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Original Article

Sport level and sex differences in sport-related concussion among Japanese collegiate athletes: Epidemiology, knowledge, reporting behaviors, and reported symptoms

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ABSTRACT

This study investigated the incidence of sport-related concussion (SRC) in sports, effect of athlete knowledge on reporting behavior differences between collegiate and non-collegiate athletes, and differences in SRC symptoms between sexes and level of participation. In this cross-sectional survey, 1 344 Japanese collegiate and non-collegiate athletes from a single institute were analyzed. Using a web-based survey, demographics, general SRC, knowledge of SRC, the most recent SRC reporting behaviors, and symptom presentation were examined. The prevalence of SRC during the academic year 2016–2017 was 2.68 (95% confidence interval [*CI*]: 1.88–3.69) across all sports. The prevalence of SRC was 33.3 (95% *CI*: 17.96–51.83) in rugby union and 8.33 (95% *CI*: 1.03–27.00) in women's soccer. The prevalence of SRC in males (3.47 [95% *CI*: 2.38–4.86] was 3.65 times higher than that in females (0.95 [95% *CI*: 0.26–2.41]). In total, the mean total score of knowledge was 5.30 (4.2) across 25 questions; dizziness was the most well-known symptom (867/1 344, 64.5%), followed by headache (59.3%). Being more emotional (44/1 345, 3.3%) was the least frequently known symptom. Level of participation did not affect scores (5.16 [3.96] vs. 5.52 [4.54]; $p = 0.131$). All 87 disclosing participants experienced drowsiness and irritability and felt more emotional. In terms of sex and participant level, no significant differences were found in any symptoms. This study found very low rates of concussion education in Japan. Dissemination of concussion education is essential in the future to recognize concussion earlier and prevent severe concussive injury.

Introduction

Risk of sport-related concussion (SRC) across all sport with a contact or collision nature is high.[1–6] According to McCrory et al., the definition of SRC is as follows: "SRC is a traumatic brain injury that is defined as a complex pathophysiological process affecting the brain, induced by biomechanical forces with several common features that help define its nature."[7] There were 3 497 SRCs reported during five academic years in National Collegiate Athletic Association.[2] According to the Japanese Trauma Data Bank annual reports 2014–2018, 3 862 patients (2.1%) were registered owing to sports injury.[8] In Japan, head and spinal injuries accounted for a quarter of severe cases, and 855 SRCs were reported over 7 years between 2005 and 2011.[9] Headache is known as the most common reported symptom, followed by dizziness, difficulty concentrating, and sensitivity to light in both males and females.[10–14] Males tended to report cognitive symptoms such as disorientation and amnesia, while females tended to report neurobehavioral symptoms such as headache, nausea and drowsiness.[10–12] However, little is known about symptoms reported by Japanese collegiate athletes. Only 12.8% reported loss of consciousness.[15] Therefore, SRC awareness needs to be increased. Adequate knowledge of common signs and symptoms is important to identify and assess SRC for not only varsity athletes but also non-varsity athletes, as they are self-governed.[16]

SRCs usually have a benign progress with limited complications so it is not a life-threatening injury; however, it lasts longer and considered as serious injury because of nature of the brain injury, unless urgent recognition and appropriate medical treatment should be provided.[17] SRC nondisclosure is frequently observed in males, participants in high-risk sport, those with a history of diagnosed SRC, gaining

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Abbreviation

SRC	sport-related concussion
TBI	traumatic brain injury
BLS	Basic life support
RTP	return-to-play
AT	Athletic Trainer
NCAA	National Collegiate Athletic Association
UNIVAS	Japan Association for University Athletics and Sport
RU	Rugby Union

knowledge about SRC, and those who experience pressure from coaches.[18] Approximately 18% of collegiate student-athletes who had a head impact injury experienced pressure from coaches.[18] SRC nondisclosure with a SRC history was 2.6 times higher than that in those without a SRC history.[19] Thus, SRC-reporting intention in the Japanese collegiate setting needs to be researched.

The present study aimed to examine 1) the prevalence of SRC in sports, 2) effect of athlete knowledge on reporting behavior differences between collegiate and non-collegiate athletes, 3) differences in SRC symptoms between sexes and level of participation in a Japanese collegiate population.

Methods

Participants

The descriptive epidemiological study was conducted at a large private university in Japan. In Japanese universities, two types of extracurricular activities exist: clubs and circles. Clubs are generally more competitive at the top level and comprise sport-related activities, whereas circles include recreational activities. All students who belonged to a sport-related club or circle were asked to participate in this study, regardless of the level of participation. We divided level of participation into two cohort; collegiate and non-collegiate. The Collegiate cohort included a collegiate varsity sports student-athlete who is a member of a sports council-designated club at Kokushikan Univeristy. The non-collegiate cohort included university students who belong to other clubs intramural, interest groups (known as “circle” in Japanese), and recreational sports team at Kokushikan Univeristy.

Measurements

A web-based survey, which took 10 min to complete, was created using Google Forms. Pamphlets with a QR code—which was directly linked to the survey on Google Forms—were distributed, and captains were asked to share the code with all team members. Informed consent was noted on the first page, and the questionnaire had four parts: 1) demographics, 2) general SRC, 3) knowledge of SRC, 4) most recent SRC reporting behavior and symptom presentation.

Participant demographics

Sex, age, year in school, and level of participation were asked.

General SRC section

SRC education

Previous SRC education, and Basic life support (BLS) training experience were queried. This aimed to compare SRC education and BLS education systems in Japan.

Previous SRC events :

Participants were asked about the history of the following events.

1) diagnosed SRCs
2) number of diagnosed SRCs
3) number of SRCs during the academic year 2016–2017 (April 2016–March 2017).

In Japan, the academic year starts in April and ends in March the following year. We used prevalence of SRC as the primary measure. This survey was taken in July, four months after the end of the 2016 academic year (April to March) in Japan. Therefore, *the concussion prevalence in the 2016 academic year* has lapsed for at least four months.

Knowledge of SRC

A series of 25 questions assessed the knowledge of SRC and assigned one point each. This included 23 questions regarding recognition of common signs and symptoms of SRC listed in the Sport Concussion Assessment Tool–5th Edition,[20] and 2 general knowledge items regarding post-concussion syndrome and second-impact syndrome. *Nausea* and *Vomiting* were asked individually and considered as different signs and symptoms. In addition to that, a study conducted by Wallace et al., Register-Mihalik et al. were referred to develop question list to access SRC knowledge for our survey.[21,22]

SRC reporting behaviors

To assess SRC reporting behavior, the following question was asked: “Did you report your suspect SRC?” For those who disclosed their SRC, questions regarding the following factors were asked: authoritative figure to whom SRC was reported, first healthcare provider, visiting hospital within 24 h from injury, return-to-play (RTP) duration, and personnel who made the RTP decision. The reported SRC signs and symptoms among the 23 common signs and symptoms were also asked.

Statistical analysis

Categorical variables were expressed using the number of cases and percentage. Continuous variables were expressed using median (interquartile range [*IQR*]) or mean (standard deviation [*SD*]). Welch's *t*-test and Fisher's exact test were conducted for background characteristics. The SRC rate by sports type and 95% confidence intervals (*CIs*) were calculated using the Clopper–Pearson interval (Tables 2 and 3). To compare knowledge of SRC and reported SRC symptoms, Fisher's exact test was conducted (Tables 4–6). All statistical analyses were conducted using R Studio version 4.1.2 (R Studio, Inc., Boston, MA, USA). The significance level was set at p-values <0.05.

