



Original Article

Predicting the occurrence of in-season groin pain in male high school soccer players: a cohort study

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Abstract. [Purpose] This study investigated whether pre-season HAGOS (Japanese Copenhagen Hip and Groin Outcome Scores) and eccentric muscle strength of the hip muscles predict in-season groin pain incidences in high school soccer players. [Participants and Methods] This study had a cohort design. The participants were male high school players under 18 years playing in the Japan Soccer League, which is an elite-level soccer league of that age category in Japan. The HAGOS and the strength of hip abductor and adductor muscles in eccentric contraction were measured before the season, and hip and groin pain incidences were recorded during the season. Multiple logistic regression analysis was performed to investigate the factors derived from the pre-season HAGOS and hip muscle strength tests, presumably pertaining to the development of in-season groin pain. [Results] The eccentric adductor muscle strength of the dominant leg and the HAGOS were selected as factors associated with groin pain during the season. [Conclusion] Low pre-season HAGOS and weak dominant-leg eccentric adductor muscle strength were suggested as factors to predict in-season groin pain occurrence in male high school soccer players.

Key words: Copenhagen Hip and Groin Outcome Score, Groin pain, Male high school soccer players

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INTRODUCTION

The most commonly reported sports injuries in soccer games are hamstring injuries and groin pain¹⁾. The most frequent movements contributing to groin pain are kicking in the open kinetic chain and jumping and sprinting in the closed kinetic chain²⁾. Furthermore, physical characteristics of patients with groin pain have been reported to include decreased hip adductor muscle strength^{3, 4)} and increased hip abduction range of motion⁴⁾. Furthermore, high school soccer players have also been reported to develop groin pain more frequently^{5, 6)}.

Groin pain is associated with a high risk of recurrence⁷⁾. As a preventive method, the Copenhagen adduction exercise, which utilizes centrifugal contraction of the adductor muscles, has been reported with good results in semi-professional and male high school soccer players^{8, 9)}. In addition, groin pain was classified at the Doha Consensus Conference as adductor muscle related pain, iliopsoas muscle related pain, groin related pain, pubis related pain, and hip related pain¹⁰⁾. The adductor muscles often cause such pain¹¹⁾, and 61% of patients are reported to have adductor muscle related pain¹²⁾.

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The Copenhagen Hip and Groin Outcome Score (HAGOS) has been used as a simple method of assessing groin pain and has been reported to be reliable and valid in previous studies¹³. The HAGOS is also used to predict the occurrence of groin pain during the playing season¹⁴. In addition, the developer has created a Japanese version of HAGOS¹⁵. However, in Japan, there are no reports of investigations of the association between HAGOS and in-season groin pain among soccer players. Therefore, this study aimed to determine whether preseason HAGOS and hip eccentric muscle strength can predict in-season groin pain in Japanese male high school soccer players.

PARTICIPANTS AND METHODS

A cohort study was conducted with male high school soccer players (total $n=111$) in the Japanese soccer league aged under 18 years old. Participants were at the highest level of the prefecture and national league, and only the top teams were eligible. We contacted 3 schools with teams in this league for potential inclusion. Consent was obtained from the principals and coaches of each school. Informed consent was also sought from all parents and players, as all participants were under 18. This study followed the Declaration of Helsinki and was approved by the Ethics Committee at the Ota College of Medical Technology, Gumma, Japan (Approved number 230821). HAGOS was evaluated through a preseason survey. Players completed HAGOS after receiving thorough written and verbal instructions from the researcher. The HAGOS questions consisted of six items. Specifically, participants were assessed on pain (10 items), symptoms (7 items), activities of daily living (5 items), sports and recreational activities (8 items), participation in physical activity (2 items), and quality of life (5 items). Each item is answered on a 5-point scale from 0 to 4, with 0 indicating no hip/groin problems and 4 indicating severe hip/groin problems. The 6 scores were calculated as the sum of the items included. Each subscale was scored independently and then normalized to a 100-point scale. Previous studies established the reliability of HAGOS (intraclass correlation coefficient=0.82–0.91)¹⁴. These surveys were conducted from January to March 2023 during the preseason.

Additionally, we measured the force during eccentric contraction of the hip adductor and abductor muscles, which has been performed as a test for groin pain in previous studies⁹. Hip abduction and adduction strength were recorded based on previously reported measurement methods using a handheld dynamometer (HHD, SAKAIMED Mobi, Tokyo, Japan)^{12, 16, 17}. Eccentric muscle strength was assessed. The participant exerted a 3-second isometric maximum voluntary contraction against the HHD, following which a 2-second break was performed by the examiner pushing the leg slowly towards the bed. One mock test and three maximum tests were performed with a break of 30 seconds between trials. The maximum scores of the three tests were recorded as Nm/kg. All measurements were performed by the principal investigator and subsequently recorded.

