
The Nature of Permanent Post-concussion Symptoms after Mild Traumatic Brain Injury

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Objective: Very few studies have examined permanent post-concussion symptoms (PCSs) after mild traumatic brain injury (MTBI). None have reported the nature of such symptoms. Our recent study was the first to report on a wide range of factors affecting PCSs in a representative sample of such patients. This paper presents the frequencies of the different PCSs experienced by this group and compares them with PCSs at earlier stages post injury.

Method: One hundred consecutively referred patients to a Community Head Injury Service in Buckinghamshire, UK, for the treatment of long-term PCSs after MTBI were invited to participate in the original study. Those consenting to do so ($n = 24$, mean time post injury = 6.9 years) completed a Rivermead Post Concussion Symptoms Questionnaire. The frequency of the types of symptoms reported is presented. These are then contrasted with comparable PCS presentations at 7–10 days and 6 months post injury from two other studies.

Results: Fatigue was reported by all long-term patients. Poor concentration, sleep disturbance, taking longer to think and irritability were the other most frequently endorsed permanent symptoms. The least reported were blurred/double vision, photophobia, nausea, headache and dizziness. A similar pattern was present in those at earlier stages post injury.

Conclusions: The most common permanent PCSs may be those best conceptualised as the more cognitively and emotionally based symptoms, and the least common the more somatically based ones. There may be some consistency in the nature of PCSs reported over time.

Keywords: mild traumatic brain injury, permanent post-concussion symptoms

Introduction

Mild traumatic brain injuries (MTBI) are very common in developed countries and approximately half of those who sustain them experience post-concussion symptoms (PCSs) (Jennett & Frankowski, 1990; Kraus & Nourjah, 1988; Mandel, 1989). PCSs are a cluster of cognitive, somatic and emotional symptoms caused by

neuropathological and/or psychological mechanisms which are poorly understood (Lishman, 1988). They include headache, dizziness, fatigue, irritability, reduced concentration, sleep disturbance, memory dysfunction, sensitivity to light or noise, double or blurred vision, frustration, restlessness, anxiety, depression and sensitivity to alcohol (Evans, 1994). These symptoms completely resolve over the first few days or weeks for the

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vast majority (Alves, Colohan, O'Leary, Rimel, & Jane, 1986; Leninger, Gramling & Farrel, 1990) but a minority have persisting symptoms (e.g., up to 6 months post injury) (King, 1997). A smaller minority have prolonged symptoms (e.g., up to 1 year) (Middelboe, Anderson, Birket-Smith, & Friis, 1992; Rutherford, Merrett, & McDonald, 1979) and a very small minority have long-term or permanent symptoms (Binder, 1986; Englander, Hall, Simpson, & Chaffin, 1992). The latter may, however, represent up to 5–10% of those admitted to hospital with MTBI (Binder, Rohling, & Larrabee, 1997).

Unfortunately the vast majority of studies examining MTBI and PCSs have focused on early, persisting or prolonged symptoms but not permanent ones (King, 2003). This is a very large gap in the literature as it is this group who often pose the greatest challenges for assessment and treatment, in both clinical and medico-legal contexts (Binder & Rohling, 1996; Fee & Rutherford, 1988). While some more recent studies have investigated factors affecting the likelihood of experiencing permanent PCSs (Andersson, Bedics, & Falkmer, 2011; Nicholas & Zasler, 2010) none have described the types of symptoms typically reported. It is therefore unclear what the most and least common symptoms are in this group. This dearth poses substantial problems for those treating such patients, as their types of disability may be very similar to those of patients with much more severe traumatic brain injury (TBI) but without any measurable evidence of any significant neuropathological involvement (King, 2003).