Ethical consideration

The study was approved by the Institutional Review Board at Kokushikan University under the registration number 16-MJ001. Informed consent was taken prior to the study enrollment.

Results

Participant demographics

We analyzed the responses of 1 344 student-athletes from a total of 1 468 students who agreed to participate in the study and answered the survey (Table 1). We excluded data from 124 participants, which corresponded to non-sport clubs ($n = 92$), not a player ($n = 14$), and deviation or missing data ($n = 18$). In total, 831 collegiate student-athletes (553 males and 278 females) and 513 non-collegiate student-athletes

Table 1
Background characteristics.

Background	Total	Sex		*p-value*	Level of Participation		*p-value*
		Males	Females		collegiate	Non-collegiate	
Overall, *n*	1344	923	421	N/A	831	514	N/A
Sex							
Male, *n* (%)		N/A	N/A	N/A	553 (66.5)	370 (72.1)	0.034
Female		N/A	N/A	N/A	278 (33.5)	143 (27.9)	
Age, mean (*SD*)	19.58 (1.22)	19.54 (1.20)	19.68 (1.26)	0.051	19.61 (1.24)	19.54 (1.18)	0.328
Year in School							
1	450 (33.5)	315 (34.1)	135 (32.1)	0.285	283 (34.1)	167 (32.6)	< 0.001
2	351 (26.1)	246 (26.7)	105 (24.9)		195 (23.5)	156 (30.4)	
3	313 (23.3)	215 (23.3)	98 (23.3)		182 (21.9)	131 (25.5)	
4	229 (17.0)	147 (15.9)	82 (19.5)		171 (20.6)	58 (11.3)	
Graduate	1 (0.1)	0 (0.0)	1 (0.2)		0 (0.0)	1 (0.2)	
Level of Participation							
Collegiate	831 (61.8)	553 (59.9)	278 (66.0)	0.034	N/A	N/A	N/A
Non-collegiate	513 (38.2)	370 (40.1)	143 (34.0)		N/A	N/A	N/A

SD, standard deviation; NA, not applicable.
t-test and Fisher's exact test were conducted.

Table 2
Sport-related concussion rates among collegiate students in men's sports.

Men's	*n*	Previous Education		Previous concussion history			Number of SRCs in the 2016 academic year			SRC prevalence in 2016 academic year (95% *CI*), %
		BLS	SRC							
		YES	YES	YES	No	unsure	None	Once time	Two times	
Basketball	75	65 (86.7)	12 (16.0)	7 (9.3)	57 (76.0)	11 (14.7)	5 (6.7)	2 (2.7)	0 (0.0)	2.67 (0.32, 9.3)
Collegiate	27	20 (74.1)	1 (3.7)	4 (14.8)	19 (70.4)	4 (14.8)	4 (14.8)	0 (0.0)	0 (0.0)	NA
Non-collegiate	48	45 (93.8)	11 (22.9)	3 (6.2)	38 (79.2)	7 (14.6)	1 (2.1)	2 (4.2)	0 (0.0)	4.17 (0.51, 14.25)
Judo	49	39 (79.6)	12 (24.5)	13 (26.5)	30 (61.2)	6 (12.2)	9 (18.4)	4 (8.2)	0 (0.0)	8.16 (2.27, 19.6)
Collegiate	45	35 (77.8)	10 (22.2)	12 (26.7)	28 (62.2)	5 (11.1)	8 (17.8)	4 (8.9)	0 (0.0)	8.89 (2.48, 21.22)
Non-collegiate	4	4 (100.0)	2 (50.0)	1 (25.0)	2 (50.0)	1 (25.0)	1 (25.0)	0 (0.0)	0 (0.0)	NA
Kendo	73	66 (90.4)	7 (9.6)	6 (8.2)	57 (78.1)	10 (13.7)	5 (6.8)	1 (1.4)	0 (0.0)	1.37 (0.03, 7.4)
Collegiate	69	62 (89.9)	6 (8.7)	6 (8.7)	53 (76.8)	10 (14.5)	5 (7.2)	1 (1.4)	0 (0.0)	1.45 (0.04, 7.81)
Non-collegiate	4	4 (100.0)	1 (25.0)	0 (0.0)	4 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Skiing	22	21 (95.5)	4 (18.2)	2 (9.1)	16 (72.7)	4 (18.2)	2 (9.1)	0 (0.0)	0 (0.0)	NA
Collegiate	4	4 (100.0)	0 (0.0)	2 (50.0)	2 (50.0)	0 (0.0)	2 (50.0)	0 (0.0)	0 (0.0)	NA
Non-collegiate	18	17 (94.4)	4 (22.2)	0 (0.0)	14 (77.8)	4 (22.2)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Soccer	97	81 (83.5)	7 (7.2)	17 (17.5)	64 (66.0)	16 (16.5)	13 (13.4)	4 (4.1)	0 (0.0)	4.12 (1.13, 10.22)
Collegiate	72	56 (77.8)	2 (2.8)	13 (18.1)	51 (70.8)	8 (11.1)	10 (13.9)	3 (4.2)	0 (0.0)	4.17 (0.87, 11.7)
Non-collegiate	25	25 (100.0)	5 (20.0)	4 (16.0)	13 (52.0)	8 (32.0)	3 (12.0)	1 (4.0)	0 (0.0)	4 (0.1, 20.35)
Volleyball	72	60 (83.3)	10 (13.9)	4 (5.6)	62 (86.1)	6 (8.3)	3 (4.2)	1 (1.4)	0 (0.0)	1.39 (0.04, 7.5)
Collegiate	39	30 (76.9)	3 (7.7)	2 (5.1)	36 (92.3)	1 (2.6)	2 (5.1)	0 (0.0)	0 (0.0)	NA
Non-collegiate	33	30 (90.9)	7 (21.2)	2 (6.1)	26 (78.8)	5 (15.2)	1 (3.0)	1 (3.0)	0 (0.0)	3.03 (0.08, 15.76)
Gymnastics	22	17 (77.3)	4 (18.2)	3 (13.6)	18 (81.8)	1 (4.5)	1 (4.5)	2 (9.1)	0 (0.0)	9.09 (1.12, 29.16)
Handball	1	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Ice hockey	3	3 (100.0)	1 (33.3)	1 (33.3)	2 (66.7)	0 (0.0)	1 (33.3)	0 (0.0)	0 (0.0)	NA
Karate	2	2 (100.0)	0 (0.0)	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Rugby	33	26 (78.8)	15 (45.5)	18 (54.5)	11 (33.3)	4 (12.1)	10 (30.3)	5 (15.2)	3 (9.1)	33.33 (17.96, 51.83)
Rythmic gymnastics	19	17 (89.5)	2 (10.5)	2 (10.5)	13 (68.4)	4 (21.1)	2 (10.5)	0 (0.0)	0 (0.0)	NA
Swimming	17	14 (82.4)	0 (0.0)	2 (11.8)	14 (82.4)	1 (5.9)	2 (11.8)	0 (0.0)	0 (0.0)	NA
Track&Field	177	135 (76.3)	15 (8.5)	9 (5.1)	139 (78.5)	29 (16.4)	8 (4.5)	1 (0.6)	0 (0.0)	0.56 (0.01, 3.11)
Wrestling	23	22 (95.7)	3 (13.0)	4 (17.4)	13 (56.5)	6 (26.1)	2 (8.7)	1 (4.3)	1 (4.3)	13.04 (2.78, 33.59)
Badminton	30	25 (83.3)	2 (6.7)	1 (3.3)	21 (70.0)	8 (26.7)	1 (3.3)	0 (0.0)	0 (0.0)	NA
Baseball	24	20 (83.3)	2 (8.3)	1 (4.2)	20 (83.3)	3 (12.5)	1 (4.2)	0 (0.0)	0 (0.0)	NA
Beach volleyball	13	11 (84.6)	0 (0.0)	0 (0.0)	10 (76.9)	3 (23.1)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Dance	16	8 (50.0)	3 (18.8)	1 (6.2)	11 (68.8)	4 (25.0)	1 (6.2)	0 (0.0)	0 (0.0)	NA
Floorball	6	6 (100.0)	1 (16.7)	3 (50.0)	3 (50.0)	0 (0.0)	2 (33.3)	1 (16.7)	0 (0.0)	16.67 (0.42, 64.12)
Lacrosse	41	38 (92.7)	10 (24.4)	0 (0.0)	35 (85.4)	6 (14.6)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Life saving	26	26 (100.0)	9 (34.6)	1 (3.8)	23 (88.5)	2 (7.7)	1 (3.8)	0 (0.0)	0 (0.0)	NA
Shooting	5	5 (100.0)	1 (20.0)	0 (0.0)	5 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Tennis	37	28 (75.7)	5 (13.5)	1 (2.7)	32 (86.5)	4 (10.8)	1 (2.7)	0 (0.0)	0 (0.0)	NA
Triathron	13	12 (92.3)	2 (15.4)	1 (7.7)	10 (76.9)	2 (15.4)	1 (7.7)	0 (0.0)	0 (0.0)	NA
Aikido	3	3 (100.0)	0 (0.0)	1 (33.3)	2 (66.7)	0 (0.0)	0 (0.0)	0 (0.0)	1 (33.3)	66.67 (9.43, 99.16)
Kyudo	5	5 (100.0)	0 (0.0)	0 (0.0)	5 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Nihon Kenpo	11	7 (63.6)	1 (9.1)	1 (9.1)	5 (45.5)	5 (45.5)	1 (9.1)	0 (0.0)	0 (0.0)	NA
Jodo:Tue-Dou	8	7 (87.5)	1 (12.5)	1 (12.5)	7 (87.5)	0 (0.0)	1 (12.5)	0 (0.0)	0 (0.0)	NA
Collegiate	553	443 (80.1)	62 (11.2)	78 (14.1)	401 (72.5)	74 (13.4)	57 (10.3)	17 (3.1)	4 (0.7)	4.52 (2.95, 6.6)
Non-collegiate	370	326 (88.1)	67 (18.1)	22 (5.9)	286 (77.3)	62 (16.8)	16 (4.3)	5 (1.4)	1 (0.3)	1.89 (0.76, 3.86)
Subtotal	923	769 (83.3)	129 (14.0)	100 (10.8)	687 (74.4)	136 (14.7)	73 (7.9)	22 (2.4)	5 (0.5)	3.47 (2.38, 4.86)

