Analysis of Quadriceps Muscle Tightness as a Risk Factor for Osgood-Schlatter Disease

A Prospective Cohort Study

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Background: The prevalence of Osgood-Schlatter disease (OSD) is unknown. Tightness of the quadriceps femoris has been reported to be a risk factor for OSD.

Hypothesis: Quadriceps muscle tightness would not contribute to the development of OSD.

Study Design: Cohort study; Level of evidence, 2.

Methods: We enrolled 150 Japanese male junior high school soccer players (N = 300 knees), with a mean age at first examination of 12.5 years (range, 12-13 years). All players were assessed annually and evaluated for 2 years. Ten players (n = 14 knees) had a history of OSD before the first medical examination. After excluding these 10 players (n = 20 knees), the remaining 140 players (n = 280 knees) were included in this prospective analysis. Age at the time of starting soccer, history of injury (including OSD and time missed), height, weight, annual increase in height, body mass index (BMI), straight-leg raise angle, heel-buttock distance (HBD), and ultrasound images of the tibial tuberosity (maturity and morphology) were compared between players who developed OSD and those who did not.

Results: OSD was identified in 8 knees of 6 players, with an incidence of 2.9% of knees (8/280) and 4.3% of players (6/140). Univariate analysis revealed significant differences between the OSD and non-OSD groups regarding BMI (17.1 $\pm$ 1 kg/m^2 vs 18.5 $\pm$ 1.6 kg/m^2, respectively; P = .018), HBD (1.5 $\pm$ 1.6 cm vs 4.8 $\pm$ 4.5 cm; $P < .001$), and stage of tibial tuberosity maturity ($P < .001$). The maturity of the tibial tuberosity was the only independent risk factor for the development of OSD in multivariate logistic regression analysis (odds ratio, 9.848 [95% CI, 3.297-29.41]; $P < .001$).

Conclusion: Study findings indicated that quadriceps muscle tightness did not contribute to the development of OSD.

Keywords: bone maturity; Osgood-Schlatter disease; tightness; ultrasonography

Osgood-Schlatter disease (OSD) is a cause of knee pain in adolescent athletes. Several cross-sectional studies have evaluated the incidence of and risk factors for OSD.[2,5,6,8,12] Except for 1 study,[6] all studies reported that the quadriceps muscles were tighter in patients with OSD and speculated that repeated contraction of the quadriceps femoris causes apophysitis of the tibial tuberosity. However, all of these studies were retrospective, and it is still unknown whether quadriceps muscle tightness is a cause or a consequence of OSD. There are only 2 prospective studies on the risk factors for OSD in the literature.[9,14] Nakase et al[9] identified tightness of the quadriceps femoris, flexibility of the hamstring muscles, and the strength of the quadriceps femoris as risk factors for OSD, while Watanabe et al[14] identified higher height and body weight, high body mass index (BMI), and tightness of the quadriceps femoris as risk factors for OSD. However, both of these studies included <40 participants.

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In this study, we prospectively investigated the risk factors for OSD in 150 Japanese adolescent soccer players over 2 years and focused on physical factors, including quadriceps muscle tightness and ultrasound images of the tibial tuberosity. We hypothesized that quadriceps muscle tightness would not contribute to the development of OSD.

METHODS

Participants

This study protocol was approved by our institutional ethics committee. All participants' parents or guardians provided informed consent. The participants in this prospective study were 150 junior high school soccer players (N = 300 knees), all of whom belonged to the same soccer club in Tokyo, Japan, and underwent a medical examination between 2014 and 2019. This soccer team consisted of male players who practiced year-round with a 1-week break in the summer and winter. There were 37 players in the first grade of junior high school in 2014, 37 in 2015, 33 in 2016, and 43 in 2017, all of whom were evaluated for 2 years during the study period. Players had a mean age of 12.5 years (range, 12-13 years) at the first examination. The mean height, body weight, and BMI at the first examination were 155.6 cm (range, 135.3-178 cm), 45 kg (range, 30.3-65.4 kg), and 18.4 kg/m^2 (range, 14.9-24.2 kg/m^2), respectively. The mean age at the time of starting soccer was 5.2 years (range, 2-9 years). We excluded 10 players who had a history of OSD before the first medical examination, and the remaining 140 players (n = 280 knees) were included in this prospective analysis. Players who developed OSD after the first medical examination were considered as the OSD group (n = 8 knees; n = 6 players), while those who did not were considered as the non-OSD group (n = 272 knees; n = 138 players) (Figure 1). Four players in the OSD group had unilateral OSD; thus, those with nonaffected knees were also included in the non-OSD group.

