RESEARCH ARTICLE

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Factors Associated with Knee and Heel Pain in Children: An Observational Web-Based Survey for 1,200 Parents with Young Japanese Footballers Aged in 8–12 Years

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ABSTRACT

The characteristics of injuries in young children differ from those of adult or adolescent players. To maintain a good physical condition among young children, knowledge of the factors associated with knee and heel pain in growth phase is essential. This study investigated the factors that correlated with growth-related knee and heel pain in Japanese football players aged 8 to 12 years. We collected 1,200 pieces of data (each 300 children in 3rd to 6th grades) on children's characteristics from their parents using a web-based questionnaire. Player's age, weight, height, leg dominance, playing position, playing surface, and weekly training volume were collected from each parent. In addition, respondents were asked whether their children had experienced knee or heel pain within the previous 12 months. If they answered "Yes" for the pain, the cause was investigated as following categories: growth related pain (Osgood-Schlatter disease or Sever's disease), contusion, fracture, sprain, and others. Univariate analyses (independent t tests and chi-square tests) were used to compare the characteristics between the groups with and without growth-related knee and heel pain. To investigate the association of the clinical factors with growth-related knee and heel pain, multivariate logistic regression analyses were performed, and the results were presented as the odds ratios (OR) and 95% confidence intervals (CI). Among young Japanese footballers, 11.2% and 10.7% had episodes of growth-related knee and heel pain within recent 12 months, respectively. Older age, larger body size, and increased training volume per week were associated with recent knee and heel pain in univariate analyses. In contrast, leg dominance, playing position, and surface were not associated with any episode of growth-related knee and heel pain. According to multivariate logistic regression analyses, older age (OR=1.24; 95% CI, 1.01–1.52), higher percentile rank in body height (OR=1.34; 95% CI, 1.04–1.74), and more training hours per week (OR=1.06; 95% CI, 1.03–1.09) were significantly associated with the episodes of growth-related knee pain in past 12 months. Moreover, higher percentile rank in body weight (OR=1.50; 95% CI, 1.21–1.85) and more training days per week (OR=1.46; 95% CI, 1.29–1.65) were associated with growth-related heel pain. The present study used a web-based questionnaire to investigate the factors associated with knee and heel pains in young football players aged 8 to 12 years. Age, body size, and external load such as weekly training volume were associated with knee and heel pain in children. Coaches and guardians, who monitor children's growth, should pay attention to modifiable risk factors that correlated with knee and heel pains in childhood.

Keywords: growth-related injury, overuse, risk factor, soccer.

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I. INTRODUCTION

Football (soccer) is one of the most popular sports, regardless of age and sex, and more than 20 million youth aged under 18 years play football worldwide (FIFA Communication Division, 2007). Youths generally include both children and adolescents (Faude *et al*., 2013). For children, football is efficacious in improving physical capacity, health-related fitness parameters, and self-esteem (Faude *et al*., 2010). However, injuries have a detrimental impact on team and individual athletic success (Drew *et al*., 2017) and those in childhood may affect long-term outcomes, including the development of osteoarthritis (Ardern *et al*., 2018) or non-union (Mills & Simpson., 2013; Mills & Simpson., 2013) in future. The characteristics

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of injuries in young children differ from those of adult or adolescent players. A relevant problem in young football players is growth-related conditions, such as osteochondral disorders like Osgood-Schlatter or Sever's disease (Faude *et al*., 2013). A descriptive epidemiological study reported that 16.8% of all injuries in footballers aged between 7–12 years were growth-related or overuse injuries (Rossler *et al*., 2016). Another prospective survey using a questionnaire dedicated to overuse injuries also reported that knee and heel complaints were the most common overuse problems in children's football (Leppanen *et al*., 2019). To maintain a good physical condition among young children, knowledge of the factors associated with knee and heel pain in growth phase is essential.

