

Cogniphobia in Mild Traumatic Brain Injury

Noah D. Silverberg,^{1,2,4} Grant L. Iverson,^{2,5} and William Panenka³

Abstract

Cogniphobia refers to avoidance of mental exertion out of a fear of developing or exacerbating a headache. Headaches are very common after mild traumatic brain injury (mTBI) and often become chronic. Cogniphobia is hypothesized to contribute to poor cognitive test performance and persistent disability in some patients with mTBI. Eighty patients with mTBI and post-traumatic headaches were recruited from specialty outpatient clinics. They completed a battery of questionnaires (including a cogniphobia scale) and neuropsychological tests (the National Institutes of Health Toolbox Cognition Battery and the Medical Symptom Validity Test) at 2–3 months post injury, in a cross-sectional design. Participants with more severe headaches reported higher levels of cogniphobia. Cogniphobia was associated with lower performance on memory testing (but not other cognitive tests), independent of headache severity. Participants who avoided mental exertion also tended to avoid physical activity and traumatic stress triggers. The findings provide preliminary support for the role of cogniphobia in persistent cognitive difficulties after mTBI, and suggest that cogniphobia may reflect a broader avoidant coping style.

Keywords: avoidance behavior; craniocerebral trauma; headache; neuropsychological tests; post-concussion symptoms

Introduction

FEAR AND AVOIDANCE OF MOVEMENT, or “kinesophobia,” is an important perpetuating factor in chronic pain conditions. It is thought to contribute to the chronicity of pain (e.g., through muscle disuse) and mediate the relationship between pain and disability.^{1–3} Similarly, patients with chronic headache tend to avoid a range of headache triggers to manage their condition.⁴ The extent of avoidance appears more related to fearful appraisal of headache pain than to pain severity.^{5,6} Although avoiding precipitating factors can be adaptive to some degree, excessive avoidance can lead to marked lifestyle changes, psychological comorbidity, as well as sensitize patients to headache triggers such that headache is elicited more readily when triggers cannot be avoided.^{4,5} “Cogniphobia” refers to fearful avoidance of a specific headache trigger, mental exertion.^{7,8} Cogniphobia may contribute to diminished cognitive effort and performance, as well as self-imposed restrictions for cognitively demanding activities, leading to increased disability.^{8,9} In one study, greater self-reported avoidance of mental exertion correlated with worse performance on a challenging serial arithmetic task in young adults with chronic headaches.⁹

Headache is among the most common symptoms after mild traumatic brain injury (mTBI).^{10,11} One in three patients continue to experience headaches 12 months after an mTBI.¹⁰ Cogniphobia may help explain why some patients with persistent headaches perform poorly on neuropsychological testing and in daily life long

after an mTBI;^{8,12} however, empirical evidence for this link is lacking. The present study investigates cogniphobia in a treatment-seeking mTBI sample. We hypothesized that cogniphobia will be associated with 1) greater headache severity, 2) lower cognitive performance, and 3) greater behavioral avoidance of other kinds. Evidence supporting these hypotheses would add further detail to an evolving biopsychosocial conceptualization of mTBI outcome and potentially help inform the design of novel interventions.

Methods

Participants were recruited from consecutive referrals to four outpatient concussion clinics in the greater Vancouver area from March 2015 to August 2016. The eligibility criteria were: 1) being 18–65 year of age, 2) having sustained an mTBI by the World Health Organization Neurotrauma Task Force operational definition¹³ within the past 6 months, 3) being fluent in English, 4) having been employed prior to injury, because the current study was embedded in a larger research program investigating return to work following mTBI, and 5) reporting having experienced at least one headache during the week prior to assessment. The present study received approval from the University of British Columbia Behavioural Research Ethics Board, the Vancouver Coastal Health Research Institute, and the Fraser Health Research Institute. Participants completed a battery of tests in a single session at the time of their first clinic visit that included the following measures.

¹Division of Physical Medicine & Rehabilitation, ³British Columbia Neuropsychiatry Program; Department of Psychiatry, University of British Columbia, Vancouver, British Columbia, Canada.

²Department of Physical Medicine and Rehabilitation, Harvard Medical School, Boston, Massachusetts.

⁴Rehabilitation Research Program, GF Strong Rehab Centre, Vancouver, British Columbia, Canada.

