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Post-concussion symptoms after traumatic brain injury at 3 and 12 months post-injury: A prospective study

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Abstract

Primary objectives: To examine self-reported post-concussion symptoms from 3–12 months post-injury in adults with traumatic brain injury (TBI) and to identify predictors of these symptoms.

Methods and procedures: A 1-year prospective study in Eastern Norway including 115 persons (16–55 years), with mild, moderate and severe TBI. The Rivermead Post Concussion Symptoms Questionnaire (RPQ) and Hospital Anxiety and Depression Scale (HADS) were administered. Magnetic resonance imaging (MRI) was performed at 12 months.

Results: In the whole sample of TBI, 27.8% of cases developed post-concussion syndrome (PCS) at 3 months and 23.6% at 12 months post-injury. The mild and moderate groups showed a decline of PCS symptoms over time, in contrast to the severe TBI group. Greater levels of somatic, cognitive and anxiety symptoms at 3 months, as well as shorter PTA duration, were found to be important predictors for the severity of PCS symptoms at 12 months. Intracranial pathology, Glasgow Coma Scale (GCS) and demographic variables were not related to the severity of PCS symptoms.

Conclusions: PCS symptoms were reported to a greater degree in persons with mild TBI at 3 months post-injury. One year after injury, no differences were found between TBI groups on the presence of PCS.

Keywords: *Post-concussion syndrome, mild TBI, predictors, cognitive, somatic, anxiety, MRI*

Introduction

Post-concussion syndrome (PCS) is a term used to describe a constellation of cognitive, emotional and somatic symptoms that can occur following a traumatic brain injury (TBI). PCS symptoms tend to be more common following mild TBI than following moderate-to-severe TBI. The annual incidence of hospital-treated TBI for the population of Oslo, Norway, is 83.3 per 100 000; with 86% of all cases classified as mild TBI, 8% as moderate and 6% as severe TBI [1]. Guidelines have been made in Scandinavia for the initial management of mild and moderate TBI, specifying three grades of injury by the Glasgow Coma Scale (GCS) in order to assess the risk of intracranial complications and to predict the outcome [2].

Recovery from mild TBI is usually good, with cognitive problems resolved within 3 months in the majority of persons [3]. However, subjective symptoms such as headache, fatigue, dizziness, depression and anxiety have been reported by 24–40% of persons with mild TBI within 3 months post-injury [4–7]. Such symptoms may last for more than 1 year in 10–20% of persons with mild TBI [3, 8]. The condition is classified as PCS by the International Classification of Diseases, 10th edition (ICD-10) [9] and is mostly applied to individuals with a mild TBI

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and the absence of objective findings [3, 10]. However, PCS has also been described as 'the cluster of signs and symptoms that can be seen after TBI of any severity' [11]. Other studies have confirmed that PCS is not limited to mild TBI, but may also follow moderate-to-severe TBI [7, 12–14].

When no brain pathology or cognitive deficits are found by neurological or neuropsychological assessments, self-reports of complaints might be the crux of the matter to differentiate PCS from psychiatric problems in individuals with mild TBI [3, 14, 15]. It has been noted that cognitive symptoms ranks amongst the most common complaints in the TBI population compared to other health-related disorders [14, 16]. Memory and concentration-related cognitive deficits are frequently reported after mild-to-moderate TBI [16, 17]. Early somatic PCS symptoms, such as headache and dizziness, predict PCS problems lasting for at least 1 month after the injury [18, 19], those are attributed to neurological aetiology and may dissipate with time. Emotional PCS symptoms such as anxiety [6] and depression [20] are more persistent. Empirical evidence shows that anxiety as a specific PCS symptom predicts the presence and severity of PCS problems [6, 21, 22], often resulting in more anxiety in populations with mild TBI than in those with moderate or severe TBI [23]. Several authors suggest that some PCS symptoms are related, such as fatigue, which is often accompanied by symptoms as headache [24] and depression [25].