According to a position statement from the American Medical Society for Sports Medicine, variables that contribute to overuse injuries in young athletes are categorized into either intrinsic or extrinsic risk factors (DiFiori *et al*., 2014). Furthermore, they emphasized that a complex interaction of multiple risk factors in specific settings coupled with an inciting event result in many overuse injuries in youth sports. For children aged between 7–12 years, age-adjusted taller players had a higher risk of overuse injury (Rossler *et al*., 2018). On the other hand, injury risk for playing surface (artificial turf vs natural grass) in young footballers does not reach a consensus in Europe（Soligard *et al*., 2012; Fuller *et al*., 2007; Rossler *et al*., 2018）. Regarding sports participation volume, several recommendations have been developed in an effort to reduce the risks of overuse injury in youth sports (Jayanthi *et al*., 2015; LaPrade *et al*., 2016). These findings are generally useful when considering preventive strategies for children.

The risk factors for overuse injury naturally vary among nations and are based on the circumstances surrounding each sport. As an example of extrinsic risk factors, Japanese children in local club teams often play football on clay ground that differs from European countries played on artificial turf or natural grass (Fuller *et al*., 2007; Rossler *et al*., 2018). Another investigation by Nagano *et al*. (2023) demonstrated that weekly days of sports participation in Japan were associated with overuse lower limb injury at elementary school age; however, these data were not limited to football players. Iwame *et al*. (2019) also presented the clinical characteristics of Japanese children with knees and heel pains (excluding acute or contact-related pain). Although they gathered responses from 602 young football players by using a paper-based questionnaire, some limitations remained. First, the players were from the same geographic region in Japan, and it is unclear whether the identified risk factors are generalizable to other regions. In addition, they only enquired about the experience of knee or heel pain without defining the timing of appearance. Their answers may include a mix of data on recent (i.e., within 12 months) and past (i.e., more than one year) pain episodes. To understand the risk factors for knee and heel pain in Japan more clearly and generally, predetermined responses from all over the country are necessary.

Recently, web-based surveys have been applied in various investigations and have been shown to be a feasible tool in paediatric research (Fang *et al*., 2021). Anonymous online questionnaires are convenient, especially for large-scale studies. Therefore, the purpose of this study was to investigate the factors that correlated with knee or heel pain in young football players aged 8 to 12 years, using a web-based survey in Japan. We hypothesized that older age, larger body size, and greater training volume would be associated with the prevalence of growth-related knee and heel pain in children.

II. Material and Methods

A. Data Collection

The present study is an observational study of the data obtained from an anonymous web-based questionnaire. To recruit the target participants, a two-step questionnaire (including screening and main questions) about own children were set in the present research. First, a screening questionnaire was randomly distributed to 18,043 people registered with a web questionnaire supplier (Rakuten Research Inc., Japan). A total of 9,549 of the 18, 043 affiliates participated in the screening survey. Next, 1,335 parents of male young footballers in the 3rd to 6th grades (aged 8 to 12 years) participated in the main survey based on the results of the screening survey. Finally, 1,200 of the 1,335-sampling data were randomly selected by a questionnaire supplier and supplied to the first author (S.S.). When the number of respondents who had children studying in the 3rd to 6th grades was equal (300 children in each age category), the survey was closed. A series of surveys achieved the desired sample size (1,200 samples) in 3 days (December 1–3, 2021). Participants who agreed to participate in this survey answered the questionnaire voluntarily, and informed consent was obtained electrically. All information was collected anonymously without revealing the identity of any individual participant. This study was approved by the ethics committee of Tokyo Ariake University of Medical and Health Sciences (approval no. 0341).

B. Questionnaire

The questionnaire consisted of five screening questions and eight main questions (Table I). These questions were based on the potential risk of injuries in young footballers aged between 7 and 12 years

(Rossler *et al*., 2018; Iwame *et al*., 2019). The screening survey assessed whether the respondent had a child with the following criteria: 1) Currently playing football in the club team, 2) Among 3rd to 6th grade, 3) Male, and 4) Playing football regularly for more than 1 day per week. If answers to the screening questions matched the inclusion criteria, the questionnaire continued to the next main survey. If they did not match even one of the inclusion criteria, the respondents were excluded from the survey. In the screening questions, the total playing days and hours per week for football were asked to each participant quantitatively. In early 2020, the global spread of the coronavirus disease 2019 (COVID-19) pandemic restricted sports activities and forced to change the normal training schedules, especially on spring to summer in 2020. Although participants answered the training volume based on recent 12 months (from December 2020 to December 2021), children have already resumed the football activity according to the guideline from Japan Football Association.

