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Risk factors of lower extremity injuries in youth athletes

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ABSTRACT

Objective Lower extremity sports injuries frequently occur during an individual's growth period. The object of the current study was to analyse the risk factors for lower extremity sports injuries for youth athletes. The secondary objective was to clarify the factors related to new injuries after a lower extremity injury.

Methods We extracted information on youth athletes (aged 10–15 years) with sports-related disorders. Background data and injury situations were collected via a specific application. During the follow-up period, new injuries were also recorded. The athletes were divided into two groups according to injury location (lower extremity or other). We performed a multiple logistic regression analysis to clarify the association between injury location and background data.

Results 1575 complaints of lower extremity disorders and 328 complaints in other body parts were registered. According to the multiple regression analysis, practice time per week was significantly shorter for the lower extremity group than the other locations group (OR 0.98; 95% CI 0.963 to 0.999). Athletes whose future goal was at the recreational level had a significantly low incidence of new injuries after experiencing lower extremity disorders.

Conclusion The practice environments and psychological factors should receive more attention to prevent lower extremity injuries.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Lower extremity sports injuries frequently occur during an individual's growth period.
⇒ Overuse lower extremity injuries also occur in adolescent athletes.
⇒ The prevention of lower extremity injuries and reinjury is thought to be very important.

WHAT THIS STUDY ADDS

⇒ Lower extremity injuries frequently occur among junior athletes with shorter weekly practice times.
⇒ The length of time as an athlete in the lower extremity group was associated with high rates of lower leg disorders.
⇒ Athletes whose future goal was at the recreational level had a significantly low incidence of new injuries after experiencing lower extremity disorders.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The current study was to clarify the risk factors for sports-related lower extremity injuries for 1903 young athletes using a prospective database system.
⇒ Lower extremity injury prevention has a greater focus on soccer and basketball players.
⇒ The practice environments and psychological factors should receive more attention to prevent lower extremity injuries including traumatic and overuse disorders.

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INTRODUCTION

The number of sport-related injuries in youth athletes has steadily increased, due to increased sports participation.[1] Lower extremity sports injuries frequently occur during an individual's growth period.[2] Research into the numerous factors related to sports injuries is important for preventing acute and overuse disorders.

Sport-related injuries can be divided by cause according to trauma or overuse. Examples of acute traumatic sports injuries include ligament tears, fractures and contusions. Numerous studies on traumatic injuries have been conducted to determine methods for injury prevention.[3 4] A hip-focused injury prevention programme also demonstrated a significant reduction in anterior cruciate ligament knee injuries in female basketball players.[4] Prevention programmes have also been reported to significantly reduce the risk of ankle injuries.[5]

Overuse injuries, known as chronic injuries, are a category of sport-related injuries that have an insidious onset and do not have a single definable event associated with their onset.[6] Typical examples of overuse injuries include tendinitis, bursitis, medial tibial stress syndrome and stress fractures.[7] Female athletes between the ages of 5 and 17 years had a higher rate of overuse injuries than traumatic injuries.[2] Osgood-Schlatter disease, a traction apophysitis of the tibial tuberosity caused by repetitive strain on the quadriceps femoris muscle,[8 9] typically occurs in adolescents ranging from 10 to 14 years of age and mainly affects boys involved in sports activities that require repetitive jumping (such

