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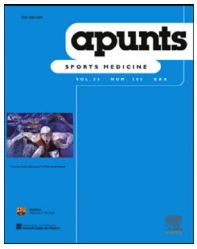

ORIGINAL ARTICLE

The effect of match congestion on hip adductor squeeze strength in youth rink hockey players

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Abstract
Introduction: Groin injuries are common among rink hockey players. Monitoring the main risk factors can reduce the likelihood of suffering such injury. The objective of this study was to evaluate the effect of a competitive congestion period on the squeeze strength of the hip adductor muscles in a group of adolescent rink hockey players, and whether the strength reduction exceeded the injury risk threshold (>15%) for sustaining a groin injury.
Materials and Methods: Twenty U-16 athletes (9 females) participated in the study. Eighty-three adductor strength measurements were recorded after 10 games (2109 min of play). Function was assessed using the Sport subscale of the Hip and Groin Outcome Score (HAGOS) questionnaire. A simple linear regression model was used to analyze the accumulated time-strength relationship, and the pre-tournament and post-tournament HAGOS results were compared.
Results: The accumulation of games resulted in a significant strength reduction in male players' (R^2= 0.27), but not in females. Eighty-five percent of the sample had their strength reduced to values at risk compared to baseline strength, but none of them stopped their activity due to discomfort in the groin region. HAGOS results were not affected by the competitive congestion (p = 0.07−0.48).
Conclusion: Match congestion can negatively impact adductor strength. However, there may not be a relationship between strength loss above 15% and the appearance of a groin injury.

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Introduction

Groin problems have gained attention in recent years due to high prevalence among different sporting disciplines.[1,2] An injury may present as an acute mechanism or due to overuse, and mainly affects the hip adductors.[3,4] Seasonal prevalence ranges from 14 to 33% in team sports, being football the discipline with a higher number of cases.[5] The main risk factors for developing a groin injury are: history of previous injury, hip adductor strength deficit, worse subjective function, and male sex.[6,7] Although recent research has claimed that these injuries can be common among female athletes (seasonal prevalence= 26%).[8] In general, periods of match congestion lead to a higher number of muscle injuries,[9] since competition generates damage to the muscle tissue.[10]

The intrinsic characteristics of rink hockey leave players prone to suffering injuries in the groin region, since a player performs around 300 sudden accelerations and decelerations in every session (either training or match),[11] this specific movement has been described to be related to groin injuries.[12] The medical group of the Spanish Skating Federation described this condition 30 years ago due to the high number of players suffering from complaints in this area.[13] Recently, various studies have confirmed the same trend in both professional and amateur players, it currently is the most common injury, with an incidence of 0.7/1000 h.[14,15]

Collecting both objective (adductor strength) and subjective (health questionnaires) data is a common strategy in monitoring players health and its relationship with groin injuries, since the appearance of risk factors precede the injury onset.[7,16] Patient reported outcomes (PROs) can distinguish between players with or without groin problems.[17,18] At this regard, the Hip and Groin Outcome Score (HAGOS) is a valid and reliable tool designed to monitor athlete hip and groin health, it includes 6 subscales with a score between 0 and 100, with 100 being the best score which indicates complete health (see "Protocol").[19] Wollin et al. described a 15% adductor strength loss and obtaining $<$75 points in HAGOS as thresholds that increase the risk of sustaining a groin injury.[20] It is common to see an adductor squeeze strength reduction above the reference threshold during competitive congestion periods (i.e. playing games on consecutive days or with insufficient recovery in-between),[9] which highlights the importance of assessing strength during congested periods.[21] This monitoring is of utmost importance in adolescent athletes, since reducing injury risk at a young age prevents the appearance of injuries in the later years.[20]

The aim of the present study was to monitor objective (hip adductor strength) and subjective (HAGOS) data in adolescent high-level athletes during an official tournament (Spanish U-16 Rink Hockey Championship). Secondary aims were to detect whether players obtained strength and function scores below the described thresholds, and whether these lower scores were associated with the appearance of groin problems.

Material and methods

Study design

The present study employs a prospective observational design. It was conducted in December 2021 during the celebration of the Spanish U-16 Rink Hockey Championship (Mieres, Principality of Asturias). The study received approval from the local Ethics Committee (code: 2021.543). All participants and their respective legal guardians were aware of the nature of the study and agreed to participate by signing an informed consent form in accordance with the Helsinki Declaration.

