficacy of training and strength intervention studies aimed specifically at the hip complex of the ice hockey athlete.

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Table 1 Mean and standard deviation for hip Range of Motion (ROM) in both ice hockey and soccer athletes.

Hip movement measured	Leg dominance	ROM of ice hockey athletes (°) (Mean ± SD) n = 16	ROM of soccer athletes (°) (Mean ± SD) n = 8
Abduction	Dom	46.31 ± 8.90	38.25 ± 4.33
	Ndom	42.88 ± 12.68	39.63 ± 9.96
Adduction	Dom	29.25 ± 8.28*	19.38 ± 3.74
	Ndom	25.13 ± 4.29	20.75 ± 4.43
FL	Dom	97.94 ± 18.43	103.88 ± 17.96
	Ndom	102.00 ± 14.50	110.63 ± 15.49
FS	Dom	42.19 ± 9.56	39.88 ± 9.67
	Ndom	45.56 ± 8.45	35.25 ± 7.11
Extension	Dom	24.44 ± 10.60	22.13 ± 5.74
	Ndom	24.25 ± 12.90	20.50 ± 8.25
IR	Dom	27.25 ± 8.34	23.13 ± 6.36
	Ndom	29.19 ± 11.15	30.13 ± 12.16
ER	Dom	29.36 ± 8.04	37.25 ± 7.87
	Ndom	28.56 ± 14.24	36.75 ± 13.71

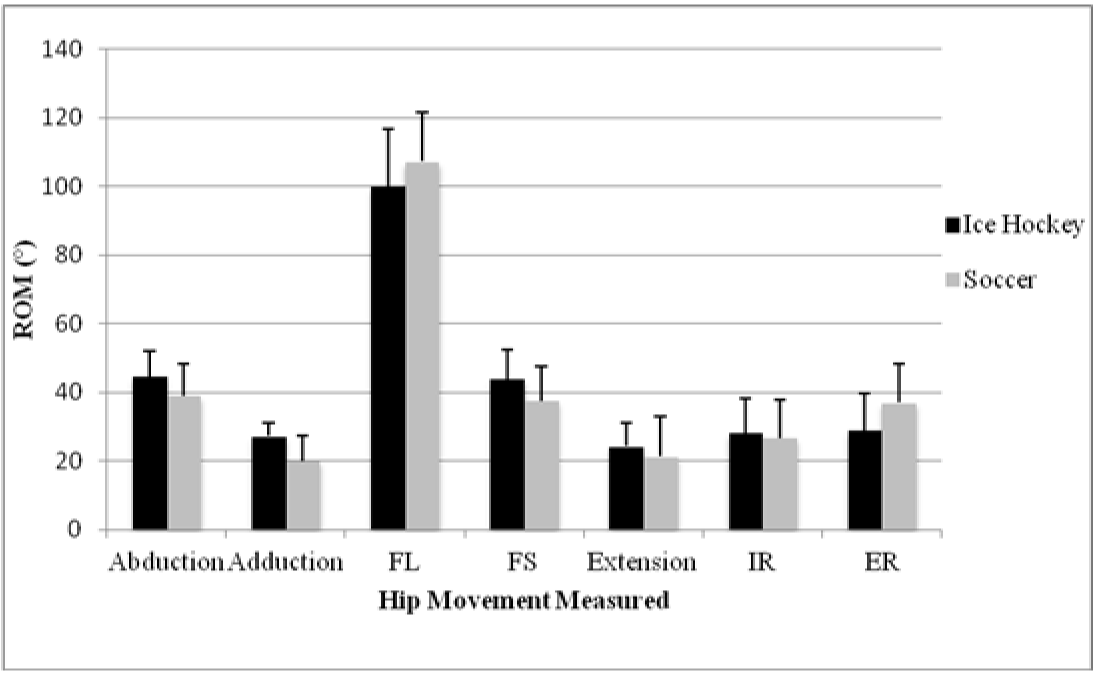
* Ice hockey athletes greater ROM on Dom leg compared to Ndom and soccer athletes (both p=0.002).

Table 2 Mean and standard deviation for hip strength in both ice hockey and soccer athletes.