Table 1 Baseline characteristics of the two groups

	Lower extremity group	Other locations group	P value
Sex, n (%)			
Male	954 (60.6)	207 (63.1)	0.391
Female	621 (39.4)	121 (36.9)	
Body mass index, mean (SD)	19.0 (3.0)	18.7 (2.7)	0.111
Body height increase over the past year, mean cm (SD)	4.8 (2.9)	5.1 (2.8)	0.059
Practice time per week, mean h (SD)	14.3 (7.4)	15.0 (9.0)	0.174
Athletic experience, mean years (SD)	4.4 (0.8)	3.9 (2.4)	0.002
Injury mechanism, n (%)			
Contact	366 (23.2)	54 (16.5)	<0.01
Non-contact	1209 (76.8)	274 (83.5)	
History of visiting other medical centres, n (%)			
Yes	647 (41.1)	140 (42.7)	0.592
No	928 (58.9)	188 (57.3)	
Competitions over the past year, n (%)			
Regional tournament	966 (61.3)	222 (67.7)	0.092
Prefectural tournament	450 (28.6)	85 (25.9)	
National tournament	148 (9.4)	20 (6.1)	
World competition	11 (0.7)	1 (0.3)	
Future goals, n (%)			
To discontinue sports	1041 (66.1)	204 (62.2)	<0.01
To achieve a recreational level	194 (12.3)	27 (8.2)	
To become a professional athlete	274 (17.4)	88 (26.8)	
To become a coaching staff	66 (4.2)	9 (2.7)	

as soccer, basketball, volleyball, baseball and tennis).[10] Medial tibial stress syndrome is also one of the common injuries in young athletes.[11] Incidence rates of 14%–20% have been reported for medial tibial stress syndrome in runners.[12] Recent studies have focused attention on the prevention of overuse injuries.[6 13] Numerous overuse injuries result from a complex interaction of intrinsic and extrinsic factors.[6] Intrinsic factors are defined as individual biological characteristics such as anatomical factors, growth-related factors and previous injuries, while extrinsic factors include training workload, equipment and environment.

The object of the current study was to analyse the risk factors of lower extremity sports injuries in youth athletes. The secondary objective of this study was to clarify the factors related to new injuries after a lower extremity injury. The hypothesis for this study is that the incidence of lower extremity injuries is related to intrinsic and extrinsic factors. These results might help suggest how to create a new injury prevention programme.

MATERIALS AND METHODS

The study participants were the higher grades elementary school or junior high school athletes living in the local region of Japan. Athletes with sports-related disorders who visited our centre were registered. They were playing sports activities at various levels. The subjects and their parent were informed that the data from the research would be submitted for publication, and gave their consent. The study included those athletes registered between April 2012 and December 2018. Patients or the public were not involved in this study.

We extracted information from the database system on athletes aged 10–15 who had been followed up until December 2019. Background data, injury condition and situation were collected via a specific application (BEAR-D; Solasto) for athletes through a tablet terminal. Background data included sex, body mass index (BMI), increase in body height over the past year, practice time per week, number of years as an athlete, injury mechanism, history of visits to other medical centres, competitions participated in over the past year, and future sports-related goals, injury location and type of sport. Athletes replied to these items using a tablet by themselves without special support. These data were stored in the database system. This study also recorded the occurrence of new injuries during the follow-up period.

We divided the athletes into two groups according to injury location (lower extremity or other). Hip, thigh, knee, ankle and foot were included in the injury location of the lower extremity. Background data from each group were compared using Student's t-test. We then

Table 2 Sports in the lower extremity injury group and other locations group

	Lower extremity group	Other locations group
Sports, n (%)		
Soccer	310 (19.7)	32 (9.8)
Basketball	221 (14.0)	27 (8.2)
Track and field	211 (13.4)	11 (3.3)
Baseball	171 (10.9)	92 (28.0)
Volleyball	98 (6.2)	34 (10.4)
Ice skating	89 (5.7)	15 (4.6)
Badminton	84 (5.3)	11 (3.4)
Tennis	55 (3.5)	8 (2.4)
Ice hockey	33 (2.1)	2 (0.6)
Judo	25 (1.6)	7 (2.1)
Table tennis	22 (1.4)	4 (1.2)
Swimming	21 (1.3)	7 (2.1)
Gymnastics	15 (1.0)	15 (4.6)
Others	220 (14.0)	63 (19.2)

performed a multiple logistic regression analysis to clarify the association between the background data and injury location. The independent variable was the injury location (lower extremity or other), while the dependent variable was the background factors. After the simultaneous adjustment for potential covariates, we calculated the ORs and 95% CIs.

