Taylor & Francis
Taylor & Francis Group

Research in Sports Medicine
An International Journal

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/gspm20

Injuries in Japanese university handball: a study among 1017 players

Sonoko Mashimo, Naruto Yoshida, Tatsu Moriwaki, Ayaka Takegami, Keita Suzuki, Daniel T.P. Fong, Grethe Myklebust & Shinzo Onishi

To cite this article: Sonoko Mashimo, Naruto Yoshida, Tatsu Moriwaki, Ayaka Takegami, Keita Suzuki, Daniel T.P. Fong, Grethe Myklebust & Shinzo Onishi (2021) Injuries in Japanese university handball: a study among 1017 players, Research in Sports Medicine, 29:5, 475-485, DOI: 10.1080/15438627.2021.1937164

To link to this article: https://doi.org/10.1080/15438627.2021.1937164

RESEARCH IN SPORTS MEDICINE
2021, VOL. 29, NO. 5, 475–485
https://doi.org/10.1080/15438627.2021.1937164

Routledge
Taylor & Francis Group

Injuries in Japanese university handball: a study among 1017 players

Sonoko Mashimo[a,b], Naruto Yoshida[c], Tatsu Moriwaki[d], Ayaka Takegami[a], Keita Suzuki[e], Daniel T.P. Fong[f], Grethe Myklebust[g] and Shinzo Onishi[h]

[a]Graduate School of Comprehensive Human Sciences, University of Tsukuba, Tsukuba, Japan; [b]Institute for Liberal Arts and Sciences, Osaka Electro-Communication University, Neyagawa, Japan; [c]Faculty of Health Care, Teikyo Heisei University, Toshima, Japan; [d]School of Physical Education, Health and Sport Sciences, University of Tsukuba, Tsukuba, Japan; [e]Sports Research and Development Core, University of Tsukuba, Tsukuba, Japan; [f]National Centre for Sport and Exercise Medicine, School of Sport, Exercise and Health Sciences, Loughborough University, Loughborough, UK; [g]Oslo Sports Trauma Research Center, Department of Sports Medicine, Norwegian School of Sports Sciences, Oslo, Norway; [h]Department of Orthopaedic Surgery, Faculty of Medicine, University of Tsukuba, Tsukuba, Japan

ABSTRACT

The aim of this study was to examine the injury profile of Japanese university handball players. In this cross-sectional study, a total of 1017 participants who played in the 2018 Japanese National University Handball Championship were followed. The incidence within the previous year was 0.59 [95% CI, confidence interval: 0.56–0.62] per player per year. The ankle (33.3%), knee (23.6%), and shoulder/clavicle (12.6%) were the body regions most affected by traumatic mechanisms, while the lumbar spine/lower back (26.0%), knee (15.7%), and shoulder (15.0%) were the body regions most affected by overuse mechanisms. Sprain (30.7%), ligamentous rupture (23.2%), and fracture (11.8%) were the main types of traumatic injuries, and stress fracture (25.0%) and lesion of meniscus or cartilage (25.0%) were the main types of overuse injuries. Female players were 1.5 times more likely (OR, odds ratio: 1.55 [95% CI: 1.20–2.01]) to experience an injury than their male counterparts, and line players were also 1.5 times more likely (OR: 1.49 [95% CI: 1.00–2.21]) to experience an injury than their wing counterparts. This study showed that there is a need for increased injury prevention efforts in Japanese handball, especially among female players.

ARTICLE HISTORY
Received 24 November 2020
Accepted 20 May 2021

KEYWORDS
Handball; university; epidemiology; traumatic injuries; overuse injuries

Introduction

According to the International Handball Federation, there are 27 million handball players worldwide (International Olympic Committee, 2016). Team handball, also known as European handball or Olympic handball, is one of the most popular sports in Europe (Seil et al., 1998), especially in the Scandinavian countries (Olsen et al., 2006). Its popularity has increased in Asian countries as well. In Japan, handball has been included in the national schooling system (Sakaue & Thompson, 2020). A recent report in Japan showed

CONTACT Sonoko Mashimo mashimo@osakac.ac.jp Institute for Liberal Arts and Sciences, Osaka Electro-Communication University, 18-8, Hatsucho, Neyagawa, Osaka 572-8530, Japan
Supplemental data for this article can be accessed here.

that the proportion of sport participants in handball was 0.1% for those over 20 years old, and 2.3% for those 10–19 years old (Matsuoka & Arai, 2017). These low numbers may reflect that handball had not been included in schools until 2008. It is expected that participation will increase in subsequent years.

