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Question Format Matters: Do Athletes Really Know the Signs and Symptoms of a Sport-Related Concussion?

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Authors of previous studies commonly used a multiselect checklist method to assess an athlete's ability to recognize true sport-related concussion (SRC) signs and symptoms (S&S) among incorrect distractor options. However, this may overinflate the evaluation of participants' knowledge because the multiselect method does not test athletes' ability to retrieve knowledge from their long-term memory. To examine this hypothesis, we sent an online survey to registered members of the Japan Lacrosse Association (n = 8530) to assess differences in reported SRC S&S by open-ended-question and multiselect formats. We also evaluated whether previous exposure to SRC education and a history of SRC influenced athletes' SRC S&S knowledge. The numbers and proportions of responses were calculated using descriptive statistics. The Pearson correlation was calculated to analyze the relationship between scores from the 2 question formats. Unpaired-samples *t* tests were conducted to compare the mean scores for each question format by previous SRC education and history of diagnosed SRC. Odds ratios were computed to express the relationship between the proportion of correct answers by question format per symptom. The response rate of the survey was 35.9% (n = 3065), and scores from the 2 question formats were correlated ($r = 0.34$, 95% CI = 0.31, 0.37; $P < .001$). For both question formats, athletes with previous exposure to SRC education and a history of SRC had a greater number of correct answers; however, the mean differences were trivial. Researchers and clinicians should acknowledge the difference between multiselect (recognition) and open-ended (free recall) formats when assessing one's understanding of SRC and managing athletes with a suspected SRC.

Key Words: injury awareness, concussion identification, health literacy

Key Points

- Multiselect and open-ended question formats resulted in dissimilar responses about sport-related concussion signs and symptoms among Japanese lacrosse athletes.
- To assess the retention and retrieval of knowledge regarding sport-related concussion signs and symptoms from athletes' long-term memory, future researchers should consider the use of open-ended questions.

Sport-related concussion (SRC) has been studied extensively in the past decade, and various professional statements[1–3] have emphasized the importance of elevating athlete awareness and knowledge about SRC through education. Authors of previous studies of SRC knowledge and education intervention effectiveness have commonly used a multiselect checklist item to assess an athlete's ability to recognize true signs and symptoms (S&S) among incorrect distractor options.[4–6] Although this method may identify the athlete's ability to recognize SRC S&S from a list, an open-ended recall question format may be more suited to identifying the ability to retrieve appropriate SRC S&S from long-term memory (ie, existing knowledge).[7] *Recognition* is one's ability to identify subject matter through the process of familiarity, whereas *retrieval* of knowledge or *recall* refers to one's ability to search the relevant information in long-term memory and is influenced by the extent to which the person was exposed to the information previously.[8] Consequently, earlier investigators who focused on the recognition of SRC S&S may not have comprehensively assessed athletes' true understanding.

Kerr et al[9] examined the knowledge of SRC S&S among parents of US middle school–aged children (10 to 15 years old) using a multiselect item and an open-ended question format. Parents were able to identify more SRC S&S when asked via the multiselect item, which may indicate that the question format can influence the S&S knowledge score. Furthermore, the patterns and frequencies of answers were also different between the 2 assessment methods; the top 3 answers via the multiselect approach were dizziness (90.2%), blurred vision (87.4%), and balance problems

(86.4%), whereas in the open-ended question format, they were headache (49.5%), dizziness (44.4%), and nausea or vomiting (28.0%).[9] If the inflation from the multiselect question format is also observed in athletes, it could potentially influence our degree of confidence in an athlete's ability to identify and self-report an SRC. However, to our knowledge, no researchers have directly addressed the influence of question type in SRC S&S assessment among athletes.

In addition, most studies with results that supported the SRC consensus statement[1] were conducted in North America and Europe. Exploration of the understanding of SRC among athletes in Asia, which has much less organizational and societal exposure to SRC information, is urgently needed.[10] Therefore, the primary aim of our study was to examine if differences existed in SRC S&S answers between 2 modes of assessment among collegiate athletes in Japan. We also assessed whether previous exposure to SRC education and a history of SRC influenced athletes' SRC S&S knowledge.

