BRAIN INJURY
https://doi.org/10.1080/02699052.2018.1432894

Taylor & Francis
Taylor & Francis Group

Untangling chronic pain and post-concussion symptoms: the significance of depression

Deborah L. Snell[a,b], Rachelle Martin[e], A.D. Macleod[a], Lois J. Surgenor[c], Richard J. Siegert[f], E. Jean, C. Hay-Smith[e], Tracy Melzer[d,g,h], Gary J. Hooper[b], and Tim Anderson[d,g,h]

[a]Concussion Clinic, Burwood Hospital, Christchurch, New Zealand; [b]Department of Orthopaedic Surgery and Musculoskeletal Medicine, University of Otago Christchurch, Christchurch, New Zealand; [c]Department of Psychological Medicine, University of Otago Christchurch, Christchurch, New Zealand; [d]Department of Medicine, University of Otago Christchurch, Christchurch, New Zealand; [e]Rehabilitation Teaching and Research Unit, University of Otago Wellington, Wellington, New Zealand; [f]Faculty of Health and Environmental Studies, AUT University, Auckland, New Zealand; [g]New Zealand Brain Research Institute, Christchurch, New Zealand; [h]Brain Research New Zealand, Centre of Research Excellence, New Zealand

ABSTRACT

Objectives: Post-concussion-like symptoms (PCS) are common in patients without a history of brain injury, such as those with chronic pain (CP). This exploratory study examined neuro-cognitive and psychological functioning in patients with PCS following mild traumatic brain injury (mTBI) or CP, to assess unique and overlapping phenomenology.

Methods: In this case-control study, participants (n = 102) with chronic symptoms after mTBI (n = 45) were matched with mTBI recovered (n = 31) and CP groups (n = 26), on age, gender, ethnicity and education. Psychological status, cognitive functioning, health symptoms, beliefs and behaviours were examined.

Results: Participants who had not recovered from an mTBI and participants with CP did not differ in terms of PCS symptoms, quality of life, distress or illness behaviours, however, the CP group endorsed fewer subjective cognitive problems, more negative expectations about recovery and more distress ($p < 0.05$). On cognitive testing participants who had not recovered from an mTBI demonstrated greater difficulties with attention ($p < 0.01$) although differences disappeared when depression was controlled in the analyses.

Conclusions: Unique patterns associated with each condition were evident though caution is required in attributing PCS and cognitive symptoms to a brain injury in people with mTBI presenting with chronic pain and/or depression. Psychological constructs such as illness and recovery beliefs appear to be important to consider in the development of treatment interventions.

ARTICLE HISTORY
Received 16 June 2017
Revised 30 November 2017
Accepted 22 January 2018
Published online 1 February 2018

KEYWORDS
mTBI; chronic pain; psychological factors; depressive symptoms

Introduction

Mild traumatic brain injury (mTBI) is common and in most cases, recovery is the expected outcome. However, there is increasing evidence that a significant minority experience ongoing symptoms with social and functional difficulties for many months and even years (1-5). Such symptoms when they persist, such as headaches, dizziness, fatigue, cognitive and emotional changes, are often referred to as the post-concussion syndrome (PCS)(6). The burden of chronic PCS after an mTBI for the person, their families and their communities can be considerable (7).

The incidence, prevalence, natural history and treatment of PCS following mTBI is not well understood and this lack of clarity may be underpinned by poor coherence across symptom domains. Different PCS symptoms require different treatments (8,9); improvements in some symptoms are not necessarily reflected in improvements in others, (3) challenging the notion of the PCS as a valid syndrome. A further difficulty is the prevalence of PCS symptoms across all severities of traumatic brain injury, and in other health conditions such as chronic pain and depression (10–12).

The mechanisms that underpin the development of chronic symptoms after an mTBI have been widely debated and have been attributed to being older and female (2,13), and various psychosocial and psychological factors (14–16). It is generally accepted that the relative influence of factors shifts with time, with neurogenic pathophysiology more relevant in the immediate recovery phase after mTBI, with psychological factors becoming more relevant with time (17). However, it is also clear that psychological factors are important throughout the course of recovery (16,17).

A similar pathway from acute to chronic symptoms is discussed in the chronic pain literature. This is not surprising given that people with chronic pain conditions and mTBI can experience similar psychosocial factors that accompany physical injury such as depression, anxiety and life stresses (11). There are a limited number of studies that have reported on PCS symptoms in patients with chronic pain (10–12). In addition, a number of studies and reviews describe cognitive deficits among people with chronic pain that are very similar to those seen in people with mTBI (18,19).

Few studies though have directly compared prevalence of PCS-like symptoms, cognitive deficits and psychological

CONTACT Deborah L. Snell debbie.snell@otago.ac.nz University of Otago Christchurch, Christchurch, New Zealand.

factors across samples of people with chronic pain and mTBI. We are aware of one study that compared the level of self-reported PCS symptoms in people with mTBI and chronic pain (11), with high levels of symptoms endorsed by both groups. Extending the focus beyond self-reported PCS symptoms may provide more information about the specificity of chronic symptoms after mTBI. In this study, we examined PCS symptom burden, neuro-cognitive and psychological functioning in patients with either chronic pain or chronic symptoms following an mTBI to assess unique and overlapping phenomenology. We were specifically interested in differences between people who had not recovered from an mTBI after more than six months and people who had developed a chronic pain condition, in terms of PCS symptom burden, recovery beliefs and expectations, general health status, cognitive functioning and quality of life.

Methods

Design and setting

This is a cross-sectional case control descriptive study with three groups matched on sex, age, ethnicity, education and where relevant, injury severity. Participants who met study inclusion and exclusion criteria (see below) were selected by file review and consultation with relevant clinicians at a regional specialist Concussion Service and a Pain Management Service based at a rehabilitation hospital in Christchurch, New Zealand. This study was approved by the New Zealand Health and Disability Ethics Committees (Southern) (ref URA/12/05/015).

Participants

Eligible participants were between 16 and 70 years of age, with no previous history of clinically significant traumatic brain injury or significant comorbid health conditions such as cardiovascular disease or neurological disorder. A clinically significant history of traumatic brain injury meant a history of recurrent mTBI (i.e. more than three mTBIs (20–22), moderate or severe traumatic brain injury).

Potential participants with mTBI were eligible to participate if they had sustained an mTBI more than six months prior to recruitment. There was no upper limit established for time since injury. The definition of mTBI was that recommended by the New Zealand Guidelines Group (23) which is based on that proposed by the World Health Organization (WHO) Neurotrauma Task Force (24,25) (see Box 1).

Participants with chronic pain for this study were those referred to a multidisciplinary pain management treatment programme at a local hospital. Participants were eligible for participation if they had a diagnosis of chronic pain and had experienced symptoms for more than six months. There was no upper limit for symptom duration. The Pain Management Team agreed to provide flyers about the study to eligible and interested potential participants.