TABLE I: QUESTIONNAIRE ABOUT KNEE AND HEEL PAIN IN YOUNG MALE FOOTBALL PLAYERS

Screening questionnaire (SC1-5)
SC1. Does your child currently play football in club teams?
Yes/No/No children
SC2. What grade is your child in that plays football?
(If you have more than two children, please answer about one child among 3rd to 6th grade preferentially)
3rd grade/4th grade/5th grade/6th grade/Others
SC3. What is the sex of your child as described in SC2?
Male/Female
SC4. How many days per week has your child played football (including practice and games) in the last 12 months?
Note: please consider the period excluding activity restriction by COVID-19.
One day per week/Two days per week/Three days per week/Four days per week/Five days per week Six days per week/Seven days per week/Others (less than one day per week)
SC5. How many hours (in total) per week has your child played football (including practice and games) in the last 12 months?
Note: please consider the period excluding activity restriction by COVID-19.
Almost hours in total per week
Main questionnaire (Q1-8)
Please answer about your child who plays football as described in previous questionnaire (SC1-5).
Q1. How old is your child?
years and months old
Q2. What is your child's weight?
kg
Q3. How tall is your child?
cm
Q4. Which leg is dominant? Note: please select the dominant leg used to kick a ball as far as possible.
Right leg/Left leg
Q5. Which is the position in football? Note: Please select the most appropriate option.
GK/DF/MF/FW
Q6. Which surface does your child usually play football on?
Clay ground / Artificial turf / Natural grass/Others
Q7-1. Did your child have knee pain within the last 12 months?
Yes (following to the next Q7-2)/No
Q7-2. What was the cause of knee pain? Note: Please select the most appropriate option.
Growth related knee pain (Osgood-Schlatter disease)/Contusion/Fracture/Sprain/Others
Q8-1. Did your child have a heel pain within last 12 months?
Yes (following to the next Q8-2)/No
Q8-2. What was the cause of the heel pain? Note: Please select the most appropriate option.
Growth related heel pain (Sever's disease) / Contusion / Fracture / Sprain / Others

The main questions asked respondents about the characteristics of their children playing football. Data on age, body weight, height, leg dominance, playing position, and surface were collected from each parent. The playing position was divided into the goalkeeper, defender, midfielder, and forward groups. The playing surface was divided into clay ground, artificial turf, natural grass, and others. In addition, respondents were asked whether their children had experienced knee or heel pain within the previous 12 months. If they answered "Yes" for the pain, the cause was investigated as following categories: growth related pain (Osgood-Schlatter disease or Sever's disease), contusion, fracture, sprain, and others. The occurrence and causes of knee and heel pain were self-reported by the responders, regardless of their diagnosis by the physician.

C. Data Setting

The first author (S.S.) reviewed the raw data (N=1,200) and confirmed the information provided. Only one data point was obviously anomalous because the playing hours of the 1-day training exceeded 24 h; therefore, these data were excluded from data analysis as outliers. To investigate the clinical factors associated with growth-related injury in young footballers, the analysed data (N=1,199) were divided into those with or without knee and heel pain within the last 12 months. Furthermore, knee and heel pain caused

by contusion, fracture, and sprain (ligament injury) were excluded from growth-related pain. Finally, growth-related knee pain including Osgood-Schlatter disease (n=134) and heel pain including Sever's disease (n=128) were selected for the case groups, whereas data without knee and heel pain (n=929 and 888, respectively) were used for the control groups (Fig. 1).