⁵Spaulding Rehabilitation Hospital; MassGeneral Hospital for Children Sports Concussion Program; Home Base, A Red Sox Foundation and Massachusetts General Hospital Program; Boston, Massachusetts.

Cogniphobia Scale

The Cogniphobia Scale⁹ was originally developed by Todd and coworkers¹⁴ for post-traumatic headaches by adapting the widely used Tampa Scale for Kinesophobia,¹⁵ a general measure of pain-related fear of movement. Suhr and Spickard⁹ revised the cogniphobia scale (raising the item total to 19) and performed a factor analysis in a chronic headache sample, deriving two subscales that measure avoidance of mental exertion (Cogniphobia-Avoidance) and beliefs that mental effort is dangerous (Cogniphobia-Dangerousness). The internal consistency (Cronbach's α) of these subscales in the present sample was 0.79 and 0.80, respectively. Higher scores indicate stronger endorsement of avoidance behavior and dangerousness beliefs.

British Columbia Postconcussion Symptom Inventory (BC-PSI)

The BC-PSI¹⁶ prompts respondents to rate the frequency and intensity with which they have experienced a range of physical, cognitive, and emotional symptoms over the previous week, including headaches. It is widely used in mTBI research.^{17–19} The headache item from this scale was used as a measure of headache intensity over the past week.

Brief pain questionnaire

Participants rated their current pain intensity (0/“none” to 3/“severe” pain “at this moment”) in multiple bodily regions, the head/skull, neck, chest/abdomen/back, arms/shoulders, and pelvis/legs. This measure has been shown to correlate with functional outcome from mTBI.²⁰ The head/skull item from this scale was used as measure of headache intensity at the time of the assessment.

National Institutes of Health Toolbox Cognition Battery (NIHTB-CB)

The NIHTB-CB²¹ is a brief neuropsychological test battery that was developed to by National Institutes of Health Blueprint for Neuroscience Research platform to serve as a cognition outcome measure across neurological conditions. It consists of two tests measuring crystallized cognitive ability (Picture Vocabulary and Oral Reading Recognition) and five tests of fluid cognitive abilities including processing speed, attention, episodic memory, and executive functioning (Flanker Inhibitory Control and Attention, Dimensional Change Card Sort, Picture Sequence Memory, Pattern Comparison Processing Speed, and List Sorting Working Memory).²¹ Initial validation studies suggest that these tests have strong convergent validity with legacy neuropsychological instruments, strong test-retest reliability, and minimal ceiling or floor effects.²² Age-adjusted standard scores based on the revised norming system described by Casaletto and coworkers²³ were used in the present analyses.

Medical Symptom Validity Test (MSVT)

The MSVT²⁴ is a purpose-built “effort,” or performance validity test that is sensitive to motivational factors, but insensitive to the effects of TBI or genuine memory impairment.^{25–27} The “easy” subtests (Immediate Recognition, Delayed Recognition, and Consistency) have evidenced-based cutoffs for identifying cases with probable below-capacity performance. Higher scores on the MSVT indicate better performance; 100 is the maximum possible score.

Secondary measures

The assessment battery also included measures of avoidance of physical activities (Fear Avoidance Beliefs Questionnaire-Physical Activity)²⁸ avoidance of traumatic stress (items 6 and 7 from the PTSD Checklist-5),²⁹ and self-imposed general activity restrictions following injury (Behavioral Response to Illness Questionnaire-Limiting scale).³⁰

Analyses

The primary hypothesis that avoidance of mental exertion (Cogniphobia-Avoidance) would be associated with lower cognitive effort (MSVT “easy” subtests) and cognitive performance (five fluid cognition subtests of the NIHTB-CB) was tested with Pearson correlations, using complete case analysis (actual sample size of 57–60 depending on which combinations of variables were used) with a Bonferroni-corrected α level of 0.01. All variables were continuous. Supplementary analyses involved linear regression and relative risk. The relative risk ratio is the probability of impaired cognitive test performance in individuals with high avoidance of mental exertion divided by the probability of impaired cognitive test performance in individuals with low avoidance of mental exertion.

Results

Of 200 consecutively screened referrals, 80 met the eligibility criteria and consented. Figure 1 displays reasons for non-enrollment in a flow diagram. The demographic and clinical characteristics of the final sample are shown in Table 1.

