J Rehabil Med 2017; 49: 228–233

ORIGINAL REPORT

LONG-TERM MENTAL FATIGUE AFTER TRAUMATIC BRAIN INJURY AND IMPACT ON EMPLOYMENT STATUS

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Objective: **Long-term mental fatigue following traumatic brain injury is endorsed as one of the most distressing symptoms, interfering considerably with return to work and social life. The objective of this cross-sectional study was to estimate the prevalence of long-term mental fatigue after traumatic brain injury and to evaluate its association with employment status.**

Methods: **All patients (age range 19–65 years) diagnosed with traumatic brain injury irrespective of severity at Kungälv Hospital, Kungälv, Sweden, over a period of 5 years ($n = 613$) were invited by post to respond to questions about their injury, employment status and complete a questionnaire about mental fatigue, the Mental Fatigue Scale (MFS).**

Results: **A response rate of 38% was achieved. Among respondents, 39% scored above the MFS cut-off of 10.5. Higher MFS scores were associated with decreased employment status ($p < 0.001$). Rating on the MFS was higher for women, for those with a longer initial duration of acute post-traumatic brain injury symptoms, and for those who had previously experienced a traumatic brain injury. No association was found between mental fatigue and age, severity of injury, or time since injury.**

Conclusion: **Long-term mental fatigue was frequent among people who had experienced a traumatic brain injury, and a higher rating on the MFS was associated with decreased employment status.**

Key words: mental fatigue; traumatic brain injury; employment status; post-concussion.

Accepted Nov 15, 2016; Epub ahead of print Feb 2, 2017

J Rehabil Med 2017; 49: 228–233

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It is estimated from a review performed by the WHO Collaboration Centre for Neurotrauma, that 600/100,000 people acquire a traumatic brain injury (TBI) annually, of which half seek medical attention (1). From a Swedish study, all ages are affected, with a higher frequency below the age of 25 years and over the age of 65 years (2). A majority, 70–90%, of the TBI are mild TBI (3). Most patients with mild TBI recover spontaneously from their symptoms within 1–3 months, but for some the acute post-mild TBI symptoms develop into a chronic condition long after the initial brain injury has healed (4–6). Long-lasting symptoms after TBI include fatigue, concentration and memory problems, sensitivity to sound, light and stress, irritability, emotional instability and headache (7, 8). Studies reporting the prevalence of long-term TBI fatigue have shown different results. The term fatigue can include both mental and physical fatigue, and when measuring fatigue different scales have been used. The incidence of fatigue also varies depending on the study population (9).

Many patients who had experienced a TBI endorsed fatigue as one of the most challenging and distressing long-term symptoms (10, 11), interfering considerably with their ability to work and lead a normal life, including social activities with family and friends. One-third of patients who had experienced a mild TBI reported severe fatigue at 6 months as well as a decrease in physical and social activities (12), and 40% reported headache and fatigue one year after a concussion (13). After 5 years, 73% reported still having a problem with fatigue affecting everyday life (14). Even after 10 years, this effect was still present, irrespective of injury severity (15). Reduced fatigue was reported during the first year, after which time it diminished (16). Fatigue was also found to uniquely contribute to disability after a TBI, after controlling for injury severity, executive functions, and depression status (17). A prospective longitudinal study with previously healthy adults, showed that most individuals with a mild TBI had returned to work 1 year later, but a sub-group still had difficulties with fatigue, other post-concussion symptoms and depression, and the authors highlight the importance of rehabilitation at an early stage after mild TBI (18).

Patients who have acquired a TBI and who experience long-term symptoms often report exhaustion after mental activity. The current study sought to evaluate the prevalence of mental fatigue, using the Mental Fatigue Scale (19, 20). A typical characteristic of mental fatigue is that the mental exhaustion becomes pronounced during sensory stimulation or when cognitive tasks are performed for extended periods (21). Another typical feature is a disproportionally long recovery time needed to restore mental energy levels after being mentally exhausted (21).

The objectives of this study were to estimate the prevalence of long-lasting mental fatigue following TBI

doi: 10.2340/16501977-2190

and to evaluate the relationship with mental fatigue and employment status. This was a cross-sectional study of patients who had experienced a TBI over a 5-year period. The time interval since injury varied from 4 months to 5 years.