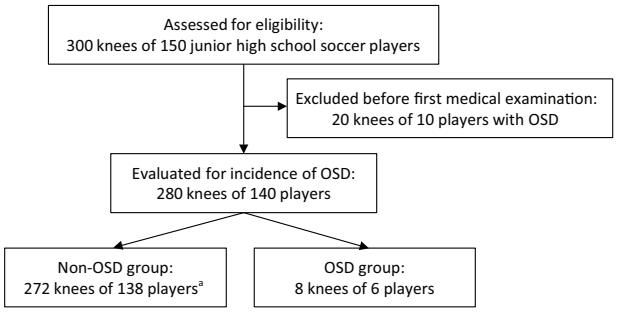

Figure 1. Flowchart of participant inclusion. OSD, Osgood-Schlatter disease. [a]Four players in the OSD group had unilateral OSD; thus, those with nonaffected knees were also included in the non-OSD group.

History of Injury Questionnaire

All participating players were asked to complete a questionnaire about their history of injury during the previous year. The questionnaire included questions about participants' age at the time of starting soccer and their history of injury, including OSD. The diagnosis of OSD as determined by an orthopaedic physician was defined as pain on motion and tenderness at the tibial tuberosity that required missing play for $\geq$1 day in the absence of any other abnormal symptoms, such as meniscus injury.

Physical Examination

Physical examination was performed by 1 of the 3 orthopaedic surgeons (D.K., A.N., and M.O.). Tightness of the hamstring muscles was assessed using the straight-leg raise angle (SLRA). During the straight-leg raise test, with the player in the supine position, 1 examiner raised the leg and another measured the SLRA between the leg and the floor. Tightness of the quadriceps femoris was assessed by measuring the heel-buttock distance (HBD), with the player in the prone position and the knee maximally flexed.

Ultrasound Examination

Ultrasound examination was performed by 2 orthopaedic surgeons (H.F. and H.H.). The maturity and morphology of the tibial tuberosity were examined using a FAZONE M ultrasound system with an FZT L14-5W probe (Fujifilm Corp). Both knees of each participant were examined in 90° of flexion in the supine position. Using the Ehrenborg classification,[4] the stage of bone maturity was classified as cartilage, apophyseal, epiphyseal, or bony (Figure 2). The morphology of the tibial tuberosity was defined as normal, irregular, or avulsion (Figure 3).

Statistical Analysis

Continuous data were reported as means with standard deviations. Potential risk factors for OSD—including age at the time of starting soccer, height, weight, BMI, annual increase in height, and SLRA and HBD measurements—were compared between the OSD and non-OSD groups using an unpaired *t* test. The Mann-

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Ethical approval for this study was obtained from The Jikei University School of Medicine, Tokyo, Japan (no. 32-492[10585]).