On the other hand, PCS symptoms are argued to be non-specific because they have been reported by 82% of individuals with chronic pain [16], by 43% of persons with non-brain injured trauma [22], as well as by 15% of healthy individuals [15]. Iverson and Lange [15] noted that PCS symptoms are highly correlated to depressive symptoms in a non-injured group of individuals.

Taken together, controversies about the mechanisms that cause the development of PCS have continued among researchers and the contribution of organic and/or emotional features still remains unclear. There is limited research comparing PCS symptoms in individuals with mild, moderate and severe TBI. In this study, the presence or absence of PCS is based on number of PCS symptoms diagnosed according to the ICD-10 and applied in previous studies [7, 26]. Outcome was chosen 1 year after injury when many individuals have returned to their baseline productivity functioning. The aims of this prospective study were:

(1) To examine the development of PCS from 3–12 months. It was hypothesized that PCS symptoms would be reported most frequently in persons with mild TBI and less frequently in those with severe TBI. Furthermore, that the precence of PCS would decrease over time after mild TBI and increase over time after severe TBI.
(2) To investigate the effects of cognitive, emotional and somatic PCS symptoms at 3 months post-injury on the presence and severity of PCS at 12 months post-injury. It was hypothesized that specific PCS symptoms at 3 months would contribute more in explaining the variation of PCS severity compared to the effects of demographic and injury-related variables.

Method

Participants

This prospective study was undertaken in Eastern Norway at Norway's largest Level I Trauma Centre, Oslo University Hospital, Ulleval. Recruitment for the study began on 15 May 2005 and continued until 14 May 2007. The study region and incidence of hospital-treated TBI have previously been described in a population-based study [1]. Patients admitted to the hospital with acute TBI were considered for inclusion. TBI was defined as loss of consciousness or some period of post-traumatic amnesia (PTA), skull fracture or objective neurological findings. Additional inclusion criteria were: (a) 16–55 years of age; (b) admitted within 24 hours of injury; (c) Computed Tomography (CT) scan of the brain performed within 24 hours post-injury; (d) fluent Norwegian speakers; (e) no severe substance abuse; (f) no known prior psychiatric or brain pathology; and (g) no associated spinal cord injury.

The initial severity of TBI was measured by the GCS score given on admission to the emergency department at the hospital or pre-intubation values assigned at the accident site. Cause of injury and severity of TBI were based on all available medical information. The gradation into mild, moderate and severe TBI is based on GCS guidelines in the TBI literature [27, 28]. Persons with GCS of 13–15 are regarded as having mild TBI, GCS of 9–12 as moderate TBI, whereas persons with GCS 3–8 are suffering from severe TBI [27].

Persons with mild TBI were included during a 1-year period and persons with moderate and severe TBI were enrolled during a 2-year period. These recruitment periods were chosen to ensure an equal number of participants in the three groups. The full 1-year cohort for mild TBI admitted to the hospital comprised 146 persons who met the inclusion criteria described previously and were living in Oslo. Of these, 45 persons consented to take part

in the study: two returned their consent 6 months after the injury, one did not speak Norwegian, one cancelled and one person did not attend the interview. Comparison between persons with mild TBI who participated in the study ($n = 40$) and those who did not ($n = 106$) showed no significant differences between the groups as regards age, gender, GCS, external cause of injury, loss of consciousness, PTA and CT scans (using *t*-tests or chi-square tests).

Over a 2-year period, 48 persons with moderate TBI and 99 persons with severe TBI who met the inclusion criteria were admitted alive to the hospital, but 23 persons with severe injuries died, as well as one person with moderate TBI. In addition, 20 persons with severe TBI and one person with moderate TBI were excluded because they were amnesic or confused and unable to participate in this study. Moreover, 27 persons were not willing to participate (12 from the moderate group, 15 from the severe group). The differences in age, gender, GCS, external cause of injury and CT scans for participants in the moderate and severe groups were compared with non-participants (using *t*-tests or chi-square and Fisher's exact test). The demographic and injury characteristics were similar in participant and non-participant groups with moderate TBI. In the severe group, a significantly higher number of participants had intracranial pathology on a CT scan ($\chi^2(1) = 5.5$, $p < 0.05$) compared with non-participants. Thus, 40 persons with mild TBI, 34 with moderate TBI and 41 persons with severe TBI participated and were followed up. The percentage of all participants lost to follow-up was 7.8% at 12 months. Written consent was obtained from all participants. The Regional Committee for Medical Research Ethics, East-Norway and the Norwegian Data Inspectorate, approved the study.