METHODS

We conducted a cross-sectional survey to examine the SRC knowledge of collegiate lacrosse athletes in Japan. An online survey (Qualtrics) was sent to registered members of the Japan Lacrosse Association for the 2021–2022 academic year (n = 8530) and was open from August 2021 through September 2021. Survey questions were adapted from Beidler et al[11] with modifications in answer options to match the cultural nuances of the Japanese collegiate sports setting (eg, modifications in the list of sports played to include domestic sports, changing examples of licensed medical professionals to fit the Japanese medical system). The survey was first translated into Japanese by 2 content experts (Y.H., M.O.). It was then reviewed by 3 certified athletic trainers who were bilingual in Japanese and English for item clarity. The translated survey was tested on Japanese college students (n = 11) to verify its clarity and that the intent of the questions was delivered accurately.

We first asked an open-ended question that required the athletes to list SRC S&S so that we could evaluate their knowledge under free-recall conditions. The next item measured athletes' level of understanding of common SRC S&S using a list of 34 options,[4] in which 20 were true S&S (eg, confusion, headache, amnesia) and 14 were incorrect distractors (eg, fever, joint stiffness, bleeding from the nose). Athletes were asked to select all S&S that they believed were associated with SRC and were not informed about the presence or number of false options on the list. The survey format restricted athletes from changing answers in the open-ended questions once they proceeded to the multiselect item. In the same survey, previous exposure to SRC education (*yes* [EDU_{YES}], *no*, or *I do not know* [EDU_{NO}]) and previous history of diagnosed SRC (*yes* [HX_{YES}], *no* [HX_{NO}]) were queried using multiple-choice questions.

The open-ended answers were first coded using text-mining software (KH Coder 3) to identify clusters of similar terms. Clusters of terms representing similar concepts were then merged to form a category (ie, SRC S&S). To allow comparisons against the multiselect answers, the list of 34 S&S served as the main category names when open-ended answers fit in them. Open-ended answers that fell outside of the 34 S&S categories were labeled a new category and counted separately. Open-ended answers that fell outside of the main category were assessed by Y.H. and M.O. to determine whether the reported S&S were correct or incorrect.

All data were analyzed using SPSS (version 27; IBM Corp). The number and proportions of responses by participants were calculated using descriptive statistics. Pearson correlation was used to analyze the relationship between scores from the 2 question formats; to prevent inflation in the number of correct answers that only appeared in open-ended answers, we counted open-ended answers that fell within the 20 correct S&S categories for this comparison. Unpaired-samples *t* tests were used to (1) compare the means of the numbers of correct and incorrect answers in the list format between participants who responded *I do not know* and participants who responded with at least 1 sign or symptom in the open-ended question and (2) compare the means of correct answers by previous SRC education and history of diagnosed SRC. Furthermore, in all S&S with at least 5 responses in the open-ended question, we compared the proportion of correct answers by question type per symptom and calculated its odds ratio using the McNemar test. Mean difference (MD), 95% CIs, and Cohen *d* for effect sizes were calculated where appropriate. Statistical significance was set a priori at $<.05$. This study was approved by the Human Research Ethics committee of Waseda University (#2021-095).

RESULTS

The response rate of the survey was 35.9% (n = 3065), with 71.9% (n = 2203; of these, 548 [24.9%] answered *I do not know*) reporting no previous exposure to SRC education (EDU_{NO}) and 92.3% (n = 2829) reporting no history of diagnosed SRC (HX_{NO}). Scores from the open-ended question and multiselect formats were moderately correlated ($r = 0.34$, 95% CI = 0.31, 0.37; $P < .001$).

Open-Ended Question

For the open-ended question, 4.5% (n = 137) of athletes responded *I do not know*. After these respondents were excluded, the average number of correct true S&S reported was 1.6 ± 1.2 (minimum = 0, maximum = 10, median = 1). Only 15 (0.5%) participants reported at least 1 false distractor that corresponded to 1 of those in the multiselect item. The top 5 true SRC S&S open-ended responses were *headache* (34.1%, n = 999), *nausea or vomiting* (33.0%, n = 966), *loss of consciousness* (28.4%, n = 832), *dizziness* (28.3%, n = 828), and *memory loss* (15.7%, n = 459; Table, Figure). Apart from the 34 S&S included in the multiselect options, the top S&S open-ended responses were *collapse or inability to get up* (true; 8.3%, n = 242), *muscle spasm* (false; 4.4%, n = 129), *slurred speech* (true; 3.8%, n = 110), and *lightheadedness* (true; 3.6%, n = 106).