Handball is a sport characterized by repetitive throwing, cutting, jumping and landing, as well as frequent physical contact between players (Aasheim et al., 2018). Previous studies have shown a high incidence of time-loss injuries in handball with numbers between 9.9 and 20.3 injuries per 1000 match hours and 0.6 to 4.6 injuries per 1000 training hours (Giroto et al., 2017; Nielsen & Yde, 1988; Olsen et al., 2006; Rafnsson et al., 2019; Seil et al., 1998). Traumatic accounts for 62 to 79% of all injuries during handball, whereas overuse accounts for 21 to 38%. (Aasheim et al., 2018; Moller et al., 2012; Olsen et al., 2006; Rafnsson et al., 2019). The most frequent acute injuries are located in the ankle and knee, while shoulder, lower back, and knee are the most common overuse injury locations (Giroto et al., 2017; Moller et al., 2012; Rafnsson et al., 2019).

The amount of research in handball has increased a lot. There were less than five articles per year during 1960–1995, but the number has increased to 40 articles per year in 2010 (Prieto et al., 2015), most of them (27%) presenting epidemiological data (Prieto et al., 2015). Although the amount of research on females has grown during years 2007–2013 (Carmen et al., 2013), the majority of these studies consisted of male players from European countries (Prieto et al., 2015). There has been only one epidemiological study published that consisted of Japanese boys and girls (aged 13–14 years) (Asai et al., 2020). Japanese handball players are also shorter, lighter, and have the lowest adiposity among Asian players (Hasan et al., 2007), but information regarding injuries in Japanese handball players with these physical characteristics is very limited.

With an increasing number of Japanese handball players, it is important to make the sport as safe as possible by implementing preventive measures as early as possible. For example, a previous injury is a well-known risk factor for both acute and overuse injuries (Giroto et al., 2017; Moller et al., 2012). Despite this evidence, there is currently a lack of epidemiologic research reporting injury incidence, location, type, and risk factors in Japanese athletes. Therefore, the aim of this study was to reveal the injury profile of 1017 handball players from 64 university handball teams across Japan, in order to give information for the governing bodies and stakeholders to plan for and implement injury prevention strategies in the future.

Materials and methods

Study design and participants

The present study was an observational, cross-sectional study including all 64 university handball teams (32 male and 32 female) competing in the 2018 Japanese National University Handball Championship. The questionnaire on injury experience was distributed two weeks before the championship by mail, and team staff was asked to distribute the questionnaire to all the players. The completed questionnaires were collected by the team staff and brought to the representation meeting the day before the championship.

This study was approved by the Ethics Committee of Osaka Electro-Communication University (approval number: 18–001). All participants signed a written informed consent form.

Injury questionnaire

The questionnaire consisted of demographics and information related to injuries. Demographics included the team name, school year, age, gender, dominant hand, height, weight, handball experience, player position, and training volume. The body mass index (BMI) was calculated as weight (kg) divided by the height (m) squared. The player position was classified into four categories; wing, back, line, and goalkeeper (Bere et al., 2015). The training volume, defined as the average volume per week, was calculated by multiplying the average training hours per day with the average number of training days per week (Giroto et al., 2017).

If players reported any injuries in the previous year, additional information was collected through the questionnaire, including details on whether it was a traumatic or overuse injury, body region, injury type, whether it occurred during a match/training, injury mechanism, any medical examination, injury severity, cause of injury, and whether it was a recurrent injury. An injury was defined as an injury sustained by a player that resulted from a handball match or handball training, that caused the player to be unable to take full part in future handball training or match play (Fuller et al., 2006; Junge et al., 2008). Injuries filled in the questionnaire were those sustained within the previous year, excluding those sustained before the previous year.

Calculations and statistical analysis

Questionnaires which did not answer whether the players had sustained an injury within the previous year were discarded. The data obtained from the questionnaires were confirmed and entered by two sports medicine experts.

Incidence was expressed as the rate of new cases per player per year with a 95% confidence interval (CI). Significant differences in incidence were assumed if the 95% CIs did not overlap (Aasheim et al., 2018).

Categorical data are presented as number of participants or number of injuries and their percentages. We used the chi-square test (Pearson's chi-square, Fisher's exact test, or Fisher's exact test with Monte Carlo estimates, as appropriate) to compare gender differences (male vs female) for categorical data. Continuous data are presented as mean and standard deviation. The Kolmogorov-Smirnov test was used to confirm the normality of the data. The Mann-Whitney U test was used to compare gender differences when normality was not found for continuous data.

Logistic regression analysis was used to examine the associations between individual player information and the occurrence of injury. We excluded "school year" due to many missing data and "dominant hand" which was not a factor of injury from previous studies (Giroto et al., 2017; Myklebust et al., 1998). Secondly, the participants with missing demographic data were excluded from the analysis. We then performed the chi-square test for categorical data and the Mann-Whitney U test for continuous data in the demographics. Additionally, univariate logistic regression analysis for all data to determine the

effect of injury occurrence. Finally, we incorporated selective demographic variables into the multiple logistic regression analysis based on the results of the chi-square test ($p < 0.05$), the Mann-Whitney U test ($p < 0.05$), and the univariate logistic regression analysis ($p < 0.05$). Results were expressed as odds ratio (OR) and 95% CI. All statistical analysis was performed using SPSS version 25.0 with the significance level set at $p < 0.05$.