Participants

The inclusion criteria were as follows: being recognized as a high-level athlete, defined as those players belonging to a regional team participating in the championship; and agreeing to participate in the research. Participation was only proposed to the regional team representing the hosting region (Asturias). Any player who had experienced at least one time-loss injury in the last 3 months would be excluded, regardless of whether it affected the groin region or not. A total of 24 players (12 females) were eligible to participate, and twenty agreed to be part of the research (83% participation rate). No potential participants were excluded for having suffered an injury in the 3 months prior to the start of the study.

Protocol

Adductor squeeze strength was assessed using a handheld dynamometer, subjective functionality was evaluated through a validated questionnaire (HAGOS), and the playing time in minutes for each athlete was recorded. All strength measurements were conducted in the same facility at a constant temperature of 23 °C, and 30 min after the conclusion of the last match of the day.

Adductor squeeze strength was assessed using a 5-Second Squeeze Test (5SST) following the protocol by Light and Thorborg.[22] The participant laid supine on the examination table with extended knees and neutral hips. The examiner placed the forearm above the medial malleoli, securing the dynamometer (ActivForce 2, ActivForce, California) against the surface of the tibia. The athlete was then instructed to progressively perform hip adduction against the resistance of the forearm for 5 s. To ensure that the athlete exerted maximum effort, encouragement was provided during each repetition, although the results were not disclosed until all measurements for that corresponding day were completed. Two submaximal repetitions were performed on the first day to familiarize the participant with the test. Subsequently, 2 maximal repetitions were performed for each leg, always starting with the dominant leg (the one used to kick a ball), with a 20-second rest between repetitions. After each measurement, the examiner recorded the maximum force value (N) on a template. Limb length and weight were recorded to calculate relative torque using the following formula: torque = Nm/Kg, where N is the force value in Newtons, m is the limb length (from the anterior superior iliac spine to the medial malleolus ($-$5 cm)), and Kg is the athlete' weight in kilograms.

The subjective function of the hip and groin was assessed using the HAGOS questionnaire.[19] This questionnaire captures the subjective perception of functionality across various domains, including Symptoms, Pain, Activities of Daily Living, Sport, Participation in Physical Activities, and Quality

Fig. 1 Flow of evaluations and games throughout the tournament Test= HAGOS+Squeeze strength, ADD= Adductor.

of Life, through 37 items. Each item has a maximum value of 4 points, and the final score for the subscale is transformed on a denominator of 100 points, where values closer to 0 indicate poorer hip and groin health, while those closer to 100 indicate better function. We chose to record the "Sport" subscale since it has the highest sensitivity for detecting injured players compared to healthy individuals and requires less data collection time,[17,23] thus improving athlete adherence. Fig. 1 displays the assessment progress throughout the tournament.

Statistical analysis

The statistical analysis was conducted using SPSS Statistics Version 27 (IBM Corporation, Chicago, IL). The ggplot2 package from RStudio (The R Foundation for Statistical Computing) was used for data visualization.[24] A significance level of $p < 0.05$ was established. The Shapiro-Wilk test was employed to assess normality distribution of continuous data. Quantitative variables were compared between sex using either the independent samples *t*-test or the Mann-Whitney U test, as appropriate. Qualitative variables were compared using the χ^2 test. Having satisfied the assumptions of normality, uncorrelated errors, and homoscedasticity, a simple linear regression model was used to evaluate the relationship between adductor strength (dependent variable) and accumulated playing time throughout the competition (independent variable) independently for the male and female samples. The difference in hip and groin function (HAGOS) before and after the championship was assessed using the Wilcoxon signed rank test.

Results

A total of 83 strength measurements were conducted (55% female team) after 10 matches and 2,109 min of gameplay. Table 1 presents the participants' demographic variables. The male team was significantly taller ($p < 0.001$) and heavier ($p = 0.02$) than the females, while no statistically significant differences were observed for the remaining variables.

Five-second squeeze test and playing time

Fig. 2 illustrates the relationship between adductor squeeze strength and playing time throughout the tournament. A significant relationship was observed between minutes played and the loss of isometric strength in male players ($R^2 = 0.27$; $p < 0.001$), indicating that for every 20 min of play, there was a loss of 10.8 N of strength. In contrast, there was no relationship between accumulated minutes throughout the tournament and squeeze strength in female players ($R^2 = 0.0217$; $p = 0.32$). Furthermore, 9 male and 8 female players experienced strength loss exceeding 15% compared to their baseline during the championship. None of the participants ceased their activity due to groin problems during the tournament.

