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Original Research

Neither Personal or Teammate Concussion Experience Influences Collegiate Athletes' Attitude or Knowledge of Concussions

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Abstract

International Journal of Exercise Science 19(6): 6007, 2026. Many athletes continue choosing not to report symptoms of a concussion. While modifiable factors like attitudes and knowledge are targeted to improve reporting, evidence of their actual influence on behaviour is mixed. One purpose was to examine if a concussed player's injury influenced their own knowledge and attitudes about concussions. The second purpose was to determine the influence of a current concussion on the knowledge and attitudes of both athletes and their teammates. A longitudinal study recruited 133 collegiate varsity athletes (64 females, 69 males) from contact sports at one Canadian university, completing 201 surveys across two seasons (some completed multiple surveys: pre-season, post-season, post-concussion). Participants used a validated survey (14 attitude, 35 knowledge items). Non-parametric tests (Kruskal-Wallis, chi-squared, Wilcoxon's, McNemar) analyzed data, with $P<0.05$ significance. For direct concussion experience, overall attitude and knowledge scores did not differ. Attitude scores did not differ for the shared concussion experience but one knowledge item, 'bleeding from the nose' as a false symptom significantly decreased from 75% pre-season to 52.5% post-season (Cohen's $g = 0.41$). These findings indicate that direct or shared concussion experiences have limited impact on overall knowledge and attitudes. Coaches must become aware of athletes whose attitude toward concussion is negative or deteriorating, i.e. difficulty or reluctance to report symptoms. While low aggregate scores imply that overall education is ineffective, a negative shift in knowledge of a specific knowledge item, like 'bleeding from the nose' in teammates, further highlights the need for modified concussion education strategies.

Keywords: Reporting, education, rehabilitation, traumatic brain injuries, concussion

Introduction

Sport-related concussions have become a growing concern in today's society. Concussions are consequential and often disregarded injuries affecting many athletes.[1,2] If symptoms are ignored, left unresolved and/or athletes return to play too quickly, the risk of more severe consequences increases (i.e., increased symptoms, recovery time, and susceptibility to other injuries: musculoskeletal, or, in rare cases, brain swelling and/or death).[3–7] Even with these risks, an estimated one-half of athletes continue playing through concussion symptoms and fail to report them.[1,2,8] Many factors related to underreporting have been identified and are classified as non-modifiable risk factors (i.e. gender, age)[8,9] but some are modifiable risk factors (i.e., knowledge,

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attitude).[10] Accordingly, interventions targeting these modifiable factors have been suggested as a strategy to prevent injuries in athletes.[10] Current literature on concussion knowledge and attitudes suggests these modifiable factors can affect reporting behaviors,[10] however it is still unclear to what extent either knowledge or attitudes can actually be modified or what the effect of doing so might be.

Register-Mihalik et al found that young athletes with greater knowledge on concussions were better able to recognize the signs and symptoms and seek help however this did not necessarily result in changed behaviour which appears to be somewhat more complex.[10] In addition, a healthy attitude toward concussions resulted in higher intentions of reporting, while an unhealthy attitude drove players to continue playing and avoid seeking help.[10,11] While caution is appropriate in comparing adolescent and collegiate athletes due to variable lived experiences and environments, in general, athletes with a concussion history were observed to be somewhat more knowledgeable and able to successfully recognize more symptoms.[1] However, athletes with a concussion history were also more likely to have unhealthy attitudes and behaviours than those with no previous reported concussions.[1,11,12] While knowledge appears modifiable, the development and modification of attitudes, which seem more closely related to behaviors, remain less understood. Modifying behavior is complex and reporting decisions are influenced by psychosocial and contextual factors that can override knowledge.[1,10,13–15] External factors like institutional policies, visibility of symptoms (e.g., loss of consciousness), and athletic environment can play a greater role in reporting immediacy than individual knowledge or attitude.[8,10,14,16,17]

Attitude is defined as a "*relatively enduring organization of beliefs, feelings and behavioral tendencies towards socially significant objects, groups, events or symbols*",[18] while knowledge can be defined as "*facts, information, and skills acquired by a person through experience or education*".[19] The experience of a concussion can explain the modification of concussion knowledge in athletes[20] but formal concussion education has been shown to have variable levels of effectiveness to influence knowledge, depending on the delivery method.[21,22] Conversely, the influence of attitudes is much more difficult to predict. Bloom et al suggest the previous experience of a concussion may leave players with psychological effects and negative thoughts, thereby influencing their attitudes and behaviors in an unhealthy way.[23] For example, being removed from play,[10,11,17] disappointing teammates,[10,11,24] and a previous long recovery process[17] may be motivating factors for not reporting a concussion.

While experience appears to play a significant role in knowledge and attitude modification,[1,11,15,16,20,25] it is possible that directly experiencing a concussion is not necessary for knowledge and/or attitudes to be modified or that these changes not be confounded by the physiological effects of directly experiencing a concussion. This raises the question of whether the direct or shared (teammate) experience of a concussion influences knowledge or attitude toward concussions? Since teammates are key contributors to player recovery[26] and are likely to be present at concussive events (since concussions most likely occur during practice and competitions),[27] concussed teammates may influence players knowledge and attitudes. Therefore, one purpose was to examine how sustaining a concussion affected athletes' own knowledge and attitudes (Objective 1). The second purpose was to determine whether a concussion influenced an athlete's or their teammates' knowledge and attitudes about concussions (Objective 2). We hypothesized that knowledge would be greater in the currently concussed group while attitudes would be worse. We also hypothesized that teammate knowledge would increase and their attitude towards concussions would be worse due to their exposure to a teammate's concussion recovery.

