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Attachment and symptom reporting in adolescents and young adults after a concussion

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Keywords: attachment dimensions, concussion, Experiences in Close Relationships-Relationship Structures Questionnaire, mild traumatic brain injury, post-concussion symptoms

Abstract

Background

The incidence of hospital-treated concussion is 100–300/100,000 person years. Reporting of long-lasting post-concussion symptoms (PCS) is estimated at 5-15%. Attachment insecurity is a potential
vulnerability factor for physical illness and poorer disease outcomes in general. This study aimed to explore associations between attachment insecurity and PCS in young people sustaining a concussion.

Methods

This cross-sectional study was embedded in a cohort of 15–30-year-old patients (n=3080) three months after sustaining a concussion. Data were obtained from a database and questionnaires. PCS were measured by the Rivermead Post-Concussion Symptoms Questionnaire and attachment dimensions (anxiety and avoidance) by the Experiences in Close Relationships-Relationship Structures Questionnaire. Multiple linear regression models were performed to investigate the association between the attachment dimensions and PCS with adjustment for demographic, injury-related and psychological factors and with additional testing for interaction between the attachment dimensions.

Results

In the final study sample, comprising 973 patients (31.6%), we found an interaction between the attachment dimensions. Hence, the effect of attachment anxiety on PCS was statistically insignificant at low avoidance (25th percentile) but significant at high avoidance (75th percentile, \( \beta = 0.64 \) (95%CI: 0.02; 1.26)), whereas the effect of attachment avoidance was significant regardless of level of attachment anxiety (25th percentile, \( \beta = 1.09 \) (95%CI: 0.18; 2.01); 75th percentile, \( \beta = 2.71 \) (95%CI: 1.80; 3.61)).

Conclusion

Attachment insecurity, especially characterised by high avoidance in combination with high anxiety, also called fearful attachment, is associated with PCS. Considering the attachment perspective can potentially improve health care for this patient group.
Introduction
The incidence of concussion (or mild traumatic brain injury) treated in hospital is estimated at 100-300/100,000 person years, with the highest incidence rates occurring among adolescents and young adults [1, 2]. As most concussion cases require no hospital treatment, the true incidence likely falls in the range of 300-750/100,000 person years [3, 4]. Most patients recover within a few weeks, but at least 5-15% self-report post-concussion symptoms (PCS) such as concentration difficulties, memory problems, fatigue, sensitivity to noise, headaches and depression and anxiety [5, 6] exceeding three months [7] with recent studies suggesting a prevalence reaching 41% [8-10]. PCS are a serious health concern and a socioeconomic challenge as they may cause prolonged limitations in vocational and social functioning [11].

Current knowledge does not support a simple relationship between mechanism of injury, degree of concussion-related neuropathology and PCS [12-14]. The prevailing explanatory model instead propose a multifactorial understanding of the development of PCS involving both neurobiological, emotional, cognitive, and social factors [1]. However, the relative significance of these factors remains poorly understood. Demographics like female sex, younger age and premorbid depression and anxiety are among the most robust prognostic factors for PCS [15]. Furthermore, numerous psychological factors may impede recovery like high levels of acute stress and development of PTSD symptoms after the injury [16] as well as negative cognitive and emotional perceptions and unhelpful behaviors, such as fear of avoidance, related to the symptoms [17-19]. Important parallels seem here to exist between PCS and other complex only partly medically explained conditions like chronic whiplash-associated disorder [20], and chronic pain [21] where negative illness perceptions and maladaptive illness behaviors have also shown to play a role for poorer outcome[22, 23]. Recent literature suggests that attachment theory may help explain further how such complex conditions may develop and become persistent and enduring [24-30] as attachment can be regarded...
as an underlying psychological factor which buffer or increase the perceived stress of illness and which can potentially influence not only behavioural responses to illness but also responses to interventions. Attachment theory posits that early childhood experiences of primary caregiver relationships form the basis of trait-like patterns of relating to others, i.e. attachment styles, that guide behaviour and expectations in personal relationships and strongly influence affect regulation and support-seeking in threatening situations, e.g. illness. Longitudinal research supports that attachment styles remain relatively stable from adolescence and onwards [31-33], though a person’s attachment style may be changed by severe negative life events, especially interpersonal traumas like physical or sexual abuse, but not non-interpersonal trauma like a motor-vehicle accident [34]. Two approaches have evolved to assess adult attachment style [32, 35]: firstly; the developmental approach which infers states of mind regarding childhood experiences with caregivers; secondly, the social and personality research approach which measures attachment-related thoughts and feelings in adult relationships. The latter approach is most prevalent in health-related research. It typically assesses two dimensions: attachment anxiety ("hyper-activation of the attachment system" due to worries/anxiety about others’ accessibility and receptiveness, i.e. negative model of self) and attachment avoidance ("deactivation of the attachment system" with discomfort with closeness and preference for self-reliance, i.e. negative model of others) [36-38]. These dimensions can be translated into four attachment categories; one secure (low on both dimensions), and three insecure, i.e. preoccupied (high anxiety, low avoidance), dismissing (low anxiety, high avoidance) and fearful (high on both dimensions) [36, 37] (see Figure 1).