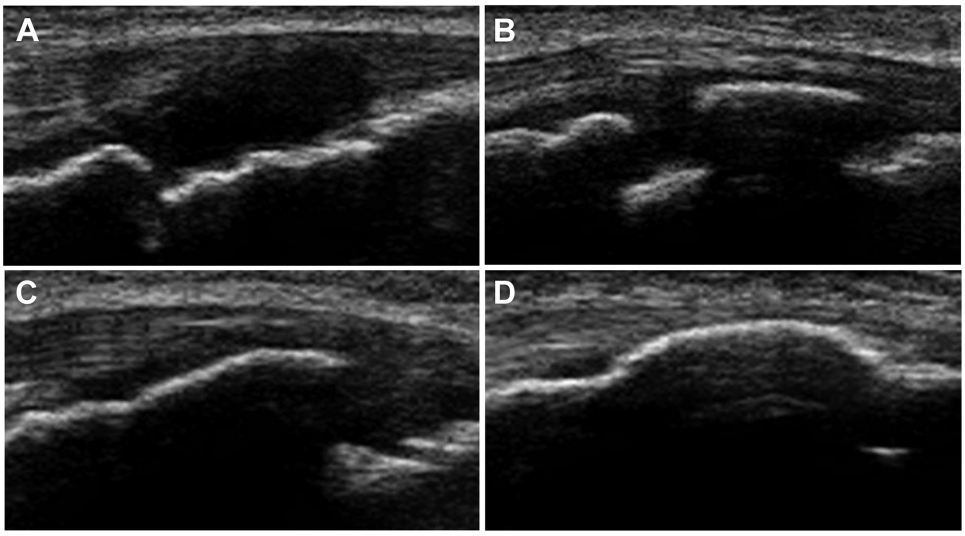

Figure 2. Ultrasound images showing various stages of tibial tuberosity maturity. (A) Cartilage stage: a large amount of apophyseal cartilage. (B) Apophyseal stage: the presence of a secondary ossification center. (C) Epiphyseal stage: no detectable distinction between the secondary ossification center and the tibial epiphysis. (D) Bony stage: no epiphyseal line.

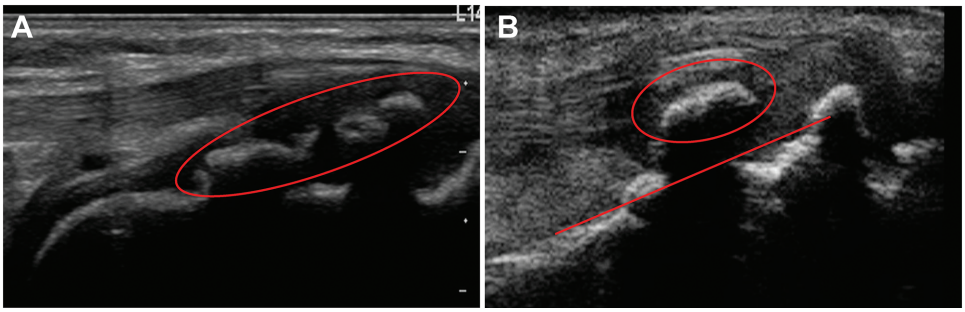

Figure 3. Ultrasound images showing morphological abnormalities of the tibial tuberosity. (A) Irregular: segmented secondary ossification (circled). (B) Avulsion: separated secondary ossification (circled) from the tibial tuberosity (indicated by line).

Whitney *U* test was used to examine the difference in the maturity of the tibial tuberosity between the groups, and the Fisher exact test was used to evaluate the between-group difference in the morphology of the tibial tuberosity. We also conducted a comparison between the morphology of the tibial tuberosity and the duration of missing practice (ie, time to return to play) in the OSD group using the Kruskal-Wallis rank sum test. All statistical analyses were performed using the R software package (R Core Team). $P < .05$ was considered statistically significant.

RESULTS

Incidence of OSD

OSD developed in 6 players (n = 8 knees) after entry into junior high school, with an incidence of 2.9% (8/280) for knees and 4.3% (6/140) for players. Four players (n = 6 knees) developed OSD in the first grade of junior high school and 2 players (n = 2 knees) developed OSD in the second grade of junior high school. The time between the previous medical examination and the diagnosis was 5 to 11 months (mean, 7.9 months).

Factors Correlated With OSD Development

Univariate analyses of the risk factors for OSD are presented in Table 1. Both the BMI (17.1 ± 1 kg/m^2 vs 18.5 ± 1.6 kg/m^2; $P = .018$) and the HBD (1.5 ± 1.6 cm vs 4.8 ± 4.5 cm; $P < .001$) were significantly smaller in the OSD group compared with the non-OSD group. There were also significant differences between the study groups in the maturity of the tibial tuberosity ($P < .001$) (Table 2).