Methods

Participants

The study involved 133 collegiate varsity athletes (64 females, 69 males) from one Canadian university. Participants were selected from the contact sports of ice-hockey, soccer, basketball, and lacrosse. The study employed a pragmatic approach to sampling this accessible population, recruiting a sample of convenience. Athletes from 1 to 6 academic years of study participated: 62 in Year 1, 45 in Year 2, 40 in Year 3, 35 in Year 4, 18 in Year 5, and 1 in Year 6. For objective one, attitude and knowledge changes of personal experience or currently concussed athletes, the inclusion criteria were: 1) collegiate varsity athletes playing contact sports, who 2) completed the pre- and post-season surveys, and, if applicable, 3) a post-concussion survey. There were no exclusion criteria. Here there were 93 participants, 16 with concussions (11 pre-season and 27 post season surveys) and 77 without concussions. For objective two, assessing the influence of a shared experience or concussed teammate, the inclusion criteria were: 1) completing both a pre- and post-season survey, 2) being an active teammate on a team with a concussed player, and 3) finishing the athletic season as a team member. There were no exclusion criteria. Here there were 40 participants, 115 pre-season surveys and 48 post season surveys. Athletes were asked to complete the survey at pre- and post-season. Additional surveys were provided during the concussion recovery. All athletes provided voluntary informed consent during their pre-season concussion baseline protocol. The study was approved by the University Research Ethics Board.

Protocol

The survey was used during two athletic seasons. A combined total of 201 surveys were returned (106 from females, 95 from males) from 133 individuals across two athletic seasons representing breakdown of the surveys rather than participants where some participants completed surveys across multiple time points (Figure 1). Once athletes consented to study participation they were emailed a link to an anonymous google form survey to be completed prior to their season (a "baseline" survey). Follow-up, post-concussion surveys (in the same format) were only provided to athletes during the second athletic season. In every case participants received a link to the form via email. The participant's email and team/sport was collected via the form. Participants were then assigned an identifier code but the team and sport was tracked. That combination allowed us to determine athlete/teammate combinations required by the study. Those who were diagnosed with a concussion within the first athletic season were asked to complete a post-concussion survey at the beginning of the second season if the concussion was resolved (3 cases). This served to determine the attitudes and knowledge for the long-term post-concussion periods. Eight participants completed 3 surveys. Of these 8, 2 completed the final survey administered in the last (Jan - April) academic term of the study, The other 6 completed intermediate surveys linked to their recovery stage. Six participants completed 2 surveys but did not complete the final survey. Again, in these cases the second survey was linked to their recovery stage. All other participants completed both the initial survey; in September-November of year 1 (54 participants) or year 2 (27 participants) and the final survey in January-Feb of year 2. (Note that because recovery is highly variable, the timing of these surveys was also highly variable): one survey was submitted mid-recovery (~ Stage 3 of concussion rehabilitation protocol) and another upon return to play/ full recovery status. Some also completed another survey 3-6 months' post-concussion for the study. This served to determine the knowledge and attitudes of the short-term post-concussion periods. Since the survey was used during two athletic seasons, some athletes completed it more than once. At the end of the second season, the surveys were sorted based on player membership to the following groups: Non-concussion group (n=163), consisting of pooling non-current and

no concussion groups, and Concussion group (n=38) as well as Pre- and Post-season for those who qualified as non concussed teammates of a concussed player. A current concussion was one that had not resolved through medical treatment.

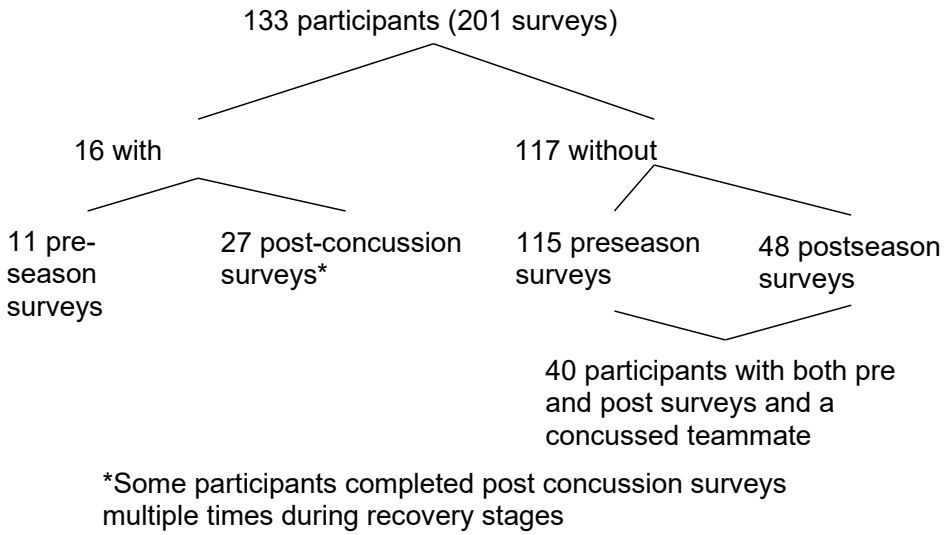

Figure 1. The distribution of surveys across the population of 133 players. Participants with no concussion were pooled with those who had no current concussion.

The survey used was developed by Register-Mihalik et al[13] and has been tested for validity and reliability (knowledge Cronbach □ = 0.72 and attitude Cronbach □ =0.80) (10). The survey consists of demographic items including name, gender, year of study and number of previous concussions. There are 14 attitude questions which seek to determine concussion attitudes based on education and reporting behaviours. A series of 35 knowledge questions follow and these are centered on concussion signs, symptoms, complications and risks to determine overall general concussion knowledge. Attitude scores were based on a 7-point Likert scale (1-7) and thus score range was 14 to 98 with a higher score indicating a more favourable and positive attitude towards concussions in relation to reporting behaviours. Scoring of knowledge was based on correct answers. If a question was answered correctly, a point was given to the individual. Scores range from 0 to 35 with a higher score representing higher knowledge of concussions.

Statistical Analysis

All of the data was assessed using statistical analysis in the R program.[28] The data items were initially tested for normality using the Shapiro-Wilk test, and for homogeneity using the Levene's test. All data was determined to be non-normal and, despite several attempts, could not be sufficiently transformed. Therefore, the data was evaluated using non-parametric tests. The Kruskal-Wallis rank sum test was used to determine differences in attitude scores between concussed and non concussed athletes but, between pre and postseason attitude scores where athletes had a teammate with a concussion a Wilcoxon Signed-Rank test was used. For the 35 individual knowledge items, a chi squared test was used to determine differences between concussed vs non concussed athletes but, between pre and post season scores of athletes who had a teammate with a concussion a McNemar test was used. In all cases, a significant difference was determined based on a P-value of alpha<0.05. While *a priori* power analysis was not conducted to determine the sample size for this study, effect sizes were calculated and reported for each test conducted (Tables 1 to 4).