Insecure attachment is believed to contribute to amplified physiological responses to stress, ineffective buffering of stress by social support, and maladaptive coping strategies to manage emotional discomfort. These responses may all increase the risk of chronic health conditions and
reduce effective management [38-40]. Similarly, insecurely attached individuals tend to experience more symptoms in various health conditions than people with secure attachment [25, 30, 41-44] and to achieve less optimal outcomes following usual treatment [45, 46]. Fearful attachment in particular is associated with the highest levels of symptom reporting [47] but also with the lowest levels of healthcare utilisation [48].

In summary, whereas the attachment approach may create no new therapy for PCS, it may guide us towards a better way of communicating therapeutic strategies to a population where early recovery can prevent chronicity [49, 50]. Thus, accommodation of currently available treatments for PCS to attachment styles may potentially increase their efficacy, e.g. patients with high attachment avoidance (negative models of others) may potentially benefit from using more self-management tools and having less direct healthcare contacts. Inversely, patients with high attachment anxiety (negative model of self) may benefit from frequent but brief healthcare contacts [27, 51]. In other words, "one size" does not fit all patients, and determining whether long-lasting symptoms after a concussion are associated with high levels of attachment insecurity may therefore have clinical relevance for improvement of patient care.

The present study is a first step in exploring if attachment insecurity may play a role in PCS. We here focus on young people whose physical suffering and illness following a concussion may have particularly serious prospects with regard to educational achievement and work ability, among others [11]. The aim was to investigate associations between attachment dimensions and PCS approximately three months after injury. We hypothesised that attachment insecurity, especially expressed by high levels of anxiety and avoidance, i.e. fearful attachment, would be associated with higher levels of PCS than secure attachment after adjusting for potential demographic, injury-related and psychological factors affecting outcome. Furthermore, we explored any interaction between the two attachment dimensions with respect to PCS.
Methods

Study population and procedures

This cross-sectional study is embedded in a larger cohort study including different sub-studies investigating the epidemiology, prognosis and early intervention in young people aged 15-30 years. The age criterion was defined *a priori* as the larger cohort study was partly financed by funds from the Danish government earmarked to strengthen treatment options for adolescents and young adults with concussion or brain injury. Questionnaires, distributed approximately three and nine months after the concussion, included measures on general health, quality of life, attachment, PTSD symptoms, emotional distress and work ability. For the present study, we only used data from the first assessment.

The study population as identified consecutively around two months after having suffered a concussion in the period from October 2014 to September 2017. Data on the study population were extracted from a regional administrative hospital database holding data from public hospitals in the Central Denmark Region. These data were linked to the Danish Civil Registration System [52] to obtain name and address. A paper questionnaire for the first assessment was distributed to eligible patients by mail 2-3 months after injury. A maximum of two reminders were sent approximately three weeks apart.

Two *inclusion criteria* applied. First, a hospital contact under an International Classification of Diseases, 10th revision (ICD-10) principal or secondary diagnosis code representing "concussion" (S0.60), "observation for concussion" (Z0.33D) or "other concussion diagnoses" (S0.20-S0.21, S0.27-S0.29, S0.61-S0.71, S0.97, T0.20, T0.40 and T0.60) with no previous registration under any of these codes from 2013 and onwards; second, age 15-30 years at the date of the hospital contact as determined by the *a-priori* defined age group (see above). [53]. The *exclusion criteria* were: first,
hospitalisation > 28 days or contact with a department of neurorehabilitation in connection with the injury; second, address outside the Central Denmark Region on the date of injury; third, name and/or address protection; and, fourth, death. Responders were also excluded if their answers failed to meet at least one of the following operational concussion three criteria: first, confusion or disorientation after the injury; second, loss of consciousness for > 0 to ≤ 30 minutes; and, third, post-traumatic amnesia for > 0 to < 24 hours [2].

The study was registered with the Danish Data Protection Agency (no. 1-16-02-742-17). Under Danish law, questionnaire-based studies require no approval by a health research ethics committee. The principles of the Declaration of Helsinki were followed; written consent was obtained from participants when they returned the questionnaire. Data were anonymised and used for research purposes only.

*Measures from the database*

The database provided information on personal identification number, sex, age, date of in- and outpatient hospital contacts in relation to concussion and diagnostic category (see above).

*Measures from the questionnaire*

Post-concussion symptoms (PCS) were assessed by *The Rivermead Post-Concussion Symptoms Questionnaire* (RPQ) [54], consisting of 16 items assessing emotional (e.g. feeling depressed or sad), cognitive (e.g. poor concentration) and somatic symptoms (e.g. headache) within the past 24 hours and compared with before the head injury [5]. Each symptom is rated on a five-point scale (from 0 “not experienced at all” to 4 “a severe problem”). In accordance with the standard scoring method, a score of 1 (“no more of a problem”) is set to 0, yielding a total score ranging from 0 to 64
with higher scores indicating more symptoms and a higher symptom severity [55]. The RPQ has demonstrated good validity and reliability both early and late after injury [54].