The in-season monitoring period was from April to December 2023. The definition of a hip/groin injury was “an injury located at the hip or surrounding soft tissue, or at the junction between the proximal adductor abdomen, the pubic symphysis and the anteromedial portion of the thigh, including the symphysis pubis”¹⁶. Players were advised to report any pain or injury from games or training, with or without treatment, to the medical staff, and groin pain was assessed by a physical therapist and recorded weekly. All injuries were reported by a physiotherapist using a standardized injury reporting form detailing the date of injury, duration of injury, date of return to training and competition, and number of training sessions and competitions. Each club’s physiotherapist was given detailed instructions on completing the form before the start of the season. The principal investigator followed up with the team physiotherapist by phone or email once a month and collected reports.

In order to clarify the factors related to groin pain, a logistic regression analysis (variable incremental method: likelihood ratio) was performed, with the presence or absence of groin pain as the dependent variable, and the HAGOS and hip physical examination variables as the independent variables. The sample size for the logistic regression analysis was determined according to $n \geq 10 \times \text{independent variables}$ ¹⁸. The independent variables were the six subscales of the HAGOS plus four variables of eccentric abductor and abductor strength of the dominant and non-dominant leg, for a total of 10 variables, and the number of participants needed to be at least 100. The targets were set taking into account a number of dropouts.

The six subscales of HAGOS (pain, symptoms, activities of daily living, sports and recreational activities, participation in physical activity, and quality of life) are highly correlated, which conflicts with collinearity and may make variables redundant. Therefore, a principal component analysis was performed on the six HAGOS items, reducing them to a small number of independent principal components¹⁹. Each principal component has a corresponding eigenvalue that reflects the variance explained by that component. Since the sum of the eigenvalues equals the number of variables in the principal component analysis (PCA), eigenvalues greater than 1 explain more variance than the original single variable. In order to identify factors related to groin pain, the presence or absence of groin pain was used as the dependent variable, and the items for which significant differences were found in the medical check and the components of HAGOS identified by PCA were used as independent variables. IBM SPSS Statistics for Windows, Version 26.0 (Armonk, NY, USA: IBM Corp Released 2018) was used for statistical analysis.

RESULTS

Table 1 shows the characteristics of the participants. Six players dropped out during the intervention period due to other injuries, retirement, or lack of compliance. A total of 105 people were analyzed. The breakdown was 22 in the groin pain

injury group and 83 in the uninjured group. There were no significant differences in participants characteristics between the groin pain injured and uninjured groups.

Table 2 shows the results of hip joint eccentric adduction and abduction muscle strength measured pre-season. When comparing players with groin pain to those without pain, significant differences were found in eccentric adduction strength both in the dominant and non-dominant legs. Additionally, significant differences were found in eccentric abductor strength on the dominant leg side.

Descriptive statistics for HAGOS subscale scores are given in Table 3. In previous studies, multicollinearity has been reported to exist for the 6 subscales of the HAGOS¹⁴. Therefore, we conducted a principal components analysis of the HAGOS. The PCA was performed using all 6 HAGOS subscales, and the eigenvalues are shown in Table 4. Only the first principal component displayed an eigenvalue greater than 1, representing 75% of the total variance in the data, and this was retained for subsequent analysis.

Table 1. Participants characteristics (n=105)

	Injured (n=22)	Uninjured (n=83)
Age (years)	16.1 ± 0.9	16.0 ± 0.7
Height (cm)	172.5 ± 4.1	171.8 ± 4.9
Weight (kg)	61.1 ± 6.3	62.0 ± 6.3
Body Mass Index (kg/m ²)	20.9 ± 1.8	20.9 ± 1.7
Dominant foot (players)		
Right	18	70
Left	4	13
Field position (players)		
Attacker	4	20
Midfielder	10	25
Defender	6	30
Goalkeeper	2	8

Age, Height, Weight, and Body Mass Index show the average value and standard deviation. Injured and uninjured patients with groin pain are shown.

Table 2. Strength in the presence or absence of groin pain

	Injured (n=22)	Uninjured (n=83)
Eccentric muscle strength		
Adduction (Nm/kg)		
Dominant leg*	2.3 ± 0.3	2.7 ± 0.3
Non-Dominant leg*	2.2 ± 0.3	2.5 ± 0.3
Abduction (Nm/kg)		
Dominant leg*	1.8 ± 0.4	2.2 ± 0.2
Non-Dominant leg	2.1 ± 0.2	2.1 ± 0.2

Eccentric muscle strength and mean values and standard deviations are shown. *p<0.05. Injured and Uninjured patients with groin pain are shown.

Table 3. Descriptive statistics for the HAGOS subscale scores

HAGOS Subscale, Component	Injured (n=22)	Uninjured (n=83)	Total (n=105)
Symptoms	73.9 ± 17.8	91.8 ± 8.8	88.4 ± 13.1
Pain	80.3 ± 18.7	96.5 ± 6.4	93.4 ± 11.7
Function in activities of daily living	91.8 ± 8.8	99.5 ± 1.5	98.0 ± 5.0
Function in sport and recreation	74.5 ± 24.1	96.8 ± 7.7	92.6 ± 15.2
Participation in physical activities	66.0 ± 26.9	95.9 ± 9.3	92.4 ± 17.1
Hip and/or groin-related quality of life	77.5 ± 30.5	95.9 ± 9.3	89.6 ± 18.2
Principal component	0.00 ± 1.00	0.01 ± 1.00	0.01 ± 1.00

Values are mean ± standard deviation.
HAGOS: Copenhagen Hip and Groin Outcome Score.