In the lower extremity group, types of injury were also investigated. We divided the athletes who complained about lower extremities into acute and chronic injury groups. A multiple logistic regression analysis was performed to analyse the relationship between the background data and pathology. Pathology (acute or chronic injury) was determined as the independent variable. We then investigated the factors related to the occurrence of new injuries in the lower extremity group during the follow-up period. Using a multiple logistic regression method, we also analysed the relationship between the occurrence of new injuries and the background factors in acute and chronic injury groups.

The variables considered in the models were sex (male or female), BMI (continuous variable), increase in body height over the past year (continuous variable), practice time per week (continuous variable), the number of years of athletic experience (continuous variable), injury mechanism (contact or non-contact), history of visiting other medical centres (yes or no), competitions participated in over the past year (eg, regional, prefectural and national tournaments and world competitions), future sports-related goals (eg, discontinuing sports, recreational level, professional athlete, coaching staff). We analysed the data with EZR statistical software (Saitama Medical Center, Jichi Medical University), a graphical user interface for R (V.2.13.3; R Foundation for Statistical Computing).[14]

RESULTS

A total of 1903 athletes aged 10–15 were registered in the database system. Of these visits, 1575 complained of lower extremity disorders, and 328 complained of disorders in other body parts. Tables 1 and 2 list the participants' baseline characteristics. In total, the lower extremity group included 954 males and 621 females. On the other hand, the other locations group contained 207 males and 121 females. The mean BMI and increase in body height over the past year for each group was 19.0±3.0, 4.8±2.9 cm for the lower extremity group and 18.7±2.7, 5.1±2.8 cm for the other location group, respectively (p=0.111, p=0.059). The practice time per week was 14.3±7.4 hours for the lower extremity group and 15.0±9.0 hours for the other location group (p=0.174). The experience as an athlete in the lower extremity group was significantly longer (4.4±0.8 years) than that of the other location group (3.9±2.4 years).

Contact sports caused 23.2% of lower extremity injuries. Non-contact sports caused the other lower extremity injuries. In the lower extremity group and other location groups, 41.1% and 42.7% of the athletes, respectively, visited other medical centres before our centre. Of the athletes with a history of competition over the past year who experienced lower extremity injuries, 61.3% had competed in a regional tournament, 28.6% had competed in a prefectural tournament, 9.4% had competed in a national tournament and 0.7% had competed in a world competition. Of the athletes with lower extremity injuries, 66.1% planned to discontinue their sports activities in the future, 12.3% planned to take it to the recreational level, 17.4% planned to become professional sports players and 4.2% planned to become coaching staff.

The incidence of lower extremity injury was highest for soccer (310 injuries, 19.7%), followed by basketball (221 injuries, 14.0%), track and field (211 injuries, 13.4%), baseball (171 injuries, 10.9%), volleyball (98 injuries, 6.2%), ice skating (89 injuries, 5.7%), badminton (84 injuries, 5.3%) and tennis (55 injuries, 3.5%). The injuries for other body parts occurred most frequently in baseball (92 injuries, 28.0%). The background data of lower extremity injured athletes caused by specific sports, soccer, basketball, track and field, baseball, and volleyball, were demonstrated in table 3. 93.9% of soccer players and 53.8% of basketball players were male. The rates of acute injuries were 38.4% in soccer and 30.8% in basketball, respectively. Sixty-two per cent of athletes who participated in basketball experienced new injuries after lower extremity injuries. In track and field, the incidence of injuries due to contact play was 2.4%, and non-contact play was 97.6%.