Box 1: Injury markers of mTBI (23–25)
Loss of consciousness ≤ 20–30 minutes
Glasgow Coma Scale[46] score ≥ 13 (30 minutes after injury)
Post-Traumatic Amnesia ≤ 24 hours
Absence of significant findings on imaging (CT/MRI)

Study measures

(1) Post-concussion symptoms

The Rivermead Post-concussion Symptoms Questionnaire (RPQ) (26) is a 16-item self-report symptom inventory of common PCS symptoms following mTBI. Three factors or domain scores (somatic, cognitive and emotional) can be derived from the RPQ (27,28) and were calculated. These RPQ symptom domains were also used to determine group membership (recovered or nonrecovered) for the participants with mTBI. A participant was deemed nonrecovered from their mTBI if they endorsed a score of two or more on any symptom within each of the three RPQ symptom domains, following our previous work (16,29).

(2) Psychological measures

The Illness Perceptions Questionnaire-Revised (IPQ-R) (30,31) provides a quantitative assessment of illness beliefs based on Leventhal's Common Sense Model (CSM) of Health and Illness Behaviour(30). Only the Identity, Timeline (Acute/Chronic), Timeline (Cyclic), Consequences, Coherence and Emotional Significance scales were administered. These six subscales evaluating beliefs about injury identity, timeline for recovery, consequences, coherence and emotional significance have been previously validated for mTBI(32).

The Hospital Anxiety and Depression Scale (HADS) (33) has utility as a measure of anxiety, depression and psychological distress symptoms following traumatic brain injury (23,34). The anxiety and depression subscales were calculated for this study.

The Behavioural Response to Illness Questionnaire (BRIQ) (35) is a brief measure examining behavioural responses to illness in order to assess the importance of these behaviours in the development of ongoing medically unexplained syndromes. Four subscales can be calculated from 21 items, addressing all or nothing and limiting behaviours, practical and social help seeking.

The Quality of Life after Brain Injury – Overall Scale (QOLIBRI-OS) (36) is a brief quality of life measure asking six questions about overall satisfaction with physical health, cognitive and emotional functioning, activities of daily living, social functioning and expectations for the future.

(3) Neurocognitive battery

The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)(37) is a brief individually administered neuropsychological test battery measuring attention, language, visuospatial/constructional abilities and immediate and delayed memory, validated for TBI(38). The RBANS provides a total scale score and five sub-scored

indices. An effort index can be calculated to screen for sub-optimal effort during testing(39).

The Colour Word Interference Test from the D-KEFS™ battery(40) is a measure of executive attention network functioning, evaluating sustained attention, ability to inhibit a dominant automatic verbal response, speeded cognitive processing and cognitive flexibility. Four scaled scores can be calculated.

Procedure

Participants who sustained an mTBI more than six-months prior to recruitment with persisting symptoms (nonrecovered group) were recruited first. Participants matching nonrecovered participants who sustained an mTBI more than six-months prior to recruitment but who no longer demonstrated persisting symptoms (recovered group) and participants with chronic pain (CP) for more than six months at time of recruitment (CP group), were then approached and invited to participate in the study. The six-month timeframe was considered sufficient for development of chronic symptoms in both mTBI and CP groups. The research literature suggests the majority of mTBI cases demonstrate recovery within three months after injury(41). Similarly, the International Association for the Study of Pain defines CP as pain without biological value that has persisted beyond the normal tissue healing time (usually taken to be three months)(42).

Participants were matched on demographic variables in a case-control fashion on the basis of age (± 5 years), gender and ethnicity. The participants with mTBI were also matched on injury severity markers of mTBI and Injury Severity Scores (ISS) (43–45).

Inclusion and exclusion criteria were applied by file review by the lead researcher (DS). Eligible potential participants (based on file review), were approached by a research assistant by phone and invited to participate in the study. Those interested in participating were sent information packs containing consent forms. At this time, PCS symptoms were screened for all participants using the RPQ to clarify group membership as described above. No potential participant who met study inclusion and exclusion criteria and who agreed to participate in the study was excluded. This resulted in more nonrecovered participants being recruited because the RPQ scores for a small number of people who appeared to meet criteria for the recovered group (based on file review and initial application of inclusion and exclusion criteria), indicated they should be moved to the nonrecovered group.

Participants agreeing to participate also gave their written consent for the study team to access demographic, injury and medical information from clinical records. Variables collected by file review and/or participant self-report included the following: age; sex; ethnicity; highest educational qualification; employment and compensation status; injury severity indicators such as Glasgow Coma Scale (GCS)(46) score, duration of post-traumatic amnesia and loss of consciousness, ISS; history of treatment for a psychiatric condition and/or comorbid psychiatric diagnosis; substance use; neurological and medical history.

Information regarding compensation status was collected given consistent findings in the literature that this is important in understanding mTBI outcome(47). All participants with mTBI in this study qualified for injury cover by New Zealand's 'no-fault' government funded injury insurance scheme (Accident Compensation Corporation) at the time of injury. For this study, participants were asked if they had experienced any difficulties with their injury claim and if so, what type of difficulties. Accordingly, compensation difficulty (yes/no) was determined on the basis of the participants own report and perception of their experiences.

Data analyses

Data were analysed using SPSSv24.0 for Mac operating systems(48). Demographic (except age) and injury severity indicators (e.g. loss of consciousness, post-traumatic amnesia, injury mechanism) were coded as categorical variables. Continuous variables included age, days post injury, GCS, ISS and all study psychological measures. The primary approach to managing missing data was list-wise deletion, the default procedure of SPSS. This resulted in $n = 9$ cases being excluded from analyses of psychological measures ($n = 4$ mTBI nonrecovered; $N = 3$ mTBI recovered; $n = 2$ CP). All participants provided complete RPQ data and all but one completed cognitive testing.

Descriptive (univariate) statistics and multivariate statistical tests (Chi-Square tests, Analysis of Variance (ANOVA), multiple regression) were used to describe the demographic, health and psychometric features of participants. A 2-tailed $p < 0.05$ was used to evaluate statistical significance and Tukeys Honest Significant Difference Test was applied to post-hoc analyses to correct for multiple comparisons. A priori sample size estimates were based on $n = 30$ for each group. At 80% power, and assuming 2-tailed alpha 0.05, moderate effect sizes of 0.6–0.70 would be detectable.

Results

Demographic and clinical characteristics of participants

One hundred and five participants were approached and of these 102 were recruited into the study. Of these $n = 45$ continued to demonstrate PCS symptoms more than six months following an mTBI (nonrecovered group), $n = 31$ were deemed recovered from an mTBI more than six months after injury (recovered group) and $n = 26$ were participants with a chronic pain condition lasting more than six months (CP group). There were no significant differences between the three participant groups on the basis of age, sex, ethnicity and years of education (see Table 1). The mean age of the mTBI nonrecovered group was 47.6 years, and although not reaching significance, there were slightly more men than woman (male: 57.8%). The mean age of the mTBI recovered group was 42.4 years and although not reaching significance, there were slightly fewer men than woman (male: 45.2%). The CP group was slightly older than the other two groups (mean age 49.4 years) and there were slightly fewer men than women (male: 38.5%), although again these findings were not statistically significant.