As no standardised method exists for classifying PCS symptom severity, we applied the same definition for high levels of PCS as a prior treatment study embedded in the same clinical cohort. This cut-off was based on data from the first 108 participants where an RPQ score ≥ 20 in 81% of the respondents corresponded to PCS having an impact on daily activities of ≥ 5 on a 10-point Likert scale ranging from "Not at all" to "Really much" [53, 56]. In the present study, the RPQ showed a high internal consistency (Cronbach’s alpha 0.94 (95% confidence interval (CI): 0.94 - 0.95)).

Attachment dimensions were assessed by The Experiences in Close Relationships-Relationship Structures Questionnaire (ECR-RS) [57]. This measure was chosen as we wanted a short self-report measure of adult attachment well suited for the purpose of an epidemiological study. Furthermore, the ECR-RS had already been formally translated to Danish and tested in young people down to 15 years [58]. The choice of a continuous measure was based on both theory [36] and research, indicating that attachment is best conceptualised by the anxiety and avoidance dimensions [37]. The ECR-RS consists of nine items derived from the 36-item ECR-revised (ECR-R) [59] and assesses attachment dimensions on two subscales: anxiety (items 7-9) (e.g. "I often worry that this person doesn't really care for me") and avoidance (items 1-6) ("I prefer not to show this person how I feel deep down"). All items are scored on a Likert Scale ranging from 1 (strongly disagree) to 7 (strongly agree). The first four items on the avoidance scale are reverse keyed. The total score for each scale is divided by the number of items to calculate the final score for each dimension (anxiety (range 1-7) and avoidance (range 1-7)). On both scales, higher scores reflect higher levels of attachment insecurity.
The ECR-RS can be used to investigate specific (parent, friend, partner) or more global attachment representations. The latter may be obtained by averaging the scores for anxiety and avoidance across the specific relationship domains or by rewording the nine items to assess attachment in general [37]. No well-established cut-points determine high and low anxious or avoidant attachment. However, the median scores of the two attachment dimensions in a given population may be used to obtain the four attachment categories [60], i.e. secure: both scores < median on both subscales; preoccupied: anxiety score ≥ median anxiety score, avoidance score < median avoidance score; dismissing: anxiety score < median anxiety score, avoidance score ≥ median avoidance score; fearful: both scores ≥ median on both subscales.

The psychometric abilities of the Danish version of the ECR-RS were found to be psychometrically valid for assessing relationship-specific adolescent attachment structures in 15-18-year-olds [58]. Like in previous similar studies [30, 61, 62], we focused on global attachment representation and reworded the Danish version accordingly. In the present study, both subscales showed a high internal consistency (Cronbach’s alpha 0.92 (95% CI: 0.91-0.94) for the anxiety subscale and 0.84 (95% CI: 0.82-0.86) for the avoidance subscale). Spearman’s rank correlation between the subscales was ρ = 0.49 (95% CI: 0.44-0.53, p < 0.001).

PTSD symptoms were assessed by the Impact of Event Scale-6 (IES-6), a short version derived from the 22-item Impact of Event Scale-Revised (IES-R) [63]. It has six questions rated on a five-point Likert scale (from 0 (not at all) to 4 (worst)). We omitted item 6 ("I had trouble concentrating") to avoid overlap with the item "Poor concentration" in our outcome measure, RPQ, and thereby potential over-adjustment in our analyses. The sum score of the modified IES-6 ranged from 0 to 20, higher scores reflecting higher levels of PTSD symptoms. The items concern injury-related thoughts and emotions (e.g. "I thought about it when I didn't mean to"). The original scale was
shown to predict long-lasting PCS [6]. Cronbach's alpha of the modified IES-6 was 0.85 (95% CI: 0.84; 0.87).

*Other questionnaire-based data* were self-reported mechanism of injury and comorbid chronic physical illnesses.

**Statistical analysis**

Scores for measures were calculated if more than half of the items were answered. For the two measures, RPQ and IES-6, this corresponded to a conservative calculation of the sum-scores based on the answered items with no replacement of missing items. For the ECR-RS, it corresponded to dividing the total score for each scale by the number of answered items to calculate the final score for each dimension. Thus, for the RPQ and the modified IES-6, the result is the sum of actually reported symptoms, whereas for the ECR-RS subscales it represents the mean of the actually answered items. To check if missing data influenced the results, sensitivity analyses were conducted where missing item scores were replaced with average non-missing item scores.

Descriptive statistics were applied to characterise the final study sample with respect to sex, age, diagnostic category, mechanism of injury, chronic physical illness and distribution of PCS, PTSD symptoms and attachment dimensions.

A moderate to high correlation between the two attachment dimensions at the level of relation-specific scales and the more global scales has previously been reported [64]. To study the independent contribution of each dimension to a specific outcome, analyses should therefore simultaneously control for the other dimension and explore any interaction. Accordingly, associations between attachment dimensions and long-lasting PCS were analysed with multiple linear regression models involving four steps. In step 1, only the two attachment dimensions and
their interaction were entered as explanatory variables. In step 2, demographic factors, i.e. age and sex, were entered as covariates. In step 3, injury-related factors, i.e. diagnostic category and mechanism of injury, were added as covariates and, in step 4, a psychological factor, i.e. PTSD symptoms, was added as the final covariate.