Results

Concussion History Statistics

The survey recorded, by self-report, whether a single or multiple previous concussion(s) had been diagnosed. Since many athletes reported having been previously diagnosed with a concussion, our data included athletes with no concussion histories, non-current concussion histories and current concussion histories. Because the study was aimed mainly at athletes with a current concussion history which occurred during the study period, we conducted a statistical analysis to determine whether non-current concussion history could be pooled with no concussion history. Non parametric tests conducted on all of the response variables revealed no significant differences between the two groups, therefore, we pooled the non-current and no concussion history groups. The result was two groups: "Non-concussion group" (no concussion during study period) and "Concussion group" (concussion during study period).

Athlete Attitude Concussion Status Descriptive & Inferential Statistics

Having suffered a concussion did not change an athlete's attitude total score (Pre mean = 79.9; SD = 9.7; Post mean = 79.7; SD = 10.8, figure 2). For the individual items (Table 1), athletes in both groups answered that reporting a concussion was "Good", "Brave", "Beneficial", "Important" and "Valuable". For those with a current concussion as compared to those without, the difficulty associated with reporting symptoms indicated a moderate effect size and statistically compelling unadjusted p-value. ($P=0.03$; $P_{adj} = 0.47$; $\eta^2=0.024$; Table 1). Specifically, the non-concussion group had a median score of 4 for symptom reporting, while the concussion group's median was 3, suggesting a noticeable reduction in the perceived ease of this task during the acute recovery period.

Table 1. Athlete Attitude vs Concussion Statistics.

Attitude Question/ Item	x^2	P	P Holm Adj	η^2
How important you think it is to take a headache or dizziness after a blow to the head or body seriously	0.63	0.73	1	-0.0068
How important you think it is to not participate in physical activity game or practice when experiencing signs and symptoms of concussion	0.14	0.93	1	-0.0093
How important you think it is to be informed about how concussions happen	0.37	0.83	1	-0.0081
How important you think it is to be informed about how concussions can be prevented	2.28	0.32	1	0.0014
How important you think it is to be informed about what to do if you have a concussion	4.52	0.10	1	0.0126
How important you think it is to report signs and symptoms to a medical professional eg doctor athletic trainer or coach	0.20	0.91	1	-0.0090
Your level of agreement with the following statement : Athletes are undereducated about concussion	0.54	0.76	1	-0.0073
Check the box about how you feel about the following statement for each pair of words listed: For me to report possible signs and symptoms to a coach or a medical professional when I experience them				
Cowardly / Brave	0.04	0.98	1	-0.0098
Embarrassing / Pleasant	2.21	0.33	1	0.0011
Harmful / Beneficial	3.14	0.21	1	0.0057
Extremely difficult / Extremely easy	6.79	0.03	0.47	0.0239
Bad / Good	1.29	0.52	1	-0.0035
Unimportant / Important	3.48	0.18	1	0.0074
Worthless / Valuable	1.22	0.54	1	-0.0039

Attitude scores (14 items, scoring between 1 and 7) were classified in two groups: a non-concussion (NC) and concussion group (C). The median, standard deviations (SD), x^2 and P-value of a Kruskall-Wallis test were calculated between the two groups to determine if there are significant differences.

Athlete Knowledge Concussion Status Descriptive & Inferential Statistics

Knowledge percentage scores ranged from 23-100% correct for those with no concussion and 11.1-100% correct for the concussion group (figure 2). Out of the 35 knowledge items, after applying the Holm correction, none showed a significant difference between the two groups (Table 2). "Increased risk for further injury" (P=0.07; P_{adj} = 1; Cohens w = 0.14), demonstrated a medium effect size indicating that the non-concussion group tended to more frequently and correctly identify this as a complication of multiple concussions, suggesting a genuine and substantively important disparity in knowledge regarding subsequent injury risk. The effect size is considered to be medium when > 0.2 but overall the effect size was small to medium for the chi-squared test. While there was little difference between concussion groups, the results demonstrate a general lack of knowledge in both groups pertaining to many items such as amnesia, bleeding from the ear, insomnia, numbness or tingling of arms and weakness in neck movements (Table 2).

Table 2. Athlete Knowledge vs Concussion Statistics.

Knowledge item	Concussion % Correct	No Concussion % Correct	χ^2	p value	cohen's w	holm adjusted
For me to report possible signs and symptoms to a coach or a medical professional when I experience them:						
Abnormal sense of smell	82.05	72.63	1.64	0.20	0.10	1.00
Abnormal sense of taste	78.21	75.79	0.04	0.85	0.01	1.00
Amnesia	70.51	65.26	0.33	0.57	0.04	1.00
Joint stiffness	67.95	66.32	0.00	0.95	0.00	1.00
Blurred vision	98.72	97.89	0.00	1.00	0.00	1.00
Black eye	71.79	73.68	0.01	0.92	0.01	1.00
Bleeding from the ear	61.54	52.63	1.04	0.31	0.08	1.00
Bleeding from the mouth	75.64	80.00	0.25	0.61	0.04	1.00
Bleeding from the nose	61.54	71.58	1.53	0.22	0.09	1.00
Confusion	97.44	95.79	0.03	0.86	0.01	1.00
Fever	84.62	73.68	2.43	0.12	0.12	1.00
Dizziness	98.72	97.89	0.00	1.00	0.00	1.00
Headache	100.00	100.00	NA	NA	NA	NA
Insomnia	70.51	64.21	0.51	0.47	0.05	1.00
Loss of consciousness	94.87	94.74	0.00	1.00	0.00	1.00
Nausea	93.59	90.53	0.21	0.65	0.03	1.00
Numbness or tingling of arms	56.41	55.79	0.00	1.00	0.00	1.00
Skin rash	98.72	97.89	0.00	1.00	0.00	1.00
Sharp burning pain in neck	57.69	58.95	0.00	0.99	0.00	1.00
Weakness in neck movements	78.21	75.79	0.04	0.85	0.01	1.00
A concussion only occurs if you lose consciousness	100.00	100.00	NA	NA	NA	NA
If you are experiencing any signs and symptoms of a concussion after a blow to the head or a sudden movement of the body you should not return to play	91.03	90.53	0.00	1.00	0.00	1.00
A concussion is an injury to the _____ brain	73.08	67.37	0.42	0.52	0.05	1.00
Multiple concussions: Of the following, what are possible complications of having multiple concussions. Check all that apply:						