Results

A total of 49 out of 64 teams responded to the questionnaire; the response rate was 76.6%. There were 1017 valid respondents out of 1048 respondents, giving a valid response rate of 97.0%. The description of the participants' characteristics can be found in Table 1.

During the previous year, 469 (46.1%) of the 1017 players reported at least one injury. Of the players who sustained injuries, 339 sustained one injury and 130 sustained two or more injuries. Comparing gender differences, 185 of 462 (40%) male players and 284 of 555 (51.2%) female players sustained an injury, the proportion of females who sustained an injury was higher than that of males ($p < 0.05$). The incidence was 0.59 [95% CI: 0.56–0.62] injuries, and 0.53 [95% CI: 0.48–0.57] injuries among males and 0.65 [95% CI: 0.61–0.69] injuries among females per player per year. Characteristics of injuries are described in Table 2.

The most affected body parts were the ankle ($n = 151$, 33.3%), knee ($n = 107$, 23.6%), and shoulder/clavicle ($n = 57$, 12.6%) by traumatic mechanisms, and lumbar spine/lower back ($n = 33$, 26.0%), knee ($n = 20$, 15.7%), and shoulder ($n = 19$, 15.0%) by overuse mechanisms. Sprain ($n = 130$, 30.7%), ligamentous rupture ($n = 98$, 23.2%), and fracture ($n = 50$, 11.8%) were the most reported traumatic injury types, and stress fracture ($n = 23$, 25.0%) and lesion of meniscus or cartilage ($n = 23$, 25.0%) were the overuse injury types most reported. Gender differences were found among traumatic injuries, with a higher proportion of finger injuries in males and knee injuries in females when analysed by body region, and fractures in males and ligamentous ruptures in females when analysed by

Table 1. Participants' characteristics.

	Male ($n = 462$)		Female ($n = 555$)		Total ($n = 1017$)	
Age, years ($n = 1013$)	20.2	(1.2)	20.1	(1.2)	20.1	(1.2)
Height, cm ($n = 1013$)	175.1	(6.4)*	161.5	(5.6)	167.7	(9.0)
Weight, kg ($n = 1004$)	71.6	(8.1)*	57.6	(5.9)	64.1	(9.9)
BMI, kg/m^2 ($n = 1003$)	23.3	(2.0)*	22.1	(1.7)	22.7	(2.0)
Handball experience, years ($n = 999$)	8.9	(3.0)	8.7	(3.0)	8.8	(3.0)
Training volume, hours/week ($n = 1007$)	13.8	(3.3)	17.3	(3.7)*	15.7	(3.9)
Dominant member ($n = 1014$)						
Right-handed	400	(87.1)	502	(90.5)	902	(89.0)
Left-handed	59	(12.9)	51	(9.2)	110	(10.8)
Both-handed	0	(0.0)	2	(0.4)	2	(0.2)
Player position ($n = 994$)						
Wing	153	(34.2)	170	(31.1)	323	(32.5)
Back	160	(35.7)	202	(37.0)	362	(36.4)
Line	70	(15.6)	86	(15.8)	156	(15.7)
Goalkeeper	65	(14.5)	88	(16.1)	153	(15.4)

Continuous data are presented as mean and standard deviation. Categorical data are presented as number of participants and percentage (%).

*: $p < 0.05$.

Table 2. Characteristics of injuries.

	Male (n = 244)		Female (n = 359)		Total (n = 603)	
Injury classification†						
Traumatic	174	(75.0)	281	(80.3)	455	(78.2)
Overuse	58	(25.0)	69	(19.7)	127	(21.8)
Injury severity‡						
Minimal (1–3 days)	10	(6.5)	22	(9.4)	32	(8.2)
Mild (4–7 days)	25	(16.1)	26	(11.2)	51	(13.1)
Moderate (8–28 days)	52	(33.5)	64	(27.5)	116	(29.9)
Severe (>28 days)	68	(43.9)	121	(51.9)	189	(48.7)
Situation§						
Match	60	(26.8)	82	(24.3)	142	(25.3)
Training	164	(73.2)	255	(75.7)	419	(74.7)
Injury Mechanism‖						
Non-contact	36	(21.2)	89	(32.4)*	125	(28.1)
Contact	134	(78.8)*	186	(67.6)	320	(71.9)
Recurrent injuries¶						
Yes	73	(33.6)	127	(38.7)	200	(36.7)
No	144	(66.4)	201	(61.3)	345	(63.3)

Data are presented as number of injuries and percentage (%).
†Information is missing for 21 injuries.
‡Only injuries that have already returned to play (Male n = 155, Female n = 233, Total n = 388).
§Information is missing for 42 injuries.
‖Only traumatic injuries that have been found mechanism (n = 445).
¶Information is missing for 18 injuries.
*: $p < 0.05$ (Pearson's chi-square).

injury type ($p < 0.05$). The description of the body region and type of injuries is shown in Tables 3 and 4.