After more severe TBI the vast majority of cerebral neurological repair occurs within the first 18 months (King & Tyerman, 2008) and therefore those with MTBI who have significant PCSs beyond a year and a half are likely to be at a very high risk of developing permanent symptoms (King & Kirwilliam, 2011). The first study, to the authors' knowledge, to use quantitative methods to examine a wide range of demographic, cognitive and psychosocial variables in a representative sample of working-age patients with permanent PCSs (7 years post injury) was published recently (King & Kirwilliam, 2010, 2011). Patients in this sample: (i) were older than those typically presenting with MTBI; (ii) often had pre- or post-morbid concurrent factors which might exacerbate PCSs; (iii) reported very high levels of PCSs; (iv) experienced elevated levels of anxiety and depression; and (v) demonstrated mildly reduced scoring on tests of short-term memory and speed of information processing. Important data on the nature and frequency of the PCSs experienced by this representative sample, however, were not reported. The

primary aim of the present paper is therefore to describe, for the first time, the different types of symptoms typically experienced by patients with permanent PCSs.

A secondary aim is to provide some extremely tentative data regarding the nature of PCSs over time, to hopefully stimulate more robust research in this area. PCSs are thought to be caused by neurogenic factors and/or psychological factors (and the interaction between the two) (King, 1997; Lishman, 1988). While the relative contribution of these variables across individuals varies enormously (Binder et al., 1997) there is broad agreement that psychological factors are likely to increase with time and neurogenic ones decrease (Potter & Brown, 2012). Indeed, at least one model (Windows of Vulnerability Model (King, 2003)) describes how different psychological factors may operate at different times post injury and how they may have a cumulative effect. Within such a context, one area of significant clinical importance that remains unclear is whether persisting PCSs are a dynamic entity (changing over time) or a more static one (with a reasonably consistent presentation regardless of time post injury). If the contribution of psychological factors increases over time, then both the type and aetiology of permanent symptoms may differ from those presented at earlier stages (King, 2003). Although this type of question has very occasionally been investigated in longitudinal studies (Lundin, De Bousard, Edma, & Borg, 2006; Meares et al., 2011), these have focused solely on early and persisting PCSs (i.e., up to 6 months post injury) and consequently have not addressed long-term PCSs at all.

To start to stimulate robust longitudinal research to answer this secondary question, this paper also presents the frequencies of PCSs experienced by representative groups of MTBI patients in early (7–10 days post injury) and persisting (6 months post injury) cohorts. These are taken from a neighbouring county to the permanent PCS group, with very similar demographics. It is hoped that this cross-sectional, retrospective and opportunistic comparison will at least provide some very tentative early data to begin to explore this area empirically.

Methods

Participants

Institutional ethics approval was obtained and all patients referred to the Community Head Injury Service (CHIS) in Buckinghamshire, UK, for the treatment of persisting PCSs following a MTBI between 1997 and 2008 were identified from

clinical records. CHIS provides community-based neurorehabilitation to all referred working-aged, head-injured patients of all severities (mild, moderate, severe and very severe) in Buckinghamshire. It serves a mixed rural and urban population of approximately 725,000 and its referrals come from a wide range of community sources – predominantly from GPs and brain injury clinical nurse specialists, but also from self- or family referrals, neurologists, social services or other clinicians. Referrals are therefore likely to be as representative of this group of long-term PCS patients as possible. Participants were required to have sustained a MTBI at least 18 months prior to the study. The Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine definition of MTBI was used, i.e., a head injury resulting in post-traumatic amnesia (PTA) of less than 24 h, Glasgow Coma Scale (GCS) of between 13 and 15 and no inter- or intracerebral complications. They were also required to have at least three current PCSs, as assessed by the Rivermead Post Concussion Symptoms Questionnaire (RPQ) (King, Crawford, Wenden, Moss, & Wade, 1995) so as to fulfil the minimum criteria for post-concussion syndrome.

Individuals were excluded from the study if they had any history prior to, or following, MTBI of a severe head injury, substance/alcohol dependence or other neurological condition. They were also excluded if they had any pre or post history of other medical or psychological conditions likely to substantially account for post-concussional-type symptoms, e.g., severe and chronic pain, severe depression.

Procedure

As part of a more-extensive assessment of the characteristics of the above sample, all participants who were identified, from the clinical records, as fulfilling the inclusion criteria were posted an RPQ to complete. This is a 16-item questionnaire about commonly experienced PCSs after a MTBI. The participant is asked to rate any PCS-type problems experienced over the previous week on a five-point scale in accordance with how severely they experienced the symptom compared to before their injury. Scores of 0 or 1 indicate that a symptom is not experienced at all or experienced to the same degree as before the head injury. Scores of 2, 3 or 4 indicate that the symptom is a mild, moderate or severe problem, respectively. The RPQ has good reliability and validity as a measure of PCSs in this type of population (King et al., 1995; Potter, Leigh, Wade, & Fleminger, 2006). These data provided the symptom frequencies of permanent PCSs to answer the first research question.