In all linear regression models, the underlying assumptions were checked by inspection of the distribution of residuals. Due to heterogeneity and skewness of the residuals, a non-parametric bootstrap method [65] with 5,000 repetitions was used to calculate 95% CIs for the regression coefficients. Tests for interaction between the two attachment dimensions were conducted with the Wald test.

The median scores of the two attachment dimensions were used to obtain the four attachment categories.

All analyses were conducted using STATA version 16 for Windows (Stata Corp, College Station, Texas, USA).

Results

Attrition and final study sample

The flowchart of the study is shown in Figure 2. The questionnaires were returned around three months after injury (median 83 days, interquartile range (IQR) 67-109 days). The response rate was 38.6% (n = 1,190), 46.6% (630/1,352) among females and 32.4% (560/1,728) among males.

Responders and non-responders were similar with respect to median age (responders 21.1 (IQR; 17.9-24.7) and non-responders 21.6 (IQR; 18.9-25.0) years) and diagnostic category (in both groups 63% were registered with "concussion", 31% with "observation for concussion" and 6% with "other concussion diagnoses"). Among responders, 973 patients (31.6% of the original cohort) provided sufficient RPQ data and constituted the final study sample. The proportion of full responses on
included measures was RPQ: 96.9% (943/973); ECR-RS anxiety subscale: 97.7% (951/973); ECR-RS avoidance: 97.0% (944/973); and IES-6: 92.0% (895/973).

Table 1 shows characteristics of the study sample and the two subsamples with no PCS (RPQ = 0 (27%)) and PCS (RPQ > 0 (73%)). Respondents with PCS were further divided into subgroups with an RPQ between 0 and 20 (41% of the study sample) and an RPQ ≥ 20, i.e. high PCS (32% of the study sample). The two subsamples differed regarding sex with a female preponderance in the subsample with PCS, which was even more outspoken in the subgroup with an RPQ ≥ 20. Median age was slightly higher in the subsample with PCS and highest in the subgroup with an RPQ ≥ 20. The distribution of diagnostic categories did not differ substantially between the two subsamples, although the subsample with no PCS had the highest percentage of individuals with "observation for concussion". Finally, the subsample with PCS reported more PTSD symptoms than those with no PCS.

Table 2 shows the scores of the two main questionnaires. The subsample with PCS scored higher on both attachment dimensions than the subsample with no PCS. This difference was even more pronounced in the subgroup with high PCS.

In the multiple linear regression models, we found an interaction between the two attachment dimensions (β = 0.71 (95% CI: 0.36; 1.06), p < 0.001). To illustrate this effect, we calculated the effect (slope) for each attachment dimension (e.g. anxiety) at different values (25th, 50th and 75th percentiles) of the opposite attachment dimension (e.g. avoidance). Tables 3a and 3b present these results.
Attachment anxiety in combination with low avoidance (25% percentile) was not significantly associated with PCS (fully adjusted model; $\beta = -0.36$ (95% CI: -1.07; 0.36)), whereas in combination with high avoidance (75th percentile) it was associated with PCS (fully adjusted model; $\beta = 0.64$ (95% CI: 0.02; 1.26)) (Table 3a). For attachment avoidance, an association with PCS was observed regardless of the level of attachment anxiety. This association increased with the level of concurrent attachment anxiety (fully adjusted model with high concurrent anxiety (75th percentile); $\beta = 2.71$ (95% CI: 1.80; 3.61)) (Table 3b). The regression coefficients and $R^2$ from all the multiple linear regression models are shown in Appendix A, Table 3c.

Figure 3 illustrates the combination of the two attachment dimensions in relation to the fitted values of the PCS outcome after adjusting for all covariates. The median values of both attachment dimension scores are depicted to illustrate the findings according to a specific attachment category.

High PCS (i.e. an RPQ score $\geq 20$) are primarily seen in patients with fearful attachment, i.e. those with both attachment scores $\geq$ the median of the whole study sample on both subscales. For the mean level of PCS for each attachment category, see Appendix B, Table 4.

In the sensitivity analyses, the overall findings remained the same (results not shown).

**Discussion**

We found an association between insecure attachment and symptom reporting, with an interaction between the two attachment dimensions. Attachment anxiety was mainly associated with symptom reporting when attachment avoidance was high, whereas attachment avoidance was associated with symptom reporting regardless of level of attachment anxiety, but with increasing effect the higher the attachment anxiety. Reporting of PCS was highest among individuals with high scores on both attachment dimensions, corresponding to fearful attachment. The findings remained after adjusting
for demographic (age, sex), injury-related (diagnostic category, mechanisms of injury) and psychological (PTSD symptoms) factors.

Our finding of a stronger association between attachment avoidance and PCS than between attachment anxiety and PCS partly differs from previous literature reporting close relationship between attachment anxiety and symptom reporting in various physical conditions [30, 66]. For instance, in chronic pain, associations have been found between anxious attachment and a more negative pain appraisal, increased pain perception, impaired pain coping and more weekly healthcare visits [25, 41, 44]. Attachment anxiety is likely to manifest as hyper-activating strategies such as catastrophising and hypervigilance [38] that inevitably lead to higher symptom experience and/or reporting.