Hip movement measured	Leg dominance	Ice hockey athletes strength (Nm/kg) (Mean ± SD) n = 16	Soccer athletes strength (Nm/kg) (Mean ± SD) n = 8
Abduction	Dom	2.26 ± 0.21	2.45 ± 0.31
	Ndom	2.27 ± 0.23	2.35 ± 0.28
Adduction	Dom	2.64 ± 0.28	2.90 ± 0.33#
	Ndom	2.39 ± 0.25*	2.68 ± 0.36
FL	Dom	1.44 ± 0.19	1.61 ± 0.14
	Ndom	1.45 ± 0.18	1.63 ± 0.17
FS	Dom	1.85 ± 0.15	2.01 ± 0.27
	Ndom	1.82 ± 0.23	2.11 ± 0.25
Extension	Dom	1.39 ± 0.27	1.63 ± 0.38
	Ndom	1.49 ± 0.37	1.78 ± 0.47
IR	Dom	1.03 ± 0.18	1.24 ± 0.28
	Ndom	1.08 ± 0.19	1.19 ± 0.28
ER	Dom	0.83 ± 0.10	0.92± 0.21
	Ndom	0.86 ± 0.13	0.95 ± 0.24

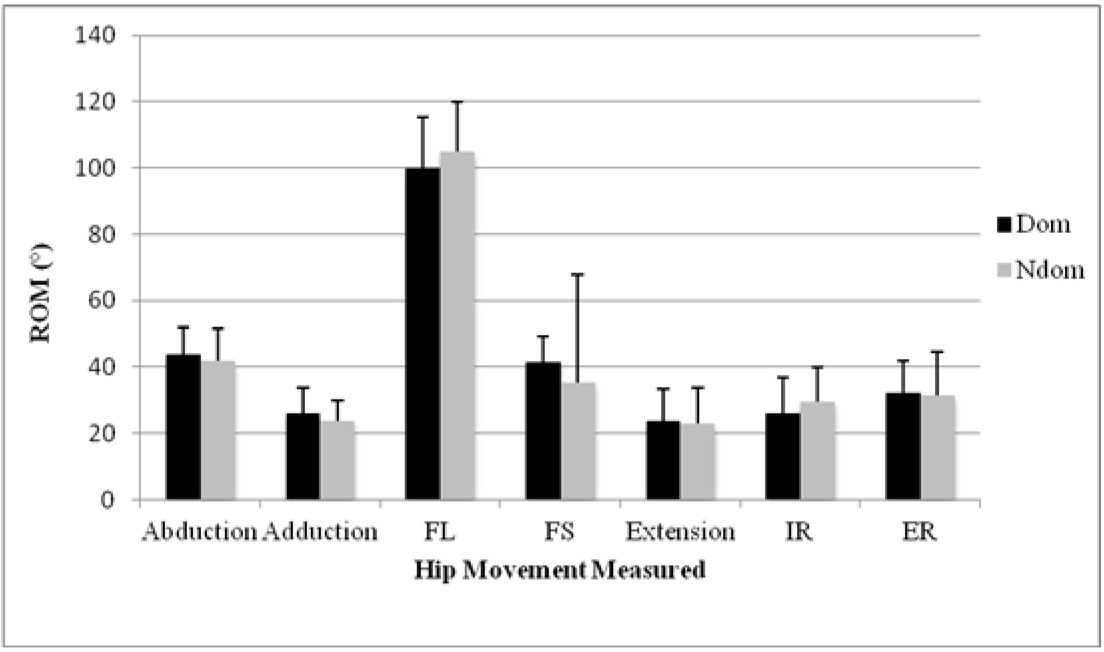
* Ice hockey athletes had less strength compared to Dom (p=0.02) and soccer athletes (p=0.40).
# Soccer athletes had greater strength compared to Ndom leg (p=0.033).

Figure 1 Range of Motion (ROM) difference between ice hockey and soccer athletes for dominant (Dom) and non-dominant (Ndom) legs.