According to the multiple regression analysis, there were no statistically significant differences between the lower extremity group and the other locations group in terms of sex, increase in body height over the past year,

Table 3 Details of background data of lower extremity injured athletes caused by specific sports

	Soccer	Basketball	Track and field	Baseball	Volleyball
Sex, n (%)					
Male	291 (93.9)	119 (53.8)	97 (46.2)	164 (95.9)	10 (10.2)
Female	19 (6.1)	102 (46.2)	113 (53.9)	7 (4.1)	88 (89.8)
Types of injury, n (%)					
Acute injury	119 (38.4)	68 (30.8)	45 (21.4)	36 (21.1)	30 (30.6)
Chronic disorders	191 (61.6)	153 (69.2)	165 (78.6)	135 (78.9)	68 (69.4)
Body mass index	18.8 (2.5)	18.5 (3.1)	18.9 (3.0)	19.3 (2.9)	19.4 (2.3)
Body height increase over the past year, mean cm (SD)	5.2 (3.0)	4.7 (2.5)	4.5 (2.9)	5.4 (2.9)	3.7 (2.4)
Practice time per week, mean h (SD)	12.4 (5.1)	13.8 (5.4)	14.0 (5.6)	20.2 (10.1)	14.7 (6.2)
Athlete experience, mean years (SD)	5.4 (2.4)	3.6 (2.5)	3.1 (2.5)	5.1 (2.3)	3.8 (2.2)
Injury mechanism, n (%)					
Contact	96 (31.0)	51 (23.1)	5 (2.4)	9 (5.3)	16 (16.3)
Non-contact	214 (69.0)	170 (76.9)	205 (97.6)	162 (94.7)	82 (83.7)
History of visiting other medical centres, n (%)					
Yes	105 (33.9)	105 (47.5)	94 (44.8)	59 (65.5)	44 (44.9)
No	205 (66.1)	116 (52.5)	116 (55.2)	112 (65.5)	54 (55.1)
Competitions over the past year, n (%)					
Regional tournament	208 (67.1)	182 (82.4)	94 (44.8)	127 (74.3)	71 (72.4)
Prefectural tournament	81 (26.1)	36 (16.3)	103 (49.0)	37 (21.6)	18 (18.4)
National tournament	10 (6.5)	2 (0.9)	13 (6.2)	6 (3.5)	9 (9.2)
World competition	1 (0.3)	1 (0.5)	0 (0.0)	1 (0.6)	0 (0.0)
Future goals, n (%)					
To discontinue sports	162 (52.2)	160 (72.4)	165 (78.6)	112 (65.5)	70 (71.4)
To achieve a recreational level	45 (14.5)	36 (16.3)	15 (7.1)	13 (7.6)	16 (16.3)
To become a professional athlete	92 (29.7)	22 (10.0)	21 (10.0)	35 (20.5)	7 (7.1)
To become a coaching staff	11 (3.5)	3 (1.4)	9 (4.3)	11 (6.4)	5 (5.1)
Occurrence of new injuries after lower extremity injury, n (%)					
Yes	146 (47.1)	137 (62.0)	88 (41.9)	85 (49.7)	40 (40.8)
No	164 (52.9)	84 (38.0)	122 (58.1)	86 (50.3)	58 (59.2)

visiting other centres and competitions over the past year comparison between lower extremity group and others group (table 4). Practice time per week was significantly shorter for the lower extremity group than the other locations group (OR 0.98; 95% CI 0.963 to 0.999). The experience as an athlete was significantly longer for the lower extremity group (OR 1.07; 95% CI 1.010 to 1.140). The injuries due to contact play were significantly higher for the lower extremity group (OR 1.65; 95% CI 1.030 to 2.640). The athletes whose future goal was to be professional sports players had a significantly lower incidence of lower extremity injuries.

In the lower extremity group, BMI was significantly higher for athletes who complained of acute injury than chronic disorders (OR 1.10; 95% CI 1.030 to 1.170). The incidence of acute injuries due to contact play was also significantly high compared with that of chronic disorders (OR 5.65; 95% CI 3.680 to 8.690) according to multiple regression analysis (table 5).