Multiselect Question

On the multiselect SRC S&S question, the average number of correct true S&S answers was 8.1 ± 4.4

Table. Sport-Related Concussion Signs and Symptoms Reported by Japanese Collegiate Lacrosse Athletes (N = 3065) by Question Format Type

Signs and Symptoms Options	Distractor Options	Answer Format, No. (%)		Odds Ratio (95% CI)
		Multiselect	Open Ended	
Dizziness		2769 (90.3)	828 (28.3)	132.4 (78.2, 223.9)
Feeling off balance		2740 (89.4)	435 (14.9)	257.1 (133.6, 494.8)
Headache		2267 (74.0)	999 (34.1)	14.6 (11.8, 18.0)
Memory loss		1896 (61.9)	459 (15.7)	47.4 (33.2, 67.6)
Blurred vision		1729 (56.4)	120 (4.1)	65.4 (44.0, 97.0)
Loss of consciousness		1703 (55.6)	832 (28.4)	4.5 (3.9, 5.1)
Nausea or vomiting		1480 (48.3)	966 (33.0)	3.7 (3.2, 4.4)
Confusion		1382 (45.1)	6 (0.2)	NA
Feeling slowed down		1323 (43.2)	88 (3.0)	33.5 (24.3, 46.3)
Fatigue or low energy		1114 (36.3)	46 (1.6)	63.8 (39.5, 103.0)
Difficulty breathing	X	1072 (35.0)	10 (0.3)	NA
Ringing in the ears		1062 (34.6)	39 (1.3)	342.0 (110.1, 1062.2)
In a fog		978 (31.9)	0 (0.0)	NA
Difficulty concentrating		943 (30.8)	14 (0.5)	465.5 (116.2, 1864.1)
Numbness or tingling in arms	X	807 (26.3)	0 (0.0)	NA
Sensitivity to light		782 (25.5)	6 (0.2)	NA
Bleeding from nose	X	540 (17.6)	3 (0.1)	NA
Sleep problems		534 (17.4)	3 (0.1)	NA
Sensitivity to sound		487 (15.9)	2 (0.1)	NA
Sharp, burning pain in the neck		459 (15.0)	8 (0.3)	452.0 (63.5, 3215.9)
Drowsiness		417 (13.6)	11 (0.4)	NA
Weakness in neck movements	X	413 (13.5)	0 (0.0)	NA
Fever	X	362 (11.8)	1 (0.0)	NA
Feeling more irritable or angry		344 (11.2)	5 (0.2)	NA
Feeling more emotional (sad, anxious)		302 (9.9)	5 (0.2)	298.0 (41.8, 2122.6)
Joint stiffness	X	248 (8.1)	0 (0.0)	NA
Stiff back	X	205 (6.7)	0 (0.0)	NA
Bleeding from the ears	X	189 (6.2)	0 (0.0)	NA
Chest pain	X	177 (5.8)	0 (0.0)	NA
Abnormal sense of taste	X	154 (5.0)	0 (0.0)	NA
Black eye	X	146 (4.8)	1 (0.0)	NA
Bleeding from mouth	X	127 (4.1)	0 (0.0)	NA
Abnormal sense of smell	X	118 (3.8)	0 (0.0)	NA
Skin rash	X	66 (2.2)	0 (0.0)	NA

Abbreviation: NA, not available.

(minimum = 0, maximum = 20, median = 8), and the average number of selected incorrect distractor answers was 1.5 ± 2.3 (minimum = 0, maximum = 14, median = 1). The top 5 selected true S&S were *dizziness* (90.3%, n = 2769), *feeling off-balance* (89.4%, n = 2740), *headache* (74.0%, n = 2267), *memory loss* (61.9%, n = 1896), and *blurred vision* (56.4%, n = 1729; Table, Figure). Overall, 60.4% (n = 1850) of athletes chose at least 1 distractor answer, with the most popular incorrect selections being *difficulty breathing* (35.0%, n = 1072) and *numbness or tingling in arms* (26.3%, n = 807).

Individuals who responded *I do not know* to the open-ended question recognized fewer SRC S&S than others in the multiselect question (MD = 2.34, 95% CI = 1.6, 3.1; $P < .001$; $d = 0.5$). The average number of distractor answers selected by these 2 groups was not different (MD = 0.30, 95% CI = −0.1, 0.7; $P = .126$; $d = 0.1$).

Of the top 10 reported SRC S&S in the multiselect question, *confusion* was the only item that did not rank in the top 10 list from the open-ended question (Table). The multiselect question also resulted in greater odds of correct answers in all examined S&S (Table).