METHODS

Participants

All patients who attended the emergency department at Kungälv Hospital (the main hospital for a population of approximately 120,000 people in the northern metropolitan area of Gothenburg, Sweden) and who were diagnosed with TBI according to the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10), code S06, between 31 May 2007 and 31 May 2012, and were between 19 and 65 years of age at the end of the interval were included in the study. The inclusion criteria were set up in order to include all patients diagnosed with a TBI regardless of severity. Each internal hospital transfer of a patient, from one hospital unit to another, was registered as a new entry in the patient's medical records and this could therefore be interpreted as a new trauma event. Thus patients who, within a 3-week period, were registered on more than one occasion with the same TBI were interpreted as having had only one trauma event. In total, 613 patients were included in the study.

Questionnaire

For this survey study, a questionnaire was posted to all included patients at their listed home addresses, together with general information about the study, a copy of a letter of approval for the study from the Chief of Medicine, Kungälv Hospital, and approvals from the Regional Ethics Committee, University of Gothenburg, Sweden. Patients were informed that participation in the study was voluntary.

The questionnaire included the patient's employment status (5 alternatives: working full-time, part-time in percentage, unemployed and actively seeking employment, on parental leave/not working/retired, full-time sick-leave/disability pension), and for how long general post-concussion symptoms had been present ("How long did the problems you experienced after the concussion last?" 8 alternatives: a few days, 1 week, 1–4 weeks, 1–3 months, 3–6 months, 6–12 months, more than 1 year/still present, don't remember) after the injury, and whether they had experienced a concussion previously, or did not know, prior to this specific event. The post also included the Mental Fatigue Scale (MFS), a self-assessment questionnaire developed to evaluate mental fatigue in patients with neurological disorders. The MFS comprises 14 questions for which the respondent is asked to indicate to what extent the particular item applies to his or her situation in the previous month. The scale has a cut-off >10.5 and healthy controls report a total mean value of the MFS at a score of approximately 5 (19, 20).

The first questionnaires were sent out towards the end of October 2012. This allowed the patients to recover from possible acute post-concussion symptoms over at least a 4-month period. The Swedish personal identification number was retrieved for the included participants, making it possible to identify their posting address from the public population register administered by the Swedish Tax Agency.

Participants were asked to respond to the questionnaire and to the MFS, and to reply by post using a prepaid envelope. After the first post, 2 reminders were sent out to non-responding patients. No financial incentives or specific interventions were offered to the participants.

Patients who returned incomplete MFS questionnaires were asked to complete them. In these cases the missing data in the questionnaires were highlighted and were posted back to the patient together with a covering letter asking the patients to complete the highlighted blanks. Completed missing-data questionnaires were then added to the study. Incomplete MFS questionnaires were not included in the study, with the following exception: questionnaires with data missing on question 4 only were considered to be complete (i.e. the value 0 was imputed to this question (Fig. 1)). From our clinical experience, the main reason why patients do not answer this question regarding recovery after mental exhaustion is that they have little or no prior experience of mental exhaustion and are thus unable to give accurate information about recovery time. In these cases the question is not applicable to the patient, thus a value of 0 was assigned to this question when it was left unanswered. A total of 230 (38%) patients were recruited into the study via the criteria of returning completed MFS questionnaires by post, declaring themselves willing and able to participate, and having been correctly diagnosed (Fig. 1).

Non-respondents

In order to determine whether a response bias was present among participating patients a non-response analysis was carried out. This analysis was performed by randomly selecting a sample of 20% (66) of the non-responding patients (333) to be contacted by phone. Of the 66 patients, no telephone number was found for 26 of these. Over a 3-week period a total of 3