No complications exist	91.03	85.26	0.85	0.36	0.07	1.00
Increased risk of further injury	100.00	93.68	3.39	0.07	0.14	1.00
Brain damage	100.00	97.89	0.33	0.57	0.04	1.00
Joint problem	57.69	53.68	0.14	0.71	0.03	1.00
Memory problems	100.00	97.89	0.33	0.57	0.04	1.00
I don't know	91.03	85.26	0.85	0.36	0.07	1.00
Returning to play too soon: Of the following, what are complications of returning to sporting activity while still experiencing possible concussion symptoms? Check all that apply:						
No complications exist	85.90	80.00	0.67	0.41	0.06	1.00
Increased risk of further injury	100.00	96.84	1.00	0.32	0.08	1.00
Brain damage	100.00	96.84	1.00	0.32	0.08	1.00
Joint problems	73.08	66.32	0.63	0.43	0.06	1.00
Paralysis	82.05	83.16	0.00	1.00	0.00	1.00
I don't know	87.18	84.21	0.11	0.74	0.03	1.00

Knowledge scores (35 T/F items) were classified in two groups: a non-concussion and concussion group. The frequency, percentage of correct answers for each group, the Chi-Squared test and P-value, Cohen's w and the Holm adjusted P value were calculated for this comparison.

Athlete Teammate Attitudes Descriptive & Inferential Statistics

A player whose teammate suffered a concussion did not change their attitude about concussions (Pre vs Post test) (Table 3). However some of the effect sizes (rank biserial) are very large and negative indicating that most of the participants who did change their attitude score did so in the same direction; in this case post-scores were lower (indicating a less favourable and positive attitude) than the pre-scores.

Table 3. Athlete Attitude Pre vs Post Concussion for Teammates Statistics.

Attitude item	V statistic	P value	P Holm Adj	Rank biserial
how important you think it is to take a headache or dizziness after a blow to the head or body seriously	74.00	0.38	1	-0.82
how important you think it is to not participate in physical activity game or practice when experiencing signs and symptoms of concussion	140.00	0.19	1	-0.66
how important you think it is to be informed about how concussions happen	50.00	0.11	1	-0.88
how important you think it is to be informed about how concussions can be prevented	110.50	0.84	1	-0.73
how important you think it is to report signs and symptoms to a medical professional eg doctor athletic trainer or coach	82.50	0.62	1	-0.80
your level of agreement with the following statement: athletes are undereducated about concussion	190.50	0.78	1	-0.54
Check the box about how you feel about the following statement for each pair of words listed: For me to report possible signs and symptoms to a coach or a medical professional when I experience them:				
cowardly / brave	149.00	0.99	1	-0.64
embarrassing / pleasant	187.50	0.98	1	-0.54
extremely difficult / extremely easy	306.00	0.13	1	-0.25
bad / good	94.00	0.28	1	-0.77
unimportant / important	27.50	0.11	1	-0.93
worthless / valuable	157.50	0.30	1	-0.62

Attitude scores (14 items, scoring between 1 and 7) were classified in two groups to determine concussed teammate influence on players attitudes. These groups consist of: a pre-concussion survey and post-concussion survey group.

The median, standard deviations and P-value scores of a Paired Wilcoxon Signed-Rank test were calculated between the pre-season and post-season surveys of teammates to determine if there are significant differences.

Athlete Teammate Knowledge Descriptive & Inferential Statistics

None of the individual knowledge items were significantly different between groups (Table 4), except for one knowledge symptom; "Bleeding from the nose" (P=0.016, P_{adj} = 0.55) with a very large effect size of Cohen's g = 0.41. In the pre-season survey, "Bleeding from the nose" was correctly identified as a symptom in 75% of teammate surveys, whereas only 52.5% correct in the post-season (Table 4).

Table 4. Athlete Knowledge Pre vs Post Concussion for Teammate Statistics.

item name	# discordpairs	Pre correct %	Post correct %	Chi square	P value	P Holm Adj	Cohen's g
abnormal sense of smell	12	85	70	2.08	0.15	1	0.25
abnormal sense of taste	14	82.5	72.5	0.64	0.42	1	0.14
amnesia	8	70	75	0.13	0.72	1	0.13
joint stiffness	13	62.5	60	0.00	1	1	0.04
blurred vision	0	100	100	0.00	1	1	0.00
black eye	11	80	72.5	0.36	0.55	1	0.14
bleeding for the ear	9	60	52.5	0.00	1	1	0.06
bleeding from the mouth	7	85	77.5	0.57	0.45	1	0.21
bleeding from the nose	11	75	52.5	5.82	0.02	0.56	0.41
confusion	2	100	100	0.50	0.48	1	0.50
fever	8	75	70	0.13	0.72	1	0.13
dizziness	1	97.5	100	0.00	1	1	0.50
headache	0	100	100	0.00	1	1	0.00
insomnia	11	65	72.5	0.36	0.55	1	0.14
loss of consciousness	4	92.5	97.5	0.25	0.62	1	0.25
nausea	4	90	100	2.25	0.13	1	0.50
numbness or tingling of arms	16	50	45	0.00	1	1	0.00
skin rash	1	100	97.5	0.00	1	1	0.50
sharp burning pain in neck	19	45	37.5	0.00	1	1	0.03
weakness in neck movements	11	75	82.5	0.36	0.55	1	0.14
a concussion only occurs if you lose consciousness	0	100	100	0.00	1	1	0.00
if you are experiencing any signs and symptoms of a concussion after a blow to the head or a sudden movement of the body you should not return to play	7	87.5	90	0.00	1	1	0.07
a concussion is an injury to the brain	15	62.5	70	0.27	0.61	1	0.10
Multiple concussions: Of the following, what are possible complications of having multiple concussions. Check all that apply:							
no complications exist	6	82.5	92.5	1.50	0.22	1	-0.33
increased risk of further injury	2	95	100	0.50	0.48	1	0.50
brain damage	0	100	100	0.00	1	1	0.00
joint problem	13	35	37.5	0.00	1	1	-0.04
memory problems	0	100	100	0.00	1	1	0.00
i don t know	5	85	92.5	0.80	0.37	1	-0.30
Returning to play too soon: Of the following, what are complications of returning to sporting activity while still experiencing possible concussion symptoms? Check all that apply:							
no complications exist	11	77.5	85	0.36	0.55	1	-0.14

increased risk of further injury	1	100	97.5	0.00	1	1	-0.50
brain damage	2	97.5	97.5	0.00	1	1	0.00
joint problems	9	27.5	25	0.00	1	1	0.06
paralysis	8	17.5	17.5	0.00	1	1	0.00
i don t know	9	80	92.5	1.78	0.18	1	-0.28