Influence of Previous SRC Education and SRC History

The number of correct answers to the open-ended question format was greater in EDU_{YES} than in EDU_{NO} (MD = 0.51, 95% CI = 0.41, 0.62; $P < .001$; $d = 0.4$) and in those with a history of diagnosed SRC (HX_{YES}; MD = 0.57, 95% CI = 0.41, 0.73; $P < .001$; $d = 0.4$) than in HX_{NO}. Similarly, the number of correct answers in the multiselect question format was greater in those with previous SRC education exposure (EDU_{YES}; MD = 1.41, 95% CI = 1.05, 1.76; $P < .001$; $d = 0.3$) than in EDU_{NO} and in those with a history of diagnosed SRC (HX_{YES}; MD = 0.64, 95% CI = 0.06, 1.23; $P = .03$; $d = 0.1$) than in HX_{NO}.

DISCUSSION

In this study, we are the first to investigate question-type differences in SRC S&S knowledge in collegiate athletes. Our findings are consistent with those of Kerr et al[9] among a sample of US parents of middle school children. The collective results of these 2 studies indicate that an open-ended item may more accurately assess an individual's true ability to retrieve previously learned SRC S&S information. Though the effect was minimal,

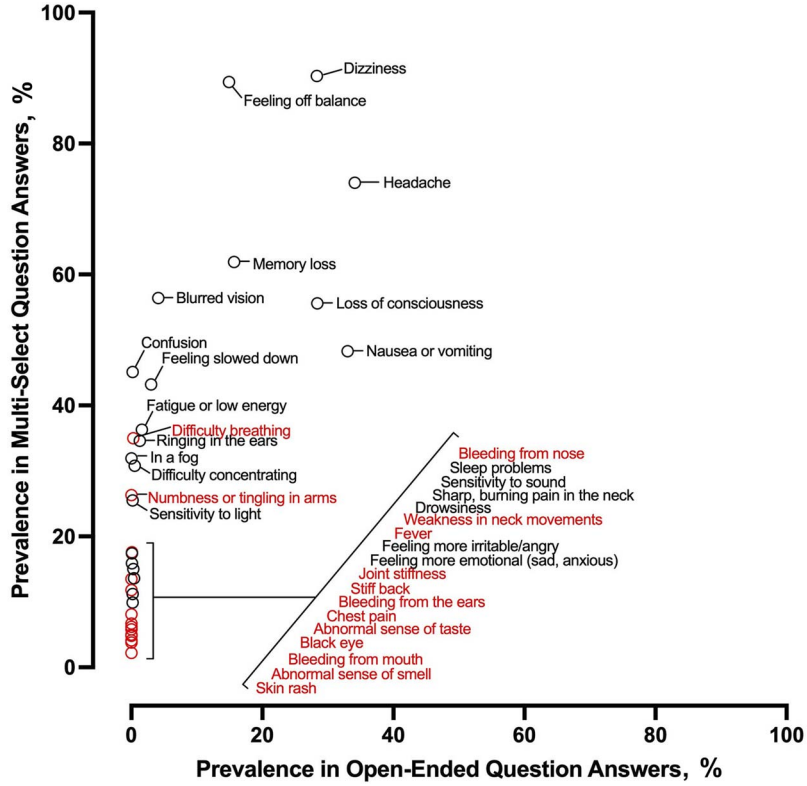

Figure. Knowledge of sport-related concussion signs and symptoms reported by Japanese collegiate lacrosse athletes (N = 3065) by question-format type. Answers reported only in the open-ended question are not shown. The items in black are true sport-related concussion signs and symptoms, whereas the items in red are distractors.

having received SRC education previously or having a history of ≥1 diagnosed SRCs may result in more robust S&S knowledge. These findings could have major implications for both SRC awareness and knowledge assessment as well as clinical applicability when considering athletes' ability to readily recognize S&S when they or a teammate sustain an SRC during sport participation.