BLS, Basic life support; SRC, sport-related concussion; *CI*, confidence interval; NA, not applicable.

(370 males and 143 females) were included (Table 1). Males accounted for the higher level of participation ($p = 0.034$).

SRC education in Japan

Previous SRC education history at any stage of their life was asked to all participants. Education style were including interactive lecture-based but not limited to practical based, e-learning, video. In total, 84.8% of participants had previous BLS training, whereas only 13.6% had previous SRC education, including 62 male (11.2%) and 31 female (11.2%) collegiate student-athletes and 67 male (18.1%) and 23 female (16.1%) non-collegiate student-athletes. In total, 45.5% of male rugby union players and 24.4% of female Judo athletes had previous SRC education (Tables 2 and 3).

Knowledge of SRC

The mean total score was 5.30 (4.2) across 25 questions, which included dizziness as the most frequently identified symptom (867/1 344, 64.5%) and being more emotional (44/1 345, 3.3%) as the least frequently identified. Moreover, 201 and 190 participants (15.0% and 14.1%) were familiar with post-SRC syndrome and second-impact syndrome, respectively. In total, those who had previous education in SRC had significantly higher scores than those who did not (7.97 [5.64] vs. 4.88 [3.75]; $p < 0.001$). Dizziness had the highest rate of recognition in both groups (81.4% vs. 61.8%; $p < 0.001$), but irritability had a three times higher rate of recognition in the former group than in the latter group (9.3% vs. 3.1%; $p < 0.001$).

In terms of differences between sexes, females received significantly higher scores than males (5.87 [4.41] vs. 5.04 [4.07]; $p = 0.001$). Similar to the overall results, dizziness had the highest rate of recognition in both males and females (81.4% vs. 61.8%; $p < 0.001$). Sensitivity to light was identified over two times more frequently by females than by males (5.9% vs. 13.5%; $p < 0.001$). In total, those who had a SRC history received significantly higher scores than those who did not or were unsure (6.49 [4.34] vs. 5.07 [4.18] vs. 5.62 [4.03]; $p < 0.001$). The level of participation did not influence the scores (5.16 [3.96] vs. 5.52 [4.54]; $p = 0.131$).

Sport-related concussion rate

History of diagnosed SRCs

A history of diagnosed SRCs were reported by 100 males (10.8%), of which 14.1% and 5.9% were collegiate and non-collegiate athletes, respectively, and 36 females (10.1%), of which 9.7% and 6.3% were collegiate and non-collegiate athletes, respectively. Moreover, 54.5%

Table 3
Sport-related concussion rates among collegiate students in men's sports women's sports.