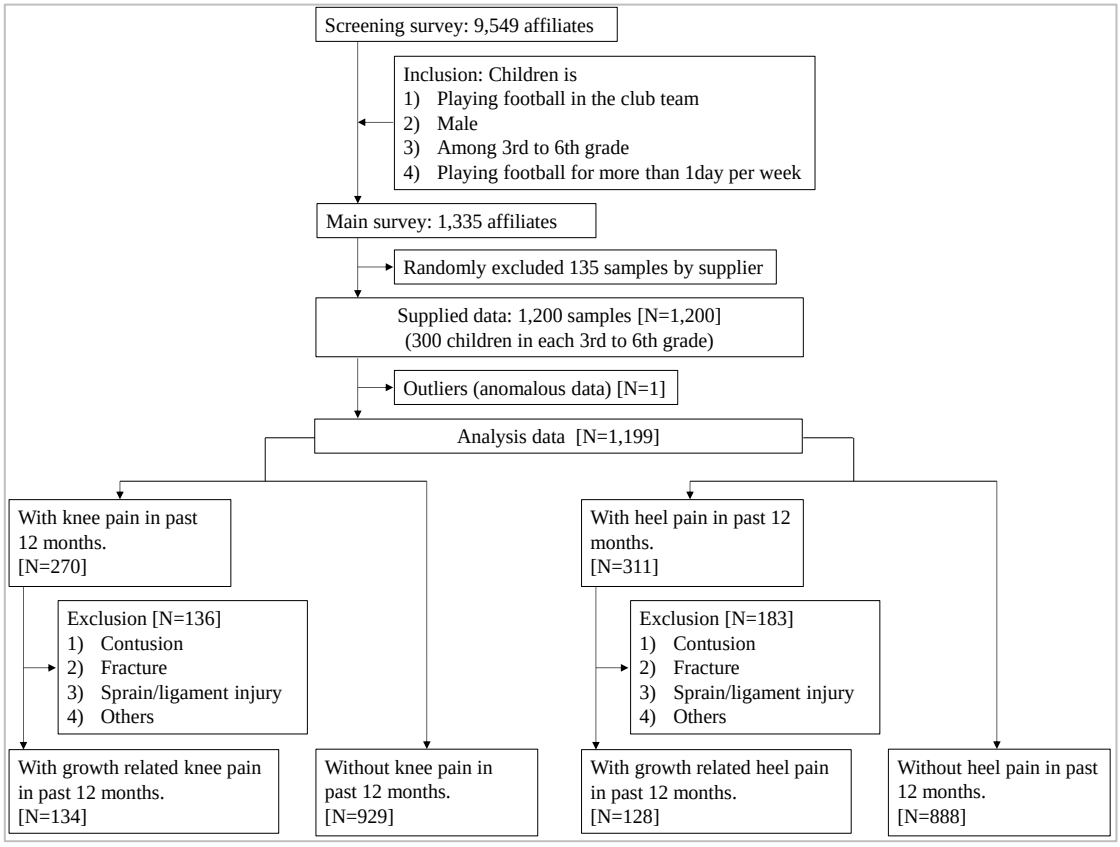

Fig. 1. Flow chart of the data setting.

D. Statistical Analysis

In the descriptive statistics, continuous variables (age, height, weight, body mass index [BMI], training days, and hours per week) were expressed as mean±standard deviation (SD), and categorical variables (percentile groups, leg dominance, playing position, and surface) were expressed as number and proportion. In the present study, we categorized children into six percentile groups (<P3; P3 to P10; P10 to P50; P50 to P90; P90 to P97; ≥P97) based on the sample itself to analyse injury risk in relation to body height and body mass independent of age, according to Rossler and colleagues (Rossler *et al*., 2018). In addition, children were categorized according to eight percentile ranges (<P3, P3 to P10, P10 to P25, P25 to P50, P50 to P75, P75 to P90, P90 to P97, and ≥P97) to analyse BMI (Rossler *et al*., 2018). In regard to the playing position, we recategorized four types of position into two groups as fielders and goalkeepers, referred to Iwame and colleagues (Iwame *et al*., 2019). Children will very often play in different positions throughout a year and the official guidelines advise that against fixed playing positions in children's football to enable the broadest possible development.