Symptom frequencies were then obtained from representative samples of MTBI patients at earlier stages post injury for comparison, in order to begin to answer tentatively the secondary question regarding the extent to which PCSs change over time. They were obtained from two previous studies conducted in the neighbouring county of Oxfordshire at 7–10 days post injury (King et al., 1995) and 6 months post injury (Wade, Crawford, Wenden, King, & Moss, 1997). Oxfordshire (Oxon) has a similar mixed rural and urban population to Buckinghamshire and is of a similar size (population approximately 600,000). Both the Oxon samples were consecutive referrals to the Oxford Head Injury Service which, during its existence, followed up every MTBI in the county. The former study administered RPQs to a random half of MTBI patients aged 16–65 years who were seen consecutively in the two admitting hospitals in the county, as part of a large-scale randomised controlled trial (RCT) investigating early intervention for PCSs. Patients were seen at 7–10 days post injury, had a mean age of 31 years, had not received treatment for their PCSs and constituted 22 men and 19 women. The latter study administered RPQs to a random half of untreated MTBI patients aged 16–65 years who were seen consecutively in the same two hospitals at 6 months post injury as part of the same RCT. They constituted 143 men and 83 women with a mean age of 32 years. These samples were therefore representative of MTBI patients in Oxfordshire. The definition of MTBI was similar across these two studies and the present study. The first-named author was involved in both of the studies, and data published in King et al. (1995) and Wade et al. (1997) were sufficient to provide comparison data.

Results

One hundred individuals were identified as eligible and invited to take part by letter, which included an RPQ to complete. Thirty individuals consented (all of whom had at least three current PCSs). Six withdrew and the sample was therefore 24. The mean time post injury was 83.7 months ($SD = 47.6$, range = 24–202 months) (i.e., 6.9 years), there were an equal number of men and women and the mean age was 44.7 years ($SD = 8.8$, range = 30–64 years). Mean PTA was 157 min ($SD = 340.1$, range = 0–1440 min). The participant group did not differ significantly from those not participating in terms of gender or length of PTA, but the latter may have been slightly younger than the former (38.6 years – significantly different at $p < .05$ but not $< .01$). The demographics of the sample are presented in Table 1.

TABLE 1
Demographic Characteristics of the Sample

Demographic variable	Variable level	<i>n</i>	Proportion of sample (%)
Gender	Male	12	50.0
	Female	12	50.0
Pre-MTBI marital status	Married/co-habiting	19	79.2
	Single	2	8.3
	Divorced/bereaved	3	12.5
Post-MTBI marital status	Married/co-habiting	14	58.3
	Single	2	16.7
	Divorced/bereaved	8	33.3
Dependent other	Present	11	45.8
	Not present	13	54.2
Pre-MTBI employment	Employed	22	91.7
	Unemployed	1	4.2
	Sick leave	0	0.0
	Retired	1	4.2
Post-MTBI employment	Employed	12	50.0
	Unemployed	3	29.2
	Sick leave	7	12.5
	Retired	2	8.3
Education	No qualifications	1	4.2
	Secondary school	9	37.5
	College	3	12.5
	University	11	45.8
MTBI causation	Domestic/leisure/work accident	4	16.7
	Road traffic accident	13	54.2
	Sports	1	4.2
	Assault	6	25.0
Compensation claim	No claim	6	25.0
	Incomplete claim	5	20.8
	Complete claim	13	54.2
Pre-MTBI serious injury/illness	Present	12	50.0
	Not present	12	50.0
Post-MTBI serious injury /illness	Present	6	25.0
	Not present	18	75.0
Previous MTBI	Present	2	8.3
	Not present	22	91.7
Pre-MTBI psychological difficulties	Present	7	29.2
	Not present	17	70.8
Post-MTBI psychological difficulties	Present	10	41.7
	Not present	14	58.3
Post-MTBI significant life event	Present	18	75.0
	Not present	6	25.0

To answer the primary question regarding the nature of permanent PCSs, Table 2 displays the RPQ scores of the long-term sample.