Table 1. Demographic and clinical characteristics of participants (n = 102).

Variable	mTBI recovered (n = 31)	mTBI Nonrecovered (n = 45)	Chronic pain (n = 26)	Significance (p)
Age [mean (SD)]	42.4 (14.5)	47.6 (14.3)	49.4 (12.2)	0.13[1]
Sex (male) [*N* (%)]	14 (45.2)	26 (57.8)	10 (38.5)	0.26[2]
Ethnicity [*N* (%)]	25 (80.6)	39 (86.7)	20 (76.9)	0.28[2]
– NZ European	1 (3.2)	4 (8.9)	2 (7.7)	
– NZ Maori	1 (3.2)	0	0	
– Pacific Peoples	4 (12.9)	2 (4.4)	4 (15.4)	
– Other				
Education [*N* (%)]	0	6 (13.3)	6 (23.7)	0.11[2]
– No qualifications	10 (32.3)	15 (33.3)	11 (42.3)	
– High school completion	17 (54.8)	20 (44.4)	6 (23.1)	
– Tertiary	2 (6.5)	1 (2.2)	1 (3.8)	
– Other				
GCS [M (SD)]	14.7 (0.5)	14.8 (0.6)	N/A	1.00[1]
PTA	7 (22.6)	4 (8.9)	N/A	0.29[2]
– None	12 (38.7)	24 (53.3)		
– < 1 hour	9 (29.0)	16 (35.6)		
– >1 hour < 24 hours				
ISS [M (SD)]	5.0 (2.3)	4.4 (2.4)	N/A	0.32[1]
LOC (yes) [*N* (%)]	20 (64.5)	30 (66.7)	N/A	0.44[2]
Months post injury [M (SD)]	37.8 (70.7)	30.1 (33.9)	N/A	
Injury mechanism [*N* (%)]	15 (48.4)	14 (31.1)	N/A	0.47[2]
– Road accident	3 (9.7)	10 (22.2)		
– Fall	3 (9.7)	6 (13.3)		
– Assault	3 (9.7)	6 (13.3)		
– Sports	7 (22.6)	9 (20.0)		
– Other				
Work Status [*N* (%)]*	2 (6.5)	12 (26.7)	7 (26.9)	**0.03[2]**
– Still off work	3 (9.7)	10 (22.2)	4 (12.9)	
– Back part time	21 (67.7)	19 (42.2)	7 (26.9)	
– Back full time	5 (16.1)	4 (8.8)	8 (30.8)	
– Other				
Compensation difficulties (yes) [*N* (%)]	5 (16.1)	12 (26.6)	6 (23.1)	0.13[2]
Previous TBI (yes) [*N* (%)]	16 (51.6)	25 (55.6)	8 (30.7)	0.19[2]
Psychiatric History (yes) [*N* (%)]*†	8 (25.8)	19 (42.2)	16 (61.5)	**0.02[2]**

* Significant difference $p < 0.05$; mTBI = mild traumatic brain injury; GCS = Glasgow Coma Scale; ISS = Injury Severity Score; PTA = post-traumatic amnesia.; LOC = loss of conciousness; TBI = traumatic brain injury (any severity). † Difference between CP and both mTBI groups significant but difference between the mTBI recovered and nonrecovered not significant.[1]ANOVA with Tukey's HSD post-hoc correction for multiple comparisons (significance = $p < 0.05$)
[2]Chi Square

Table 1 also shows there were no significant differences between the two mTBI groups on the basis of injury mechanism or severity, in terms of Glasgow Coma Scale scores, duration of post-traumatic amnesia, loss of consciousness, or injury severity scores. However, at time of study participation, the recovered group were on average more likely to be back at work either full or part time than the other groups, with 77.4% of mTBI recovered participants back at work compared with 64.4% nonrecovered and 42.3% CP participants ($p < 0.05$). The only other significant demographic or clinical difference between the groups was with respect to past psychiatric history. The CP group were more likely to have a past psychiatric diagnosis than both mTBI groups.

A range of pain conditions characterized participants with CP. These conditions were characterized using International Association for the Study of Pain terminology as follows: musculoskeletal syndrome of lower limbs (n = 14); musculoskeletal syndrome of shoulders and upper limbs (n = 3); musculoskeletal syndrome lower back (n = 8); abdominal pain not otherwise specified (n = 5); fibromyalgia (n = 4) and chronic regional pain syndrome (n = 2). Some participants had more than one pain condition.

Psychological characteristics of participants

Table 2 shows psychological characteristics compared across the three participant groups with respect to symptom burden, anxiety and depression symptoms, illness beliefs and behaviours and quality of life. There were significant differences between participants who had recovered from an mTBI and both other study groups across all measures, with the exception of three BRIQ subscales. These were the all or nothing, emotional and practical support seeking subscales, where no differences were evident between any of the groups.

The mTBI nonrecovered and CP groups were similar with respect to reported levels of depressive symptoms, use of limiting behaviours and quality of life. However, differences were evident in that participants with CP; (i) endorsed higher levels of anxiety about their health condition, (ii) were more

Table 2. Psychological characteristics across participants groups (n = 102).

Variable/Measure	mTBI Recovered (n = 31) [M (SD)]	mTBI Non Recovered (n = 45) [M (SD)]	CP (n = 26) [M (SD)]
RPQ			
– Total score*	12.9 (7.0)*	31.9 (9.1)	26.7 (13.7)
– Somatic subscore*	6.7 (4.0)*	17.5 (6.2)	15.5 (7.9)
– Emotional subscore*	2.3 (2.4)*	6.3 (2.3)	6.2 (3.7)
– Cognitive subscore**	4.0 (2.8)	7.9 (2.1) **	5.0 (3.6)
HADS Anxiety†	5.7 (4.3) †	8.0 (3.4)	8.9 (5.2)†
HADS Depression*	2.8 (3.1)*	6.7 (3.7)	7.2 (5.5)
BRIQ (Limiting Behaviour)*	16.9 (4.9)*	19.8 (3.9)	20.7 (5.1)
BRIQ (all or Nothing Behaviour)	16.6 (5.0)	17.8 (4.1)	17.7 (4.9)
BRIQ (Emotional Support Seeking)	6.0 (2.4)	6.1 (2.1)	7.0 (3.3)
BRIQ (Practical Support Seeking)	6.8 (2.8)	7.3 (3.6)	8.4 (3.6)
IPQR Identity**	30.3 (3.5)	25.7 (3.0)**	28.3 (3.8)
IPQR Timeline (acute/chronic)*†	17.1 (4.6)*	19.7 (3.6) †	23.6 (3.7) †
IPQR Timeline (cyclic)¥	10.0 (3.6) ¥	12.5 (3.9) ¥	11.8 (4.3)
IPQR Consequences*	15.5 (5.3)*	20.1 (5.5)	22.1 (4.8)
IPQR Emotional Rep‡	15.0 (5.6) ‡	17.3 (4.7)	19.9 (5.6) ‡
IPQR Coherence	17.3 (4.6)	16.5 (4.8)	17.5 (5.8)
QOLIBRI*	21.5 (5.7)*	16.5 (5.7)	15.7 (6.9)