Although no statistically significant difference was found between the groups in the frequency of abnormal morphology of the tibial tuberosity on ultrasound examination, irregular and avulsion morphologies were more common in the OSD group (Table 3). In the OSD group,

TABLE 1
Univariate Analysis of Potential Risk Factors for OSD[a]

	OSD (n = 8)	Non-OSD (n = 272)	*P*
Age at starting soccer, y	5.3 ± 1.1	5.2 ± 1.4	.9
Height, cm	153.2 ± 10.1	155.4 ± 8.3	.45
Weight, kg	40.6 ± 7	44.9 ± 7.4	.1
Height increase/y, cm	8.4 ± 2.7	7.2 ± 2.4	.18
BMI, kg/m^2	17.1 ± 1	18.5 ± 1.6	**.018**
SLRA, deg	62.5 ± 8.9	68.5 ± 11.4	.14
HBD, cm	1.5 ± 1.6	4.8 ± 4.5	<**.001**

[a]Data are presented as mean ± SD. Bold *P* values indicate statistically significant differences between groups ($P < .05$). BMI, body mass index; HBD, heel-buttock distance; OSD, Osgood-Schlatter disease; SLRA, straight-leg raising angle.

TABLE 2
Univariate Analysis of Maturity Stage of the Tibial Tuberosity According to OSD[a]

	OSD	Non-OSD	*P*
Stage of maturity			<.001
Cartilage	4	13	
Apophyseal	4	57	
Epiphyseal	0	202	

[a]Data are presented as No. of knees. OSD, Osgood-Schlatter disease.

TABLE 3
Univariate Analysis of Tibial Tuberosity Morphology According to OSD Status[a]

	OSD	Non-OSD	*P*
Morphology			.056
Normal	5	236	
Irregular	2	29	
Avulsion	1	7	

[a]Data are presented as No. of knees. OSD, Osgood-Schlatter disease.

TABLE 4
Results of Multivariate Logistic Regression Analysis of Risk Factors for OSD[a]

Risk Factor	*P*	OR (95% CI)
Maturity of tibial tuberosity	<**.001**	9.848 (3.297-29.41)
BMI, kg/m^2	.963	NA
HBD, cm	.422	NA

[a]The bold *P* value indicates statistical significance ($P < .05$). BMI, body mass index; HBD, heel-buttock distance; NA, not applicable; OR, odds ratio; OSD, Osgood-Schlatter disease.

morphology was normal in 5 knees, irregular in 2, and avulsion in 1; the respective numbers were 236, 29, and 7 in the non-OSD group.

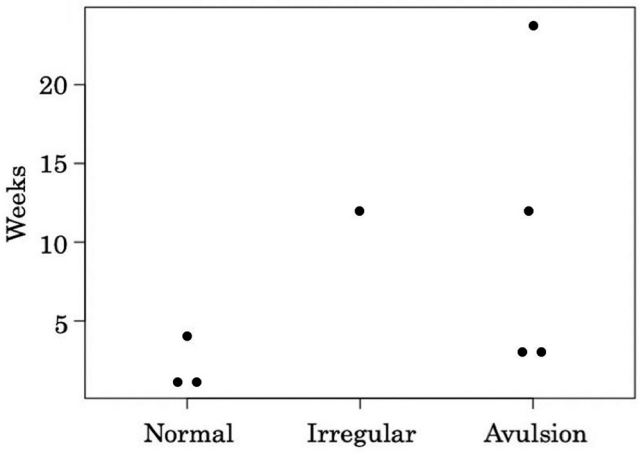

Figure 4. Weeks to return to play for the 8 knees in the OSD group according to morphological abnormality of the tibial tuberosity.

The only independent risk factor for OSD identified in multivariate logistic regression analysis was the maturity of the tibial tuberosity (odds ratio, 9.848 [95% CI, 3.297-29.41]; $P < .001$) (Table 4). According to morphological findings on ultrasound images, there was no significant difference in the time to return to play in the OSD group ($P = .227$) (Figure 4).