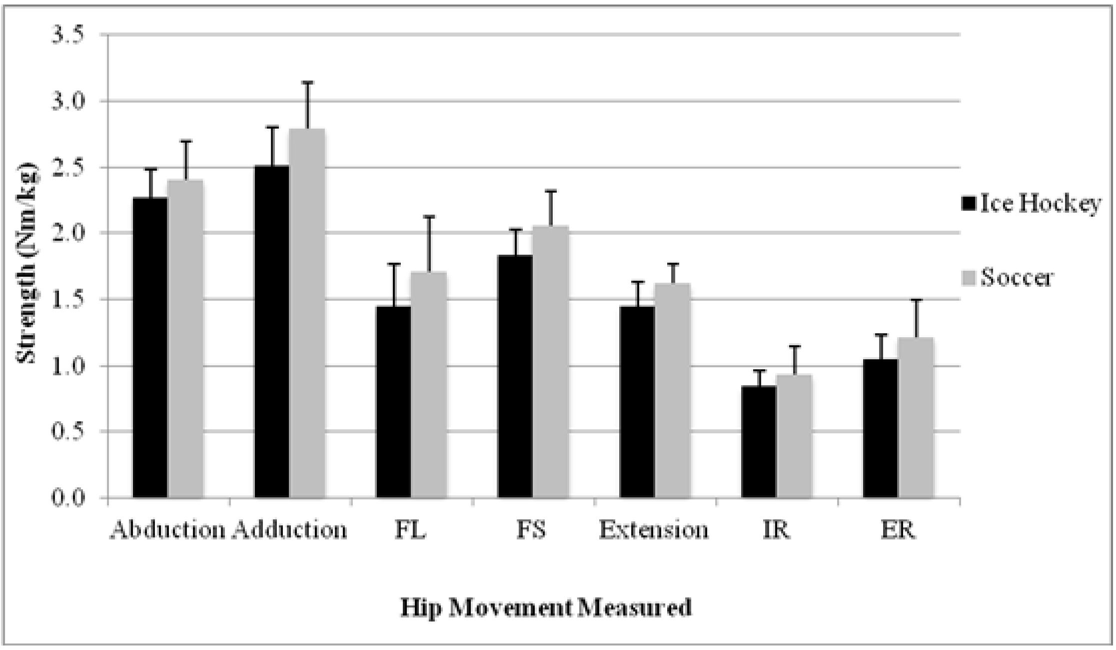
* Ice hockey athletes had significantly greater hip adduction (p=0.010).
# Ice hockey athletes had significantly less hip ER (p=0.042).

Figure 2 Range of Motion (ROM) differences between dominant (Dom) and non-dominant (Ndom) legs of ice hockey and soccer athletes combined.



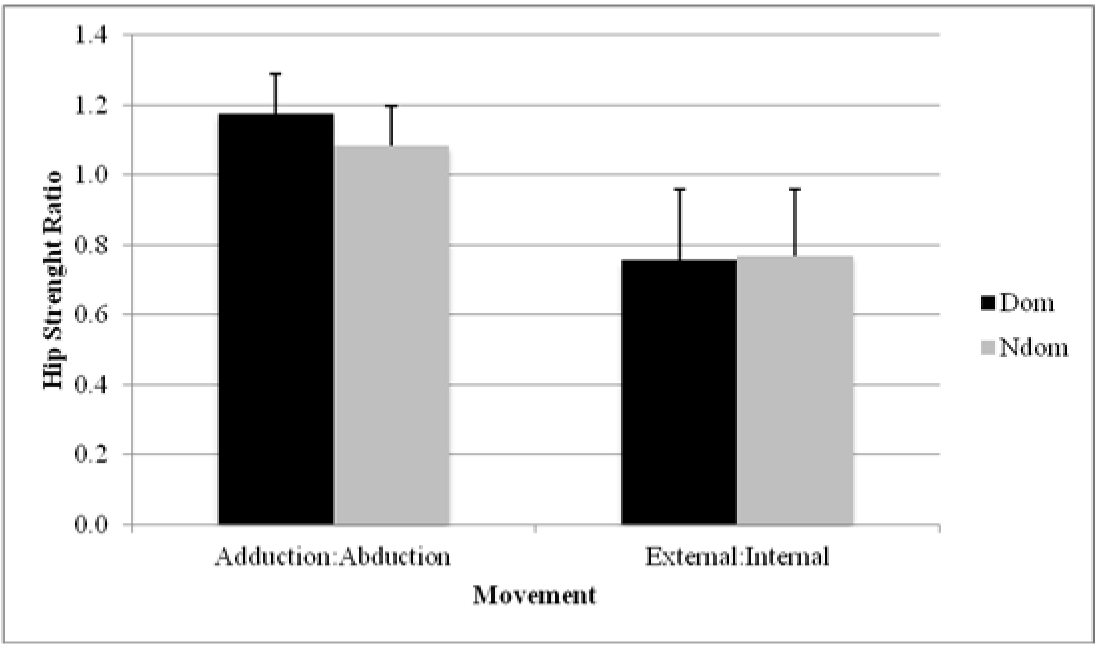
* Ndom leg had significantly greater hip FL (p=0.017)
# Dom leg had significantly greater hip FS (p=0.015)
~ Ndom leg had significantly greater IR (p=0.015)

Figure 3 Strength differences between ice hockey and soccer athletes for dominant (Dom) and non-dominant (Ndom) legs.



* Ice hockey athletes had significantly less hip adduction (p=0.030)
# Ice hockey athletes had significantly less hip FL (p=0.030)
~ Ice hockey athletes had significantly less hip FS (p=0.023)

Figure 4 Strength ratio differences between dominant (Dom) and non-dominant (Ndom) legs of ice hockey and soccer athletes combined.



* Dom leg showed significantly higher ratio than Ndom (p=0.008)