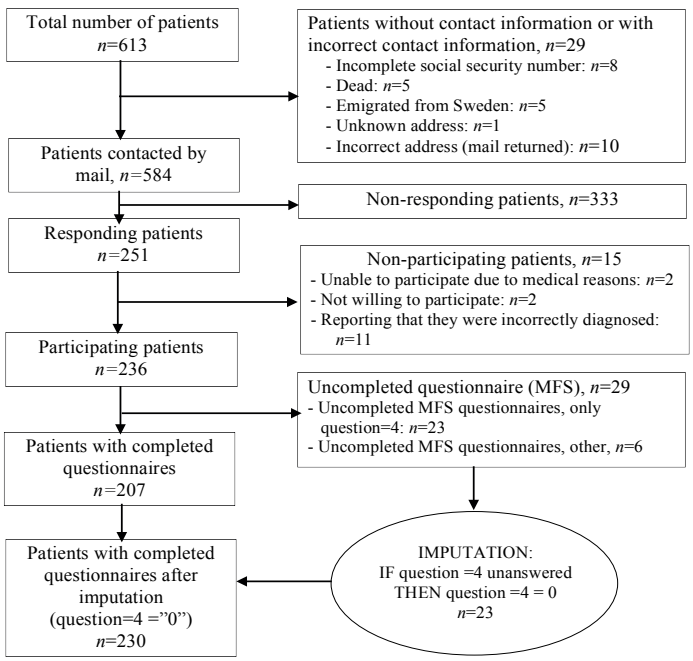

Fig. 1. Patients' inclusion and participation in the study.

attempts were made to contact patients during office hours and weekday evenings. Eighteen patients did not answer. Among the remaining 22 patients, 2 were not willing to participate in the interview and 2 claimed that they had been incorrectly diagnosed. Patients who could be interviewed using this method ($n=18$, 5.4%) were invited to briefly assess and explain (during a 3–5 min conversation) their own degree of mental fatigue and also to explain the manifestations or symptoms of their mental fatigue in their own words. At the end of the interview patients were asked if they thought they had more symptoms of mental fatigue than the average person in a life situation similar to their own and if these symptoms affected their employment status. If either of these criteria were met the patients were considered as having symptoms of mental fatigue. They were not asked whether their fatigue was related to the TBI.

Statistical analysis

All variables were summarized with standard descriptive statistics, including mean values, standard deviations (SD) and frequencies. Comparisons were made using *t*-tests. Pearson and Spearman's rho correlation were calculated to examine the relationship between primary variables. Kruskal-Wallis H tests and Mann–Whitney *U* tests were used for analysing non-parametric (non-homogenous) data. Results were considered significant at $p<0.05$. Data were analysed using the Statistical Package for the Social Sciences (SPSS), version 22.

RESULTS

Among the patients who chose to participate, the mean age (SD) was 41.0 (SD 15.0) years. The participants were significantly older compared with non-participants (35.1; SD 14.2); t=4.852, $p<0.001$. Most participants had been diagnosed with a mild TBI (87%, ICD-10 S06.0, concussion) and 13% severe or moderate TBI (ICD-10, S06.1–9). Significantly more men (52%) participated compared with women (48%, Table I). Among the non-respondents, a significantly greater number (95%) were diagnosed with a mild TBI ($\chi^2=9.489$, $p=0.002$). The ratio of women in the participating group was significantly higher, 48% compared with 36% in the non-participating group ($\chi^2=8.341$, $p=0.004$). No significant differences were found between participants and non-participants regarding time from injury to assessment.

Among those who participated in the study, 39% scored above the MFS cut-off (≥10.5, Fig. 2). The analysis conducted using the telephone interview method with the patients who had not responded to the postal questionnaire showed a prevalence of experienced fatigue of 27%.

Women reported significantly higher MFS scores than men (Table I). No significant differences in MFS rating were found for varying severities of injury. However, patients with mild TBI scored significantly lower on the MFS beneath the cut-off, but not above it (Table I). For those with intracranial injury, 38% scored above cut-off and for those with mild TBI, 34% scored above cut-off. No correlations were found between MFS score and age (r=0.079, $p=0.234$) or between MFS score and number of days since injury (r=0.084, $p=0.206$), this being irrespective of sex and severity of brain injury.

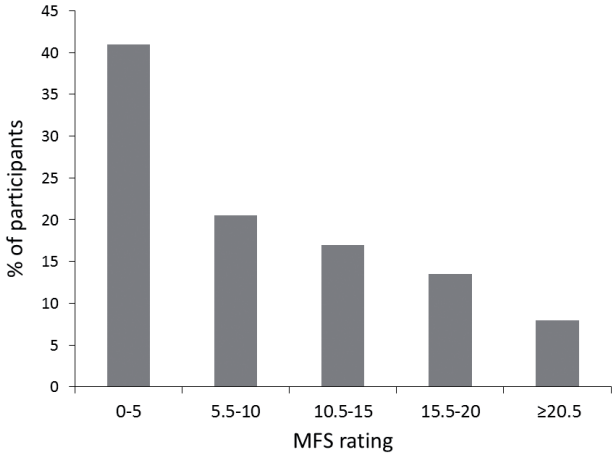

Fig. 2. Distribution of participants' ratings on the Mental Fatigue Scale (MFS) ($n=230$). Thirty-nine percent scored above the cut-off score of 10.5.