Procedures

All consecutive persons with TBI received a letter containing information about the study 4–6 weeks after the injury, together with a form for written informed consent. Persons were invited to enrol in a follow-up study that would include an interview and neuropsychological assessment. Neuropsychological functioning following TBI will be presented in another paper [29]. Evaluations were performed at 3 and 12 months post-injury.

Measures

- *The Rivermead Post Concussion Symptoms Questionnaire* (RPQ) [30] is a 16-item self-report checklist designed to evaluate the severity of PCS symptoms. The RPQ has been validated in Norway [26] to generate the diagnosis of PCS by the ICD-10. Individuals are asked to rate each symptom on a scale of 0–4 ('not experienced at all' to 'a severe problem') over the last 24 hours. The 16 symptoms have been divided into three sub-scales: *Cognitive* (poor memory, poor concentration, taking longer to think), *Emotional* (irritability, depression, frustration, restlessness) and *Somatic* (headache, dizziness, nausea, noise sensitivity, sleep disturbance, fatigue, blurred vision, light sensitivity, double vision) symptoms [16, 31]. In the present study, all the RPQ items were summed to a total score (range 0–64), excluding ratings of 1 as recommended by King et al. [30]. The items of each sub-scale were also summed to a total score, excluding ratings of 1. In order to make all three sub-scales comparable, the total scores from each sub-scale were divided by the number of items. Thus, the total score ranged from 0–4 for each sub-scale. In this study the interpretation of the ICD-10 of PCS by Mittenberg and Strauman [7] was applied, i.e. at least one cognitive, one emotional and one somatic symptom. Following a procedure used by Iverson and Lange [15], a symptom was regarded as a current PCS symptom when rated as moderate or severe (scores ≥ 3).
- *Non-concussion symptoms* were added to a separate list including the five physical items (dry mouth, neck pain, neck stiffness, arm pain, itching) as in the study by van der Naalt et al. [17] and used as 'distractor items', as recommended by Bernstein [8]. Participants responded to each symptom using the same rating scale of 0–4 and with the same instructions as the RPQ.
- *The Hospital Anxiety and Depression Scale* (HADS) [32] is a 14-item rating scale used as a measure of anxiety and depression. The range of scores for each item is 0–3 and for each sub-scale of anxiety or depression 0–21; with scores 0–7 representing 'normal' levels, 8–10 'mild', 11–14 'moderate' and 15–21 'severe' symptoms. Symptoms of anxiety are not directly measured on the RPQ, even though 'restlessness' may be a sign of anxiety. Hence, the HADS anxiety sub-scale was added as an emotional symptom in the present study. The HADS has shown acceptable reliability, with a Cronbach's alpha of 0.83 for the anxiety sub-scale [33].
- *Galveston Orientation and Amnesia Test* (GOAT) [34] is a 10-item scale to measure recovery of orientation and length of PTA. The total score is calculated by deducing the sum of error points from 100. This study only included persons who had returned to full orientation with a GOAT score above 75/100.
- *Magnetic resonance imaging* (MRI) scan of the brain was performed 1 year post-injury. MRI was

performed using a system with a 1.5 T MRI unit (Siemens). Conventional scanning sequences consisted of T1-, T2-, T*-, FLAIR, T1 IR and diffusion-weighted images in different plane (sagittal, axial and coronal) and were analysed by one neuroradiologist. An MRI scan is more sensitive than a CT scan for detecting non-haemorrhagic lesions, as well as brain lesions in mild TBI [28]. In this study, intracranial pathology was defined as the presence of contusion or diffuse axonal injury as revealed by an MRI scan. Intracranial pathology was dichotomized into presence/absence of abnormality.