Women's	*n*	Previous Education		Previous SRC history			Number of SRCs in the 2016 academic year			SRC prevalence in 2016 academic year (95% *CI*), %
		BLS	SRC							
		YES	YES	YES	No	Unsure	None	Once time	Two times	
Basketball	37	35 (94.6)	2 (5.4)	3 (8.1)	28 (75.7)	6 (16.2)	2 (5.4)	1 (2.7)	0 (0.0)	2.7 (0.07, 14.16)
Collegiate	21	20 (95.2)	0 (0.0)	1 (4.8)	18 (85.7)	2 (9.5)	1 (4.8)	0 (0.0)	0 (0.0)	NA
Non-collegiate	16	15 (93.8)	2 (12.5)	2 (12.5)	10 (62.5)	4 (25.0)	1 (6.2)	1 (6.2)	0 (0.0)	6.25 (0.16, 30.23)
Kendo	27	24 (88.9)	4 (14.8)	1 (3.7)	22 (81.5)	4 (14.8)	0 (0.0)	1 (3.7)	0 (0.0)	3.7 (0.09, 18.97)
Collegiate	26	23 (88.5)	4 (15.4)	1 (3.8)	22 (84.6)	3 (11.5)	0 (0.0)	1 (3.8)	0 (0.0)	3.85 (0.1, 19.64)
Non-collegiate	1	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Ski	11	9 (81.8)	1 (9.1)	3 (27.3)	6 (54.5)	2 (18.2)	3 (27.3)	0 (0.0)	0 (0.0)	NA
Collegiate	1	1 (100.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	NA
Non-collegiate	10	8 (80.0)	1 (10.0)	2 (20.0)	6 (60.0)	2 (20.0)	2 (20.0)	0 (0.0)	0 (0.0)	NA
Volleyball	46	41 (89.1)	5 (10.9)	1 (2.2)	36 (78.3)	9 (19.6)	1 (2.2)	0 (0.0)	0 (0.0)	NA
Collegiate	24	22 (91.7)	2 (8.3)	0 (0.0)	19 (79.2)	5 (20.8)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Non-collegiate	22	19 (86.4)	3 (13.6)	1 (4.5)	17 (77.3)	4 (18.2)	1 (4.5)	0 (0.0)	0 (0.0)	NA
Artistic Swimming	7	7 (100.0)	2 (28.6)	0 (0.0)	7 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Gymnastics	12	11 (91.7)	1 (8.3)	4 (33.3)	4 (33.3)	4 (33.3)	4 (33.3)	0 (0.0)	0 (0.0)	NA
Handball	27	21 (77.8)	0 (0.0)	4 (14.8)	18 (66.7)	5 (18.5)	4 (14.8)	0 (0.0)	0 (0.0)	NA
Judo	18	12 (66.7)	6 (33.3)	1 (5.6)	9 (50.0)	8 (44.4)	1 (5.6)	0 (0.0)	0 (0.0)	NA
Soccer	24	21 (87.5)	3 (12.5)	5 (20.8)	15 (62.5)	4 (16.7)	4 (16.7)	0 (0.0)	1 (4.2)	8.33 (1.03, 27)
Softball	31	29 (93.5)	7 (22.6)	3 (9.7)	24 (77.4)	4 (12.9)	3 (9.7)	0 (0.0)	0 (0.0)	NA
Karate	1	1 (100.0)	1 (100.0)	1 (100.0)	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	NA
Rythmic gymnastics	19	15 (78.9)	2 (10.5)	0 (0.0)	18 (94.7)	1 (5.3)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Swimming	10	9 (90.0)	0 (0.0)	1 (10.0)	8 (80.0)	1 (10.0)	1 (10.0)	0 (0.0)	0 (0.0)	NA
Track&Field	55	51 (92.7)	3 (5.5)	5 (9.1)	43 (78.2)	7 (12.7)	5 (9.1)	0 (0.0)	0 (0.0)	NA
Wrestling	2	1 (50.0)	0 (0.0)	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Badminton	14	10 (71.4)	0 (0.0)	0 (0.0)	13 (92.9)	1 (7.1)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Beach volleyball	4	4 (100.0)	0 (0.0)	0 (0.0)	4 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Cheer dance	6	6 (100.0)	1 (16.7)	0 (0.0)	5 (83.3)	1 (16.7)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Dance	13	12 (92.3)	2 (15.4)	2 (15.4)	8 (61.5)	3 (23.1)	2 (15.4)	0 (0.0)	0 (0.0)	NA
Floorball	8	8 (100.0)	2 (25.0)	1 (12.5)	6 (75.0)	1 (12.5)	1 (12.5)	0 (0.0)	0 (0.0)	NA
Lacrosse	33	28 (84.8)	6 (18.2)	1 (3.0)	27 (81.8)	5 (15.2)	1 (3.0)	0 (0.0)	0 (0.0)	NA
Life saving	1	1 (100.0)	1 (100.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Shooting	2	2 (100.0)	0 (0.0)	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Tennis	2	2 (100.0)	1 (50.0)	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Triathron	2	2 (100.0)	0 (0.0)	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Kyudo	2	2 (100.0)	0 (0.0)	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Nihon Kenpo	2	2 (100.0)	2 (100.0)	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Jodo:Tue-Dou	5	5 (100.0)	2 (40.0)	0 (0.0)	5 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Collegiate	278	244 (87.8)	31 (11.2)	27 (9.7)	206 (74.1)	45 (16.2)	25 (9.0)	1 (0.4)	1 (0.4)	1.08 (0.22, 3.12)
Non-collegiate	143	127 (88.8)	23 (16.1)	9 (6.3)	109 (76.2)	25 (17.5)	8 (5.6)	1 (0.7)	0 (0.0)	0.7 (0.02, 3.83)
Subtotal	421	371 (88.1)	54 (12.8)	36 (8.6)	315 (74.8)	70 (16.6)	33 (7.8)	2 (0.5)	1 (0.2)	0.95 (0.26, 2.41)
Overall	1344	1140 (84.8)	183 (13.6)	136 (10.1)	1002 (74.6)	206 (15.3)	106 (7.9)	24 (1.8)	6 (0.4)	2.68 (1.88, 3.69)

BLS, Basic life support; SRC, sport-related concussion; CI, confidence interval; NA, not applicable.

Table 4
Knowledge of concussion.