Table I. Mental Fatigue Scale (MFS) scores for men and women, for mild traumatic brain injury (TBI) and other intracranial damage and the distribution below and above MFS cut-off. The results from the statistical comparison between groups are presented (with *t*-test)

Variable	*n*	MFS score Mean (SD)	*t*-value	*p*-value
Distribution of sex				
Men	120	7.38 (6.73)	−2.738	0.007*
Women	110	10.07 (8.03)		
Men, MFS≤10.0	82	3.64 (3.16)	−0.300	0.765
Women, MFS ≤10.0	59	3.81 (3.31)		
Men, MFS ≥10.5	38	15.45 (5.10)	−1.668	0.099
Women, MFS ≥10.5	51	17.31 (5.31)		
Distribution of diagnosis				
Mild TBI	201	8.47 (7.51)	−1.027	0.306
Other intracranial damage	29	10.00 (7.30)		
Mild TBI, MFS ≤10.0	123	3.45 (3.10)	−2.582	0.011*
Other intracranial damage, MFS ≤10.0	18	5.50 (3.49)		
Mild TBI, MFS ≥10.5	78	16.40 (5.24)	−0.567	0.572
Other intracranial damage, MFS ≥10.5	11	17.36 (5.68)		

*$p<0.05$. SD: standard deviation.

Table II. Comparison between duration of initial post-concussion symptoms and Mental Fatigue Scale (MFS) score

Duration of initial post-concussion symptoms	MFS score Mean (SD)	*n*
1–2 days	3.89 (5.50)	49
1 week	6.33 (5.22)	35
1–4 weeks	9.13 (7.30)	45
1–3 months	5.93 (4.51)	15
3–6 months	11.30 (7.65)	15
6–12 months	10.18 (6.65)	8
More than 1 year/symptoms still present	14.30 (7.76)	30
Do not remember	13.81 (8.12)	21

SD: standard deviation.

Table III. Level of employment and rating on Mental Fatigue Scale (MFS)

Level of employment	*n*	MFS score Mean (SD)
Working, 76–100%	151	7.29 (6.96)
Working, 51–75%	15	9.07 (7.16)
Working, 26–50%	12	11.10 (6.63)
Working, <25%	5	13.70 (10.50)
On sick leave/disability pension	17	16.76 (7.79)
Unemployed and actively seeking employment	15	10.80 (7.78)
Not working/retired/parental leave	12	7.46 (5.67)

SD: standard deviation.

Participants who reported a longer duration of initial post-concussion symptoms scored higher on the MFS than those who had reported a shorter duration (Kruskal-Wallis H, χ^2 (7)=55.78, $p<0.001$; Table II) and a significant positive correlation was also found (r=0.477, $p<0.001$, Spearman's rho). Number of days since injury correlated negatively with duration of initial post-concussion symptoms (those who have reported "I don't remember" are excluded, $n=200$, r=–0.242, $p=0.001$, Spearman's rho).

Patients who reported prior experience of concussion scored significantly higher on the MFS (mean 10.48, SD 7.1) than those who reported that they had not experienced a previous TBI (mean 6.95, SD 7.43, $\chi^2(2)=16.12$, $p<0.001$).

MFS and employment status

The MFS rating differed significantly with regard to level of employment (Kruskal–Wallis test, χ^2 (6)=26.646, pp <0.001; Table III); a higher rating on the MFS correlated significantly with a lower level of employment (Spearman, r=0.29, $p=0.01$). Of the 15 unemployed, 8 rated above cut-off on the MFS.

Those who reported that their employment status had been affected by the TBI rated significantly higher on the MFS (mean 14.9, SD 7.35, $n=45$) compared with those who reported that employment status was not affected (mean 5.41, SD 5.03, $n=126$, Mann–Whitney $U=803.0$, $p<0.001$).