Knowledge scores (35 T/F items) were classified in two groups: a pre-concussion survey and post-concussion survey group (40 respondents per group), to determine possible concussed teammate influence on players' attitudes. The number of discordant pairs, percentage of correct answers pre and post and P-value scores of McNemar test were calculated between the pre-season and post-season to determine if there are significant differences.

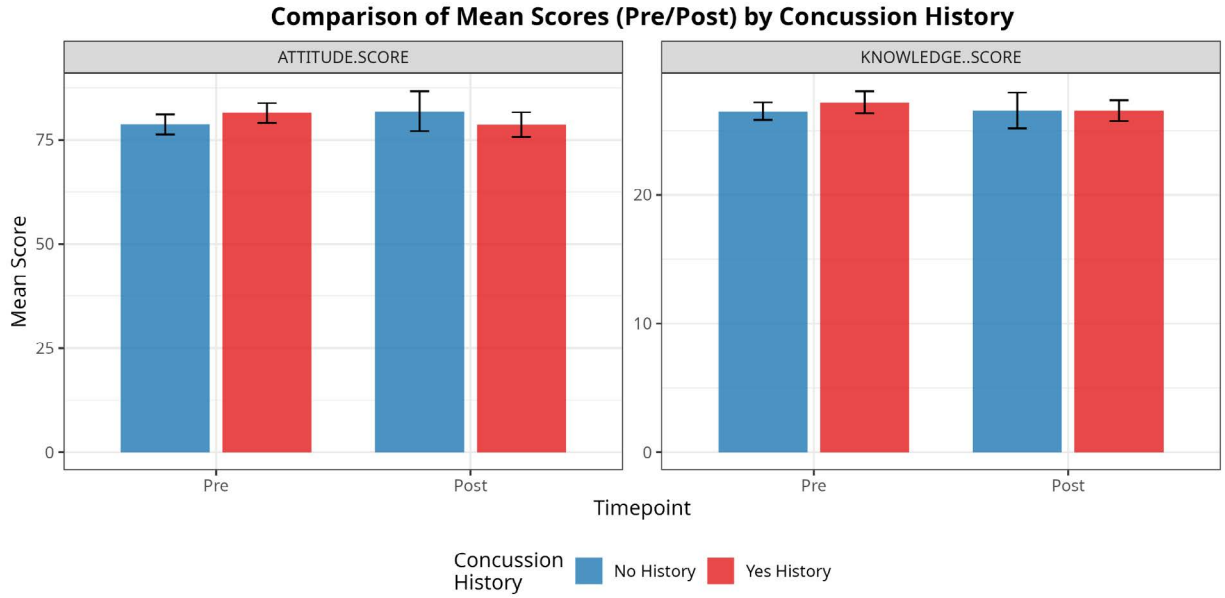

Figure 2. Comparison of mean scores by concussion history.

Discussion

Our hypothesis that concussion knowledge would increase in currently concussed athletes and these athletes would experience a more negative attitude were not supported by the results. There was no change in either total knowledge or attitude scores between athletes concussed or not, nor pre and post season. Likewise in the teammate results; between the pre and post season survey, no substantive changes occurred in the total attitude or knowledge of players whose teammate had a diagnosed concussion during the study period. It seems that the occurrence of either a direct or shared concussion experience has very little impact on either the knowledge or attitude of the concussed players or of their teammates.

Knowledge In Non-Concussed, Current Concussed and Teammate Athletes

Previous research suggests athletes with a concussion history have increased concussion knowledge due to experience.[20,29] Similarly, previously concussed athletes are more likely to have been educated about concussions, putting them in a position for improved future recognition of the occurrence and indications of a concussion.[1] Mrazic et al suggest a potential downside where these athletes would be aware of symptoms to avoid disclosing.[15] While there are conflicting results in this regard, in this study, as in a few others,[29–31] there seems to be little to no relationship between knowledge or education and reporting or even attitude/beliefs.[29,30] The evidence of this study similarly suggests no difference in concussion knowledge between athletes with or

without a concussion history.[11,32] We observed differences in three knowledge items out of 35 between the groups in our survey where the Concussion group was significantly more likely to be incorrect but the effect size was small. It is becoming increasingly clear that, while concussion education strategies may modify the knowledge of these athletes, these do not appear to modify attitude. Reporting behaviour seems to be much more dependent on social pressures, external mediation such as institutional systems (funding, therapist/player ratios) and visible symptoms (altered mental status and loss of consciousness).[16] In teammates, we found similar results; the knowledge of athletes was not influenced by teammates' concussion. Only one symptom was significantly different, with a large effect size, between the groups: bleeding from the nose ($p = 0.016$; $P_{adj} = 0.555$, Cohen's $g = 0.41$). Since over 80% of concussions likely occur during practice and competitions,[25,31] teammates are likely to be present to concussive events,[27,33] as a result there is a possibility players will associate the perceived symptoms at the time of the concussive event with actual concussion symptoms. Others have also found that reporting of concussions tends to be mediated by external factors, including externally visible symptoms.[16] However, in the present study, teammates incorrectly identified "bleeding from the nose" more often in the postseason (52.5%) than in the preseason (75%) i.e. correct responses decreased after seeing more concussions. (Table 4). Chrisman et al saw a similar effect where athletes confused the characteristics of the concussion event with actual concussion symptoms and other etiologies in given scenarios.[13] Additionally, the fast pace of competition can lead athletes to make false modifications to their concussion knowledge: athletes may mistakenly associate highly visible or dramatic signs of an injury (like bleeding from the nose, which is not necessarily a core concussion symptom) with a concussion, leading to incorrect knowledge modification.[34]