Open-ended question and multiselect formats displayed considerable differences in the number of correct and incorrect SRC S&S reported, with a greater number of the true S&S recognized using the multiselect format (Table, Figure). This is not surprising, as recognition-question formats are well known to result in increased performance compared with free-recall items.[7] However, we also observed that the selection of incorrect distractor options increased from 0.5% to 60.4% with the multiselect format (Table). Taken together, these findings provide evidence that athletes remain confused regarding SRC S&S, athletes may be guessing when faced with multiselect items, or both. Therefore, accurate knowledge of SRC S&S may be best measured by asking an open-ended question or by also considering the identification of incorrect distractor items in the total knowledge score (eg, correctly recognized true items − incorrectly identified distractor items = true knowledge). Furthermore, it was also concerning that >130 respondents answered the open-ended item by stating that they simply did not know any SRC S&S. Although these individuals were able to identify some SRC S&S using the multiselect format, their recognition of these answers does not translate to the ability to freely recall the information from long-term memory. These results warrant a reevaluation of the utility of the previous literature in which authors found acceptable SRC S&S knowledge in athletes using the multiselect item format. Clinically, this gap emphasizes the importance of using both approaches to conduct a multifaceted evaluation of SRC S&S, such as asking injured athletes to describe how they are feeling during their immediate on-field assessment (ie, open ended) and using the symptom checklist included in the Sports Concussion Assessment Tool (SCAT) during the SRC evaluation (ie, multiselect).[1]

When the correct SRC S&S answer list was compared between the multiselect and open-ended formats, the top 10 answers were similar except for *confusion* (multiselect: eighth popular correct answer, 45.1% [n = 1382]; open ended: 14th popular correct answer, 0.2% [n = 6]). The proportions of answers were vastly different, yet *dizziness*, *feeling off balance*, *headache*, *memory loss*, *blurred vision*, *loss of consciousness*, *nausea or vomiting*, *feeling slowed down*, and *fatigue or low energy* were present in both question formats, which covers the following symptom clusters developed by Harmon et al[2]: ocular, vestibular, cognitive, fatigue, and headache-migraine. This leaves anxiety-mood–related SRC S&S as the least recognized symptom cluster in both question formats among our participants, which agrees with previous examinations of collegiate athletes.[12,13] Although anxiety-mood–related S&S are likely to appear in combination

with other S&S,[14] future athlete education on SRC S&S should emphasize this symptom cluster to raise awareness and normalize the presence of psychological challenges after SRC.

When compared by previous exposure to SRC education, the MD in the number of correct answers was statistically different, but the magnitude of clinical relevance was questionable. This outcome may have reflected the cultural differences in the quality and frequency of SRC education in Japan compared with other countries. It was not until 2019 that evidence-based SRC information became readily available in the Japanese language.[15] Therefore, despite the reporting by some participants of EDU_{YES}, the extent and quality of the actual SRC education they received is unknown. The comparison by a history of diagnosed SRC also resulted in a statistical difference in the MD with trivial clinical relevance. Earlier researchers also failed to demonstrate a strong relationship between a history of SRC and current SRC knowledge,[16,17] so sustaining an SRC may not independently improve one's SRC knowledge despite the statistical significance we observed. Thus, investigators and health care providers should not assume that athletes who have received SRC education or sustained an SRC previously are more knowledgeable about SRC S&S based on these experiences alone.

Limitations and Future Directions

Our work was not without limitations. First, the study participants were recruited from a single sport organization (Japan Lacrosse Association) in a single geographic location (Japan). As noted, SRC awareness education is not widely mandated in Japan,[10] and access to sports medicine services is restricted in most collegiate settings. These characteristics hinder our ability to generalize our findings to countries in which athletes are more readily exposed to SRC education and SRC topics are sensationalized by local media outlets (eg, United States, Canada). Although we still expect to observe a discrepancy in the number of correct SRC S&S by question formats, the number of correct answers in both formats will likely differ in countries where SRC is a topic of public health interest. Furthermore, the questionnaire collected self-report answers, which are subject to response biases, varying levels of survey completion effort, and an inability of participants to accurately recall information. Lastly, our intention in using an open-ended question format was to shed light on the potential need to assess SRC S&S through recall, but memory recall is not a flawless model.[18] Our aim was not to suggest which question format, multiselect or open ended, is superior.

Future research is warranted to replicate the current study among diverse sport populations globally. This will help identify concussion health literacy disparities regarding S&S knowledge, which can directly affect injury-awareness approaches and injury-recognition abilities.

CONCLUSIONS

The open-ended and multiselect-question formats resulted in different SRC S&S knowledge assessments, with the possibility of inflation in the SRC recognition results via the multiselect-question format. Researchers and clinicians should acknowledge the differences between recognition and free recall when assessing one's understanding of SRC and managing athletes with suspected SRC.

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