Details of the multivariate logistic regression model are shown in Table 5. Univariate analysis determined eccentric adductor strength (dominant and non-dominant leg) and eccentric abduction strength (dominant leg). Furthermore, HAGOS extracted by PCA was used as one component. These items were used as independent variables in a multivariate logistic regression analysis as predictors of the development of groin pain. As a result, we selected eccentric adduction muscle strength of the dominant leg and HAGOS. The odds ratio for each item was 0.12 (95% CI: 0.04 to 0.39) for eccentric adductor strength of the dominant leg and 0.13 (95% CI: 0.02 to 0.83) for HAGOS. The results of the Hosmer–Lemeshow test in this model were compatible with $p=0.11$, with the percentage of correct classifications being 86.2%.

DISCUSSION

This study used the Japanese version of the HAGOS in male high school soccer players to determine whether pre-season HAGOS values and hip eccentric muscle strength could predict in-season groin pain.

Another previous study of amateur soccer players found that players with weak adductor muscle strength were four times more likely to suffer future injury than those with good adductor muscle strength²⁰. A previous study reported that people with groin pain have decreased eccentric adductor strength of their dominant leg^{3, 4}. The results of univariate analysis conducted in this study showed that those who developed groin pain had a significant decrease in the eccentric adductor muscle strength of both legs as well as eccentric abductor muscle strength of the dominant leg. These results are similar to that of the previous study and complement each other. It has been reported that the hip adductor muscles are highly active during soccer matches, especially during kicking movements. Additionally, the hip adductor and abductor muscles are thought to work together to enable a stable kicking motion^{21, 22}. In a randomized controlled trial of soccer players using the Copenhagen Adductor Strengthening Program, hip adductor strength training reduced groin injury rates by 41%⁸. This predicts that eccentric strength of the adductor muscles is highly associated with groin pain. Therefore, the finding of reduced eccentric hip muscle strength in this study is a potential important new finding in the prevention of groin injuries in soccer players.

Multivariate logistic regression analysis identified pre-season HAGOS values and reduced hip eccentric adductor muscle strength as risk factors for in-season groin pain in Japanese high school soccer players. The HAGOS is the most frequently used tool for subjective monitoring of hip/groin health in soccer players²³. Furthermore, it has been reported that players with lower pre-season HAGOS values have a higher incidence of in-season groin pain²⁴. In this study, pre-season HAGOS values were lower for those who suffered groin pain during the season, which is similar to previous studies findings²⁴. This data supports the use of HAGOS as a pre-season and in-season monitoring tool and suggests that HAGOS may be useful in identifying elite soccer players at risk of sustaining hip/groin injuries in the future. Previous reports on male professional soccer players have also reported imbalance between hip adductor and abductor muscles strength pointing to a potential value of hip adductor and abductor muscles in assessing groin pain¹². The present study also identified imbalance in strength between the adductor and abductor muscles in male high school soccer players. This finding was similar to a previous study in which low eccentric hip adductor muscle strength was found to be a risk factor in male high school soccer players⁴.

Table 4. Eigenvalues for the HAGOS

Principal component	Eigenvalue	Percent	Cumulative percent
1	4.525	0.754	0.754
2	0.561	0.936	0.848
3	0.377	0.628	0.910
4	0.242	0.403	0.951
5	0.190	0.316	0.982
6	0.105	0.176	1.000

HAGOS: Copenhagen Hip and Groin Outcome Score.

Table 5. Multivariable logistic regression

	B	SE	Odds	95% CI of Odds	
				Min	Max
Eccentric adduction muscle strength of dominant leg*	-16.23	3.99	0.12	0.04	0.39
PC: HAGOS*	-2.02	9.37	0.13	0.02	0.83
Constant	25.86	8.69			

* $p<0.05$, Likelihood ratio: $p\text{-value}<0.01$, Hosmer–Lemeshow test: $p=0.11$, percentage of correct classifications was 86.2%. B: regression coefficient. SE: standard error. 95%CI: 95% confidence interval; PC: principal component; HAGOS: Copenhagen Hip and Groin Outcome Score.

Potential weakness of our study is its limited sample size, which may have resulted in low power due to the small number of groin pain occurrences relative to the independent variables. A more extensive and diverse sample would have formed a more robust multiple logistic regression analysis model. In addition, only male high school soccer players from the top teams were included, which may have led to selection bias. Also, all injuries were evaluated by each team's physical therapist, which may introduce measurement bias. In addition, the preseason Japanese version of HAGOS was shown to be predictive of in-season groin pain, but this has not been proven in each category and needs further investigation.

In conclusion, lower preseason HOGOS values predicted in-season groin pain in Japanese male high school soccer players. Reduced hip eccentric adductor muscle strength also predicted the occurrence of groin pain.

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The authors declare that they have no funding or competing interests.

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