	Total	Previous education in concussion		*p-value*	sex		*p-value*	Previous concussion history			*p-value*	Level of participation		*p-value*
		YES	NO		male	female		YES	NO	Unsure		Collegiate	Non- collegiate	
Total, *n*	1 344	183	1 161		923	421		136	1 002	206		831	513	
Signs and symptoms knowledge														
Headache	797 (59.3)	123 (67.2)	674 (58.1)	0.019	534 (57.9)	263 (62.5)	0.120	87 (64.0)	590 (58.9)	120 (58.3)	0.501	511 (61.5)	286 (55.8)	0.040
"Pressure in head"	320 (23.8)	54 (29.5)	266 (22.9)	0.061	202 (21.9)	118 (28.0)	0.016	30 (22.1)	241 (24.1)	49 (23.8)	0.897	187 (22.5)	133 (25.9)	0.166
Neck Pain	355 (26.4)	62 (33.9)	293 (25.2)	0.019	246 (26.7)	109 (25.9)	0.790	46 (33.8)	246 (24.6)	63 (30.6)	0.024	206 (24.8)	149 (29.0)	0.098
Nausea	670 (49.9)	123 (67.2)	547 (47.1)	< 0.001	439 (47.6)	231 (54.9)	0.014	87 (64.0)	475 (47.4)	108 (52.4)	0.001	425 (51.1)	245 (47.8)	0.239
Vomiting	514 (38.2)	101 (55.2)	413 (35.6)	< 0.001	350 (37.9)	164 (39.0)	0.717	61 (44.9)	370 (36.9)	83 (40.3)	0.161	309 (37.2)	205 (40.0)	0.326
Dizziness	867 (64.5)	149 (81.4)	718 (61.8)	< 0.001	574 (62.2)	293 (69.6)	0.010	104 (76.5)	624 (62.3)	139 (67.5)	0.003	518 (62.3)	349 (68.0)	0.035
Blurred vision	517 (38.5)	90 (49.2)	427 (36.8)	0.002	334 (36.2)	183 (43.5)	0.011	57 (41.9)	372 (37.1)	88 (42.7)	0.220	299 (36.0)	218 (42.5)	0.018
balance problems	683 (50.8)	124 (67.8)	559 (48.1)	< 0.001	439 (47.6)	244 (58.0)	< 0.001	83 (61.0)	477 (47.6)	123 (59.7)	< 0.001	412 (49.6)	271 (52.8)	0.261
Sensitivity to light	111 (8.3)	32 (17.5)	79 (6.8)	< 0.001	54 (5.9)	57 (13.5)	< 0.001	14 (10.3)	82 (8.2)	15 (7.3)	0.585	63 (7.6)	48 (9.4)	0.263
sensitivity to noise	78 (5.8)	27 (14.8)	51 (4.4)	< 0.001	42 (4.6)	36 (8.6)	0.005	12 (8.8)	57 (5.7)	9 (4.4)	0.219	38 (4.6)	40 (7.8)	0.016
feeling slowed down	176 (13.1)	44 (24.0)	132 (11.4)	< 0.001	106 (11.5)	70 (16.6)	0.011	16 (11.8)	133 (13.3)	27 (13.1)	0.917	101 (12.2)	75 (14.6)	0.212
feeling like "in a fog"	153 (11.4)	39 (21.3)	114 (9.8)	< 0.001	94 (10.2)	59 (14.0)	0.042	23 (16.9)	107 (10.7)	23 (11.2)	0.106	86 (10.3)	67 (13.1)	0.134
"Don't feel right"	265 (19.7)	63 (34.4)	202 (17.4)	< 0.001	170 (18.4)	95 (22.6)	0.089	40 (29.4)	182 (18.2)	43 (20.9)	0.010	155 (18.7)	110 (21.4)	0.230
Difficulty concentrating	254 (18.9)	64 (35.0)	190 (16.4)	< 0.001	168 (18.2)	86 (20.4)	0.330	30 (22.1)	177 (17.7)	47 (22.8)	0.132	147 (17.7)	107 (20.9)	0.152
Difficulty remembering	251 (18.7)	59 (32.2)	192 (16.5)	< 0.001	170 (18.4)	81 (19.2)	0.763	37 (27.2)	176 (17.6)	38 (18.4)	0.030	164 (19.7)	87 (17.0)	0.221
Fatigue or low energy	141 (10.5)	35 (19.1)	106 (9.1)	< 0.001	87 (9.4)	54 (12.8)	0.068	16 (11.8)	95 (9.5)	30 (14.6)	0.085	80 (9.6)	61 (11.9)	0.200
Confusion	230 (17.1)	52 (28.4)	178 (15.3)	< 0.001	159 (17.2)	71 (16.9)	0.938	28 (20.6)	159 (15.9)	43 (20.9)	0.108	138 (16.6)	92 (17.9)	0.551
Drowsiness	59 (4.4)	20 (10.9)	39 (3.4)	< 0.001	36 (3.9)	23 (5.5)	0.199	9 (6.6)	42 (4.2)	8 (3.9)	0.389	36 (4.3)	23 (4.5)	0.892
Trouble falling asleep	47 (3.5)	14 (7.7)	33 (2.8)	0.003	26 (2.8)	21 (5.0)	0.054	5 (3.7)	35 (3.5)	7 (3.4)	0.968	29 (3.5)	18 (3.5)	1.000
More emotional	44 (3.3)	15 (8.2)	29 (2.5)	< 0.001	26 (2.8)	18 (4.3)	0.186	7 (5.1)	31 (3.1)	6 (2.9)	0.404	25 (3.0)	19 (3.7)	0.529
irritability	53 (3.9)	17 (9.3)	36 (3.1)	< 0.001	29 (3.1)	24 (5.7)	0.033	5 (3.7)	40 (4.0)	8 (3.9)	1.000	29 (3.5)	24 (4.7)	0.313
Sadness	46 (3.4)	17 (9.3)	29 (2.5)	< 0.001	25 (2.7)	21 (5.0)	0.036	5 (3.7)	36 (3.6)	5 (2.4)	0.769	28 (3.4)	18 (3.5)	0.879
Nervous or Anxious	99 (7.4)	26 (14.2)	73 (6.3)	0.001	63 (6.8)	36 (8.6)	0.262	13 (9.6)	73 (7.3)	13 (6.3)	0.517	64 (7.7)	35 (6.8)	0.592
General knowledge														
Post concussion syndrome	201 (15.0)	55 (30.1)	146 (12.6)	< 0.001	129 (14.0)	72 (17.1)	0.138	30 (22.1)	142 (14.2)	29 (14.1)	0.059	122 (14.7)	79 (15.4)	0.753
Second impact syndrome	190 (14.1)	54 (29.5)	136 (11.7)	< 0.001	148 (16.0)	42 (10.0)	0.003	38 (27.9)	119 (11.9)	33 (16.0)	< 0.001	118 (14.2)	72 (14.0)	1.000
Total score, mean (*SD*)	5.30 (4.20)	7.97 (5.64)	4.88 (3.75)	< 0.001	5.04 (4.07)	5.87 (4.41)	0.001	6.49 (4.34)	5.07 (4.18)	5.62 (4.03)	< 0.001	5.16 (3.96)	5.52 (4.54)	0.131

Fisher's exact test was conducted to compare each factors; *SD*, standard deviation.

Table 5
The most recent concussion reporting behaviors and presentation symptoms tendency in college student.

	Total	Sex			Level of Participation		*p-value*
		Males	Females	*p-value*	Collegiate	Non- collegiate	
Concussion reporting behaviors ($n = 136$)							
disclosure	87 (64.0)	62 (45.6)	25 (8.4)	0.355	72 (52.9)	15 (11.0)	< 0.001
nondisclosure	49 (36.0)	38 (28.0)	11 (8.1)		33 (24.3)	16 (11.8)	
Concussion disclosure variable ($n = 87$)							
Reporting authoritative figure [select all that apply]							
Athletic Trainers	17 (19.5)	15 (24.2)	2 (8.0)	0.134	17 (23.6)	0 (0.0)	0.036
Coaches	72 (82.8)	50 (80.6)	22 (88.0)	0.539	60 (83.3)	12 (80.0)	0.717
Parents	44 (50.6)	30 (48.4)	14 (56.0)	0.637	38 (52.8)	6 (40.0)	0.408
Teammate	26 (29.9)	16 (25.8)	10 (40.0)	0.206	22 (30.6)	4 (26.7)	1.000
Physicians	32 (36.8)	24 (38.7)	8 (32.0)	0.629	27 (37.5)	5 (33.3)	1.000
The first examined healthcare provider [select one]							
Physician	61 (70.1)	44 (71.0)	17 (68.0)	0.341	50 (69.4)	11 (73.3)	0.555
Athletic Trainer	13 (14.9)	11 (17.7)	2 (8.0)		12 (16.7)	1 (6.7)	
Paramedic	6 (6.9)	4 (6.5)	2 (8.0)		5 (6.9)	1 (6.7)	
Nurse	2 (2.3)	1 (1.6)	1 (4.0)		1 (1.4)	1 (6.7)	
None	5 (5.7)	2 (3.2)	3 (12.0)		4 (5.6)	1 (6.7)	
Visiting hospital within 24 h from injury							
Yes	69 (79.3)	50 (80.6)	19 (76.0)	0.771	57 (79.2)	12 (80.0)	1.000
Return-to-play duration							
Immediately (within 30 min)	14 (16.1)	10 (16.1)	4 (16.0)	0.501	8 (11.1)	6 (40.0)	0.508
A day later	38 (43.7)	23 (37.1)	15 (60.0)		33 (45.8)	5 (33.3)	
2–3 days	4 (4.6)	4 (6.5)	0 (0.0)		4 (5.6)	0 (0.0)	
4–7 days	19 (21.8)	14 (22.6)	5 (20.0)		15 (20.8)	4 (26.7)	
8–14 days	6 (6.9)	5 (8.1)	1 (4.0)		6 (8.3)	0 (0.0)	
15–21 days	2 (2.3)	2 (3.2)	0 (0.0)		2 (2.8)	0 (0.0)	
1 month ~	4 (4.6)	4 (6.5)	0 (0.0)		4 (5.6)	0 (0.0)	
RTP decision made personnel							
Athlete himself/herself	40 (46.0)	28 (45.2)	12 (48.0)	1.000	34 (47.2)	6 (40.0)	0.442
Coaches	2 (2.3)	2 (3.2)	0 (0.0)		1 (1.4)	1 (6.7)	
Physicians	30 (34.5)	21 (33.9)	9 (36.0)		23 (31.9)	7 (46.7)	
Athletic Trainers	12 (13.8)	9 (14.5)	3 (12.0)		11 (15.3)	1 (6.7)	
Supervising teacher	3 (3.4)	2 (3.2)	1 (4.0)		3 (4.2)	0 (0.0)	

RTP: return-to-play.

rugby union athletes reported a history of diagnosed SRCs (Fig. 1). A total of 206 participants answered "unsure" to previous SRC history (136 males and 70 females). This was consisted of 13.4% of collegiate and 16.8% of non-collegiate in males, 16.2% of collegiate and 17.5% of non-collegiate in females. Among all 1 344 participants, 10.1% had previous SRC history and 15.3% had previous unawares SRC history.