DISCUSSION

Long-term mental fatigue was frequent among people who had experienced a TBI irrespective of injury severity, and a reduced employment status was found for those who reported a rating on the MFS above the cut-off. Among respondents, 39% reported long-term post-TBI mental fatigue. While we cannot provide an accurate assessment of mental fatigue after a TBI from this study, we can conclude that long-term mental fatigue is frequent after TBI. No differences in the MFS rating according to severity of TBI, time since injury (from 4 months up to 5 years after the injury) or age were detected. Those who had experienced a previous TBI and those who reported a longer duration of acute post-concussion symptoms reported a higher rating on the MFS. Women rated their mental fatigue slightly higher than men.

The study shows that, after a TBI irrespective of severity, people can experience long-term mental fatigue. Long-term fatigue after TBI has also been reported by other research groups (14, 15). In this study, and from other studies, no correlations were found between fatigue and age (22–24), between fatigue and severity of TBI (24–27), or between fatigue and time since injury (26, 27). We detected a higher level of mental fatigue among women compared with men, and a higher fatigue for women was also reported by Cantor et al. (28), while other studies have not found a difference in sex and fatigue rating (24, 26, 29).

A higher level of mental fatigue also correlated with lower employment status. These results do not imply a causal relationship, but suggest that post-TBI mental fatigue can have a negative impact on employment status. These findings are supported by the results from Willmott et al. (30), who reported that a return to study after a TBI was limited by fatigue and required reduced study hours and a need for far greater effort. It has been difficult to find predictors for the failure or success of a return to work after TBI (31, 32). However, depression and anxiety measured with the Hospital Anxiety and Depression Scale (HADS) (33) and the subscales cognition (e.g. memory, mental speed, concentration) and behaviour (e.g. irritability, disinhibition, loss of initiative) from the Differentiated Outcome Scale (DOS) (34) were suggested as being predictors for return to work. Fatigue has not been included in these studies, but mental fatigability sets limits for the endurance of activities to be performed over and over again during a working day and this may have a significant impact on return to work. In this study, the level of fatigue correlated with employment, as a higher rating on MFS resulted in less working time.

Very few reported treatment studies have had a focus on fatigue after a TBI. Consequently, we could find neither recommended treatment guidelines nor promising new interventions (35). Our research group have found fatigue after TBI to be alleviated but not cured. This has been demonstrated in pharmacological studies with both methylphenidate (36, 37) and a dopamine stabilizer OSU6162 (38), and also after a mindfulness intervention with the Mindfulness-Based Stress Reduction programme (MBSR) (39, 40). However, a greater knowledge of the pathophysiological mechanisms underlying fatigue is needed as well as further information regarding the risk factors. It is important

to identify treatment options at an early stage after the injury, with the intention of shortening the period of post-injury mental fatigue and/or preventing the development of long-term or chronic mental fatigue.

Study limitations

The low response rate in this study makes it difficult to estimate the prevalence of mental fatigue after TBI. The non-responding patients were slightly younger, comprising a greater number of men, and more of these patients had experienced a mild TBI. However, the telephone interview carried out among those who had not responded to the postal questionnaire indicated that one-quarter of them experienced fatigue to some extent. It would have been better to carry out a prospective study for a more accurate estimation of prevalence. The evaluation of mental fatigue after a TBI is also limited in this study, as we did not ask the patients about unknown factors that can contribute to increased fatigue, as emotional distress, medication, other illnesses and pre-injury factors. However, fatigue after TBI is suggested a cause, not a consequence, of anxiety, depression, and daytime sleepiness (41, 42).

A positive correlation was found between MFS and duration of initial post-concussion symptoms. However, 30 participants were not able to recall the duration of these. In addition, the longer the time that had elapsed since the injury, the shorter the initial phase of difficulties reported. This may be due to patients experiencing difficulty recalling the length of time involved and should be taken into account when interpreting the results.

Conclusion

This study showed that long-term mental fatigue after TBI is common regardless of the severity of injury, age of the patient or time since injury. We also found that mental fatigue can have a negative impact on employment status. This shows the importance of evaluating long-term mental fatigue after a TBI as it can have a significant impact on the ability to return to work or studies.

ACKNOWLEDGEMENTS

The study was funded by grants from The Health & Medical Care Committee of the Region, Västra Götaland.

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