Data relating to the relationship between PCSs and psychosocial factors in the long-term sample are published in King & Kirwilliam (2011). To answer tentatively the secondary question regarding the nature of PCSs over time, Table 3 displays the frequencies of the different symptoms reported by

the long-term sample alongside those reported in the samples from 7–10 days and 6 months post injury. A symptom was deemed to be present if a score of 2, 3 or 4 was endorsed.

Table 2 indicates that those with permanent PCSs all had very high levels of symptoms and all reported fatigue as part of their symptom picture. Forgetfulness, sleep disturbance, poor concentration, taking longer to think and irritability were also

TABLE 2
Percentage Endorsement of RPQ Scores at 7 years post injury

Symptom	RPQ Score					Total % endorsement (i.e., scores of 2, 3 or 4)
	0	1	2	3	4	
Fatigue	0	0	4	46	50	100
Forgetfulness	0	4	25	42	29	96
Sleep disturbance	8	0	33	25	33	92
Poor concentration	0	8	17	46	29	92
Taking longer to think	4	4	4	50	38	92
Irritability	0	17	17	46	21	83
Noise sensitivity	17	0	46	13	25	83
Frustration	8	13	29	25	25	79
Depression	8	17	17	46	13	75
Restlessness	21	17	21	29	13	63
Headaches	17	25	21	21	17	58
Dizziness	38	8	29	17	8	54
Light sensitivity	33	13	21	17	17	54
Blurred vision	46	13	17	13	13	42
Nausea	63	8	25	0	4	29
Double vision	67	17	13	0	4	17

Where the sum of individual RPQ percentages does not tally with 'Total %' or add up to 100% this is due to rounding up/down of the data.

extremely common symptoms. The least common ones were headache, dizziness, light sensitivity, blurred vision, nausea and double vision. Table 3 indicates that the most and least commonly experienced PCSs were also those endorsed as being the most and least 'severe', respectively (with the exception of 'headache').

Table 3 also shows that there was a cluster of PCSs very frequently reported across all time frames post injury, i.e., ranked in the top six symptoms in all samples. These were fatigue (ranked first in all samples), sleep disturbance (ranked third, third and fourth), taking longer to think (ranked third, fourth and sixth) and irritability (ranked third, fifth and sixth). Similarly, the least frequently reported symptoms were consistently endorsed over time, i.e., ranked in the bottom four – sensitivity to light, blurred vision, nausea and double vision.

Discussion

The vast majority of the most commonly reported permanent PCSs (i.e., forgetfulness, poor concentration, etc.) have been conceptualised as being primarily cognitive–affective in nature (Cicerone & Kalmar, 1995; Levin, Mattis, & Ruff, 1987). The

least common ones (i.e., nausea, blurred vision, etc.) have been conceptualised as somatic–sensory (Cicerone & Kalmar, 1995; Levin et al., 1987). It has been speculated that cognitive–affective symptoms may reflect predominantly limbic dysfunction, and somatic–sensory ones, vestibular and visual disturbances (Cicerone & Kalmar, 1995). Should the current findings be replicated from larger samples, it is possible that permanent PCSs will be shown to adhere generally to a particular grouping of symptoms and be associated with particular kinds of neuropathological dysfunction. It should be acknowledged, however, that this neurogenic explanation is highly speculative and it could be strongly argued that the very high levels of symptoms overall may reflect the accumulation of psychological factors over a long period of time. Indeed, the most frequently reported permanent PCSs are very similar to the PCS-type symptoms which are most often reported in non-head-injured populations, e.g., in pain (sleep disturbance, fatigue and irritability) (Iverson & McCracken, 1997), depression (fatigue, sleep disturbance, poor concentration, forgetfulness and irritability) (Iverson, 2006) and healthy controls (fatigue, irritability, poor concentration, poor sleep, tension and sadness) (Iverson & Lange, 2003). The

TABLE 3

Percentage of PCSs Reported at 7 years, 6 months and 7–10 days Post Injury (Ranked Frequency)