Statistical analysis

Data analyses were performed using SPSS software version 16.0 (SPSS Inc., Chicago, IL). Analysis of variance (ANOVA) was used for between-group comparisons (mild, moderate, severe) on demographic and injury-related variables. Chi-square (χ^2) analysis was used in the case of categorical variables and for frequency analysis. To investigate associations between severity groups and changes in the elevation of the RPQ total score (3 and 12 months), repeated-measures ANOVA was performed. A stepwise regression analysis was conducted with backward selection of variables to predict PCS severity at 12 months after injury as measured by the RPQ total score (dependant variable). Age, years of education, gender, GCS, PTA, intracranial pathology, the RPQ sub-scales at 3 months and HADS anxiety at 3 months were included as independent variables and entered simultaneously, then sequentially deleted, until those that remained were all statistically significant ($p < 0.05$).

Results

An overview of demographic and injury characteristics is presented in Table I. The three TBI groups differed significantly on all characteristics except for gender. Males ($n = 81$) were over-represented (70.4%) in all groups. Individuals with mild TBI were better educated ($F(2,112) = 6.5$, $p < 0.01$), significantly older ($F(2,112) = 5.0$, $p < 0.01$) and more often involved in assault than those with severe TBI, $\chi^2(6) = 13.2$, $p < 0.05$. A significant difference in the mean duration of PTA was found between the TBI groups ($F(2, 110) = 41.7$, $p < 0.001$). An MRI scan of the head was performed in 88% of the participants at the 1-year follow-up. TBI related intracranial pathology as revealed by MRI is shown in Table I.

In this study, the location of additional injuries was assigned to body regions (face, neck, chest, abdomen, dorsum, extremities or multiple injuries). Further analysis revealed that 37.5% of persons with mild TBI had additional injuries to the face or neck and 7.5% had multiple injuries. In the moderate group, 17.6% had injuries to the face or neck and 29.4% had multiple injuries. Forty-four per cent suffered multiple injuries within the severe group, one person had a neck injury and 12.2% had injuries to the face.

The frequency of PCS cases in the mild, moderate and severe TBI groups is presented in Table II. The presence or absence of PCS is diagnosed according to the ICD-10. Of the entire sample of TBI, 32 persons (27.8%) met the ICD-10 criteria for PCS at 3 months. Of these, 56% ($n = 18$) also met criteria for a PCS at 12 months, 25% ($n = 8$) showed symptoms improvement and 19% ($n = 6$) did not attend at 12 months evaluation. A total of 25 persons with TBI (23.6%) met the diagnosis at 12 months. Of those who did not meet the criteria for the PCS at

Table I. Demographics and injury characteristics of 115 participants with TBI.

	Mild TBI $n = 40$	Moderate TBI $n = 34$	Severe TBI $n = 41$
Mean age at injury (SD)**	35.9 (11.4)	33.5 (10.8)	28.5 (10.4)
Females (*n* (%))	15 (37.5)	9 (26.5)	10 (24.4)
Education years (SD)**	14.3 (2.5)	12.5 (3.0)	12.6 (1.9)
Cause of injury (*n* (%))*			
Traffic accident	11 (27.5)	15 (44.1)	27 (65.9)
Fall	14 (35.0)	9 (26.5)	9 (22.0)
Assault	11 (27.5)	7 (20.6)	3 (7.3)
Sports injury, other	4 (10.0)	3 (8.8)	2 (4.8)
GCS (SD)***	14.7 (0.6)	10.8 (1.3)	5.5 (1.8)
PTA (days, hours, minutes)***	0, 03, 27	5, 05, 24	35, 11, 30
MRI Intracranial pathology***	27.6%	83.3%	97.5%

GCS = Glasgow Coma Scale; PTA = Post-traumatic amnesia; MRI = Magnetic resonance imaging.
Note: MRI scan was not performed in 14 cases (mild, $n = 9$; moderate, $n = 4$; severe, $n = 1$).
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

3 months, only three persons in the moderate group and four persons in the severe group went on to develop PCS at 12 months.