Despite the importance of players being able to correctly identify concussion symptoms, in our study, all of the athletes, including the Concussion, Non-Concussion and Teammates groups displayed knowledge deficits compared to previous research.[10,21,35] They failed to correctly identify some less frequently seen complications such as insomnia, amnesia, numbness/tingling of arms and incorrectly attributed symptoms like paralysis and joint problems. While this may be due to the delay between repeated tests, they did however, succeed in identifying the classic somatic symptoms and complications such as headache, dizziness and blurred vision. This was the case even though varsity athletes have increased participation in formal concussion education,[21] perhaps calling into question the efficacy of this type of education. In particular, nausea, amnesia and neck pain were commonly missed by our athletes, as in other studies.[10,35,36] Notably, recognition of amnesia as a symptom among athletes has been speculated to be low because they may not be familiar with the term. Utilising knowledge transfer strategies outside of formal concussion education and focusing on the commonly unrecognised symptoms might improve overall concussion knowledge in collegiate athletes but, it does not seem likely to change athlete attitudes. Chinn et al suggest potentially utilising procedural learning in the actual competition or practice setting as a feasible, but unproven, effective educational transfer strategy.[34] As well, reinforcing team knowledge through messaging at key points in time during the season can serve to prevent misassociation of symptoms and improve team knowledge.[8] Innovative education strategies may result in improving concussion knowledge however, it is also likely that these would not improve the concussion reporting rates because, as shown here, knowledge does not affect attitudes nor do concussions affect knowledge and others have shown that a lack of knowledge does not seem to be the main barrier to reporting.[13,24]

Attitudes In Non-Concussed, Current Concussed and Teammate Athletes

Athletes with a concussion history generally have a more negative (unhealthy) attitude towards

concussions.[1,11] This includes the well documented lack of or late reporting behaviour[29–31] and as reported by Baker et al[29] the disconnect between high knowledge scores, safe reporting attitudes and dangerous on-field behaviors. While we only tracked the history of concussion in the previous 2 years, attitudes in currently concussed athletes were not significantly different from those in the non-concussion group. Konstantinides[31] found that higher baseline concussion-reporting intention was significantly associated with a greater likelihood of reporting a simulated concussion but in this study a related attitude item (difficulty in reporting symptoms; $P = 0.03$; $\eta^2 = 0.0239$) remained unchanged post concussion of a teammate. However, the increased difficulty to report symptoms in those who'd had a concussion may be related to, as suggested by previous literature, a negative experience with the concussion; i.e. removal from play;[10,11,17] return to play protocol too long;[17,29,30] and/or teammates' dissatisfaction.[10–12,24] Amongst those examples, the literature strongly holds that removing a player from play is a predominant reason for non-disclosure and negativity following a concussion injury.[12–14,16,29,30] According to Balague, sport performance is a valuable attribute to an athlete's self-identity and without it, athletes can feel lost and frustrated.[37] Therefore, the inability to participate in athletic performance during concussion rehabilitation may immediately harm an athlete's self-identity, later affecting their attitude, possibly explaining the difficulty in reporting symptoms. Tracey suggests that, while some student athletes may view the concussion experience negatively, others may view it more positively i.e. "good timing" in the sense that they could then focus on their academic work.[38] This suggests, in some cases, the negative association with removal from play may be counteracted by the positive "good timing" theory suggested by Tracey et al.[38]

Hurley has suggested teammates may also be left disappointed with the injury of a player and may be susceptible to negative social contagion so as not to deviate from the team outlook.[39] For example, in a study of knee injuries, teammates who saw a player suffer a knee injury were subsequently more fearful and had worse attitudes towards this injury.[40] However, our findings are inconsistent with this. We found no significant attitude changes between the pre- and post-season survey, suggesting teammate attitudes did not change with the concussion of a team member. One possible explanation is that survey timing is important; ours may have had too much delay, which may have extended to nearly 2 years. Another possible explanation is the physical presentation of a concussion is unlike any other athletic injury (i.e. knee injury) as its impairment is not as obvious and distinguishable,[41] therefore not having as much of an effect on the teammates. In addition to concussions being "invisible", a teammate who does not experience the injury, does not understand the physical and psychological ramifications and therefore can't empathize.[42] As a result, sensitization of attitudes in teammates may not be as prevalent as we had anticipated.

The remaining attitude items were unchanged in both groups, and also tended to be moderate; neither negative or positive. This implies these athletes generally had poor concussion attitudes but Tracey has suggested that strategies such as involving a sport psychologist, could serve to help them.[38] However, changing attitudes may be difficult to do; even with the experience of a concussion or concussed teammate. Health behaviour theories suggest change is based on expected outcomes.[25] In the case of a concussion, the immediate outcome would entail being removed from play, which, as previously stated, is not a preferred outcome for most athletes. Thus, in order for an attitude change to occur, the outcome would also need to hold more positive immediate value to athletes. The longer term negative outcome of permanent damage or greater susceptibility to concussions, is less likely to positively influence an athlete's attitude (i.e., incite better reporting behaviour), particularly when, from a medical perspective, the immediate

outcome must be "negative" - removal from play. This may suggest that in conditions where return to play is initiated more quickly, athletes may exhibit more positive attitudes. While there is evidence that delayed reporting and removal from play predicts prolonged recovery,[2,43] future research efforts are encouraged to better understand how concussion attitudes in athletes can be affected positively.

The focus of this research was on university varsity athletes, hence, the results cannot be generalized to the rest of the athletic population (i.e. high school athletes and the general public). In addition, these athletes were restricted to certain sports which may limit these findings to these sports. This study did not account for personal (or positional) relationships between players which may affect the perception of injury to a teammate. The use of surveys, sent out electronically, with no face-to-face interaction may have contributed to a lower response rate. Approximately 42% of surveys were not returned. For those surveys which were returned, outcomes may have been influenced by a social desirability response bias. In addition to this there may have been unreported concussions during the study period which could have affected participant survey responses, particularly unconcussed participants. Similarly, while we attempted to track concussion history, undocumented prior concussions may have also affected survey responses. We did not calculate power a-priori for this study since we had to accept concussions as they occurred in the student athlete population, as a result we had a relatively small sample size (n=133) for survey based research. Lastly, we used a pre-existing survey which left out age and this may affect outcomes considering maturity, morals and values may differ.