Univariate analyses (independent t tests and chi-square tests) were used to compare the characteristics between the groups with and without growth-related knee and heel pain. To assess the number of cases required to determine significant differences in the t-test, a prior power analysis was performed at an effect size d = 0.5 and α level = 0.05, power (1‑β level) = 0.95, allocation ratio=10. The analysis showed that 632 samples (group 1=57, group 2=575) were required to achieve sufficient statistical power to detect significant differences. In addition, power analysis for the chi-square test (effect size w=0.3, α level=0.05, power (1‑β level)=0.95, larger df=7) also showed that 243 samples were required. Based on these values, the sample size of the present study (1,063 for knee pain and 1,016 for heel pain) was sufficient.

To investigate the association of the clinical factors with growth-related knee and heel pain, multivariate logistic regression analyses were performed, and the results were presented as the odds ratios (OR) and 95% confidence intervals (CI). Variables with $p<0.05$ in the univariate analysis were entered into multivariate models. In cases of multicollinearity between variables with a p value<0.05, we included the one with the smaller p value in the multivariate analysis. We preliminarily confirmed the multicollinearity between body height and body weight (r=0.700); therefore, either the percentile category of body height or

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weight was included in the multivariate regression. The final model was developed using a forward stepwise regression. All statistical procedures were performed using IBM SPSS Statistics for Windows (version 22.0), and statistical significance for all tests was set at $p<0.05$.

III. Results

Among the young Japanese footballers aged 8–12 years, 11.2% (134 out of 1199 players) had episodes of growth-related knee pain within recent 12 months. Besides, 10.7% (128 out of 1199 players) had episodes of growth-related heel pain in the previous 12 months (Fig. 1). Fifty players (4.2%) reported both knee and heel pain. Univariate associations of clinical factors with growth-related knee and heel pain analyzed by t tests and chi-square tests are summarized in Table II and III. Older age, taller and heavier body size (higher percentile rank), and more training days and hours per week were associated with recent growth-related pain in both the knee and heel. In contrast, BMI, leg dominance, playing position, and surface were not different regardless of the episode of knee and heel pain.

TABLE II: Clinical Characteristics of Young Footballers With and Without Growth-related Knee Pain Within Recent 12 Months

	With growth-related knee pain (n=134)	Without knee pain (n=929)	p value
Age, mean±SD, years	11.1±1.1	10.6±1.1	<0.001
Body height, mean±SD, m	1.45±0.11	1.40±0.10	<0.001
Body height percentile cat. (%)			<0.001
<P3	0 (0.0)	8 (100.0)	
P3 to P10	8 (8.5)	86 (91.5)	
P10 to P50	27 (7.8)	321 (92.2)	
P50 to P90	69 (13.9)	482 (86.1)	
P90 to P97	23 (27.1)	62 (72.9)	
>=P97	7 (22.6)	24 (77.4)	
Body weight, mean±SD, kg	36.4±8.0	33.7±7.9	<0.001
Body weight percentile cat. (%)			0.002
<P3	3 (11.5)	23 (88.5)	
P3 to P10	4 (6.7)	56 (93.3)	
P10 to P50	36 (8.2)	405 (91.8)	
P50 to P90	70 (16.7)	349 (83.3)	
P90 to P97	16 (18.6)	70 (81.4)	
>=P97	5 (16.1)	26 (83.9)	
Body mass index, mean±SD, kg/m^2	17.2±2.4	17.0±2.8	0.564
Body mass index percentile cat. (%)			0.206
<P3	3 (9.7)	28 (90.3)	
P3 to P10	6 (8.1)	68 (91.9)	
P10 to P25	13 (9.0)	132 (91.0)	
P25 to P50	45 (16.0)	236 (84.0)	
P50 to P75	31 (11.7)	234 (88.3)	
P75 to P90	26 (16.1)	135 (83.9)	
P90 to P97	6 (8.0)	69 (92.0)	
>=P97	4 (12.9)	27 (87.1)	
Training days per week, mean±SD, days	2.9±1.5	2.4±1.3	<0.001
Training hours per week, mean±SD, hours	8.7±6.9	6.3±4.9	<0.001
Leg dominance, number (%)			0.741
Right foot preferred	102 (11.0)	827 (89.0)	
Left foot preferred	16 (11.9)	118 (88.1)	
Position, number (%)			0.490
Fielder	112 (11.5)	860 (88.5)	
Goalkeeper	12 (14.8)	69 (85.2)	
Training surface, number (%)			0.962
Clay ground	101 (12.3)	717 (87.7)	
Artificial turf	23 (13.1)	152 (86.5)	
Natural grass	8 (14.5)	47 (85.5)	
Others	2 (13.3)	13 (86.7)	