The incidence of new injuries after a lower extremity injury was significantly lower for those who visited another centre before our hospital consultation. However, sex, BMI, increase in body height over the past year, practice time per week, length of experience as an athlete, injury mechanism and competitions over the past year were not significantly associated with the occurrence of new injuries. Athletes with a future goal of a recreational level of sports had a significantly lower incidence of new injuries (table 6). In the athletes of acute lower extremity injuries group, statistical significance was found concerning about history of visiting the other medical centres (table 7). On the other hand, in the athletes of chronic lower extremity

Table 4 Multiple regression analysis of injury rates in the lower extremity and other location groups

	OR	95% CI	P value
Sex	0.94	0.682 to 1.300	0.72
Body mass index	1.00	0.948 to 1.050	0.98
Increase in height over the past year	0.96	0.910 to 1.010	0.12
Practice time per week	0.98	0.963 to 0.999	0.04
Athletic experience	1.07	1.010 to 1.140	0.03
Injury mechanism	1.65	1.030 to 2.640	0.04
History of visiting other medical centres	0.98	0.735 to 1.300	0.89
Competitions over the past year			
Regional tournament	0.99	0.626 to 1.580	0.98
Prefectural tournament	1.13	0.669 to 1.900	0.65
National tournament	1.45	0.698 to 3.020	0.32
World competition	2.44	0.268 to 22.200	0.43
Future goals			
To discontinue sports	0.83	0.456 to 1.530	0.56
To achieve a recreational level	1.32	0.806 to 2.170	0.27
To become a professional athlete	0.58	0.404 to 0.841	<0.01
To become a coaching staff	1.52	0.617 to 3.770	0.36

disorders group, there were statistically significant differences concerning future goals as a player (table 8).

DISCUSSION

The current study represents the characteristics of lower extremity injuries in youth athletes. The most important finding was that the athletes with shorter practice times per week and/or longer experience as athletes had a significantly higher incidence of lower extremity injuries. Furthermore, contact mechanisms more frequently cause lower extremity injuries than other body parts. Athletes who had become accustomed to competition tended to engage in a strenuous practice, resulting in an increased number of lower extremity injuries caused by contact sports in the current study. This result suggests that prevention should receive greater focus on acute

Table 5 Multiple regression analysis of incidences of acute lower extremity injury and chronic disorders

	OR	95% CI	P value
Sex	0.88	0.608 to 1.280	0.52
Body mass index	1.10	1.030 to 1.170	<0.01
Increase in height over the past year	0.95	0.891 to 1.010	0.11
Practice time per week	1.01	0.989 to 1.040	0.31
Athletic experience	1.04	0.975 to 1.110	0.22
Injury mechanism	5.65	3.680 to 8.690	0.28
History of visiting other medical centres	1.34	0.956 to 1.870	0.09
Competitions over the past year			
Regional tournament	1.11	0.617 to 2.000	0.73
Prefectural tournament	1.32	0.698 to 2.490	0.40
National tournament	1.52	0.678 to 3.390	0.31
World competition	0.35	0.031 to 3.980	0.40
Future goals			
To discontinue sports	0.93	0.445 to 1.970	0.86
To achieve a recreational level	1.42	0.859 to 2.330	0.17
To become a professional athlete	0.85	0.531 to 1.370	0.52
To become a coaching staff	1.43	0.639 to 3.220	0.32

Table 6 Multiple regression analysis of the incidence of new injuries after lower extremity injuries

	OR	95% CI	P value
Sex	0.96	0.687 to 1.330	0.79
Body mass index	0.98	0.929 to 1.040	0.56
Increase in height over the past year	1.05	0.992 to 1.110	0.09
Practice time per week	0.99	0.971 to 1.010	0.45
Athletic experience	1.00	0.937 to 1.060	0.89
Injury mechanism	0.90	0.591 to 1.360	0.61
History of visiting the other medical centres	0.58	0.432 to 0.791	<0.01
Competitions over the past year			
Regional tournament	0.84	0.505 to 1.380	0.49
Prefectural tournament	0.98	0.562 to 1.700	0.94
National tournament	0.97	0.471 to 2.000	0.94
World competition	0.63	0.101 to 3.900	0.62
Future goals			
To discontinue sports	0.70	0.346 to 1.420	0.32
To achieve a recreational level	0.47	0.278 to 0.791	<0.01
To become a professional athlete	1.43	0.960 to 2.130	0.08
To become a coaching staff	1.53	0.729 to 3.220	0.26

traumatic lower extremity injuries. On the other hand, the majority of the lower extremity and other injuries were caused by non-contact mechanisms. Most of the non-contact mechanism injuries were related to overuse disorders. It is therefore important to develop prevention programmes that include the training time and environmental factors for overuse disorders.