Persons with mild TBI met the criteria for PCS significantly more often at 3 months, $\chi^2(2) = 6.5$, $p < 0.05$, compared to the moderate and severe TBI groups. Within the mild group, there was no statistically significant difference of cases with a PCS at 3 months in those with intracranial pathology compared to those without intracranial pathology ($\chi^2(1) = 1.34$, $p = 0.25$).

The mean RPQ total score for the total sample was 16.1 (SD = 15.8) at 3 months and 15.1 (SD = 15.1) at 12 months. No main group effects were detected by repeated-measures ANOVA. Significant time × severity interactions were found for the RPQ total score ($F(2,100) = 4.93$, $p < 0.01$) and for the HADS anxiety sub-scale ($F(2,100) = 3.10$, $p < 0.05$). These significant interactions indicate that the groups were changing in different ways regarding the severity of PCS symptoms and level of anxiety. No significant gender differences were evident in these measures at 3 and 12 months post-injury.

The percentage of persons reporting problems (score ≥ 2) among the 16 items of the RPQ at 3 months is shown in Figure 1. Significant differences between the TBI groups were observed regarding nausea and depression ($\chi^2(2) = 7.3$, $p < 0.05$; $\chi^2(2) = 6.5$, $p < 0.05$, respectively), with differences found between the mild vs severe TBI groups. The measure of the five 'distractor items' was added to address the amount of symptom reporting associated with mild injury [17]. Chi-square analysis of these data identified significant group differences at 3 months between the mild and moderate groups compared to the severe TBI group regarding neck pain and neck stiffness ($\chi^2(2) = 6.7$,

Table II. Post-concussion symptoms at 3 and 12 months post-injury for participants with mild, moderate and severe TBI.

	Mild TBI		Moderate TBI		Severe TBI	
	3 months	12 months	3 months	12 months	3 months	12 months
No. participants	40	33	34	33	41	40
Presence of PCS[b]⋆	40.0%	27.3%	29.4%	27.3%	14.6%	17.5%
RPQ mean total score (SD)[a]⋆⋆	20.8 (18.3)	15.9 (16.9)	17.0 (15.4)	15.6 (16.2)	10.5 (11.2)	14.1 (12.6)
HADS Anxiety mean score (SD)[a]⋆	6.9 (4.9)	5.4 (4.6)	4.9 (4.2)	4.6 (4.6)	4.7 (4.1)	5.4 (4.9)

PCS = Postconcussion syndrome; RPQ = Rivermead Post Concussion Symptoms Questionnaire; HADS = Hospital Anxiety and Depression Scale.
[a] Repeated-measures of ANOVA: significant time × severity effect.
[b] Chi-square: significant group differences at 3 months post-injury.
⋆$p < 0.05$; ⋆⋆$p < 0.01$.