Concussion reporting behaviours can be associated with modifiable factors such as concussion knowledge and attitude. These factors are not uniform and some have shown that they can change however, we found little variation in either knowledge or attitudes. Coaches should be aware that sensitization of athletes to a negative attitude may be crucial to prevent worsening of reporting. Very little knowledge fluctuation occurred in either group signifying the need to make some modification in concussion patient education, particularly when current knowledge levels lead to underreporting. Likewise, no attitude changes were seen in teammates, but at least one "knowledge of concussion symptoms" items changed indicating the need for changes in traditional education strategies. This study may help educators, coaches, athletes and health care providers understand player decision-making around concussions including the knowledge and attitudes of athletes. While this study is a step forward, research remains to be conducted to address and understand how to change athlete behaviour.

References

1. Torres DM, Galetta KM, Phillips HW, Dziemianowicz EMS, Wilson JA, Dorman ES, et al. Sports-related concussion: Anonymous survey of a collegiate cohort. *Neurol Clin Pract*. 2013;3(4):279–287. https://doi.org/10.1212/CPJ.0b013e3182a1ba22

2. Asken BM, McCrea MA, Clugston JR, Snyder AR, Houck ZM, Bauer RM. "Playing through it": Delayed reporting and removal from athletic activity after concussion predicts prolonged recovery. *J Athl Train*. 2016;51(4):329–335. https://doi.org/10.4085/1062-6050-51.5.02

3. Fino PC, Becker LN, Fino NF, Griesemer B, Goforth M, Brolinson PG. Effects of recent concussion and injury history on instantaneous relative risk of lower extremity injury in Division I collegiate athletes. *Clin J Sport Med Off J Can Acad Sport Med*. 2019;29(3):218–223. https://doi.org/10.1097/JSM.0000000000000502

4. Harada GK, Rugg CM, Arshi A, Vail J, Hame SL. Multiple concussions increase odds and rate of lower extremity injury in National Collegiate Athletic Association Athletes after return to play. *Am J Sports Med*. 2019;47(13):3256–3262. https://doi.org/10.1177/0363546519872502

5. Iverson GL, Gaetz M, Lovell MR, Collins MW. Cumulative effects of concussion in amateur athletes. *Brain Inj*. 2004;18(5):433–443. https://doi.org/10.1080/02699050310001617352

6. Signoretti S, Lazzarino G, Tavazzi B, Vagnozzi R. The pathophysiology of concussion. *PMR*. 2011;3(10S2):S359-368. https://doi.org/10.1016/j.pmrj.2011.07.018

7. Wetjen N, Pichelmann M, Atkinson J. Second impact syndrome: concussion and second injury brain complications. *J Am Coll Surg*. 2010;211(4):553-557. https://doi.org/10.1016/j.jamcollsurg.2010.05.020

8. Kroshus E, Garnett B, Hawrilenko M, Baugh CM, Calzo JP. Concussion under-reporting and pressure from coaches, teammates, fans, and parents. *Soc Sci Med*. 2015;134:66–75. https://doi.org/10.1016/j.socscimed.2015.04.011

9. Wallace J, Covassin T, Beidler E. Sex differences in high school athletes' knowledge of sport-related concussion symptoms and reporting behaviors. *J Athl Train*. 2017;52(7):682–688. https://doi.org/10.4085/1062-6050-52.3.06

10. Register-Mihalik JK, Guskiewicz KM, McLeod TCV, Linnan LA, Mueller FO, Marshall SW. Knowledge, attitude, and concussion-reporting behaviors among high school athletes: A preliminary study. *J Athl Train*. 2013;48(5):645–653. https://doi.org/10.4085/1062-6050-48.3.20

11. Register-Mihalik JK, Valovich McLeod TC, Linnan LA, Guskiewicz KM, Marshall SW. Relationship between concussion history and concussion knowledge, attitudes, and disclosure behavior in high school athletes. *Clin J Sport Med Off J Can Acad Sport Med*. 2017;27(3):321–324. https://doi.org/10.1097/JSM.0000000000000349

12. Kerr ZY, Register-Mihalik JK, Kroshus E, Baugh CM, Marshall SW. Motivations associated with non-disclosure of self-reported concussions in former collegiate athletes. *Am J Sports Med*. 2016;44(1):220–225. https://doi.org/10.1177/0363546515612082

13. Chrisman SP, Quitiquit C, Rivara FP. Qualitative study of barriers to concussive symptom reporting in high school athletics. *J Adolesc Health Off Publ Soc Adolesc Med*. 2013;52(3):330-335. https://doi.org/10.1016/j.jadohealth.2012.10.271

14. Conway FN, Domingues M, Monaco R, Lesnewich LM, Ray AE, Alderman BL, et al. Concussion symptom underreporting among incoming National Collegiate Athletic Association Division I college athletes. *Clin J Sport Med Off J Can Acad Sport Med*. 2020;30(3):203–209. https://doi.org/10.1097/JSM.0000000000000557

15. Mrazik M, Dennison CR, Brooks BL, Yeates KO, Babul S, Naidu D. A qualitative review of sports concussion education: prime time for evidence-based knowledge translation. *Br J Sports Med*. 2015;49(24):1548–1553. https://doi.org/10.1136/bjsports-2015-094848

16. Kroshus-Havril E, Leeds DD, McAllister TW, Kerr ZY, Knight K, Register-Mihalik JK, et al. Optimizing concussion care seeking: Using machine learning to predict delayed concussion reporting. *Am J Sports Med*. 2024;52(9):2372-2383. https://doi.org/10.1177/03635465241259455

17. Kneavel M, Ernst W, Brandsma L. Collegiate Athletes' Perceptions of the Culture of Concussion Reporting. *J Am Coll Health*. 2021;69(4):435–443. https://doi.org/10.1080/07448481.2019.1679816