Table 5 illustrates the association between individual characteristics and the occurrence of injuries on multiple logistic regression analysis. A total of 958 participants with complete demographic data were included in the analysis. Based on the results of the chi-square test (Supplementary Table 1), the Mann-Whitney U test (Supplementary Table 2), and the univariate logistic regression analysis (Supplementary Table 3), we incorporated "age", "gender", "handball experience", and "player position" into the multiple logistic regression analysis. Female players to male players (OR: 1.55 [95% CI: 1.20–2.01]) and line players to wing players (OR: 1.49 [95% CI: 1.00–2.21]) were more likely to experience an injury.

Discussion

In this study, we have investigated the injury patterns of 1017 handball players from 64 university handball teams in Japan. During the previous year, 46.1% of all players suffered at least one injury. Female and line players were more likely to experience an injury. The ankle, knee, and shoulder/clavicle were the body regions most affected by traumatic mechanisms, and lumbar spine/lower back, knee, and shoulder were the body regions most affected by overuse mechanisms. Sprains, ligamentous ruptures, and fractures were the main types of traumatic injuries, and stress fracture and lesion of meniscus or cartilage were the main types of overuse injuries.

Approximately 45% of university players had at least one injury due to participation in handball during the previous year, with the proportion being 40% among males and more

Table 3. Injuries by body region.

	Male† (n = 244)		Female‡ (n = 359)		Total§ (n = 603)	
Traumatic injuries	(n = 173)		(n = 280)		(n = 453)	
Face	5	(2.9)	6	(2.1)	11	(2.4)
Head	1	(0.6)	2	(0.7)	3	(0.7)
Neck/cervical spine	1	(0.6)	0	(0.0)	1	(0.2)
Thoracic spine/upper back	0	(0.0)	0	(0.0)	0	(0.0)
Sternum/ribs	1	(0.6)	0	(0.0)	1	(0.2)
Lumbar spine/lower back	9	(5.2)	9	(3.2)	18	(4.0)
Abdomen	0	(0.0)	0	(0.0)	0	(0.0)
Pelvis/sacrum/buttock	1	(0.6)	1	(0.4)	2	(0.4)
Shoulder/clavicle	23	(13.3)	34	(12.1)	57	(12.6)
Upper arm	0	(0.0)	0	(0.0)	0	(0.0)
Elbow	8	(4.6)	8	(2.9)	16	(3.5)
Forearm	1	(0.6)	1	(0.4)	2	(0.4)
Wrist	7	(4.0)	4	(1.4)	11	(2.4)
Hand	4	(2.3)	2	(0.7)	6	(1.3)
Finger	15	(8.7)*	10	(3.6)	25	(5.5)
Thumb	2	(1.2)	7	(2.5)	9	(2.0)
Hip	0	(0.0)	0	(0.0)	0	(0.0)
Groin	0	(0.0)	0	(0.0)	0	(0.0)
Thigh	6	(3.5)	7	(2.5)	13	(2.9)
Knee	24	(13.9)	83	(29.6)*	107	(23.6)
Lower leg	1	(0.6)	4	(1.4)	5	(1.1)
Achilles tendon	0	(0.0)	0	(0.0)	0	(0.0)
Ankle	58	(33.5)	93	(33.2)	151	(33.3)
Foot/toe	6	(3.5)	9	(3.2)	15	(3.3)
Overuse injuries	(n = 58)		(n = 69)		(n = 127)	
Face	0	(0.0)	0	(0.0)	0	(0.0)
Head	0	(0.0)	0	(0.0)	0	(0.0)
Neck/cervical spine	0	(0.0)	0	(0.0)	0	(0.0)
Thoracic spine/upper back	0	(0.0)	0	(0.0)	0	(0.0)
Sternum/ribs	1	(1.7)	0	(0.0)	1	(0.8)
Lumbar spine/lower back	17	(29.3)	16	(23.2)	33	(26.0)
Abdomen	0	(0.0)	0	(0.0)	0	(0.0)
Pelvis/sacrum/buttock	2	(3.4)	0	(0.0)	2	(1.6)
Shoulder	7	(12.1)	12	(17.4)	19	(15.0)
Upper arm	0	(0.0)	1	(1.4)	1	(0.8)
Elbow	3	(5.2)	0	(0.0)	3	(2.4)
Forearm	0	(0.0)	0	(0.0)	0	(0.0)
Wrist	0	(0.0)	1	(1.4)	1	(0.8)
Hand	0	(0.0)	0	(0.0)	0	(0.0)
Finger	0	(0.0)	1	(1.4)	1	(0.8)
Thumb	0	(0.0)	0	(0.0)	0	(0.0)
Hip	0	(0.0)	2	(2.9)	2	(1.6)
Groin	0	(0.0)	1	(1.4)	1	(0.8)
Thigh	8	(13.8)	2	(2.9)	10	(7.9)
Knee	8	(13.8)	12	(17.4)	20	(15.7)
Lower leg	3	(5.2)	8	(11.6)	11	(8.7)
Achilles tendon	1	(1.7)	0	(0.0)	1	(0.8)
Ankle	4	(6.9)	5	(7.2)	9	(7.1)
Foot/toe	4	(6.9)	8	(11.6)	12	(9.4)