Note: SD, standard deviation; Cat, category.

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TABLE III: CLINICAL CHARACTERISTICS OF YOUNG FOOTBALLERS WITH AND WITHOUT GROWTH-RELATED HEEL PAIN WITHIN RECENT 12 MONTHS.

	With growth-related heel pain (n=128)	Without heel pain (n=888)	p value
Age, mean±SD, years	11.0±1.1	10.6±1.2	<0.001
Body height, mean±SD, m	1.45±0.10	1.40±1.1	<0.001
Body height percentile cat. (%)			0.009
<P3	0 (0.0)	8 (100.0)	
P3 to P10	5 (5.4)	87 (94.6)	
P10 to P50	35 (10.6)	295 (89.4)	
P50 to P90	66 (13.9)	408 (86.1)	
P90 to P97	13 (16.3)	67 (83.8)	
>=P97	9 (28.1)	23 (71.9)	
Body weight, mean±SD, kg	36.7±8.2	33.6±7.7	<0.001
Body weight percentile cat. (%)			0.005
<P3	2 (7.7)	24 (92.3)	
P3 to P10	3 (5.3)	54 (94.7)	
P10 to P50	39 (9.2)	383 (90.8)	
P50 to P90	62 (15.4)	340 (84.6)	
P90 to P97	15 (19.0)	64 (81.0)	
>=P97	7 (23.3)	23 (76.7)	
Body mass index, mean±SD, kg/m^2	17.4±2.7	16.9±2.8	0.057
Body mass index percentile cat. (%)			0.457
<P3	3	27 (90.0)	
P3 to P10	7	61 (89.7)	
P10 to P25	12	134 (91.8)	
P25 to P50	32	231 (87.8)	
P50 to P75	37	216 (85.4)	
P75 to P90	25	130 (83.9)	
P90 to P97	7	64 (90.1)	
>=P97	5	25 (83.3)	
Training days per week, mean±SD, days	3.1±1.6	2.3±1.3	<0.001
Training hours per week, mean±SD, hours	8.9±5.8	6.2±4.8	<0.001
Leg dominance, number (%)			0.935
Right foot preferred	95 (10.7)	793 (89.3)	
Left foot preferred	14 (10.9)	114 (89.1)	
Position, number (%)			1.000
Fielder	119 (12.6)	823 (87.8)	
Goalkeeper	9 (12.2)	65 (87.8)	
Training surface, number (%)			0.108
Clay ground	93 (11.8)	698 (88.2)	
Artificial turf	28 (17.5)	132 (82.5)	
Natural grass	7 (13.7)	44 (86.3)	
Others	0 (0.0)	14 (100.0)	

Note: SD, standard deviation; Cat, category.

According to the multivariate logistic regression analyses, older age (OR=1.24; 95% CI, 1.01–1.52, p=0.042), higher percentile rank in body height (OR=1.34; 95% CI, 1.04–1.74, p=0.025), and more training hours per week (OR=1.06; 95% CI, 1.03–1.09, p<0.001) were significantly associated with the episodes of growth-related knee pain in past 12 months (Table IV). Training days per week were excluded from the final multivariate logistic regression model for episodes of knee pain. Besides, higher percentile rank in body weight (OR=1.50; 95% CI, 1.21–1.85, p<0.001) and more training days per week (OR=1.46; 95% CI, 1.29–1.65, p<0.001) were significantly associated with growth-related heel pain in recent 12 months (Table V). Age and number of training hours per week were excluded from the final model for heel pain episodes.