The first step in researching sports injury prevention programmes is to describe the magnitude of the problem.[13] During the growth period, the musculoskeletal system

Table 7 Multiple regression analysis of the incidence of new injuries after acute lower extremity injuries

	OR	95% CI	P value
Sex	1.19	0.615 to 2.320	0.60
Body mass index	1.02	0.927 to 1.130	0.66
Increase in height over the past year	1.08	0.964 to 1.200	0.19
Practice time per week	0.96	0.923 to 1.010	0.09
Athletic experience	1.08	0.954 to 1.210	0.23
Injury mechanism	0.63	0.332 to 1.180	0.15
History of visiting the other medical centres	0.30	0.160 to 0.549	<0.01
Competitions over the past year			
Regional tournament	0.80	0.264 to 2.440	0.70
Prefectural tournament	0.67	0.199 to 2.260	0.52
National tournament	0.78	0.182 to 3.330	0.74
World competition	N/A	N/A	
Future goals			
To discontinue sports	0.55	0.133 to 2.290	0.41
To achieve a recreational level	0.55	0.230 to 1.320	0.18
To become a professional athlete	0.98	0.433 to 2.220	0.96
To become a coaching staff	0.83	0.228 to 3.020	0.78

N/A, not available.

Table 8 Multiple regression analysis of the incidence of new injuries after chronic lower extremity disorders

	OR	95% CI	P value
Sex	0.90	0.604 to 1.330	0.58
Body mass index	0.95	0.880 to 1.020	0.14
Increase in height over the past year	1.05	0.982 to 1.120	0.16
Practice time per week	1.00	0.977 to 1.030	0.86
Athletic experience	0.98	0.909 to 1.050	0.55
Injury mechanism	0.92	0.481 to 1.780	0.81
History of visiting the other medical centres	0.72	0.502 to 1.030	0.07
Competitions over the past year			
Regional tournament	0.77	0.433 to 1.380	0.38
Prefectural tournament	1.03	0.540 to 1.950	0.94
National tournament	0.93	0.392 to 2.220	0.88
World competition	0.32	0.032 to 3.210	0.33
Future goals			
To discontinue sports	0.79	0.344 to 1.800	0.57
To achieve a recreational level	0.42	0.213 to 0.817	0.01
To become a professional athlete	1.57	0.985 to 2.510	0.06
To become a coaching staff	1.90	0.736 to 4.920	0.18

displays rapidly changing characteristics, especially in the epiphysial and apophyseal areas, making it more vulnerable to specific injuries.[15 16] Overuse injuries to soft tissue were considered one of the most common reasons for orthopaedic injuries in elite adolescent athletes.

This current study investigated the characteristics of sports-related lower extremity injuries and found that the legs were the part of the body most frequently injured while engaging in sports and recreational activities. The most commonly injured locations during the Summer Youth Olympic Games are the knees (13%), ankles (12%) and thighs (11%) .[17] During the winter games, the lower leg was the most frequent injury location.[18 19] In Canadian junior high school athletes, the largest proportion of injuries occurred in basketball (14%), soccer (12%) and hockey (8.6%), and the most frequently injured body parts were the ankles (21.2%) and knees (15.7%).[20] The highest knee injury rates were reported for football, soccer, wrestling and basketball, whereas the lowest knee injury rates were for baseball and softball.[21] Our results also demonstrated that athletes who participated in soccer and basketball frequently experienced lower extremity injuries. Furthermore, a new injury has occurred in 62.0% of basketball players who complained of lower extremity injuries. It was suggested that lower extremity injury prevention has a greater focus on soccer and basketball youth athletes.