Data are presented as number of injuries and percentage (%).
†Information is missing for 13 injuries.
‡Information is missing for 10 injuries.
§Information is missing for 23 injuries.
*: $p < 0.05$ (Fisher's exact test using Monte Carlo estimates.)

than 50% among females. The injury incidence was 0.59 injuries per player per year, which was higher than a study of senior players at the amateur level in Germany (0.49 injuries per player per year) (Seil et al., 1998). The study also reported that 39.2% of players sustained at least one injury during one season (Seil et al., 1998). Additionally, a study

Table 4. Type of injuries.

	Male† (n = 244)		Female‡ (n = 359)		Total§ (n = 603)	
Traumatic injuries	(n = 143)		(n = 280)		(n = 423)	
Concussion	1	(0.7%)	2	(0.7%)	3	(0.7%)
Fracture	24	(16.8%)*	26	(9.3%)	50	(11.8%)
Stress fracture	1	(0.7%)	3	(1.1%)	4	(0.9%)
Other bone injuries	0	(0.0%)	6	(2.1%)	6	(1.4%)
Dislocation, subluxation	18	(12.6%)	23	(8.2%)	41	(9.7%)
Tendon rupture	1	(0.7%)	5	(1.8%)	6	(1.4%)
Ligamentous rupture	19	(13.3%)	79	(28.2%)*	98	(23.2%)
Sprain	51	(35.7%)	79	(28.2%)	130	(30.7%)
Lesion of meniscus or cartilage	10	(7.0%)	30	(10.7%)	40	(9.5%)
Strain/muscle rupture/tear	6	(4.2%)	13	(4.6%)	19	(4.5%)
Contusion/haematoma/bruise	3	(2.1%)	3	(1.1%)	6	(1.4%)
Tendinosis/tendinopathy	1	(0.7%)	0	(0.0%)	1	(0.2%)
Bursitis	1	(0.7%)	1	(0.4%)	2	(0.5%)
Laceration/abrasion/skin lesion	0	(0.0%)	2	(0.7%)	2	(0.5%)
Dental injury/broken tooth	0	(0.0%)	0	(0.0%)	0	(0.0%)
Nerve injury/spinal cord injury	1	(0.7%)	0	(0.0%)	1	(0.2%)
Muscle cramps or spasm	0	(0.0%)	0	(0.0%)	0	(0.0%)
Others	6	(4.2%)	8	(2.9%)	14	(3.3%)
Overuse injuries	(n = 41)		(n = 51)		(n = 92)	
Concussion	0	(0.0%)	0	(0.0%)	0	(0.0%)
Fracture	0	(0.0%)	2	(3.9%)	2	(2.2%)
Stress fracture	9	(22.0%)	14	(27.5%)	23	(25.0%)
Other bone injuries	2	(4.9%)	4	(7.8%)	6	(6.5%)
Dislocation, subluxation	0	(0.0%)	1	(2.0%)	1	(1.1%)
Tendon rupture	2	(4.9%)	1	(2.0%)	3	(3.3%)
Ligamentous rupture	1	(2.4%)	3	(5.9%)	4	(4.3%)
Sprain	2	(4.9%)	1	(2.0%)	3	(3.3%)
Lesion of meniscus or cartilage	8	(19.5%)	15	(29.4%)	23	(25.0%)
Strain/muscle rupture/tear	2	(4.9%)	1	(2.0%)	3	(3.3%)
Contusion/haematoma/bruise	0	(0.0%)	0	(0.0%)	0	(0.0%)
Tendinosis/tendinopathy	6	(14.6%)	4	(7.8%)	10	(10.9%)
Bursitis	1	(2.4%)	0	(0.0%)	1	(1.1%)
Laceration/abrasion/skin lesion	0	(0.0%)	0	(0.0%)	0	(0.0%)
Dental injury/broken tooth	0	(0.0%)	0	(0.0%)	0	(0.0%)
Nerve injury/spinal cord injury	2	(4.9%)	0	(0.0%)	2	(2.2%)
Muscle cramps or spasm	0	(0.0%)	0	(0.0%)	0	(0.0%)
Others	6	(14.6%)	5	(9.8%)	11	(12.0%)

Data are presented as number of injuries and percentage (%).
†Information is missing for 60 injuries.
‡Information is missing for 28 injuries.
§Information is missing for 88 injuries.
*: $p < 0.05$ (Fisher's exact test using Monte Carlo estimates.)

among youth players showed that 22.7% of players had at least one injury during a season (Olsen et al., 2006). On the other hand, in studies among elite players, 59.3% of players in Brazil and 56.9% of players in Iceland had at least one injury during one season (Giroto et al., 2017; Rafnsson et al., 2019). Therefore, the proportion of injuries among Japanese university handball players was higher than both senior amateur and youth players, especially among female players.