DISCUSSION

Reports of the incidence of OSD in studies with >100 participants have ranged widely from 2.9% to 12.9% in the previous cross-sectional studies.[1,2,7,8,10,11,12] In 2017, the German Olympic Sports Federation reported that the incidence of OSD varied according to type of sport, being highest in football players and high in basketball players.[3] In our study, the longitudinal observation of 140 Japanese adolescent male soccer players identified 6 cases of OSD (n = 8 knees), with an incidence of 2.9% (8/280) for knees and 4.3% (6/140) for players. Provided that all cases of OSD developed before the beginning of the third grade of junior high school, the prevalence of OSD was 7.3% of knees (22/300) and 10.6% of players (16/150), which included 14 knees in the 10 players with a history of OSD before the first medical examination.

Quadriceps muscle tightness has been reported to be a major risk factor for OSD. The pathology of OSD is thought to be apophysitis of the tibial tuberosity caused by repeated contraction of the quadriceps femoris. Other factors—including tightness of the hamstring muscles, tall height, heavy weight, and a high annual increase in height—have also been reported as risk factors of OSD.[9,10,14] Omodaka et al[12] reported that adolescent baseball players with OSD had significantly longer practice times than those without OSD. Previous studies were either retrospective[2,5,12] or prospective, but they included a small number of participants.[9,14] The present study

included 150 participants, making it the largest study population to be prospectively investigated to date .

Our univariate analysis of potential risk factors for OSD identified BMI and HBD values to be significantly lower in the OSD group. The HBD is considered to be an indicator of the flexibility of the quadriceps muscles. Unlike previous studies, we found that the quadriceps muscles were more flexible in players who developed OSD than in those who did not. We suspect that the quadriceps muscle tightness becomes apparent after OSD onset. Several studies have evaluated the maturity of the tibial tuberosity in patients with OSD and found it to be mainly in the epiphyseal stage[7,10,11] or the apophyseal stage.[9] In our prospective study, ultrasound examination revealed that the tibial tuberosity was less mature in the OSD group than in the non-OSD group. Four knees in the OSD group were in the cartilage stage and 4 were in the apophyseal stage before OSD onset. Furthermore, multivariate logistic regression analysis revealed that the maturity of the tibial tuberosity was the only independent risk factor for the development of OSD.

In our study, of 8 knees that developed OSD during the junior high school years, ultrasound imaging showed that the morphology of the tibial tuberosity was irregular in 2 knees, avulsion in 1, and normal in 5 before OSD onset. After onset, the morphology was found to be irregular in 1 knee, avulsion in 4, and normal in 3. Although we found no significant difference in abnormalities of the tibial tuberosity between the OSD group and the non-OSD group ($P = .056$), irregular or avulsion morphology could be a risk factor for OSD to some degree. Furthermore, although not a statistically significant finding, the time to return to play was longer in players with irregular or avulsion morphology than in those with normal morphology. Further research is needed to determine whether the morphology of the tibial tuberosity is a risk factor for OSD and whether it is correlated with time to return to play.

Limitations

This study has some limitations. First, 10 players (n = 14 knees) had a history of OSD before entering junior high school. Therefore, it would have been preferable to observe the players from a younger age (eg, sixth grade of elementary school). Second, we were not able to obtain the physical examination data just before OSD onset because the time between the previous medical examination and the diagnosis was 5 to 11 months (mean, 7.9 months). Third, we could not evaluate other possible risk factors, including trunk stability, ball kicking, and running performance. Fourth, the ultrasound examination did not include color-enhanced Doppler imaging. Neovessels around the tibial tuberosity and the patellar tendon have been associated with painful OSD.[13]

CONCLUSION

In this prospective study, the incidence of OSD in male Japanese junior high school soccer players was 2.9% (8/280) for knees and 4.3% (6/140) for players. Univariate analysis revealed a significant difference in BMI, HBD, and maturity of the tibial tuberosity between the OSD group and the non-OSD group. However, in multivariate logistic regression analysis, the maturity of the tibial tuberosity was the only independent risk factor for OSD.

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