ANOVA with Tukey's HSD post-hoc correction for multiple comparisons (significance = $p < 0.05$)

* Difference between mTBI recovered and both other groups significant; †Difference between mTBI nonrecovered and CP significant; ‡Difference between mTBI recovered and CP significant. ** Difference between mTBI nonrecovered and both other groups significant; ¥ Difference between mTBI recovered and mTBI nonrecovered significant.

mTBI = mild traumatic brain injury; CP = chronic pain; RPQ = Rivermead Post-Concussion Symptom Questionnaire; HADS = Hospital Anxiety and Depression Scale; BRIQ = Behavioural Responses to Illness Questionnaire; IPQR = Illness Perceptions Questionnaire Revised; QOLIBRI = Quality of Life In Brain Injury – Overall Scale.

negative about prospects for recovery, (iii) endorsed more expected negative consequences, and (iv) were less clear about the identity of their condition.

Cognitive functioning

Table 3 shows that across cognitive measures both participants who had not recovered from an mTBI and participants with CP achieved lower RBANS index scores than the participants who had recovered from an mTBI for immediate and delayed memory. These scores fell in the average ability range across all groups so the clinical significance of these patterns in terms of suggested impairment is not clear. There were no other significant differences between the groups across RBANS indices. Table 3 also shows that the mTBI nonrecovered group performed at a lower level on average than both other groups in terms of their colour word interference test scaled scores suggesting lower sustained attention, speeded cognitive processing and cognitive flexibility. These results were consistent with higher levels of self-reported cognitive problems on the RPQ (see Tables 2 and 6). There were no other significant differences across the three groups regarding cognitive functioning, including an index of effort.

However, when the impact of psychological symptoms was considered, results indicated that variance in scores between groups could be explained by presence of depressive symptoms (HADS scores). The RBANS indices (immediate and delayed memory, attention) and colour word interference scores were highly correlated with HADS scores for the whole sample as shown in Table 4. Multiple regression analyses identified the impact of depression in terms of explained variance in cognitive performances (Table 5). Gender, age and group assignment were not significant in the final models.

Table 3. Performances on cognitive tests across participant groups (n = 102).

Variable/Measure	mTBI Recovered (n = 31) [M (SD)]	mTBI Non Recovered (n = 45) [M (SD)]	CP (n = 26) [M (SD)]
RBANS Total Score	110.4 (12.6)	104.4 (14.5)	105.6 (12.9)
RBANS Immediate Memory Index*	109.3 (13.7)*	99.4 (20.6)*	99.9 (13.6)
RBANS Delayed Memory Index*	111.1 (12.0)*	101.9 (16.3)*	104.3 (11.9)
RBANS Language Index	103.0 (9.7)	101.4 (10.3)	104.8 (9.8)
RBANS Visuospatial Index	114.1 (8.8)	112.8 (10.1)	110.6 (11.6)
RBANS Attention Index	102.7 (15.1)	100.4 (16.2)	102.4 (13.9)
RBANS Effort Index [*N* (%)]			
– score of 0	28 (90.3)	41 (91.1)	23 (92.0)
– Score 1 or more	3 (9.7)	4 (8.9)	3 (8.0)
CWIT-I Scaled Score	8.9 (3.0)	8.6 (3.4)	9.7 (2.9)
CWIT-II Scaled Score	9.2 (2.6)	9.2 (3.0)	10.0 (2.7)
CWIT-III Scaled Score	10.2 (2.6)	8.4 (4.0)	10.2 (2.7)
CWIT-IV Scaled Score**	10.4 (2.5)	8.5 (4.0)**	10.5 (2.2)

ANOVA with Tukey's HSD post-hoc correction for multiple comparisons (significance = $p < 0.05$); 1 = Chi Square Test

*Difference between mTBI recovered and mTBI nonrecovered significant; ** Difference between mTBI nonrecovered and both other groups significant

mTBI = mild traumatic brain injury; CP = chronic pain; RBANS = Repeatable Battery for the Assessment of Neuropsychological Status; CWIT = Colour Word Interference Test from D-KEFS Battery.

Table 4. Pearson's correlations between HADS anxiety and depression symptoms and cognitive measures for the whole sample (n = 102).

	RBANS IMI	RBANS VCI	RBANS LI	RBANS AI	RBANS DMI	RBANS TS	CWIT III	CWIT IV
HADS Anxiety	−0.21*	−0.13	−0.19	−0.09	−0.25*	−0.23*	−0.13	0.07
HADS Depression	−0.35**	−0.15	−0.22*	−0.28**	−0.36**	−0.39**	−0.34**	−0.20

* $p < 0.05$; ** $p < 0.01$.

[HADS = Hospital Anxiety and Depression Scale; RBANS = Repeatable Battery for Assessment of Neuropsychological Status; IMI = immediate memory index; VCI = visuospatial/constructional index; LI = language index; AI – attention index; DMI = delayed memory index; TSI = total scale index; CWIT-III = colour word interference test condition 3 (from Delis Kaplin Executive Function System [DKEFS] Battery); CWIT-IV = colour word interference test condition 4 (from DKEFS battery)].

Table 5. Regression analyses demonstrating impact of depression on selected cognitive performances (n = 102).

	RBANS IMI	RBANS DMI	RBANS AI	CWIT III	CWIT IV
Adjusted R^2 (step 3)	0.10*	0.12*	0.06*	0.19*	0.16*
F Change (step 3)	4.96*	5.65*	10.89*	11.25*	10.72*
B (step 3)					
- mTBI nonrecovered	−4.28 (ns)	−5.78 (ns)	1.88 (ns)	−0.61 (ns)	−1.44 (ns)
- CP	−3.29 (ns)	−2.90 (ns)	3.83 (ns)	1.24 (ns)	0.33 (ns)
- Age	−0.15 (ns)	0.14 (ns)	0.10 (ns)	−0.01 (ns)	0.04 (ns)
- Gender (male)	2.67 (ns)	0.54 (ns)	0.77 (ns)	0.41 (ns)	0.40 (ns)
- HADS Anxiety	0.14 (ns)	0.04 (ns)	0.74 (ns)	0.12 (ns)	0.29*
- HADS Depression	−1.23*	−1.07*	−1.61*	−0.35*	−0.33*

* $p < 0.05$; ns = not significant;

Variables entered at step 1: group, gender, age; Variables entered at step 2: HADS anxiety; Variables entered at step 3: HADS Depression.