Female players were 1.5 times more likely to experience an injury than their male counterparts in contrast to Moller et al.'s study (Moller et al., 2012), who did not find any sex differences in senior players but a greater risk of injury among males than females in u-18 handball players. A study targeting Brazilian elite handball players showed that female players were more associated with traumatic injuries compared to male players (Giroto et al., 2017). Michalsik et al. (Michalsik & Aagaard, 2015) reported that female

Table 5. Logistic regression analysis for occurrence of injuries.

Independent variables	Adjusted OR (95%CI)		*p*
Age (years) †	1.09	(0.97–1.22)	0.131
Gender			
Male	Reference		
Female	1.55	(1.20–2.01)	<0.001
Handball experience (years) †	1.03	(0.98–1.08)	0.227
Player position			
Wing	Reference		
Back	1.20	(0.88–1.64)	0.254
Line	1.49	(1.00–2.21)	0.049
Goalkeeper	0.90	(0.61–1.36)	0.620

OR, odds ratios; CI, confidence intervals.
†OR based on one year increase.

players covered a longer distance and exercised at a greater relative workload than male players during game. It is possible that these physical loads may be related to the occurrence of injuries.

Another potential risk was seen in the player position, line players were 1.5 times more likely to experience an injury than their wing counterparts. Our data differs from several studies showing that back players are at the highest risk (Moller et al., 2012; Myklebust et al., 1998). The majority of injuries in handball occur during the attacking phase (Olsen et al., 2006), meaning that most injuries occur when the team has ball possession and control in the opponent's half of the court (Bere et al., 2015). A possible explanation is that the majority of ball movements in the offence is done by the back players who therefore perform a substantial amount of planting and cutting movements as well as jump shots (Karcher & Buchheit, 2014). On the other hand, some studies showed that wing players had the highest risk of injury (Seil et al., 1998) as well as line players (Bere et al., 2015). Collectively, court players (wing, back, and line) have a higher risk of injury than goalkeepers in these previous studies (Bere et al., 2015; Moller et al., 2012; Myklebust et al., 1998; Seil et al., 1998). In this current study, the wing player was set as a reference category to clarify the difference in injury risk between court players, since the movement demands of court players and goalkeepers are different. A high injury risk in line players may be explained by the fact that these players play in the smallest area and for the most time between two defenders, as well as a position requiring a diverse range of motion, for example, pivoting, frequent throwing, side-step cutting, and jumping and landing (Bere et al., 2015; Karcher & Buchheit, 2014).

The most affected traumatic injury locations were the ankle, knee, and shoulder/clavicle. Previous studies reported that most traumatic injuries in handball involved the lower limbs with the ankle and knee as the main locations, regardless of age and gender (Asai et al., 2020; Rafnsson et al., 2019). In particular, this study revealed that the percentage of knee injury was about twice as high in females (29.6%) than in males (13.9%). On the other hand, the lumbar spine/lower back, knee, and shoulder were the most affected body regions in overuse injuries, with a high proportion especially found in lumbar spine/lower back (26.0%). This is in line with data from Icelandic elite male players where the most common locations of overuse injuries were the lumbar back/pelvis, knee, and shoulder, and the highest percentage was found in the lumbar back/pelvis (39.4%)

(Rafnsson et al., 2019). Other studies have shown that shoulder and knee overuse injuries are more common (Clarsen et al., 2015; Moller et al., 2012). Therefore, it could be possible that Japanese university handball players have insufficient strength, stability, and movement control in the lower back to meet the handball physical requirements (Rafnsson et al., 2019).

In the current study, sprains, ligamentous ruptures, and fractures were the most common traumatic injuries. Previous studies reported that the common types of traumatic injury were sprains, muscle strains, and contusions with fewer fractures and dislocations (Bere et al., 2015; Giroto et al., 2017; Moller et al., 2012). The present retrospectively study was conducted as a cross-sectional study, registering injuries sustained within the previous year. Therefore, less severe injuries may have been missed due to recall bias (Bahr & Holme, 2003), resulting in a higher percentage of more severe injuries such as ligamentous ruptures and fractures. When comparing male and female players, sprain was the most common injury type in both sexes (male 35.7%, female 28.2%). In addition, fracture was more common in male players (male 16.8%, female 9.3%), and ligamentous rupture was more common in female players (male 13.3%, female 28.2%). Possible reasons for the high percentage of fractures in males could be higher intensity, faster play, and more contact than females during handball (Moller et al., 2012; Olsen et al., 2006).