	7 years ^a		6 months ^b		7–10 days ^c	
Fatigue	100	(1)	30	(1)	51	(1)
Forgetfulness	96	(2)	20	(4=)	29	(7)
Sleep disturbance	92	(3=)	20	(4=)	41	(3)
Poor concentration	92	(3=)	16	(10)	37	(4)
Taking longer to think	92	(3=)	20	(4=)	31	(6)
Irritability	83	(6=)	24	(3)	34	(5)
Noise sensitivity	83	(6=)	13	(11=)	24	(10=)
Frustration	79	(8)	17	(9)	27	(8=)
Depression	75	(9)	20	(4=)	21	(12)
Restlessness	63	(10)	18	(8)	24	(10=)
Headache	58	(11)	26	(2)	46	(2)
Dizziness	54	(12=)	13	(11=)	27	(8=)
Light sensitivity	54	(12=)	9	(14)	20	(13)
Blurred vision	42	(14)	11	(13)	12	(14=)
Nausea	29	(15)	8	(15)	12	(14=)
Double vision	17	(16)	1	(16)	0	(16)

^a Present study ($n = 24$); ^b Wade et al. (1997) ($n = 226$); ^c King et al. (1995) ($n = 41$).

present findings, therefore, clearly do not allow for the testing of any aetiological hypotheses but might stimulate studies that could shed further light on this area.

The very high frequencies of symptoms in the permanent PCS group were almost certainly due the self-selected nature of this symptomatic and treatment-seeking population. The lowish response rate of 24% also means that the sample has additional inherent biases. This, alongside the small sample size, means that all conclusions regarding the nature of permanent PCSs should be considered as very tentative, pending replication with larger and more representative samples. It should also be acknowledged, though, that the response rate is not substantially lower than many other studies following up MTBI patients late-on post injury (e.g., the very well resourced, large-scale study used as a comparator in the present paper applied considerable effort and resources to maximise their response rate and achieved a take-up of 41% at 6 months (Wade et al., 1997)). Finally to access representative samples of symptomatic MTBI patients at 7 years post injury, where the vast majority will be asymptomatic and may not even remember having received an injury, is likely to be prohibitively difficult without very high resource levels. Pragmatically therefore, exploring treatment-seeking patients with known ongoing symptoms represents a very useful start in describing the nature of permanent PCSs and furthering the understanding of this condition.

The study's finding that the most and least common PCSs were very similar over time also provides some extremely tentative initial evidence that there may be some consistency in the nature of PCSs regardless of whether they are early, persisting or permanent symptoms. It might, therefore, weakly suggest that the nature of PCSs may be more fixed than dynamic, and that any increasing psychological factors over time may add to the severity of a patient's presentation rather than the type of it. Unfortunately, the types of commonly reported PCSs do not discriminate well from the kinds of symptoms reported by non-head-injured populations, and the results do not clarify how to discern in any given case the relative contribution of neurogenic, psychological or mixed factors in a patient's presentation. Individualised and thoughtful clinical judgements will therefore continue to be essential in all cases of permanent PCSs (King, 2003).

Conclusions regarding the nature of PCSs over time should be made very tentatively due to two reasons (in addition to the limitations already described). First, the comparison groups in the present study were not equivalent in a number of important areas – treatment seeking vs non-treatment seeking, selected for endorsement of PCSs vs non-selected, mean age (45 vs 32 vs 31 years), gender mix (50 vs 63 vs 54% men) and sample size (24 vs 226 vs 41). The significant strengths of the comparison groups, however, were the strong similarities in the sources of the samples (mixed

rural and urban populations of a similar size from an adjacent county) and the consistency of the definitions and methodologies used. Second, because this part of the study was mainly cross-sectional, opportunistic, descriptive and retrospective.

Longitudinal studies with better control of the variables and larger sample sizes will clearly be required for many of the conclusions to be confirmed and asserted. The study does, nevertheless, provide the first empirical attempt to answer some key clinical and theoretical questions regarding the nature of permanent PCSs. As no data in this area have been reported previously, even a small empirical sample may be a helpful start in beginning to examine the type of symptoms typically reported by this group and the degree to which PCSs may change or remain the same over time.

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