Cogniphobia-Avoidance and Cogniphobia-Dangerousness were correlated ($r[60]=0.649$, $p<0.001$). Neither Cogniphobia-Avoidance or Cogniphobia-Dangerousness were associated with age ($r[58]=0.004$, $p=0.974$; $r[58]=-0.116$, $p=0.386$) or time since injury ($r[60]=-0.081$, $p=0.538$; $r[60]=-0.119$, $p=0.366$). Men and women reported similar levels of Cogniphobia-Avoidance (mean = 33.48, SD = 4.83 vs. mean = 35.27, SD = 5.39) and Cogniphobia-Dangerousness (mean = 18.00, SD = 3.22 vs. mean = 18.12, SD = 3.89).

The main analyses are presented in Table 2. Cogniphobia-Avoidance, and to a lesser extent, Cogniphobia-Dangerousness, correlated significantly with headache severity and other measures of avoidance (of physical movement and traumatic stress). Despite a severely restricted range on the MSVT (i.e., 61.7%, 60%, and 51.7% of sample achieved the ceiling score on the Immediate Recognition, Delayed Recognition, and Consistency subtests, respectively), there were significant correlations between Cogniphobia-Avoidance and the MSVT subtests. Cogniphobia-Avoidance correlated with only one NIHTB-CB fluid cognition test at $p<0.01$, the Picture Sequence Memory test.

Low scores on the MSVT may reflect avoidance of mental effort caused by headache fear and/or unmeasured confounds, such as intentional below-capacity performance for secondary gain (malingering). To investigate whether the relationship between Cogniphobia-Avoidance and the NIHTB-CB fluid cognition tests held in participants without performance validity concerns, we reran the correlations after excluding participants who failed the MSVT (performed below established cutoffs for credible performance; $n=20$). These results are also reported in Table 2. The correlation between Cogniphobia-Avoidance and Picture Sequence Memory was very modestly attenuated.

To better appreciate the clinical significance of the Picture Sequence Memory finding, we dichotomized the outcome as impaired (Picture Sequence Memory Test age-adjusted standard score <85) versus not, and calculated the risk associated with scoring above the cutoff on the Cogniphobia-Avoidance (raw score >36) that optimally discriminated impaired versus normal Picture Sequence Memory Test performance in this sample. In the full sample, the risk ratio for low memory test performance associated with high avoidance of mental exertion was 3.71 (95% confidence interval = 1.76–7.80). In the sample who passed the MSVT, the risk ratio was 3.39 (95% confidence interval = 1.16–9.91).

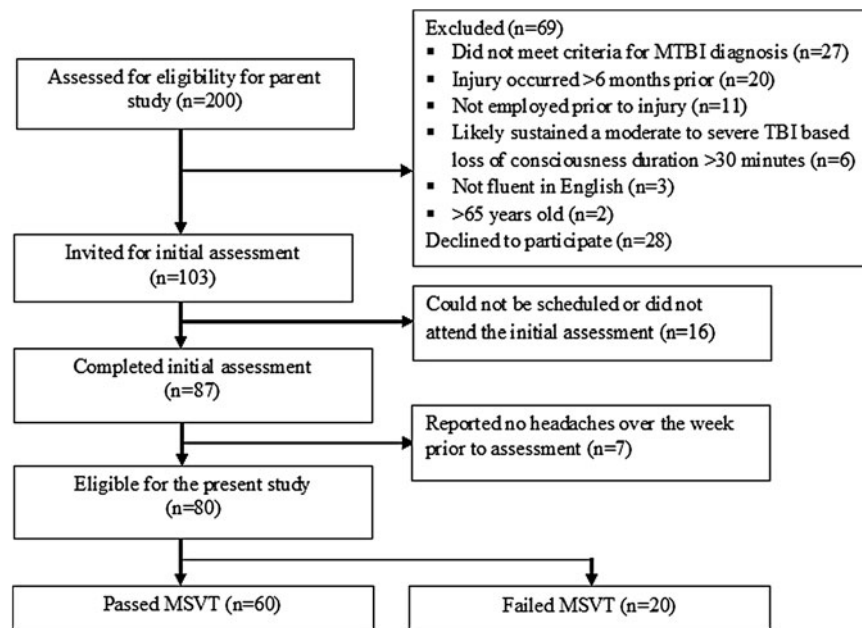


FIG. 1. Flow diagram. MSVT, Medical Symptom Validity Test.