In contrast, avoidant attachment typically leads to more deactivating strategies [67]. Minimised symptom reporting occurs due to underestimation or threat avoidance as a coping strategy, more self-reliance when handling illness or more disregard of symptoms [38, 39]. Indeed, individuals with high avoidance levels express less pain and pain behaviours than individuals with secure or anxious attachment [68] and more maladaptive self-care [69], post-operative appointment non-attendance [70] and less primary care utilisation [48].

However, the impact of avoidant attachment on symptom reporting may vary with study sample and illness-related situation. Thus, in a general population-based study, only avoidant attachment remained significantly associated with reporting of medically unexplained chronic pain when considering the two attachment dimensions together [43]. Furthermore, our results corroborate findings from a prospective study of chronic whiplash-associated disorder, which is arguably more like concussion. In this study, both attachment dimensions were positively associated with psychosocial disability six months after injury [29], but particularly with attachment avoidance measured early after the whiplash injury. Furthermore, a study of patients with acute coronary
syndrome suggests that in severe illness it may be harder for highly avoidant-attached individuals to use deactivating strategies to conceal latent vulnerabilities and suffering, and thereby more difficult to suppress symptom experience/reporting [71].

Our finding of a positive interaction between attachment anxiety and avoidance adds to this literature by underscoring the importance of distinguishing between dismissing and fearful insecurity, which produce different behaviours in stressed individuals [72]. The dismissing individual (low concurrent attachment anxiety) displays an avoidant behaviour grounded in self-reliance or independence minimising both the experience and reporting of distress, whereas the fearful individual (high concurrent attachment anxiety) feels highly distressed by symptoms and by the fear of being hurt and rejected [72]. As a result of increased distress and wishing support but having no good way of recruiting others to help, individuals with fearful attachment may self-report more physical symptoms. This interpretation is supported by our finding that the strongest association was seen in patients with high scores on both attachment dimensions. This was also observed in a previous study showing fearful attachment to be associated with the highest levels of symptom reporting [47, 48] and inconsistent healthcare use with risk of delayed medical care for significant symptoms or for obtaining needed treatment [48]. This suggests that experiencing high levels of both attachment anxiety and attachment avoidance may prolong suffering without relief from interventions relying on help from others. Future studies should explore fearful attachment more fully in young patients with PCS to inform novel treatment approaches. As young patients are usually harder to reach for health services, it may be worth trying to study how patients who are also fearfully attached might accept care and if presenting care in a manner appreciating their attachment style produces a better pick-up and higher treatment adherence. Furthermore, this population should be compared with other same-aged clinical populations undergoing medical
treatment due to traumatic injuries not affecting the head/brain to understand if the current attachment findings are unique for young patients with concussion or may be regarded as generic.

**Strengths and limitations**

A major strength is that the data represent a large inception cohort of consecutive young patients all medically examined by a physician at their initial hospital contact in a large Danish region. We also used well-validated questionnaires for the main dimensions, applied statistical methods with mutual adjustment for the two attachment dimensions and tested for their potential interaction. The cross-sectional design did not allow us to establish the direction of the associations. Although insecure attachment is theorised to be a preinjury vulnerability factor, we cannot be rule out that the experience of a head injury and subsequent distressing PCS may result in self-reporting of more insecurity. Furthermore, we did not have information on other potentially important explanatory factors for PCS, such as premorbid mental health, post-injury neuropsychological functioning and medication use, which may have been relevant to include as additional covariates [14]. For clinical purposes, we found it relevant to translate the results into the four attachment categories. As there currently is no well-defined cut-offs on the two ECR-RS subscales that can guide this categorisation, we used the median of each dimension in our study sample as recommended by the authors of the ECR-RS. However, since these numbers will be sample dependent, this is likely to reduce the external validity of our results. Therefore, it will be important in future research to determine formal clinical cut-offs on the ECR-RS for both attachment dimensions if findings based on this measure are to be better transferred to clinical practice.

The proportion of responders was quite low, but still typical of other questionnaire studies of young people [73]. Initial non-participation is unlikely to pose any considerable threat to the internal validity [74, 75]. However, if patients with severe PCS were more likely to respond, this may
explain the higher prevalence of high PCS (32%) than the commonly reported 5-15% prevalence [7], though recent studies have implied higher rates [8-10]. Furthermore, the responder group counted more females (53%) than the non-responder group (38%). Some studies report no sex differences in attachment dimensions [33], but a meta-analysis from 2011 found that females showed more attachment anxiety than males [76]. The skewed sex distribution might therefore have exaggerated the association between attachment anxiety and PCS. Finally, the participants were 15-30 years old and in the subacute phase of recovery. Our findings may therefore not be generalisable to other phases of recovery and other age groups.

Conclusion
This cross-sectional study found positive associations between attachment insecurity and PCS in young patients three months after a concussion, adding to the existing evidence that adult attachment insecurity is linked to long-standing physical illness. The findings also suggest an interaction between the two attachment dimensions. Attachment anxiety was positively associated with PCS only when attachment avoidance was at high levels, whereas attachment avoidance was associated with PCS regardless of the level of attachment anxiety, although with an increasing effect with higher attachment anxiety. Finally, patients with high levels on both attachment dimensions, i.e. fearful attachment, displayed the highest levels of PCS.