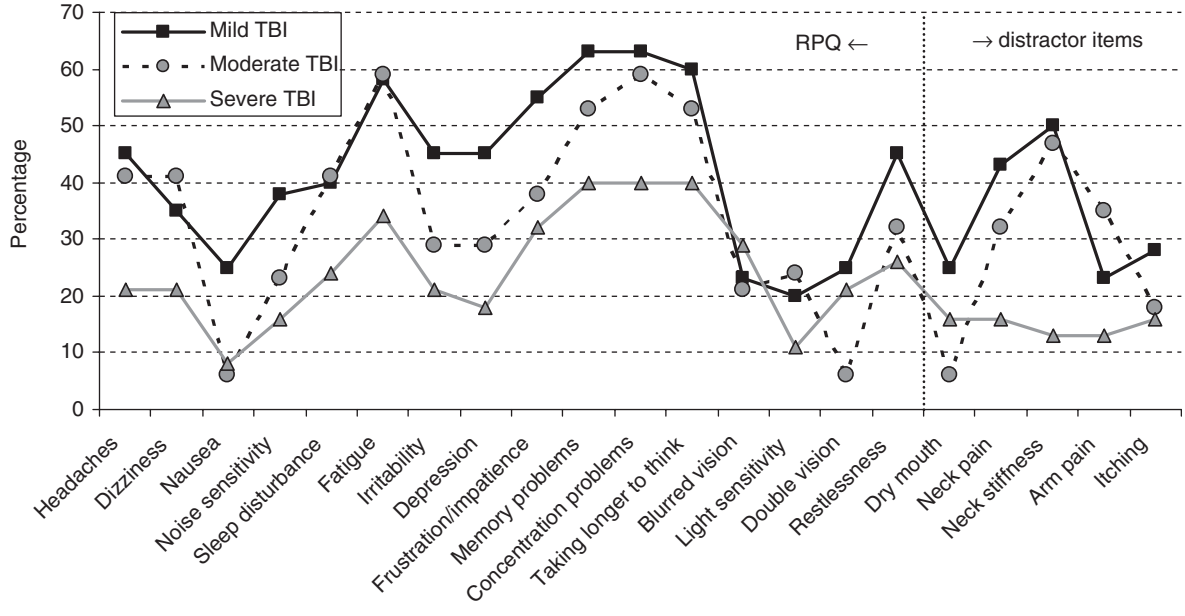

Figure 1. Percentage of persons within each TBI group who reported symptoms rated mild or greater (score ≥2) on the Rivermead Post Concussion Symptoms Questionnaire (RPQ) and on the 'distractor items' at 3 months post-injury.

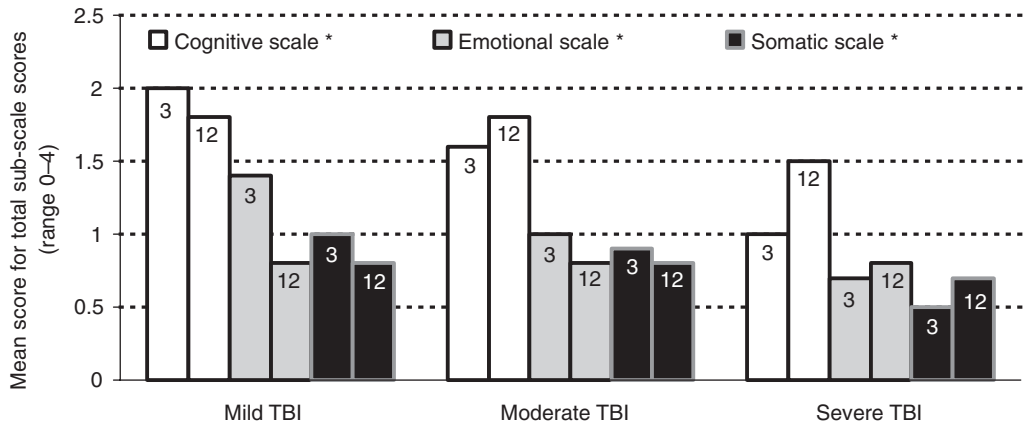

Figure 2. Bar graph illustrating the sub-scales of the Rivermead Post Concussion Symptoms Questionnaire within each TBI group at 3 and 12 months post-injury.
Bars are mean values for the sub-scales at 3 months (3) and 12 months (12) post-injury. The white bars represent the cognitive scale, the grey bars represent the emotional scale, and the black bars represent the somatic scale.
*$p < 0.05$; ANOVA: significant group differences at 3 months post-injury.

Table III. Means, standard deviations and linear regression coefficients (B, β) for predictors in the model of Rivermead Post Concussion Symptoms Questionnaire (RPQ) at 12 months for 106 participants with TBI.