Hip and Groin Outcome Score

Variation in function before and after the tournament is depicted in Fig. 3. Baseline measurements yielded a score of 91 (interquartile range (IQR): 81—100) in the male team and 97 (IQR: 86—100) in the female squad, while post-tournament measurements resulted in scores of 92.5 (IQR: 89—100) and 100 (IQR: 94—100), respectively. There were no significant differences between the pre- and post-tournament measurements, regardless of sex ($p = 0.068$—0.46).

Discussion

This is the first study documenting the variation in adductor strength in rink hockey athletes during a period of competitive congestion and the first to record these data in women from any sport. The main findings were: (1) accumulation of games negatively affected adductor strength ($p < 0.001$), with a reduction of 10.8 N for every 20 min played in the male cohort; (2) 17 participants (85% of the sample) experienced >15% strength loss compared to their baseline assessment; and (3) the subjective function was not significantly altered in any of the studied participants ($p = 0.07$—0.46).

Official tournaments are excellent for assessing the effect of competitive congestion on the musculoskeletal system. These periods lead to an increased perception of fatigue among players,[10] which negatively impacts performance and may predispose athletes to injury.[16] In this

Table 1 Baseline characteristics.

Variables	Males ($n = 11$)	Females ($n = 9$)	All ($n = 20$)	p-value
Age (years)	15 (15—15)	14 (14—15)	15 (14—15)	n.s.
Height (cm)	176 (6.5)	159 (5.6)	168 (10)	< 0.001
Body mass (kg)	65 (60—78)	58 (52—61)	61 (58—67)	0.02
BMI	22.2 (2.7)	22.5 (1.6)	22.3 (2.3)	n.s.
Playing position (OP)	9 (81%)	8 (88%)	17 (85%)	n.s.
Previous groin injury	2 (18.2%)	0	2 (10%)	n.s.

BMI= Body Mass Index, OP= Outfield player, n.s.= non-significant.
Data is represented as mean (standard deviation), median (interquartile range), or frequency (%).

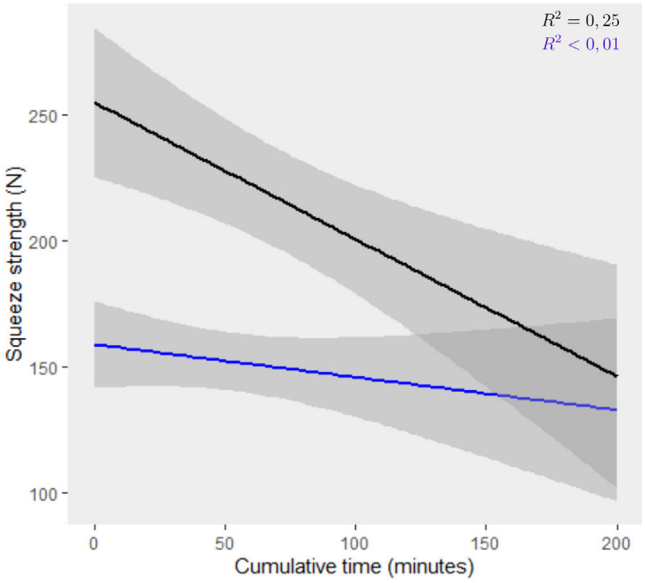

Fig. 2 Adductor strength and cumulative played time throughout the tournament Fitted regression line for males (black) and females (blue) with 95% confidence intervals (gray shading).

regard, Werner et al. identified that groin injuries were concentrated during periods of the season characterised by a higher accumulation of games.[25]

In this study, a significant and inverse relationship has been observed between the accumulated time played and adductor squeeze strength ($R^2 = 0.27$). Similarly, several experimental studies aiming to simulate competitive conditions found similar results. For example, a repeated sprint protocol reduced hamstring peak torque by 12% in athletes from various disciplines.[26] Others observed reductions from 9% to 24% in eccentric hamstring strength compared to a non-fatigued state after simulating a soccer game.[27,28] Over the course of a season, adductor strength fluctuates in ice