This is the first large-population study of injuries among Japanese handball players, but there are some limitations. First, we used a retrospective registration design to collect injury data. Therefore, the proportion of injured players and injury incidence may be underestimated, and we could have missed reports of less severe injuries due to recall bias (Bahr & Holme, 2003). In this study, approximately 50% of all injuries were severe that required more than 28 days to recover. However, recent prospective cohort studies investigating injuries in handball players showed that severe injuries accounted for 5 to 27% of all injuries (Moller et al., 2012; Rafnsson et al., 2019; Raya-González et al., 2021). Therefore, a prospective cohort study is needed to obtain more detailed injury data on Japanese handball players, including less severe injuries, to develop strategies for injury prevention in future. Another limitation of this study is that the results obtained from the questionnaire were self-reported by the participants. Because they do not have expert medical knowledge, the information about the injury obtained may contain erroneous answers. For example, they may have perceived some symptoms, such as fatigue or delayed-onset muscle soreness, as signs of an injury (Clemente et al., 2019; Leppänen et al., 2019). However, the data were confirmed and entered by two sports medicine experts. Therefore, the number of erroneous responses could be minimal in the analysed data.

Conclusions

The results of this study indicated that female and line players were associated with the highest occurrence of injuries. Implementing prevention programmes in Japanese handball should be a future focus. Injury prevention programmes need to focus on the ankle and knee, especially the knee in female players. In addition, we need to address the strength, stability, and movement control in the lower back for prevention of overuse injuries. This study used a retrospective registration design to collect data about injuries,

and therefore, minor injuries could be underestimated in this study. In the future, a large prospective cohort study is needed to obtain more detailed injury data, including the mechanism of injury for injury prevention.

Acknowledgments

The authors would like to thank the team staff and the handball players who participated in this study, as well as the staff of the Japan University Handball Federation and Japan Handball Association Medical Committee Trainer Section for their support.

Disclosure statement

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

ORCID

Sonoko Mashimo http://orcid.org/0000-0002-2982-3890
Naruto Yoshida http://orcid.org/0000-0003-1647-5900
Keita Suzuki http://orcid.org/0000-0003-1762-2116
Daniel T.P. Fong http://orcid.org/0000-0001-7314-189X
Grethe Myklebust http://orcid.org/0000-0002-0692-7494

References

Aasheim, C., Stavenes, H., Andersson, S. H., Engbretsen, L., & Clarsen, B. (2018). Prevalence and burden of overuse injuries in elite junior handball. *BMJ Open Sport and Exercise Medicine*, *4*(1), e000391. https://doi.org/10.1136/bmjsem-2018-000391

Asai, K., Nakase, J., Shimozaki, K., Toyooka, K., Kitaoka, K., & Tsuchiya, H. (2020). Incidence of injury in young handball players during national competition: A 6-year survey. *Journal of Orthopaedic Science*, *25*(4), 677–681. https://doi.org/10.1016/j.jos.2019.06.011

Bahr, R., & Holme, I. (2003). Risk factors for sports injuries-a methodological approach. *British Journal of Sports Medicine*, *37*(5), 384–392. https://doi.org/10.1136/bjsm.37.5.384

Bere, T., Alonso, J. M., Wangensteen, A., Bakken, A., Eirale, C., Dijkstra, H. P., Ahmed, H., Bahr, R., & Popovic, N. (2015). Injury and illness surveillance during the 24th Men's Handball World Championship 2015 in Qatar. *British Journal of Sports Medicine*, *49*(17), 1151–1156. https://doi.org/10.1136/bjsports-2015-094972

Carmen, M., Juan, T. M., Helena, V., Carmen, F., & Petra, P. (2013). Performance factors in women's team handball: Physical and physiological aspects-A review. *Journal of Strength and Conditioning Research*, *27*(6), 1708–1719. https://doi.org/10.1519/JSC.0b013e3182891535

Clarsen, B., Bahr, R., Heymans, M. W., Engedahl, M., Midtsundstad, G., Rosenlund, L., Thorsen, G., & Myklebust, G. (2015). The prevalence and impact of overuse injuries in five Norwegian sports: Application of a new surveillance method. *Scandinavian Journal of Medicine & Science in Sports*, *25*(3), 323–330. https://doi.org/10.1111/sms.12223

Clemente, F. M., Oliveira, H., Vaz, T., Carriço, S., Calvete, F., & Mendes, B. (2019). Variations of perceived load and well-being between normal and congested weeks in elite case study handball team. *Research in Sports Medicine*, *27*(3), 412–423. https://doi.org/10.1080/15438627.2018.1530998

Fuller, C. W., Ekstrand, J., Junge, A., Andersen, T. E., Bahr, R., Dvorak, J., Hägglund, M., McCrory, P., & Meeuwisse, W. H. (2006). Consensus statement on injury definitions and data collection

procedures in studies of football (soccer) injuries. *British Journal of Sports Medicine*, *40*(3), 193–201. https://doi.org/10.1136/bjsm.2005.025270

Giroto, N., Hespanhol Junior, L. C., Gomes, M. R. C., & Lopes, A. D. (2017). Incidence and risk factors of injuries in Brazilian elite handball players: A prospective cohort study. *Scandinavian Journal of Medicine & Science in Sports*, *27*(2), 195–202. https://doi.org/10.1111/sms.12636

Hasan, A. A., Reilly, T., Cable, N. T., & Ramadan, J. (2007). Anthropometric profiles of elite asian female handball players. *Journal of Sports Medicine and Physical Fitness*, *47*(2), 197–202.