[mTBI = mild traumatic brain injury group; CP = chronic pain group; RBANS = Repeatable Battery for Assessment of Neuropsychological Status; IMI = immediate memory index; DMI = delayed memory index; AI = attention index; CWIT-III = colour word interference test condition 3 (from Delis Kaplin Executive Function System [DKEFS] Battery); CWIT-IV = colour word interference test condition 4 (from DKEFS battery)].

Finally, differences in cognitive functioning were examined on the basis of age and gender for the whole sample. The only significant difference was for the Language Index of the RBANS where women on average achieved higher scores than men (t = 4.19, mean difference = 7.60, 95% confidence interval 3.94, 11.26; $p < 0.05$).

Self-reported post-concussion symptoms

Table 6 shows the breakdown of item scores from the RPQ across the three groups indicating that participants who had recovered from an mTBI reported significantly less difficulties than both other groups across all items except item 16 (restlessness). The mTBI nonrecovered group and the group with chronic pain differed across emotional and cognitive symptom items, and blurred vision. There were no differences on the basis of age or gender for total RPQ scores but when responses to individual item scores were examined, men endorsed higher levels of irritability than women (item 7: $X^2 = 13.54$; $p = 0.01$).

Discussion

There were similarities between participants who had not recovered from mTBI and participants with CP in this study. Both groups endorsed high levels of PCS symptoms, expected to experience negative consequences of their health condition, engaged in limiting behaviours, reported low QOL and high distress. However, participants who had not recovered from mTBI endorsed more self-reported cognitive problems and demonstrated more objective cognitive difficulties than those with CP. These differences though appeared associated with level of reported depressive symptoms. The CP group were less clear about the identity of their condition and more negative about prospects of recovery.

That people without a history of TBI might also report PCS-like symptoms is not surprising when base rates in the general population are considered (49–51). Our findings of high reported PCS-like symptoms by participants with CP are consistent with studies that have reported such symptoms in people with depression (52–54) as well as chronic pain (10,12), and research challenging the specificity of PCS symptoms in mTBI (55,56). Our findings add to this body of literature and suggest as a diagnostic classification, the term PCS is of limited use and should be discarded. Indeed shift away from this terminology has been endorsed by the recently published 5th edition of the Diagnostic and Statistical Manual for Mental Disorders (DSM-V)(57) where the term post-concussional disorder has been removed entirely in favour of neurocognitive disorder after traumatic brain injury.

Patterns of PCS symptom reporting across the mTBI nonrecovered and CP groups in our study are also highly consistent with the one other study by Smith-Seemiller et al (11) comparing self-reported PCS symptoms in chronic pain and mTBI. In this previous study, levels of PCS symptom reporting were compared across 63 people with chronic pain and 32 people who were recruited 12 months after an mTBI, although participants were not matched across demographic variables. Findings were very similar to those of the present study, with the mTBI group endorsing a higher level of self-reported cognitive symptoms, and with both groups endorsing similar levels of PCS symptoms. Our study however extends these observations(11) by also evaluating objective cognitive performances across these two patient groups, recognizing the limitations of reliance on self-reported symptoms (58,59).

Table 6. Percentage of scores ≥ 2 for each item of the rivermead post-concussion symptoms questionnaire (RPQ) across the three study groups (n = 102).

	mTBI recovered (n = 31) [N (%)]			mTBI nonrecovered (n = 45) [N (%)]			CP (n = 26) [N (%)]		
RPQ score	2	3	4	2	3	4	2	3	4
RPQ1* (Headaches)	6 (19.4)	3 (9.7)	0 (0.0)	11 (24.4)	15 (33.3)	10 (22.2)	7 (26.9)	4 (15.4)	3 (11.5)
RPQ2* (Dizzines)	3 (9.7)	0 (0.0)	1 (3.2)	20 (44.4)	11 (24.4)	0 (0)	7 (26.9)	3 (11.5)	1 (3.8)
RPQ3* (Nausea)	1 (3.2)	0 (0.0)	1 (3.2)	9 (20.0)	4 (8.9)	0 (0.0)	6 (23.1)	2 (7.7)	2 (7.7)
RPQ4* (Noise)	10 (32.2)	2 (6.5)	0 (0.0)	11 (24.4)	11 (24.4)	10 (22.2)	3 (11.5)	8 (30.8)	1 (3.8)
RPQ5* (Sleep)	5 (16.1)	0 (0.0)	0 (0.0)	10 (22.2)	17 (37.8)	8 (17.8)	1 (3.8)	9 (34.6)	11 (42.3)
RPQ6* (Fatigue)	8 (25.8)	3 (9.7)	1 (3.2)	7 (15.6)	21 (46.7)	14 (31.1)	3 (11.5)	11 (42.3)	9 (34.6)
RPQ7*† (Irritability)	4 (12.9)	2 (6.5)	1 (3.2)	15 (33.3)	14 (31.1)	8 (17.8)	5 (19.2)	5 (19.2)	4 (15.4)
RPQ8*† (Depressed)	2 (6.5)	1 (3.2)	0 (0.0)	19 (42.2)	5 (11.1)	2 (4.4)	4 (15.4)	4 (15.4)	7 (26.9)
RPQ9*† (Frustration)	7 (22.6)	2 (6.5)	0 (0.0)	13 (28.9)	20 (44.4)	5 (11.1)	8 (30.8)	3 (11.5)	7 (26.9)
RPQ10*† (Memory)	7 (22.6)	7 (22.6)	6 (19.4)	13 (28.9)	20 (28.9)	8 (17.8)	6 (23.1)	4 (15.4)	3 (11.5)
RPQ11*† (Concentration)	7 (22.6)	3 (9.7)	0 (0.0)	14 (31.1)	19 (42.2)	7 (15.6)	9 (34.6)	3 (11.5)	4 (15.4)
RPQ12*† (Slow thinking)	14 (45.2)	2 (6.5)	1 (3.2)	12 (26.7)	24 (53.3)	5 (11.1)	6 (23.1)	4 (15.4)	2 (7.7)
RPQ13*† (Blurred Vision)	3 (9.7)	1 (3.2)	1 (3.2)	13 (28.9)	8 (17.8)	1 (2.2)	2 (7.7)	1 (3.8)	1 (3.8)
RPQ14* (Light)	6 (19.4)	0 (0.0)	0 (0.0)	16 (36.4)	8 (18.2)	4 (9.1)	5 (19.2)	2 (7.7)	3 (11.5)
RPQ15* (Double vision)	0 (0.0)	0 (0.0)	0 (0.0)	4 (8.9)	0 (0.0)	1 (2.2)	0 (0.0)	1 (3.8)	1 (3.8)
RPQ16 (Restless)	5 (16.7)	2 (6.7)	0 (0.0)	15 (33.3)	9 (20.0)	2 (4.4)	5 (19.2)	4 (15.4)	4 (15.4)

* Difference between mTBI recovered and both other groups significant $p < 0.05$; †Difference between mTBI nonrecovered and CP significant $p < 0.05$.
mTBI = mild traumatic brain injury; CP = Chronic Pain; RPQ = Rivermead Post-Concussion Symptom Questionnaire; a score of 2 = mild difficulty, 3 = moderate difficulty, 4 = severe difficulty.