Sport-related SRC prevalence during the academic year 2016–2017

SRC prevalence was 2.68 (95% *CI*: 1.88–3.69) across all sports (Tables 2 and 3). Rugby union athletes had the highest SRC rate ($n = 11$). SRC prevalence was 33.3 (95% *CI*: 17.96–51.83) in rugby union and 8.33 (95% *CI*: 1.03–27.00) in women's soccer.

Reporting behaviors

SRC reporting behaviors

SRC reporting behavior was examined in 136 participants who had previously experienced a SRC (Table 5); of these 87 and 49 participants (64% and 36%, respectively) had and had not disclosed SRC at the time of injury, respectively. A significant difference was found between levels of participation ($p < 0.001$), as 72 collegiate athletes and 33 non-collegiate athletes had disclosed the SRC. No difference was found between sexes.

Reporting authoritative figure

Of the disclosing participants, 72 (82.8%) reported to coaches. The authoritative figure to whom SRC was reported differed betweencollegiate and non-collegiate athletes; owing to the limitation of access to ATs, only collegiate athletes reported to ATs.

Initial examiner

Among the 87 disclosing participants, physicians were the most common first healthcare providers (70.1%; Table 5). In total, 79.3% of these participants visited a medical facility within 24 h of the injury. A total of 14 participants returned to play immediately within 30 min. Most participants (43.7%) returned a day later. The RTP decision was most frequently made by the players themselves (46.0%), followed by physicians (34.5%).

Reported SRC signs and symptoms

All 87 disclosing participants experienced drowsiness and irritability and felt more emotional (Table 6). Headache was the fourth most common symptom reported in SRC-disclosing participants (67.8%). Sadness and sensitivity to light were the least experienced symptoms. In terms of sex and level of participation, no significant differences were found in any symptoms.

Discussion

Before 2019, there was no organization in Japan equivalent to the National Collegiate Athletic Association (NCAA) in the United States. The medical support system varied depending on the university and sports. As a result, safe and secure medical care in sports was lagging behind such as low rate of concussion education and access to ATs.

Table 6
Reported sport-related concussion symptoms.

Symptoms	Total	Sex		*p-value*	Level of participation		*p-value*
		Males	Females		Collegiate	Non-collegiate	
	(*n* = 87)	(*n* = 62)	(*n* = 25)		(*n* = 72)	(*n* = 15)	
Headache	59 (67.8)	46 (74.2)	13 (52.0)	0.074	51 (70.8)	8 (53.3)	0.229
"Pressure in head"	14 (16.1)	8 (12.9)	6 (24.0)	0.213	13 (18.1)	1 (6.7)	0.448
Neck Pain	21 (24.1)	14 (22.6)	7 (28.0)	0.591	20 (27.8)	1 (6.7)	0.104
Nausea	39 (44.8)	28 (45.2)	11 (44.0)	1.000	32 (44.4)	7 (46.7)	1.000
Vomiting	13 (14.9)	9 (14.5)	4 (16.0)	1.000	9 (12.5)	4 (26.7)	0.226
Dizziness	39 (44.8)	24 (38.7)	15 (60.0)	0.096	31 (43.1)	8 (53.3)	0.572
Blurred vision	16 (18.4)	10 (16.1)	6 (24.0)	0.380	12 (16.7)	4 (26.7)	0.463
balance problems	28 (32.2)	16 (25.8)	12 (48.0)	0.074	24 (33.3)	4 (26.7)	0.765
Sensitivity to light	2 (2.3)	2 (3.2)	0 (0.0)	1.000	2 (2.8)	0 (0.0)	1.000
sensitivity to noise	4 (4.6)	3 (4.8)	1 (4.0)	1.000	3 (4.2)	1 (6.7)	0.538
feeling slowed down	5 (5.7)	5 (8.1)	0 (0.0)	0.316	4 (5.6)	1 (6.7)	1.000
feeling like "in a fog"	6 (6.9)	6 (9.7)	0 (0.0)	0.176	5 (6.9)	1 (6.7)	1.000
"Don't feel right"	9 (10.3)	6 (9.7)	3 (12.0)	0.712	8 (11.1)	1 (6.7)	1.000
Difficulty concentrating	6 (6.9)	4 (6.5)	2 (8.0)	1.000	6 (8.3)	0 (0.0)	0.584
Difficulty remembering	13 (14.9)	8 (12.9)	5 (20.0)	0.508	10 (13.9)	3 (20.0)	0.690
Fatigue or low energy	5 (5.7)	4 (6.5)	1 (4.0)	1.000	5 (6.9)	0 (0.0)	0.582
Confusion	12 (13.8)	7 (11.3)	5 (20.0)	0.314	10 (13.9)	2 (13.3)	1.000
Drowsiness	87 (100.0)	62 (100.0)	25 (100.0)	NA	72 (100.0)	15 (100.0)	NA
Trouble falling asleep	3 (3.4)	1 (1.6)	2 (8.0)	0.197	3 (4.2)	0 (0.0)	1.000
More emotional	87 (100.0)	62 (100.0)	25 (100.0)	NA	72 (100.0)	15 (100.0)	NA
irritability	87 (100.0)	62 (100.0)	25 (100.0)	NA	72 (100.0)	15 (100.0)	NA
Sadness	1 (1.1)	0 (0.0)	1 (4.0)	0.287	1 (1.4)	0 (0.0)	1.000
Nervous or Anxious	4 (4.6)	3 (4.8)	1 (4.0)	1.000	4 (5.6)	0 (0.0)	1.000

Fishers' exact test was conducted for statistical analysis.
NA; not applicable.