Variables	B	SE B	β	M	SD
Constant	0.26	1.58			
Post-traumatic amnesia (days)	0.09	0.04	0.15*	14.5	24.8
RPQ Somatic sub-scale at 3 months	11.30	1.68	0.59***	0.8	0.9
RPQ Cognitive sub-scale at 3 months	1.86	0.89	0.18*	1.6	1.5
HADS Anxiety at 3 months	0.53	0.26	0.15*	5.5	4.5

Note: $R^2 = 0.67$ ($p < 0.001$). RPQ sub-scale total scores (range 0–4).

$p < 0.05$; $\chi^2(2) = 13.7$, $p < 0.001$, respectively). At 12 months post-injury, there were no significant group differences regarding any of the complaints illustrated in Figure 1. Group comparisons (ANOVA) between the TBI groups across the RPQ sub-scales are presented in Figure 2. Significant differences were found for all these sub-scales between TBI groups at 3 months ($p < 0.05$). However, there were no significant group differences regarding scores on the RPQ sub-scales 1 year after injury.

Result of a multiple regression analysis of the RPQ total scores at 12 months is presented in Table III. Age, years of education, gender, GCS, PTA, intracranial pathology, the three RPQ sub-scales and HADS anxiety at 3 months as independent variables were entered into the regression analysis. A backward regression resulted in four statistically significant predictor variables, the RPQ somatic sub-scale, RPQ cognitive sub-scale, HADS anxiety and PTA. This model explained 67% of the variance in the RPQ total scores at 12 months post-injury ($R^2 = 0.67$, $p < 0.001$). The collinearity diagnostic indicated acceptable degree of collinearity (all variance inflation factors <2.20). No single case within the data exceeded an undue influence on the model, based on Cook's distance ($D < 1$).

Discussion

This prospective study aimed to investigate the presence of PCS and to find predictors for severity of PCS symptoms 1-year after mild, moderate and severe TBI. In the whole sample of TBI, 27.8% of cases met the ICD-10 definition of PCS at 3 months and 23.6% at 12 months post-injury. As expected, it was found that persons with mild TBI were more likely to develop PCS at 3 months than those with severe TBI, consistent with the literature on TBI [7, 14]. At 1 year post-injury, there were no differences in the presence or severity of PCS symptoms between the TBI groups. Greater levels of somatic, cognitive and anxiety symptoms reported at 3 months and shorter PTA duration were the best predictors for the severity of PCS at 12 months. Thus, the hypothesis that cognitive, emotional and somatic PCS symptoms contributed more to severity of PCS than injury related and demographic variables was confirmed.

In this study, 40% of persons with mild TBI fullfilled the criteria for a PCS at 3 months and 27.3% became PCS cases 1 year after the trauma. A similar finding was made by a Scandinavian study [26] that also reported PCS in 40% of persons with mild TBI at 3 months post-injury. It has been clear in the TBI literature that persons with mild TBI report changes in cognition and emotion as consequences of their injuries [5, 6, 8, 10, 19, 20]. However, self-reported PCS symptoms following moderate-to-severe TBI are not well documented. A few studies have grouped together mild-to-moderate [6, 17] and moderate-to-severe TBI [7, 14, 20]. Mittenberg and Strauman [7] found the presence of PCS in 28% of individuals with mild TBI and in 31% of those with moderate-to-severe TBI 6 months post-injury. In the present study, the mild and moderate TBI groups showed a significant decline of PCS symptoms over time, whereas individuals with severe TBI tended to increase self-reported symptoms. Noting a similar result, Gordon et al. [14] concluded that individuals with severe TBI may be less aware of their deficits for organic reasons and under-report symptoms during the first months post-injury.

Some questions have been raised with regard to the diagnostic formulations of ICD-10 as it requires neither evidence of cognitive deficits nor neurological abnormalities for diagnosis of the PCS [7]. Comparison between diagnostic guidelines [35] on the prevalence rate of PCS at 3 months after mild TBI indicate a rate of 64% using ICD-10, compared to 11% identified by the requirements of DSM-IV (Diagnostic and Statistical Manual of Mental Disorders); a distinction with a large difference. The three symptoms criterion based on ICD-10 in this study may be considered as too lax and at risk of over-diagnosis of PCS. Nonetheless, the DSM-IV may be too strict and at risk of under-diagnosis.