Persisting cognitive impairment after mTBI is a contentious issue. A number of systematic reviews with and without meta-analyses involving many thousands of patients have indicated that for the majority, resolution of cognitive difficulties is evident between 1–3 months following a mTBI (60–63). However, some studies report residual cognitive difficulties, often in the attention domain long after injury (4,64). In the present study participants with mTBI meeting criteria for nonrecovery were on average 30 months' post injury at time of study participation. This group, consistent with some prior research (4,64), demonstrated difficulties with higher level attention compared with both participants with chronic pain and those who had recovered from an mTBI. However, we noted that these difficulties appeared associated with level of reported depressive symptoms underscoring the importance of controlling for depression and other psychiatric symptoms when cognitive difficulties long after an mTBI are explored.

We also sought to compare aspects of psychological functioning across two groups with some similarities in terms of vulnerability for development of chronic symptoms. We hoped this might shed light on the pathway from acute to chronic symptoms particularly with respect to understanding and managing chronic symptoms after mTBI. Contrary to expectations, our findings did suggest some condition specific psychological factors. For example, participants who had not recovered from mTBI, compared with the participants with CP, demonstrated a stronger tendency to attribute difficulties to their health condition (mTBI) even more than two years following injury, as measured with the IPQ-R Identity Scale. Such (mis)attribution of symptoms to injury has been discussed in the wider mTBI literature(65) as potentially harmful as this may limit a person's ability to shift to considering other factors that might underpin chronic symptoms such as life stress, depression and anxiety(17).

We also examined illness behaviours using a measure validated for use in a context of medically unexplained symptoms (66). Of the four Behavioural Responses to Illness Questionnaire (BRIQ) subscales, both the mTBI nonrecovered and CP participant groups endorsed a higher level of engagement in limiting behaviours than the mTBI recovered group. This included avoidance of activities, putting life on hold, and spending time in bed. Beliefs about the dangerousness of exertion and corresponding fear avoidance behaviour, termed kinesiophobia by some(67), may lead some people with chronic pain and mTBI to restrict their activities. In addition and perhaps specific to mTBI, avoidance of cognitive activities, coined cogniphobia (67,68), may result in avoidance of cognitive activities in particular.

Findings from the current study also underscore the importance of recovery beliefs and understandings. In a recently published qualitative study involving a subset of the mTBI participants from the present study(69), the possession of a coherent understanding about their injury symptoms and a

pathway or roadmap to recovery seemed to have a buffering effect. When managed well participants indicated that these factors helped them cope with anxiety, and facilitated self-esteem, self-control, and positive recovery expectations. In another qualitative study considering the perspectives of military personnel with mTBI who were injured while serving in Iraq and Afghanistan(70), participants highlighted chaos and confusion as hindering recovery, with intervention perceived as helpful if this enabled them to re-establish a sense of stability and order. Accordingly, interventions focusing on optimizing recovery expectations by providing evidence-based educational information, reassurance regarding expected recovery, and a pathway to wellness may be helpful. Educational interventions can help validate the individual's experience. There are a number of systematic reviews now that demonstrate the effectiveness of educational interventions after mTBI (71–73), however, the components and timing of such interventions remain unclear and not all patients benefit from this type of approach(73).

The patterns of similarities and differences between the participants who had not recovered from mTBI and participants with CP in this study suggest individualized treatment approaches may be beneficial and highlight the need to consider psychological constructs that might enhance vulnerability to development of chronic symptoms in both people with mTBI and chronic pain. There is a growing body of work indicating that psychological and psychosocial factors predict outcomes after mTBI (14,16,74), and can discriminate between clusters of cases at risk for persistent unremitting symptoms beyond nine months(16).

Limitations

This was a small study with convenience samples, albeit closely matched across demographic variables. Prospective examination of the psychological factors examined in the present study, with larger samples of participants will be helpful to better understand associations between the myriad of pre-, peri- and post-injury risk factors and outcomes after mTBI. In addition, we did not collect information about treatment experiences or medication use meaning we could not explore the impact that intervention medications may have had on symptom endorsement and neurocognitive measures examined in this study. These are importance factors to consider in terms of understanding persisting symptoms and recovery in both people with mTBI and chronic pain. Finally, we did not collect information about duration of symptoms from the participants with CP. This would have been helpful in providing comparison data across the groups and could have been an influencing factor, for example if participants with CP had experienced their pain symptoms for a longer duration, this may have contributed to differences in psychological status.

Conclusions

Similar patterns of psychological and psychosocial functioning were evident across CP and mTBI nonrecovered groups in this study. Both groups endorsed high levels of PCS-like symptoms, expected to experience negative consequences of their health condition, engaged in limiting behaviours, reported low QOL and high distress. While participants who had not recovered from an mTBI endorsed more cognitive symptoms than those in the CP group, cognitive differences appeared associated with depressive symptoms. These findings raise concern about attributing PCS and cognitive symptoms to a brain injury in people with mTBI who present long after injury with chronic pain and/or depression as comorbidities.

Declaration of interest

The authors report no declarations of interest

Funding

This research has been supported by an Emerging Researcher First Grant from the Health Research Council of New Zealand (Grant no13/702).

References

1. Cancelliere C, Kristman V, Cassidy J, Hincapié C, Côté P, Boyle E, Carroll L, Stålnacke B, Nygren-De Boussard C, Borg J. Systematic review of return to work after mild traumatic brain injury: results of the international collaboration on mild traumatic brain injury prognosis. Arch Phys Med Rehabil. 2014;95:S201–S209.
2. Belanger H, Barwick F, Kip K, Kretzmer T, Vanderploeg R. Post-concussive symptom complaints and potentially malleable positive predictors. Clin Neuropsychol. 2013;27:343–55.
3. Iverson G, Silverberg N, Lange R, Zasler N. Conceptualizing outcome from mild traumatic brain injury. In: Zasler N, Katz D, Zafonte R, editors. Brain injury medicine: principles and practice. New York: Demos Medical Publishing; 2012. pp. 470–97.
4. Barker-Collo S, Jones K, Theadom A, Starkey N, Dowell A, McPherson K, Ameratunga S, Dudley M, Te Ao B, Feigin V. Neuropsychological outcome and its correlates in the first year after adult mild traumatic brain injury: a population based New Zealand study. Brain Inj. 2015;29:1604–16.
5. Theadom A, Parag V, Dowell T, McPherson K, Starkey N, Barker-Collo S, Jones K, Ameratunga S, Feigin V. Persistent problems one year after mild traumatic brain injury: a longitudinal population study in New Zealand. Br J Gen Pract. 2016;66:e16–23.
6. McCauley S, Boake C, Pedroza C, Brown S, Levin H, Goodman H, Merritt S. Correlates of persistent postconcussional disorder: DSM-IV criteria versus ICD-10. J Clin Exp Neuropsychol. 2008;30:360–79.
7. Wood RL. Understanding the 'miserable minority': a diathesis-stress paradigm for post-concussional syndrome. Brain Inj. 2004;18:1135–53.
8. Alexander MP. Mild traumatic brain injury: pathophysiology, natural history, and clinical management. Neurology. 1995;45:1253–60.
9. Arciniegas D, Anderson C, Topkoff J, McAllister T. Mild traumatic brain injury: a neuropsychiatric approach to diagnosis, evaluation, and treatment. Neuropsychiatr Dis Treat. 2005;1:311–27.
10. Iverson G, McCracken L. 'Postconcussive' symptoms in persons with chronic pain. Brain Inj. 1997;11:783–90.
11. Smith-Seemiller L, Fow NF, Kant R, Franzen MD. Presence of post-concussion syndrome symptoms in patients with chronic pain vs mild traumatic brain injury. Brain Inj. 2003;17:199–206.
12. Stålnacke B. Postconcussion symptoms in patients with injury-related chronic pain. Rehabil Res Pract. 2012;2012:528265.