TABLE IV: MULTIVARIATE ASSOCIATION (FINAL MODEL DEVELOPED BY USING FORWARD STEPWISE REGRESSION) OF CLINICAL CHARACTERISTICS OF YOUNG FOOTBALLERS WITH GROWTH-RELATED KNEE PAIN WITHIN RECENT 12 MONTHS.

	Coefficient	OR	[95% CI]	p value
Age	0.213	1.24	[1.01–1.52]	0.042
Body height percentile cat.	0.296	1.34	[1.04–1.74]	0.025
Training hours per week	0.055	1.06	[1.03–1.09]	<0.001
Constant	−5.769			

Cat, category; OR odds ratio; CI; confidence interval.
Model chi-square test (P<0.05). The overall percentage of correctly predicted: 87.3%. Goodness-of-fit (Hosmer-Lemeshow statistic): 0.399.

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TABLE V: MULTIVARIATE ASSOCIATION (FINAL MODEL DEVELOPED BY USING FORWARD STEPWISE REGRESSION) OF CLINICAL CHARACTERISTICS OF YOUNG FOOTBALLERS WITH GROWTH-RELATED HEEL PAIN WITHIN RECENT 12 MONTHS

	Coefficient	OR	[95% CI]	p value
Body weight percentile cat.	0.405	1.50	[1.21–1.85]	<0.001
Training days per week	0.377	1.46	[1.29–1.65]	<0.001
Constant	−4.430			

Cat, category; OR odds ratio; CI; confidence interval.
Model chi-square test (P<0.01). Overall percentage of correctly predicted: 87.4%. Goodness-of-fit (Hosmer-Lemeshow statistic): 0.199.

IV. DISCUSSIONS

Among the Japanese children aged 8 to 12 years who played football, approximately one out of ten players experienced growth-related knee and heel pain within recent 12 months. Observing the clinical characteristics, children with knee or heel pain tended to be older, taller, and heavier than those without painful episodes. However, there was no association between BMI and knee or heel pain in the past 12 months. Previous research by Iwame *et al*. (2019) showed similar results in that there were significant associations between older age and knee and heel pain in a non-adjusted model. Another epidemiological study also showed that the incidence rate of growth-related injuries was obviously higher in players aged 11 to 12 years than in the other groups aged 7 to 10 years (Rossler *et al*., 2016). The likelihood of reporting an overuse problem in children's football increases with age 9; therefore, age is an essential variable when considering the factor of growth-related knee and heel pain in children. In regard to the body size, Rossler *et al*. (2018) reported that percentile-adjusted body height and body weight affect the risk of overuse and training injuries, respectively. Meanwhile, some studies (Rossler *et al*. 2018; Iwame *et al*., 2019) are consistent with the present results showing no association between BMI and painful episodes. Anthropometric characteristics such as body height and weight reflect the maturity status of children (Malina *et al*., 2005); therefore, biological age may be associated with the latest growth-related knee and heel pain in young football players.

Leg dominance, playing position, and surface were not associated with any episode of growth-related knee and heel pain in Japan. A previous study showed that left-leg-dominant players tended to be at an increased risk of injury for adolescent football players aged 12–18 years (Emery *et al*., 2005); however, their data contained various types of injuries. Left-footed players did not have a higher overuse-injury risk for young footballers aged 7–12 years (Rossler *et al*. 2018), which is in line with our results. Similarly, playing position has been previously discussed and was not associated with either overuse injuries (Rossler *et al*. 2018) or knee/heel pain (Iwame *et al*., 2019). Regarding the playing surface, previous research has focused on the difference between artificial turf and natural grass (Fuller *et al*., 2007; Steffen *et al*. 2007; Soligard *et al*., 2012; Rossler *et al*., 2018;). However, majority of training surfaces in Japan are clay ground (more than 75%, Table 1). Our findings for unique circumstances in Japan will be a basis for future research on footballers who play on clay ground.