18. Hogg MA, Vaughan GM. Social psychology. 2018.

19. Lexico Dictionaries | English [Internet]. [cited 2022 June 23]. KNOWLEDGE English Definition and Meaning | Lexico.com. Available from: https://www.lexico.com/en/definition/knowledge

20. Cusimano MD, Zhang S, Topolovec-Vranic J, Hutchison MG, Jing R. Factors affecting the concussion knowledge of athletes, parents, coaches, and medical professionals. *SAGE Open Med*. 2017;5:2050312117694794. https://doi.org/10.1177/2050312117694794

21. Knollman-Porter K, Brown J, Flynn M. A preliminary examination of concussion knowledge by collegiate athletes and non-athletes. *Am J Speech Lang Pathol*. 2018;27(2):778–795. https://doi.org/10.1044/2018_AJSLP-17-0108

22. Kroshus E, Daneshvar DH, Baugh CM, Nowinski CJ, Cantu RC. NCAA concussion education in ice hockey: An ineffective mandate. *Br J Sports Med*. 2014;48(2):135–140. https://doi.org/10.1136/bjsports-2013-092498

23. Bloom G, Horton A, McCrory P, Johnston K. Sport psychology and concussion: New impacts to explore. *Br J Sports Med*. 2004;38:519–521. https://doi.org/10.1136/bjsm.2004.011999

24. Lininger MR, Wayment HA, Huffman AH, Craig DI, Irving LH. An exploratory study on concussion-reporting behaviors from collegiate student athletes' perspectives. *Athl Train Sports Health Care*. 2017;9(2):71–80. https://doi.org/10.3928/19425864-20161116-01

25. Munro S, Lewin S, Swart T, Volmink J. A review of health behaviour theories: how useful are these for developing interventions to promote long-term medication adherence for TB and HIV/AIDS? *BMC Public Health*. 2007;7(1):104. https://doi.org/10.1186/1471-2458-7-104

26. Kroshus E, Garnett BR, Baugh CM, Calzo JP. Engaging teammates in the promotion of concussion help seeking. *Health Educ Behav Off Publ Soc Public Health Educ*. 2016;43(4):442–451. https://doi.org/10.1177/1090198115602676

27. Daneshvar DH, Nowinski CJ, McKee AC, Cantu RC. The epidemiology of sport-related concussion. *Clin Sports Med*. 2011;30(1):1–17. https://doi.org/10.1016/j.csm.2010.08.006

28. R Core Team. R: A language and environment for statistical computing. [Internet]. Vienna, Austria: R Foundation for Statistical Computing; 2018. Available from: https://www.R-project.org/

29. Baker R, Bond B, Irwin G, Connelly S, Williams G. A systematic review of concussion education, knowledge, and attitudes in football. *Sci Med Footb*. 2025;1-20. https://doi.org/10.1080/24733938.2025.2488521

30. Pennock KF, McKenzie B, Steacy LM, Mainwaring L. Under-reporting of sport-related concussions by adolescent athletes: a systematic review. *Int Rev Sport Exerc Psychol*. 2023;16(1):66-92. https://doi.org/10.1080/1750984X.2020.1824243

31. Konstantinides N, Baugh CM, Bugwadia A, Kroshus E, Schowalter S, Hainline B, et al. Association between concussion□reporting intention and reporting behavior in a simulated game setting. *PMR*. In Press. https://doi.org/10.1002/pmrj.13441

32. Myrdal CN, Huang S, Beach HN, Waterbrook AL. Comparison of knowledge, perception and attitudes of concussion in previously concussed versus non-concussed youth soccer players. *Phys Sportsmed*. 2017;45(3):286–292. https://doi.org/10.1080/00913847.2017.1345569

33. Roby PR, Mozel AE, Arbogast KB, Buckley T, Caccese JB, Chrisman SPD, et al. postinjury outcomes after non–sport-related concussion: A CARE consortium study. *Br J Sports Med*. 2024;58:A93. https://doi.org/10.1136/bjsports-2023-concussion.244

34. Chinn NR, Porter P. Concussion reporting behaviours of community college student-athletes and limits of transferring concussion knowledge during the stress of competition. *BMJ Open Sport – Exerc Med*. 2016;31;2(1):e000118. https://doi.org/10.1136/bmjsem-2016-000118

35. Wallace J. Exploring differences that may contribute to high school athletes' knowledge of concussion and reporting behaviors. 2015. Available from: https://www.semanticscholar.org/paper/Exploring-differences-that-may-contribute-to-high-Wallace/ec25536933ea5ee1c32c2b00c1cd2d61849f76c3

36. Cournoyer J, Tripp BL. Concussion knowledge in high school football players. *J Athl Train*. 2014;49(5):654–658. https://doi.org/10.4085/1062-6050-49.3.34

37. Balague G. Understanding identity, value, and meaning when working with elite athletes. *Sport Psychol*. 1999;13(1):89–98. https://doi.org/10.1123/tsp.13.1.89

38. Tracey J. The emotional response to the injury and rehabilitation process. *J Appl Sport Psychol*. 2003;15(4):279–293. https://doi.org/10.1080/714044197

39. Hurley OA. Impact of player injuries on teams' mental states, and subsequent performances, at the Rugby World Cup 2015. *Front Psychol*. 2016;7:00807. https://doi.org/10.3389/fpsyg.2016.00807

40. O'Neill DF. Injury contagion in alpine ski racing: The effect of injury on teammates' performance. *J Clin Sport Psychol*. 2008;2(3):278-292. https://doi.org/10.1123/jcsp.2.3.278

41. Oliaro S, Anderson S, Hooker D. Management of cerebral concussion in sports: The athletic trainer's perspective. *J Athl Train*. 2001;36(3):257–262.

42. Fisher AC, Hoisington LL. Injured athletes' attitudes and judgments toward rehabilitation adherence. *J Athl Train*. 1993;28(1):48–54.

43. Asken BM, Bauer RM, Guskiewicz KM, McCrea MA, Schmidt JD, Giza CC, et al. Immediate removal from activity after sport-related concussion is associated with shorter clinical recovery and less severe symptoms in collegiate student-athletes. *Am J Sports Med*. 2018;46(6):1465–1474. https://doi.org/10.1177/0363546518757984