According to the current study, track and field had one of the highest rates of lower extremity injuries for athletes aged 10–15 years. It was reported that the overuse injury rates were also high in men's and women's outdoor track and field for collegiate and high school athletes.[22] Our results also indicated that the rate of chronic disorders was 78.6% of youth athletes participating in track and field. In elite track-and-field athletes, the most frequent injuries were gradual-onset inflammation and pain, and the highest injury rates were for the knees and lower legs.[23] According to injury surveillance during the International Association of Athletics Federations Championships, approximately half of all injuries were expected to result in the athlete being unable to participate in competition or training.[24] Preventing lower extremity and overuse injuries in youth track-and-field athletes is essential.

The current study demonstrated that those athletes with the future goal of professional sports had a low incidence of lower extremity injuries. It indicated that highly motivated athletes might take better care of their bodies. In contrast, there was a high incidence of new injuries after chronic lower extremity disorders in the athletes who had the goal of professional sports compared with the athletes whose future goals were at the recreational level. Adolescence represents a critical period in an athlete's life and is characterised by rapid growth that affects skeletal biomechanics, muscle strength and thus athletic performance.[15 25] Intrinsically motivated students should be provided facilities and opportunities to participate in sports and enjoy their health benefits.[26 27] A negative correlation between anxiety and several measures of motivation for team sports athletes has been reported.[26] Similarly, the 'optimal' state of anxiety (which depends on the athlete's recollection) was associated with high performance in track and field athletes.[28] It has been suggested that athletes who experience chronic pain should be assessed including social and mental aspects.

This study was several limitations. First, the current study participants were athletes who lived in a local area of Japan. However, this region is famous for sports, with many Olympic athletes born and raised there. The results of the current study provide important findings for various levels of adolescent athletes. Another limitation is that we did not analyse the details of the lower extremity injuries. The data-gathering method was based on the patients' reports; therefore, an accurate diagnosis was not demonstrated in the current survey. Third, the participants were athletes who complained of sports-related pain, and we could not compare the characteristics between the injured athletes and the healthy younger population.

In conclusion, lower extremity injuries frequently occur among youth athletes with shorter weekly practice times and longer sports experiences. The lower extremity injury prevention has a greater focus on soccer and basketball players. Future goals and motivation were also associated with lower extremity injuries, especially chronic disorders. The practice environments and psychological factors should receive more attention to

prevent lower extremity injuries including traumatic and overuse disorders.