It might be argued that the use of symptom checklists as the RPQ for the detection of PCS might have some shortcomings. In this study, it was chosen to include the HADS anxiety sub-scale because the precise content of 'feeling anxious' is not included in the RPQ. The HADS anxiety contributed significantly to the severity of PCS symptoms, whereas the RPQ emotional sub-scale did not. Indeed, King [6] reports that early PCS symptoms of anxiety as measured by the HADS predict persistent PCS. Emotional reactions such as anxiety are common PCS symptoms in mild TBI [6, 21, 22] with an increase in anxiety at 1 year compared to 1, 3 and 6 months after injury [17]. Other studies have found symptoms of anxiety within the first week after mild TBI [19, 30] and at 1 year post-injury [20].

Based on this data it seems clear that cognitive symptoms were the most common complaints in all TBI groups. This finding is consistent with previous studies that found cognitive symptoms to be condition-specific in TBI, compared to other health-related disorders such as spinal cord injury, HIV, liver transplantation and chronic pain [14, 16]. However, the strongest predictor of elevation of the RPQ total score 1 year post-injury was the somatic sub-scale at 3 months, supporting the notion of a somatization to the PCS condition [18, 24]. Shorter PTA duration and greater scores on the cognitive sub-scale were also significant predictors. Not all studies have found PTA to contribute to PCS [22]. Other factors such as previous psychiatric problems and female gender have been identified as useful predictors in the development of PCS [5, 10].

The findings that specific PCS symptoms were more related to persistent PCS, rather than intracranial pathology and GCS, suggest a poor relationship between self-reported complaints and objective findings, thus confirming other studies [5, 6, 8, 36]. It was noted that the percentages of mild TBI cases with intracranial pathology (27.6%) were similar as those with a PCS at 1-year (27.3%) in this study, suggesting that PCS may reflect brain dysfunction. However, development of PCS after mild TBI in the presence or absence of intracranial pathology demonstrated no significant differences. It is concluded that the presence of PCS reflects functional disturbances in the milder injuries, as none of those were identified as malingering in this study [29]. Differential diagnosis is important and, of course, the underlying mechanisms of those with poor recovery must be clarified.

Comparisons between non-concussion and PCS symptom reporting at 12 months indicated that two of the distractor items, neck pain and neck stiffness, were often reported (~31–37%) by persons with mild and moderate injuries. About half of the persons in these TBI groups suffered from additional injuries to the face or neck or multitrauma, in such a way that neck pain/stiffness may be a more general effect of physical trauma in this study. In the study by van der Naalt et al. [17] on mild-to-moderate TBI, neck pain was the most commonly reported non-concussion symptom (22%) at 1-year follow-up, with 37% of patients having physical problems at the same point of time.

This is one of few prospective studies that examines PCS symptoms, irrespective of TBI severity. Participants with mild TBI were representative of the TBI population of Oslo, excluding children and elderly persons. The strengths of this study are that questionnaires were collected by personal interviews by the same person and MRI scans were routinely performed 1 year after injury. A caveat in this study is the absence of an uninjured comparison group to control for the effect of trauma

on self-reported PCS symptoms. Another weakness is that sample sizes were relatively small.

In conclusion, PCS symptoms were reported to a greater degree in persons with mild TBI at 3 months post-injury. One year after injury, no differences were found between TBI groups on the presence of PCS symptoms. Greater levels of somatic, cognitive and anxiety symptoms at 3 months, as well as shorter PTA duration, were found to be important predictors for the severity of PCS at 12 months. Future research needs to look at effective treatment and the natural history of somatic complaints specific in the TBI population, as sleep disturbances and headaches and outcome for those symptomatic cases.

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