Implications and future directions
Overall, our findings suggest that an appreciation of attachment dimensions may improve our understanding and management of PCS. To inform optimal models of care, further research is warranted with longitudinal studies exploring the possible interplay between attachment and social support, illness perception and illness behaviour in patient presentations and the potential
association between attachment insecurity and other long-term outcomes such as work ability, morbidity and healthcare use. It is also important to compare the present population with other clinical populations to determine the specificity of the attachment perspective in young patients sustaining a concussion.

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Conflicts of interest

None.

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Authors’ contributions

All authors had full access to all study data, take responsibility for all aspects of the work and approved the final version for publication. Data collection, A.H.T and S.W.S.; Methodology, A.H.T, S.W.S., J.F.N, A.S., M.M.T, E.T.N. and C.U.R.; Data analysis A.H.T, S.W.S, J.S.J and
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**Figure 1.** The translation between attachment dimensions and attachment categories.

Legend: Bartholomew's two dimensional, four-category model of adult attachment (modified after Bartholomew et al, 1991 [36]).

*Pen portrait of each attachment category:* Securely attached people are confident about their ability to function independently and also about asking for help from others. People with a preoccupied attachment category prefer to be close to others; they feel vulnerable if left alone under stressful conditions. People with a dismissing attachment category emphasise independence and self-reliance and tend to suppress expressions of distress, while fearfully attached people live with the tension of distrusting their own ability to function while also not being confident recruiting others to help (Hunter & Maunder, 2016 [38]).
Figure 2. Flowchart of the study. The final study sample was divided into two subsamples: those who did not report symptoms three months post injury (RPQ = 0) and those who did (RPQ > 0).

Abbreviations: RPQ= Rivermead Post-Concussion Symptoms Questionnaire. WHO= World Health Organisation.

Figure 3. Illustration of the adjusted multiple linear regression model (step 4) showing the model-based "predictions" of post-concussion symptoms for different values of the two attachment
Y-axis: Attachment avoidance is measured by the Experiences in Close Relationships-Relationship Structures Questionnaire (ECR-RS) avoidance subscale. X-axis: Attachment anxiety is measured by the ECR-RS anxiety subscale. Axis to the right: grey tone scale showing the level (in 5-unit intervals) of post-concussion symptoms (PCS) measured by The Rivermead Post-Concussion Symptoms Questionnaire (RPQ). Notice: RPQ scores 0–5 and 30-40 are not in the illustration as none of the fitted values were within this area.

In order to translate the scores of attachment dimensions into attachment categories, the median of each dimension in the study sample was used as described in the manual for ECR-R (Fraley, R. C. [60]): the black vertical line is the median score for anxiety (2.7), the black horizontal line is the median score for avoidance (3.2). Thus, scores within the lower left quadrant correspond to secure attachment category, scores within the upper left quadrant correspond to dismissing attachment category, scores within the lower right quadrant correspond to preoccupied attachment category and scores within the upper right quadrant correspond to fearful attachment category.

Table 1. Characteristics of the final study sample and the two subsample without and with post-concussion symptoms (PCS), further divided into those with low and high levels of PCS.
<table>
<thead>
<tr>
<th>Administrative data</th>
<th>Final study sample</th>
<th>Subsample without PCS (RPQ = 0)</th>
<th>Subsample with PCS (RPQ &gt; 0)</th>
<th>Subgroup with low PCS (RPQ &gt; 0 &lt; 20)</th>
<th>Subgroup with high PCS (RPQ ≥ 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, female, n (%)</td>
<td>527 (54)</td>
<td>83 (32)</td>
<td>444 (62)</td>
<td>226 (56)</td>
<td>218 (69)</td>
</tr>
<tr>
<td>Age at injury, years, median (IQR)</td>
<td>21.1 (18.0–24.6)</td>
<td>20.3 (17.4–24.2)</td>
<td>21.4 (18.3–24.7)</td>
<td>21.1 (18.3–24.2)</td>
<td>22.0 (18.4–25.3)</td>
</tr>
<tr>
<td>Diagnostic category, n (%)</td>
<td>631 (65)</td>
<td>150 (58)</td>
<td>481 (67)</td>
<td>269 (67)</td>
<td>212 (68)</td>
</tr>
<tr>
<td>Concussion</td>
<td>294 (30)</td>
<td>98 (38)</td>
<td>196 (28)</td>
<td>110 (27)</td>
<td>86 (27)</td>
</tr>
<tr>
<td>Observation for concussion</td>
<td>48 (5)</td>
<td>10 (4)</td>
<td>38 (5)</td>
<td>110 (27)</td>
<td>16 (5)</td>
</tr>
<tr>
<td>Other concussion diagnoses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22 (6)</td>
</tr>
</tbody>
</table>
### Questionnaire data