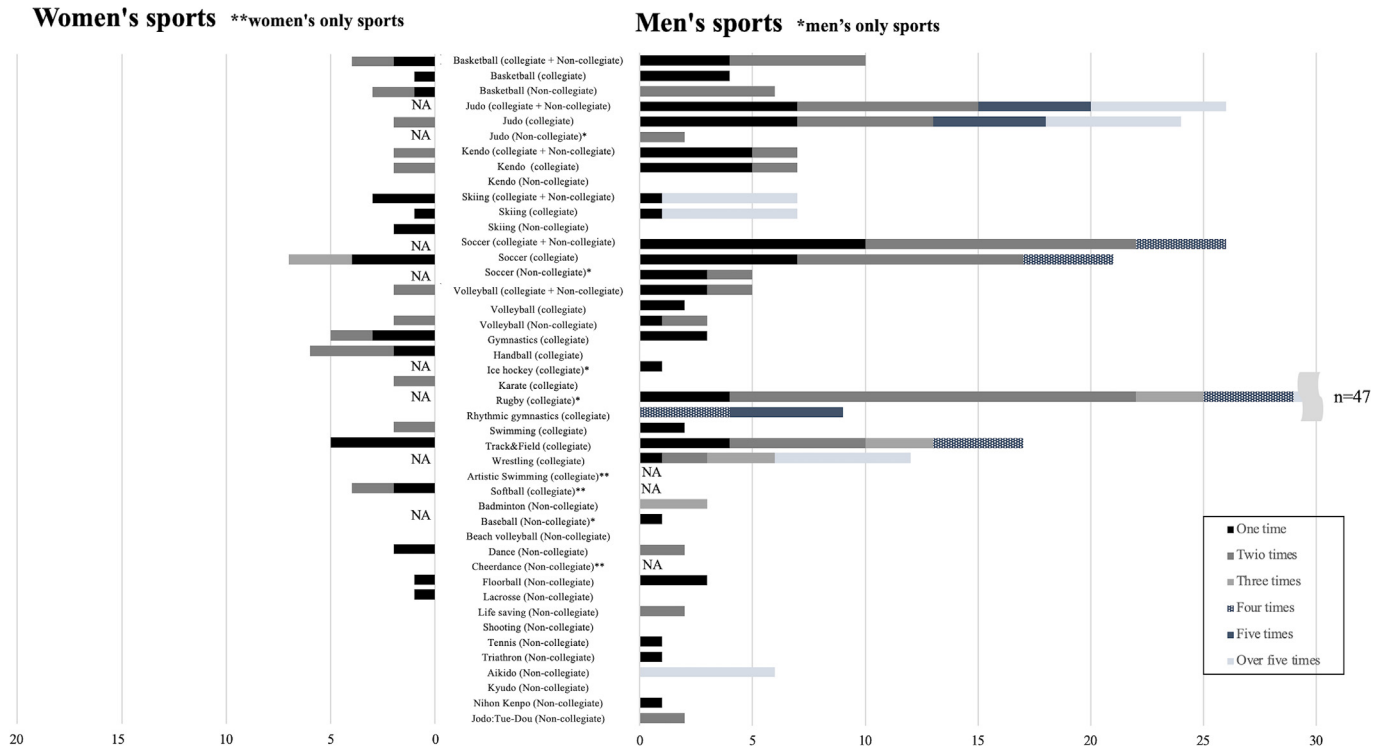

Fig. 1. Total number of previous Sports-related SRCs history by sports.

SRC education in Japan

While BLS training has been widely spread in Japan as 75% of Japanese laypeople answered previous BLS training experience,[23] SRC education rate in Japan has not known. Therefore, previous experience in BLS training and SRC education was asked to compare. In this study, only 13.6% of student-athletes had previous education in SRC compared with 84.8% of participants who had received BLS training. SRC education should be mandatory, especially for high-risk sport participants. Approximately 45.5% of male participants who played rugby, one of the high-risk sports, had received SRC education, but the rate of SRC education in judo athletes seems low (24.5%). An educational lecture in SRC improved the knowledge of college athletes.[24] Guidelines and regulations are depending on the sports, for example, the All Japan Judo Federation created protocol for head trauma in Judo, and the International Rugby Board changed the regulation.[25] Public awareness of SRC in

professional sports has recently begun, and college sports are rapidly leading the change with The Japan Association for University Athletics and Sport (UNIVAS).

Previous history of diagnosed SRCs

Approximately 10.1% of 1 344 student-athletes had experienced a SRC, including 10.8% of male and 8.6% of female participants. Males reported having experienced more SRCs than females, especially in Rugby Union. Contact sports account for most SRCs.[26]

The occurrence of SRCs in rugby union is notable. In judo, 40 cases of 88 sports-related catastrophic head injuries were reported among students aged 7–18 years over 14 academic years.[27] In college setting, mechanism of SRC is primary known as player and equipment contact.[2,28,29] Largest rate was seen by player contact in males and equipment contact in females.[2] Depending on sports, primary mechanism has been differed: player contact in football and males basketball, equipment contact in males baseball, surface contact in females gymnastics.[2]

Knowledge

Similar to our finding that 59.3% of all participants identified headache as a symptom of SRC, previous findings have reported that headache is the most commonly recognized symptom of SRC.[18] Most of these studies included populations who already had a SRC education, but only 13.6% in our study had had previous education in SRC. This indicates that headache is widely known as a key symptom of SRC regardless of educational experience, as 58.1% chose headache in the non-educated group. In other words, general population may misinterpret an injury without a headache. Nausea and amnesia are the most commonly missed SRC symptoms among coaches and high school athletes.[22,30] In contrast, in our study, nausea was the second highest chosen symptom. At medical facility in Japan, patients are often asked to come back or seek medical attention again when they feel nausea after head injury. We think this is why Japanese college student considered nausea as one of SRC symptoms.

Approximately 76.5% of athletes with a previous diagnosed SRC selected dizziness as the most common symptom. Similarly, 74.8% of high school students who had sustained a SRC reported dizziness.[26] Athletes who had experienced a SRC were better at recognizing its symptoms. Usually dizziness is seen after the head trauma. If the symptoms of dizziness are transient and disappear, we choose to continue observation. If the dizziness persists, we will visit a nearby medical facility and perform a head CT or MRI scan. The following signs and symptoms were not well known: feeling slowed down, having trouble falling asleep, and feeling more emotional. Education regarding signs and symptoms of SRC would not affect the reporting behavior, but it is still crucial to emphasize that a concussed patient would present symptoms other than headache.

Sport-related SRC prevalence during the academic year 2016–2017

During a single academic year, 36 SRCs were reported in total. In a similar setting, 51.5 SRCs per 10 000 students were reported.[31] We found a SRC prevalence of 2.68 (95% *CI*: 1.82–3.54) across all sports.

Reporting behaviors

Disclosure and nondisclosure

In total, 64% of all participants reported a SRC, including 68.6% (n = 72/105) of collegiate athletes and 48.4% (n = 15/31) of non-collegiate athletes, suggesting that a higher proportion of collegiate athletes tended to disclose a SRC than non-collegiate athletes. In the recent study, following factors may result in non-disclosure: high-risk sport, male sex, SRC knowledge, history of diagnosed SRC and pressure from coaches,[18] In addition to that, we think access to AT and coaches is also a factor in Japan. In Japan, access to AT is very limited and not all team have medical access every activity day. In our study, some of non-collegiate athletes, such as clubs and circle, have limited access to both ATs and coaches due to recreational activity, which is one of the reasons. Collegiate athletes can speak to coaches continuously. However, previous study indicated that one in five student-athletes felt pressured by coaches, especially after a head impact injury.[9] Athletes have to deal with how coaches react, which may lead to not being able to play.[18] Previous study indicated that SRC culture in team depended on the coach.[32] Intention to SRC disclose is affected by coach. Therefore, education to coaches is of significant important. No only to good understanding of SRC knowledge, but also creating good team SRC culture and open communication environment is important educate to make sport safety setting.