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REFERENCES

1 Fabricant PD, Lakomkin N, Sugimoto D, *et al*. Youth sports specialization and musculoskeletal injury: a systematic review of the literature. *The Physician and Sportsmedicine* 2016;44:257–62.
2 Stracciolini A, Casciano R, Levey Friedman H, *et al*. Pediatric sports injuries: a comparison of males versus females. *Am J Sports Med* 2014;42:965–72.
3 Grimm NL, Jacobs JC Jr, Kim J, *et al*. Anterior cruciate ligament and knee injury prevention programs for soccer players: a systematic review and meta-analysis. *Am J Sports Med* 2015;43:2049–56.
4 Omi Y, Sugimoto D, Kuriyama S, *et al*. Effect of hip-focused injury prevention training for anterior cruciate ligament injury reduction in female basketball players: a 12-year prospective intervention study. *Am J Sports Med* 2018;46:852–61.
5 Grimm NL, Jacobs JC Jr, Kim J, *et al*. Ankle injury prevention programs for soccer athletes are protective: a level-I meta-analysis. *J Bone Joint Surg Am* 2016;98:1436–43.
6 DiFiori JP, Benjamin HJ, Brenner JS, *et al*. Overuse injuries and burnout in youth sports: a position statement from the American medical Society for sports medicine. *Br J Sports Med* 2014;48:287–8.
7 Wilder RP, Sethi S. Overuse injuries: tendinopathies, stress fractures, compartment syndrome, and shin splints. *Clin Sports Med* 2004;23:55–81,
8 Osgood RB. Lesions of the tibial tubercle occurring during adolescence. *The Boston Medical and Surgical Journal* 1903;148:114–7.
9 Schlatter C. Verletzumgen der schnabelformigen fortsatzes der obseren tibia epiphyse. *Beitr Klin Chir* 1903;38:874–87.
10 Draghi F, Danesino GM, Coscia D, *et al*. Overload syndromes of the knee in adolescents: sonographic findings. *J Ultrasound* 2008;11:151–7.
11 Moen MH, Tol JL, Weir A, *et al*. Medial tibial stress syndrome: a critical review. *Sports Med* 2009;39:523–46.
12 Lopes AD, Hespanhol Júnior LC, Yeung SS, *et al*. What are the main running-related musculoskeletal injuries? A systematic review. *Sports Med* 2012;42:891–905.
13 Clarsen B, Myklebust G, Bahr R. Development and validation of a new method for the registration of overuse injuries in sports injury epidemiology: the Oslo sports trauma research centre (OSTRC) overuse injury questionnaire. *Br J Sports Med* 2013;47:495–502.
14 Kanda Y. Investigation of the freely available easy-to-use software " EZR " for medical statistics. *Bone Marrow Transplant* 2013;48:452–8.
15 Caine D, DiFiori J, Maffulli N. Physeal injuries in children's and youth sports: reasons for concern? *Br J Sports Med* 2006;40:749–60.
16 Engebretsen L, Steffen K, Bahr R, *et al*. The International Olympic Committee consensus statement on age determination in high-level young athletes. *Br J Sports Med* 2010;44:476–84.
17 Steffen K, Soligard T, Mountjoy M, *et al*. How do the new Olympic sports compare with the traditional Olympic sports? injury and illness at the 2018 youth Olympic summer games in Buenos Aires, Argentina. *Br J Sports Med* 2020;54:168–75.
18 Steffen K, Moseid CH, Engebretsen L, *et al*. Sports injuries and illnesses in the lillehammer 2016 youth Olympic winter games. *Br J Sports Med* 2017;51:29–35.
19 Watanabe K, Akama T, Asakawa S, *et al*. Medical services at the 2017 Sapporo Asian winter games: injury and illness epidemiology at a 34-nation multisport event. *Br J Sports Med* 2019;53:32–6.
20 Emery C, Tyreman H. Sport participation, sport injury, risk factors and sport safety practices in Calgary and area junior high schools. *Paediatr Child Health* 2009;14:439–44.
21 Ingram JG, Fields SK, Yard EE, *et al*. Epidemiology of knee injuries among boys and girls in US high school athletics. *Am J Sports Med* 2008;36:1116–22.
22 Roos KG, Marshall SW, Kerr ZY, *et al*. Epidemiology of overuse injuries in collegiate and high school athletics in the United States. *Am J Sports Med* 2015;43:1790–7.
23 Jacobsson J, Timpka T, Kowalski J, *et al*. Prevalence of musculoskeletal injuries in Swedish elite track and field athletes. *Am J Sports Med* 2012;40:163–9.
24 Alonso JM, Edouard P, Fischetto G, *et al*. Determination of future prevention strategies in elite track and field: analysis of Daegu 2011 IAAF championships injuries and illnesses surveillance. *Br J Sports Med* 2012;46:505–14.
25 Bergeron MF, Bahr R, Bärtsch P, *et al*. International Olympic Committee consensus statement on thermoregulatory and altitude challenges for high-level athletes. *Br J Sports Med* 2012;46:770–9.
26 Rice SM, Gwyther K, Santesteban-Echarri O, *et al*. Determinants of anxiety in elite athletes: a systematic review and meta-analysis. *Br J Sports Med* 2019;53:722–30.
27 Timpka T, Jacobsson J, Dahlström Ö, *et al*. The psychological factor " self-blame " predicts overuse injury among top-level Swedish track and field athletes: a 12-month cohort study. *Br J Sports Med* 2015;49:1472–7.
28 Turner PE, Raglin JS. Variability in precompetition anxiety and performance in college track and field athletes. *Med Sci Sports Exerc* 1996;28:378–85.