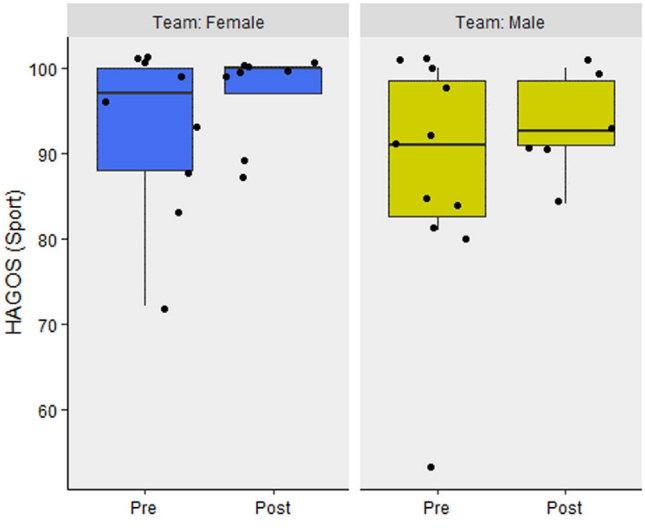

Fig. 3 HAGOS Sport scores from pre- to post-tournament Pre: Scores before the competition began. Post: results obtained 24 h after the last game.

hockey players, although it does not seem to affect the incidence of groin injuries.[18] Wollin et al.[21] monitored adductor strength during a soccer tournament and observed an inverse association between the cumulative competition time and adductor strength ($p = 0.027$). These results are consistent with those obtained in the present study. The male team experienced a loss of strength related to the cumulative time played, whereas this was not the case for the female team ($p = 0.32$). There is limited literature on female athletes, making it impossible to compare our results with those of previous studies. One possible hypothesis is that the female players from our cohort, who regularly compete in higher-level leagues, have better physical conditioning compared to their male counterparts, and therefore, the stimulus of the championship they participated in was not sufficient to observe significant changes in their strength. It is important to note that this article only focuses on maximum squeeze strength since it is the primary expression of strength studied in groin injuries.[29] However, we are unaware of what may occur regarding different strength manifestations, and we cannot explain the divergence in results observed between sexes.

On the other hand, adductor strength (>15%) drops from baseline were recorded in 85% of the participants throughout the championship (Fig. 1), although no participant was restricted from participating in the tournament due to problems in the groin region. Recent studies have noted that a loss of adductor squeeze strength precedes an episode of groin injury.[16] It is possible that participants from our study preferred not to report pain or inability to participate due to the importance of the event (Spanish U-16 Rink Hockey Championship), with the aim of not missing any game (semi-finals, final).[21,30] Therefore, caution is advised in the interpretations of these results.

This is the first study that assessed hip and groin function in rink hockey players in a context of competitive congestion. In this regard, we did not observe any effect of group or time on the score obtained on the HAGOS. Wörner et al.[18] followed up groin function during one season and found no variation in any of the subscales of the HAGOS form over the study period. Although HAGOS consists of 6 subscales, most studies observe a greater effect of the independent variable on the Sport subscale,[17,31,32] which explains why we have included this subscale exclusively. However, it is possible that the form is not sensitive enough to distinguish between fatigued or in pain players compared to healthy subjects. A ceiling effect has been described, where healthy players score perfect results and differences are insufficient to be significant compared to injured athletes.[33] Based on the results here reported, the use of HAGOS does not seem to be of interest in monitoring athletes in this precise context, although it may have relevance in other cases.[7]

There are various strengths and limitations that must be acknowledged. Hip adductor strength were evaluated for the first time in young female rink hockey players, the main risk factors associated with groin pain described in the scientific literature (history of previous injury, adductor strength, subjective function, and sex) have been taken into account, this is the first study that monitored adductor strength and its relationship with the occurrence of groin pain during a real competition, unlike previous research that simulated fatigue conditions experimentally.[34] These observations are

highly relevant, since suffering a groin injury at a young age can predispose athletes to re-injure themselves in the future.[35] However, participant sample was limited, which is conditioned by the intrinsic characteristics of the championship. Given the scheduling of games during the tournament and the time required to perform the tests, a single researcher (MQ) carried out the evaluations with the aim of minimizing the risk of bias in the collection of data. Therefore, it would not be possible to evaluate two teams facing each other because there would be too much time between the first and the last participant evaluated, which could condition the results.

Conclusion

Handheld dynamometry seems to be a valid tool capable of detecting adductor strength deficits caused by cumulative load. However, there does not seem to be a relationship between strength drop (>15%) and competitive activity cessation due to groin pain. Player monitoring including the squeeze test appears to be a suitable strategy to incorporate into an injury prevention program during periods of match congestion.

Conflicts of interest

The authors declare no conflicts of interest.

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Ethical considerations

The Ethics Committee of the Principality of Asturias approved this study (code: 2021.543), and all participants and their legal tutors signed an informed consent before the study commencement.

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