<table>
<thead>
<tr>
<th>Mechanism of injury, n (%)</th>
<th>Missing, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic accident</td>
<td>167 (17)</td>
</tr>
<tr>
<td>Fall</td>
<td>345 (36)</td>
</tr>
<tr>
<td>Direct blow to the head</td>
<td>268 (28)</td>
</tr>
<tr>
<td>Assault</td>
<td>71 (7)</td>
</tr>
<tr>
<td>Other</td>
<td>98 (10)</td>
</tr>
<tr>
<td>Missing, n (%)</td>
<td>24 (2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chronic physical illness, n (%)*</th>
<th>Missing, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>107 (11)</td>
<td>43 (11)</td>
</tr>
<tr>
<td>23 (2)</td>
<td>13 (3)</td>
</tr>
<tr>
<td>3 (0-7)</td>
<td>3 (0-6)</td>
</tr>
<tr>
<td>PTSD symptoms (IES-6**), range 0-20 (worst)</td>
<td>68 (7)</td>
</tr>
<tr>
<td>68 (7)</td>
<td>25 (6)</td>
</tr>
<tr>
<td>Missing, n (%)</td>
<td>8 (3)</td>
</tr>
<tr>
<td></td>
<td>8 (2)</td>
</tr>
</tbody>
</table>
Abbreviations: IQR = Inter Quartile Range, PCS = post-concussion symptoms, RPQ = Rivermead Post-Concussion Symptoms Questionnaire.

* Diabetes, epilepsy and other long-term illnesses.** In the current study we omitted item 6 ("I had trouble concentrating") to avoid overlap with the RPQ, i.e. the IES sum score was based on the remaining 5 items.

**Table 2.** Scores of post-concussion symptoms (PCS) and attachment dimensions in the final study sample, and the two subsamples without and with PCS, further divided into those with low and high levels of PCS. Scores are presented as medians (inter-quartile range).

<table>
<thead>
<tr>
<th></th>
<th>Final study sample</th>
<th>Subsample without PCS</th>
<th>Subsample with PCS (RPQ &gt; 0)</th>
<th>Subgroup with low PCS (RPQ &gt; 0 - &lt; 20)</th>
<th>Subgroup with high PCS (RPQ ≥ 20)</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Post-concussion symptoms (RPQ, range 0–64 (worst))</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.0</td>
<td>0.0</td>
<td>16.0 (7.0–30.0)</td>
<td></td>
<td>8.0 (4.0–25.0)</td>
<td>32.0 (25.0–41.0)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>(0.0–24.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Attachment anxiety (ECR-RS, range 1–7 (high))</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.7</td>
<td>2.0 (1.0–3.0)</td>
<td>3.0 (1.3–5.0)</td>
<td></td>
<td>2.7 (1.3–4.7)</td>
<td>4.0 (1.7–5.7)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>(1.3–4.7)</td>
<td>3.3</td>
<td>5.0</td>
<td></td>
<td>7(2)</td>
<td>4 (1)</td>
<td></td>
</tr>
<tr>
<td>4.7</td>
<td>9 (3)</td>
<td>11 (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Attachment avoidance (ECR-A, range 1–7 (high))</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.2</td>
<td>2.8 (2.0–3.5)</td>
<td>3.5 (2.4–4.5)</td>
<td></td>
<td>3.0 (2.2–4.2)</td>
<td>4.0 (2.7–5.0)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>(2.2–4.5)</td>
<td>3.7</td>
<td>4.5</td>
<td></td>
<td>7 (2)</td>
<td>4 (1)</td>
<td></td>
</tr>
</tbody>
</table>

*Missing, n (%)**

<table>
<thead>
<tr>
<th></th>
<th>Final study sample</th>
<th>Subsample without PCS</th>
<th>Subsample with PCS (RPQ &gt; 0)</th>
<th>Subgroup with low PCS (RPQ &gt; 0 - &lt; 20)</th>
<th>Subgroup with high PCS (RPQ ≥ 20)</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.7</td>
<td>2.0 (1.0–3.0)</td>
<td>3.0 (1.3–5.0)</td>
<td></td>
<td>2.7 (1.3–4.7)</td>
<td>4.0 (1.7–5.7)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>(1.3–4.7)</td>
<td>3.3</td>
<td>5.0</td>
<td></td>
<td>7(2)</td>
<td>4 (1)</td>
<td></td>
</tr>
<tr>
<td>4.7</td>
<td>9 (3)</td>
<td>11 (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Attachment avoidance (ECR-A, range 1–7 (high))</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.2</td>
<td>2.8 (2.0–3.5)</td>
<td>3.5 (2.4–4.5)</td>
<td></td>
<td>3.0 (2.2–4.2)</td>
<td>4.0 (2.7–5.0)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>(2.2–4.5)</td>
<td>3.7</td>
<td>4.5</td>
<td></td>
<td>7 (2)</td>
<td>4 (1)</td>
<td></td>
</tr>
</tbody>
</table>
Abbreviations: ECR-RS = Experiences in Close Relationships-Relationship Structures Questionnaire; RPQ = Rivermead Post-Concussion Symptoms Questionnaire.* Calculated using the Wilcoxon ranksum test.