International Olympic Committee. (2016, June 10). *8 things you didn't know about handball*. Athlete365. https://web.archive.org/web/20180719152012/https://www.olympic.org/athlete365/es/noticias/8-things-you-didnt-know-about-handball/

Junge, A., Engebretsen, L., Alonso, J. M., Renström, P., Mountjoy, M., Aubry, M., & Dvorak, J. (2008). Injury surveillance in multi-sport events: The International Olympic Committee approach. *British Journal of Sports Medicine*, *42*(6), 413–421. https://doi.org/10.1136/bjsm.2008.046631

Karcher, C., & Buchheit, M. (2014). On-court demands of elite handball, with special reference to playing positions. *Sports Medicine*, *44*(6), 797–814. https://doi.org/10.1007/s40279-014-0164-z

Leppänen, M., Pasanen, K., Clarsen, B., Kannus, P., Bahr, R., Parkkari, J., Haapasalo, H., & Vasankari, T. (2019). Overuse injuries are prevalent in children's competitive football: A prospective study using the OSTRC Overuse Injury Questionnaire. *British Journal of Sports Medicine*, *53*(3), 165–171. https://doi.org/10.1136/bjsports-2018-099218

Matsuoka, H., & Arai, A. (2017). The Japanese sport industry. In J. J. Zhang, R. H. Huang, & J. Nauright (Eds.), *Sport business in leading economies* (pp. 205–237). Emerald Publishing Limited. https://doi.org/10.1108/978-1-78743-563-620171009

Michalsik, L. B., & Aagaard, P. (2015). Physical demands in elite team handball: Comparisons between male and female players. *Journal of Sports Medicine and Physical Fitness*, *55*(9), 878–891.

Moller, M., Attermann, J., Myklebust, G., & Wedderkopp, N. (2012). Injury risk in Danish youth and senior elite handball using a new SMS text messages approach. *British Journal of Sports Medicine*, *46*(7), 531–537. https://doi.org/10.1136/bjsports-2012-091022

Myklebust, G., Maehlum, S., Holm, I., & Bahr, R. (1998). A prospective cohort study of anterior cruciate ligament injuries in elite Norwegian team handball. *Scandinavian Journal of Medicine & Science in Sports*, *8*(3), 149–153. https://doi.org/10.1111/j.1600-0838.1998.tb00185.x

Nielsen, A. B., & Yde, J. (1988). An epidemiologic and traumatologic study of injuries in handball. *International Journal of Sports Medicine*, *9*(5), 341–344. https://doi.org/10.1055/s-2007-1025037

Olsen, O. E., Myklebust, G., Engebretsen, L., & Bahr, R. (2006). Injury pattern in youth team handball: A comparison of two prospective registration methods. *Scandinavian Journal of Medicine & Science in Sports*, *16*(6), 426–432. https://doi.org/10.1111/j.1600-0838.2005.00484.x

Prieto, J., Gómez, M. Á., & Sampaio, J. (2015). A bibliometric review of the scientific production in handball. *Cuadernos de Psicología Del Deporte*, *15*(3), 145–154. https://doi.org/10.4321/S1578-84232015000300014

Rafnsson, E. T., Valdimarsson, Ö., Sveinsson, T., & Árnason, Á. (2019). Injury pattern in Icelandic elite male handball players. *Clinical Journal of Sport Medicine*, *29*(3), 232–237. https://doi.org/10.1097/JSM.0000000000000499

Raya-González, J., García-Esteban, S., de Ste Croix, M., Manuel Clemente, F., & Castillo, D. (2021). Longitudinal differences in the injury profile of professional male handball players according to competitive-level. *Research in Sports Medicine*, *29*(1), 90–102. https://doi.org/10.1080/15438627.2020.1800465

Sakaue, Y., & Thompson, L. (2020). The rise of modern sport and the Olympic Movement in Japan. In Fan Hong and Lu Zhouxiang (Eds.), *The Routledge handbook of sport in Asia* (pp. 426–432). Routledge. https://doi.org/10.4324/9781315768250

Seil, R., Rupp, S., Tempelhof, S., & Kohn, D. (1998). Sports injuries in team handball. A one-year prospective study of sixteen men's senior teams of a superior nonprofessional level. *American Journal of Sports Medicine*, *26*(5), 681–687. https://doi.org/10.1177/03635465980260051401