Three variables such as older age, higher percentile rank in body height, and more training hours per week, were identified as the most significant risk factors of growth-related knee pain in the multivariate logistic regression model with a Hosmer-Lemeshow goodness-of-fit score of 0.399 and correctly predicted overall percentage of 87.3%. For youth football players, Osgood-Schlatter disease is the most common diagnosis of knee apophyseal injury and peaks in footballers under 14 years of age (Materne *et al*., 2022). Experience of overuse knee pain in Japanese local football players aged 8 to 12 years was previously reported by 29.4% and associated with a trend of increasing age in multivariate-adjusted models (Iwame *et al*., 2019). In addition, apophyseal injuries generally occur at immature tendon-bone attachment sites, which are exposed to a relative increase in stress during the adolescent growth spurt (Materne *et al*., 2022). The cause of Osgood-Schlatter disease is believed to be secondary to the tractional pull of the tibial tuberosity (Lau *et al*., 2008) and this traction mechanism results from a rapidly increasing body height. Indeed, the risk of overuse injuries was associated with an increase in leg length for elite-level young (under-10 to under-12) soccer players (Rommers *et al*., 2020). Changes in body height or leg length were not unfortunately investigated in this research, which is the future challenges. However, these studies will support our findings that players' age and height in football were associated with the appearance of recent growth-related knee pain in Japanese children.

As risk factors for growth-related heel pain, higher percentile rank in body weight and more training days per week were identified in the multivariate logistic regression model, with a goodness-of-fit score of 0.199 and correctly predicted overall percentage of 87.4%. Unlike the Osgood-Schlatter disease, the peak incidence of foot-ankle time-loss apophyseal injuries, such as Sever's disease, occurs in children under 11 years (Materne *et al*., 2022) and present children aged 8 to 12 years have an increased tendency for heel pain. Variables in this period that increase strain and load on the posterior heel are the cause of Sever's

disease (Agyekum & Ma, 2015). James *et al*. (2015) reported that children presenting with calcaneal apophysitis differed from their peers in heavier and taller anthropometry. Obesity and high levels of physical activity are also risk factors for Sever's disease in paediatric athletes (Ramponi & Baker., 2019). These findings support the present results in Japanese children.

Focused on the external load, amount of training hours or days per week were associated with recent growth-related pains in multivariate regression models. Iwame *et al*. (2019) similarly reported a significant association between weekly playing time in more than 10 hours and painful episodes of the knee and heel. Regarding participation volume in youth sports, some recommendations have been developed to reduce the risk of overuse injury. Jayanthi *et al*. (2015) suggested that young athletes should aim to keep the number of weekly hours in training below their age. Another study by Brenner (Brenner., 2016) also indicated that young athletes with at least one to two days off per week from their particular sports of interest can decrease the chance of injuries. Indeed, exceeding a ratio of 2:1 for weekly hours in organized sports to a free play participation was linked with overuse injury only in youth footballers but not in basketball or volleyball players (Post *et al*., 2020). Weekly exposure to sport participation is one of the modifiable risk factors; therefore, controlling volume and/or frequency of practice and competition may decrease the growth-related pains in knee and heel for Japanese footballers aged 8–12 years.

The present study had some limitations. First, the web-based questionnaire was self-reported by parents, which might include a degree of recall bias. Furthermore, knee and heel pain were not diagnosed by the physician. It should be noted that growth-related pain in the present study is any complaint of the knee and heel during the growing period and may contain various conditions. Second, the present retrospective study cannot consider the grade of severity, presence or absence of time loss, and mechanism of onset. Future research should be prospectively designed using methods for recording epidemiological data on injury (Bahr *et al*., 2020). Finally, our study represented only a small part of the factor of heel and knee pains in Japanese footballers aged 8–12. We must continue our efforts to investigate other intrinsic and extrinsic risk factors or biomechanical information related to injury mechanisms to prevent growth-related overuse injury in children.

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CONFLICT OF INTEREST

No potential conflict of interest was reported by the author(s).

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