Table 3a. Results of the interaction effect for the associations between attachment anxiety (ECR-RS anxiety subscale) and post-concussion symptoms (measured by RPQ) three months post injury using results for the 25%, 50%, and 75% percentiles of the ECR-RS avoidance subscale as examples.

<table>
<thead>
<tr>
<th>Model</th>
<th>Attachment avoidance = 25th percentile</th>
<th>Attachment avoidance = 50th percentile</th>
<th>Attachment avoidance = 75th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>95% CI</td>
<td>P</td>
</tr>
<tr>
<td>Step 1 (n = 950)</td>
<td>Attachment anxiety</td>
<td>0.43</td>
<td>-0.33; 0.270</td>
</tr>
<tr>
<td></td>
<td>1.19</td>
<td>1.74</td>
<td>2.56</td>
</tr>
</tbody>
</table>

Step 2 (n = 950)
### Step 3 (n = 927)

Step 2 +

<table>
<thead>
<tr>
<th>Age and sex</th>
<th>0.10</th>
<th>-0.66;</th>
<th>0.798</th>
<th>0.70</th>
<th>0.09;</th>
<th>0.024</th>
<th>1.37</th>
<th>0.72;</th>
<th>&lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>0.86</td>
<td>1.31</td>
<td>2.01</td>
<td>0.001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Step 4 (n=864)

Step 3 + PTSD symptoms at baseline

| PTSD symptoms at baseline | 0.36 | 1.07;0.36 | 0.46;0.70 | 1.26 |

| Abbreviations: CI = confidence interval, ECR-RS = Experiences in Close Relationships-Relationship Structures questionnaire, RPQ = Rivermead Post-Concussion Symptoms Questionnaire. |

**Interpretation (step 4):** If two persons with the same age, sex, diagnostic category, mechanism of injury, and PTSD symptoms at baseline both score corresponding to the 25th percentile on the ECR-RS avoidance subscale but differ one point on the ECR-RS anxiety subscale, the person with higher attachment anxiety will have a 0.36 point lower RPQ score (range 0-64 points), whereas if they both score corresponding to the 75th percentile on the ECR-RS avoidance subscale, the person with higher attachment anxiety will have a 0.64 point higher RPQ score.
Table 3b. Results of the interaction effect for the associations between attachment avoidance (ECR-RS avoidance subscale) and post-concussion symptoms (measured by RPQ) three months post-injury using results for the 25%, 50%, and 75% percentiles of the ECR-RS anxiety subscale as examples

Dependent variable: post-concussion symptoms

<table>
<thead>
<tr>
<th>Model</th>
<th>Attachment anxiety</th>
<th>Attachment anxiety = 50% percentile</th>
<th>Attachment anxiety = 75% percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>95% CI</td>
<td>P</td>
</tr>
<tr>
<td>25% percentile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 1 (n=950)</td>
<td>1.28</td>
<td>0.31; 2.24</td>
<td>&lt; 0.009</td>
</tr>
<tr>
<td>Step 2 (n=950)</td>
<td>1.84</td>
<td>0.90; 2.77</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Step 3 (n=927)</td>
<td>1.78</td>
<td>0.80; 2.77</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Step 4 (n=864)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Interpretation (step 4): If two persons with the same age, sex, diagnostic category, mechanism of injury, and PTSD score at baseline both score corresponding to the 25th percentile on the ECR-RS avoidance subscale but differ one point on the ECR-RS anxiety subscale, the person with higher attachment anxiety will have a 1.09 point higher RPQ score (range 0–64 points), whereas if they both score corresponding to the 75th percentile on the ECR-RS avoidance subscale, the person with higher attachment anxiety will have a 2.71 point higher RPQ score.

Highlights

- Attachment insecurity is related to symptom reporting and chronic pain
- At least 5-15% of people with a concussion develop post-concussion symptoms (PCS)
- In young people with a concussion we found attachment insecurity associated with PCS
- Those with fearful attachment displayed the highest levels of PCS
- The attachment perspective may help improve health care for this patient group
Figure 1

- **Dismissive**
  - Compulsively self-reliant
  - Low trust in others
  - Downplay the importance of the intimate relationships

- **Fearful**
  - Dependent of others
  - Low trust in others
  - Avoids intimacy due to fear of rejection
  - Low self-esteem
  - Focus on negative affect

- **Secure**
  - Comfortable with intimacy
  - Trust in others
  - Feels worthy of others attention
  - Autonomy in close relationships
  - Self-confident

- **Preoccupied**
  - Dependent of others for self-worth
  - Preoccupied with close relationships
  - Demanding
  - Low self-esteem
  - Focus on negative affect

Axes:
- Low avoidance: Positive model of others
- High avoidance: Negative model of others
- Low anxiety: Positive model of self
- High anxiety: Negative model of self
Mailed questionnaires: n = 3080

Non-responders: n = 1890 (61.4%)

Responders: n = 1190 (38.6%)

WHO criteria for concussion not fulfilled: 
  n = 202 (6.6%)

Eligible sample: n = 988 (32.1%)

Missing RPQ: n = 15 (0.5%)

Final study sample: N = 973 (31.6%)

RPQ=0: n = 258 (8.4%)

RPQ > 0: n = 715 (23.2%)

Figure 2