13. Bazarian J, Blyth B, Mookerjee S, He H, McDermott M. Sex differences in outcome after mild traumatic brain injury. J Neurotrauma. 2010;27:527–39.
14. Losoi H, Silverberg N, Wäljas M, Turunen S, Rosti-Otajärvi E, Helminen M, Luoto T, Julkunen J, Öhman J, Iverson G. Resilience is associated with outcome from mild traumatic brain injury. J Neurotrauma. 2015;32:942–49.
15. Silverberg N, Gardner A, Brubacher J, Panenka W, Li Jun J, Iverson G. Systematic review of multivariable prognostic models for mild traumatic brain injury. J Neurotrauma. 2015;32:517–26.
16. Snell D, Surgenor L, Hay-Smith E, Williman J, Siegert R. The contribution of psychological factors to recovery after mild traumatic brain injury: is cluster analysis a useful approach? Brain Inj. 2015;29:291–99.
17. Iverson G, Silverberg N. Etiology of the post-concussion syndrome: physiogenesis and psychogenesis revisited. NeuroRehabilitation. 2011;29:317–29.
18. Hart R, Martelli M, Zasler N. Chronic pain and neuropsychological functioning. Neuropsychol Rev. 2000;10:131–50.
19. Moriarty O, McGuire B, Finn D. The effect of pain on cognitive function: a review of clinical and preclinical research. Prog Neurobiol. 2011;93:385–404.
20. Iverson GL, Gaetz M, Lovell M, Collins M. Cummulative effects of concussion in amateur athletes. Brain Inj. 2004;18:433–43.
21. Iverson GL, Brooks BL, Lovell MR, Collins MW. No cummulative effects for one or two previous concussions. Br J Sports Med. 2006;40:72–75.
22. Silverberg N, Lange R, Millis S, Rose A, Hopp G, Leach S, Iverson G. Post-concussion symptom reporting after multiple mild traumatic brain injuries. J Neurotrauma. 2013;30:1398–404.
23. NZGG. Traumatic brain injury: diagnosis, acute management and rehabilitation. Evidence Based Best Practice Guideline. Wellington, New Zealand: New Zealand Guidelines Group; 2006.
24. Carroll L, Cassidy J, Holm L, Kraus J, Coronado V. Methodological issues and research recommendations for mild traumatic brain injury: the WHO collaborating centre task force on mild traumatic brain injury. J Rehabil Med. 2004a;43:113–25.
25. Holm L, Cassidy J, Carroll L, Borg J. Summary of the WHO collaborating centre for neurotrauma task force on mild traumatic brain injury. J Rehabil Med. 2005;37:137–41.
26. King N, Crawford S, Wenden F, Moss N, Wade D. The Rivermead Post Concussion Symptoms Questionnaire: a measure of symptoms commonly experienced after head injury and its reliability. J Neurol. 1995;242:587–92.
27. Herrmann N, Rapoport M, Rajaram R, Chan F, Kiss A, Ma A, Feinstein A, McCullagh S, Lanctôt K. Factor analysis of the rivermead post-concussion symptoms questionnaire in mild-moderate traumatic brain injury. J Neuropsychiatry Clin Neurosci. 2009;21:181–88.
28. Potter S, Leigh E, Wade D, Fleminger S. The rivermead post concussion symptoms questionnaire: a confirmatory factor analysis. J Neurol. 2006;253:1603–04.
29. Heitger M, Jones R, Macleod A, Snell D, Frampton C, Anderson T. Impaired eye movements in post-concussion syndrome indicate suboptimal brain function beyond the influence of depression, malingering or intellectual ability. Brain. 2009;132:2850–70.
30. Leventhal H, Leventhal E, Cameron L. Representations, procedures, and affect in illness self-regulation: a perceptual-cognitive model. In: Baum A, Revenson T, Singer J, editors. Handbook of health psychology. Mahwah, NJ: Lawrence Erlbaum Associates; 2001. pp. 19–47.
31. Moss-Morris R, Weinman J, Petrie K, Horne R, Cameron L, Buick D. The revised illness perception questionnaire (IPQ-R). Psychol Health. 2002;17:1–16.
32. Snell D, Siegert R, Hay-Smith E, Surgenor L. An examination of the factor structure of the revised illness perception questionnaire modified for adults with mild traumatic brain injury. Brain Inj. 2010;24:1595–605.
33. Zigmond A, Snaith R. The hospital anxiety and depression scale. Acta Psychiatr Scand. 1983;67:361–70.
34. Whelan-Goodinson R, Ponsford J, Schönberger M. Validity of the hospital anxiety and depression scale to assess depression and anxiety following traumatic brain injury as compared with the structured clinical interview for DSM-IV. J Affect Disord. 2009;114:94–102.
35. Spence M, Moss-Morris R, Chalder T. The behavioural responses to illness questionnaire (BRIQ): a new predictive measure of medically unexplained symptoms following acute infection. Psychol Med. 2005;35:583–93.
36. Von Steinbüchel N, Richter S, Morawetz C, Riemsma R. Assessment of subjective health and health-related quality of life in persons with acquired or degenerative brain injury. Curr Opin Neurol. 2005;18:681–91.
37. Randolph C. The repeatable battery for the assessment of neuropsychological status (RBANS). San Antonio: The Psychological Corporation; 1998.
38. McKay C, Jeffrey C, Wertheimer J, Fichtenberg N, Casey J. The repeatable battery for the assessment of neuropsychological status (RBANS): clinical utility in a traumatic brain injury sample. Clin Neuropsychol. 2008;22:228–41.
39. Silverberg N, Wertheimer J, Fichtenberg N. An effort index for the repeatable battery for the assessment of neuropsychological Status (RBANS). Clin Neuropsychol. 2007;21:841–54.
40. Delis D, Kaplan E, Kramer J. Delis-Kaplan executive function system (D-KEFS). San Antonio, TX: The Psychological Corporation; 2001.
41. McCrea M, Guskiewicz K, Randolph C, Barr W, Hammeke T, Marshall S, Kelly J. Effects of a symptom-free waiting period on clinical outcome and risk of reinjury after sport-related concussion. Neurosurgery. 2009;65:876–82.
42. International Association for the Study of Pain (IASP). Definitions of Chronic Pain Syndromes. [accessed 2017 Apr 17]. http://www.iasp-pain.org
43. Baker S, O'Neill B, Haddon W, Long W. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. J Trauma. 1974;14:187–96.
44. Osler T, Baker S, Long W. A modification of the injury severity score that both improves accuracy and simplifies scoring. J Trauma. 1997;41:922–26.
45. Stevenson M, Segui-Gomez M, Leschohier I, Di Scala C, McDonald-Smith G. An overview of the injury severity score and the new injury severity score. Inj Prev. 2001;7:10–13.
46. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. Lancet. 1974;2:81–84.
47. Silver J. Neuropsychiatry of persistent symptoms after concussion. Psychiatr Clin America. 2014;37:91–102.
48. IBM Corporation. IBM SPSS statistics for Mac, Version 24.0, released 2016. Armonk, NY: IBM Corp; 2016.
49. Donnell A, Kim M, Silva M, Vanderploeg R. Incidence of post-concussion symptoms in psychiatric diagnostic groups, mild traumatic brain injury, and comorbid conditions. Clin Neuropsychol. 2012;26:1092–101.
50. Chan R. Base rate of post-concussion symptoms among normal people and its neuropsychological correlates. Clin Rehabil. 2001;15:266–73.
51. Garden N, Sullivan K. An examination of the base rates of post-concussion symptoms: the influence of demographics and depression. Appl Neuropsychol. 2010;17:1–7.
52. Iverson GL. Misdiagnosis of the persistent postconcussion syndrome in patients with depression. Arch Clin Neuropsychol. 2006;21:303–10.
53. Lange R, Iverson G, Rose A. Depression strongly influnces post-concussion symptom reporting following mild traumatic brain injury. J Head Trauma Rehabil. 2011;26:127–37.
54. Lange R, Brickell T, Kennedy J, Bailie J, Sills C, Asmussen S, Amador R, Dilay A, Ivins B, French L. Factors influencing post-concussion and posttraumatic stress symptom reporting following military-related concurrent polytrauma and traumatic brain injury. Arch Clin Neuropsychol. 2014;29:329–47.