In total, 36% of 136 participants who did not report a SRC, which was similar to the percentage reported by Kerr et al.—33.2% of 214 former athletes did not disclose a SRC.[33] Females tend to have a low rate of nondisclosure (14.9%).[33] However, we found that 30.6% of 36 females and 38% of 100 males did not disclose a SRC. The most frequently cited reason for nondisclosure in collegiate club-sport athletes and high school athletes in previous studies was that "they did not think it was serious."[16,21] Moreover, among higher-level sports participants, 78.9% of retired NCAA varsity athletes stated that "they did not want to leave the game/practice" in progress.[33]

It is known that SRC knowledge does not affect reporting behaviors although participants recognize the signs and symptoms of SRC.[16] Increasing reporting behaviors and recognition would not be considered SRC knowledge.[16,21,22] We found the disclosure group demonstrated higher knowledge in 17 items of 25 items regarding accurate identification of SRC signs and symptoms than the nondisclosure group. A moderate-to-high SRC knowledge (true or false questions in recognition of 29 SRC signs and symptoms and knowledge regarding general, multiple concussion, and RT) was seen in collegiate club-sport athletes, but they did not use the knowledge to identify a concussive injury, as 22.7% of participants had not disclosed SRC because of initial failure to recognize a concussive injury.[16]

Medical access and return-to-play decision

In our study, 79.3% of athletes went to a hospital within 24 h after having sustained an injury. ATs accounted for 71.3% of the initial examiners,[34] but we found only 14.9%. Four reasons for ATs are absence on site in Japan.

(1) The economic burden on the employer is large in Japan.

Although few trainers are contracted on a full-time basis, most ATs are employed as a part-time (1–3 times a week).

(2) Difference in laws

In the US, there is a law that university high schools must employ ATCs. If the AT is at a clinic in an educational institution, it can be billed by insurance and may be involved in school health, so there is work and importance within the school depending on the state.

(3) Differences in perception of need

Many coaches need AT, but coaches often cannot clarify what they entrust to trainers. Coaches do not recognize ATs' abilities, skills, and duties. The value of AT becomes a lower priority compared to others as hiring competition coaches. Hiring ATs is an afterthought. Few coaches and employers demand the need of AT. Therefore, even if they sign a contract, it is often for a short period of time. If they cannot find a good AT, they will not hire an AT afterwards.

(4) The number of sports teams themselves is decreasing

In sports such as football and rugby union, where injuries are common and the number of players is high, the need for AT is easily understood. However, the number of players themselves is decreasing, partly due to the declining birth rate and the changing attitudes of parents regarding the risk of injury. The number of players is decreasing, making it difficult to maintain and manage the teams operations themselves.

We did not investigate the mode of transport to the hospital. However, a Japanese study reported that the time taken for an athlete with SRC to arrive at a hospital was (89.0 ± 55.6) min by walk-in and (53.8 ± 36.7) min by ambulance.[35] Collegiate club-sport athletes lack immediate medical care.[16] Non-collegiate athletes lacked access to ATs owing to which they decide to go to a hospital either by themselves or with coaches. These individuals cannot have no immediate access to a healthcare professional post injury as only 5.6% of 410 collegiate club-sport athletes have an access to an AT.[16] Decisions need to be made based on their knowledge and past experience.[16] The results of previous study revealed that college club-sports athletes was unable to identify a SRC as 22.7% did not report and recognize.[16]

It is known that symptoms in 80% of SRCs disappear within 10 days,[36] but some symptoms persist for months.[1] However, we found that most of players returned to play within 7 days, whereas the median time to authorized clearance for RTP was 11 days.[34] Unfortunately, this may be owing to limited SRC education, as only 38 athletes out of 136 athletes with a previous diagnosed SRC were aware of second-impact syndrome. The diagnosis of concussion cannot be determined by visual appearance, and it is not depicted on imaging. Because it is "invisible," athletes hide it by lying in response to simple questions asked during a medical interview. Therefore, physicians who do not specialize in concussions will often approve the RTP. In these cases, the doctor's diagnosis misleads the athlete and the coaches into believing that the RTP is suitable. Since a concussion cannot be visualized, the coach has no choice but to believe what the athlete says. Images are effective in diagnosing the structure but not the function of brain. If a physician detects a brain structure issue based on imaging, it is assumed to be a brain injury or hemorrhage, and concussion is an afterthought. If functional impairment is not suspected, it is often missed during the patient's examination. Athletes, coaches, and physicians must understand that SRC is a functional issue and judge it based on the results of tests that examine function. However, effective tests have not been widely used in Japan. A baseline can be taken with SCAT5 during pre-season, and the same test can be performed post-injury to check for functional impairment, but there is no standard of taking a baseline in Japan. In addition, SCAT was introduced in Japan as a tool for medical professionals, so its use is not widespread among ATs, as they are not considered medical professionals in the culture.

About 45% of 401 college football athletes returned to play within 7–13 days, but 4.7% of them made return-to-play less than 24 h post SRC.[3] According to NCAA Injury Surveillance Program, 70.2% of 1 670 SRCs took minimum of 1 week prior to RTP.[11] Returning within 24 h could lead to presenting delayed SRC symptoms.[1] Students-athletes need days to weeks to heal symptoms.[37] In order to create safety environment, SRC suspected athlete should be away from sports. SRC education should be mandated among athletes, coaches, and referees in Japan, not only college setting, but also youth setting.

Authorized clearance for RTP was obtained in 80% of athletes, and 82.8% of authorized clearance was from physicians.[34] In contact sports, only 34.5% obtained clearance from physicians, and the other 46.0% of the RTP decisions were attributed to the players themselves. In a study conducted in the United States, the reason why students did not want to go to the doctor was because a physician clearance note is necessary for students to return to play according to SRC legislation and regulation.[21] In Japan, not all athletes and medical personnel understand return-to-play protocol. Unless athletes visit either ATs or hospital, they have to make judgement by themselves when to return and cannot follow return-to-play protocol.

Common symptoms reported

Previous studies indicated that headache was the commonly reported symptom, as over 90% of high school athletes experienced it,[26,38] and 23 in 38 athletes with SRC in a Japanese study complained of headache.[35] In NCAA Injury Surveillance Program, 88.8% of males and 93.8% of females reported headache.[12] We found that 67.8% of our population experienced headache (74.2% in males and 52.0% in females, $p = 0.074$). Drowsiness, being more emotional, and irritability were experienced in our study; however, 37.1% and 21.8% of athletes reported drowsiness and irritability, respectively.[12] In college setting, headache, dizziness and difficulty concentrating were highly reported in males, while headache, dizziness and sensitivity to light were highly reported in females.[12] The least frequent symptoms reported in our study were sadness (1.1%) and sensitivity to light (2.3%). However, 52% of NCAA athletes experienced sensitivity to light.[12]

Conclusion

Rugby Union had the highest SRC rate among Japanese college student-athletes. Drowsiness was the most reported symptom in this population. Non-disclosure rates were similar to previous studies, and reporting rates were higher among collegiate student-athletes with access to medical care than among non-collegiate athletes with lack of medical access. For athletes with insufficient knowledge of SRC, knowledge of SRC is an important factor in early detection of SRC. However, this study found very low rates of concussion education in Japan. A change in education in SRC in Japanese sports is necessary. Dissemination of concussion education is essential in the future to recognize concussion earlier, create concussion culture in team, and mainly prevent severe concussive injury.

Submission statement

All authors have read and agree with manuscript content. This manuscript has not been published and is not under consideration for publication elsewhere.

Ethical approval statement

The study was approved by the Institutional Review Board at Kokushikan University under the registration number 16-MJ001. Informed consent was obtained from each participant.

Authors' contribution

Shota Tanaka: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing. **Ryo Sagisaka:** Visualization, Formal analysis, Writing - review & editing. **Etsuko Sone:** Investigation. **Hideharu Tanaka:** Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Writing – review & editing.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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