55. Meares S, Shores E, Batchelor J, Baguley I, Chapman J, Gurka J, Marosszeky J. The relationship of psychological and cognitive factors and opioids in the development of the postconcussion syndrome in general trauma patients with mild traumatic brain injury. J Int Neuropsychological Soc. 2006;12:792–801.
56. Meares S, Shores E, Taylor A, Batchelor J, Bryant R, Baguley I, Chapman J, Gurka J, Dawson K, Capon L, et al. Mild traumatic brain injury does not predict acute postconcussion syndrome. J Neurology, Neurosurg Psychiatry. 2008;79:300–06.
57. American Psychiatric Association. Diagnostic and statistical manual of mental disorders: DSM-5. Washington, D.C: American Psychiatric Association; 2013.
58. Iverson G, Brooks B, Ashton L, Lange R. Interview versus questionnaire symptom reporting in people with the postconcussion syndrome. J Head Trauma Rehabil. 2010;25:23–30.
59. Iverson G, Lange R, Brooks B, Ashton Rennison V. "Good old days" bias following mild traumatic brain injury. Clin Neuropsychol. 2010;24:17–37.
60. Belanger H, Spiegel E, Vanderploeg R. Neuropsychological performance following a history of multiple self-reported concussions: a meta-analysis. J Int Neuropsychological Soc. 2009;16:262–67.
61. Frencham K, Fox A, Maybery M. Neuropsychological studies of mild traumatic brain injury: a meta-analytic review of the research since 1995. J Clin Exp Neuropsychol. 2005;27:334–51.
62. Pertab J, James K, Bigler E. Limitations of mild traumatic brain injury meta-analyses. Brain Inj. 2009;23:498–508.
63. Schretlen DJ, Shapiro AM. A quantitative review of the effects of traumatic brain injury on cognitive functioning. Int Rev Psychiatry. 2003;15:341–49.
64. Beaupre M, De Guise E, McKerral M. The association between pain-related variables, emotional factors, and attentional functioning following mild traumatic brain injury. Rehabil Res Pract. 2012;2012Article ID 924692:924610.
65. Mittenberg W, DiGiulio D, Perrin S, Bass A. Symptoms following head injury: expectation as etiology. J Neurology, Neurosurg Psychiatry. 1992;41:611–16.
66. Spence M, Moss-Morris R, Chalder T. The Behavioural Responses to Illness Questionnaire (BRIQ): a new predictive measure of medically unexplained symptoms following acute infection. Psychol Med. 2004;35:583–93.
67. Suhr J, Spickard B. Pain-related fear is associated with cognitive task avoidance: exploration of the cogniphobia construct in a recurrent headache sample. Clin Neuropsychol. 2012;26:1128–41.
68. Silverberg N, Iverson G, Panenka W. Cogniphobia in mild tramatic brain injury. J Neurotrauma. 2016. doi:10.1089/neu.2016.4719.
69. Snell D, Martin R, Surgenor L, Siegert R, Hay-Smith E. What's wrong with me? Seeking a coherent understanding of recovery after mild traumatic brain injury. Disabil Rehabil. 2017;39(19):1968–75.
70. Brunger H, Ogden J, Malia K, Eldred C, Terblance R, Mistlin A. Adjusting to persistent post-concussive symptoms following mild traumatic brain injury and subsequent psycho-educational intervention: A qualitative analysis in military personnel. Brain Inj. 2014;28:71–80.
71. Comper P, Bisschop S, Carnide N, Triccio A. A systematic review of treatments for mild traumatic brain injury. Brain Inj. 2005;19:863–80.
72. Nygren-De Boussard C, Holm L, Cancelliere C, Godbolt A, Boyle E, Sta°Lnacke B, Hincapie´ C, Cassidy J, Borg J. Nonsurgical interventions after mild traumatic brain injury: aSystematicReview. Results of the international collaboration on mild traumatic brain injury prognosis. Arch Phys Med Rehabil. 2014;95:S257–264.
73. Snell D, Surgenor L, Hay-Smith E, Siegert R. A systematic review of psychological treatments for mild traumatic brain injury: an update on the evidence. J Clin Exp Neuropsychol. 2009;31:20–38.
74. Snell D, Hay-Smith E, Surgenor L, Siegert R. Predicting long-term outcome after mild traumatic brain injury: the contribution of injury beliefs and leventhal's common sense model. Neuropsychol. Rehabil. 2013;23(3):333–62.