Migraine headaches are classically worsened by activity^{31,32} and can cause reversible cognitive dysfunction.³³ To explore the possibility that the link among cogniphobia, headache pain, and reduced cognitive performance was restricted to migraine-type headache, we performed a supplementary analysis limited to only selected participants ($n=32$) who probably did not have migraine-type headaches based on their reporting no more than mild nausea and sensitivity to noise on the BC-PSI (both item scores = 0–2; note that photophobia is not measured by the BC-PSI). As in the primary analyses, Cogniphobia-Avoidance correlated with MSVT Delayed Recognition ($r[32] = -0.529, p = 0.002$), MSVT Consistency ($r[32] = -0.461,$

$p = 0.007$), and Picture Sequence Memory Test ($r[32] = -0.540, p = 0.001$) in the subgroup without migraine features. The correlation with Dimensional Change Card Sort was $r(32) = -0.283, p = 0.117$. Cogniphobia-Dangerousness did not significantly correlate with any NIHTB-CB fluid cognition test ($p > 0.05$). After removing participants who failed the MSVT from this subgroup, the correlation with the Picture Sequence Memory Test held ($r[28] = -0.386, p = 0.042$) and a correlation between Cogniphobia-Avoidance and the Dimensional Change Card Sort test emerged ($r[24] = -0.386, p = 0.042$).

Further supplementary analyses aimed to determine if the relationship between avoidance of mental exertion and performance on

TABLE 1. DEMOGRAPHIC AND CLINICAL CHARACTERISTICS OF THE SAMPLE

	Full sample ($n=80$)	Cogniphobia-avoidance		p^{\ddagger}
		Low [^] ($n=52$)	High [^] ($n=28$)	
Age, mean (SD)	40.8 (12.0)	41.2 (12.2)	39.9 (12.1)	0.643
Sex, n females (%)	43 (53.1%)	27 (51.9%)	16 (57.1%)	0.655
Education, n with postsecondary degree (%)	37 (46.3%)	30 (57.7%)	10 (35.7%)	0.061
Ethnicity, n Caucasian (%)	61 (75.3%)	40 (76.9%)	20 (71.4%)	0.588
Weeks since injury, mean (SD)	11.5 (6.1)	12.2 (6.2)	10.3 (5.8)	0.188
Receiving or seeking injury compensation, n (%)	71 (86.4%)	43 (82.7%)	26 (92.9%)	0.208
Cogniphobia-Avoidance, mean (SD)	34.5 (5.1)	31.6 (3.3)	40.0 (2.9)	<0.001
Cogniphobia-Dangerousness, mean (SD)	18.1 (3.6)	16.6 (2.8)	21.0 (3.3)	<0.001
MSVT Immediate Recognition, mean (SD)	91.7 (14.7)	94.7 (10.6)	85.9 (19.2)	0.010
MSVT Delayed Recognition, mean (SD)	91.4 (14.8)	94.4 (11.1)	85.7 (19.0)	0.012
MSVT Consistency, mean (SD)	90.6 (13.8)	93.0 (12.8)	86.3 (14.9)	0.037
NIHTB-CB Crystallized Composite, mean (SD)	106.5 (13.4)	107.9 (13.0)	103.7 (14.3)	0.207
NIHTB-CB Dimensional Card Sort, mean (SD)	92.2 (17.0)	94.4 (16.8)	87.1 (16.8)	0.080
NIHTB-CB Flanker, mean (SD)	89.0 (18.4)	91.3 (18.7)	83.5 (16.7)	0.072
NIHTB-CB List Sort, mean (SD)	94.9 (14.7)	95.4 (14.9)	93.2 (14.7)	0.541
NIHTB-CB Picture Sequence Memory, mean (SD)	91.5 (22.1)	96.5 (18.6)	80.5 (25.2)	0.002
NIHTB-CB Pattern Comparison, mean (SD)	86.5 (20.8)	87.4 (21.8)	84.1 (19.3)	0.524

[^]Sample stratified based on Cogniphobia-Avoidance raw scores ≤ 36 or >36 .

[‡] p value for independent samples t test (for continuous variables) or χ^2 test (for proportions).

MSVT, Medical Symptom Validity Test; NIHTB-CB, National Institutes of Health Toolbox Cognition Battery.

TABLE 2. CORRELATIONS BETWEEN COGNIPHOBIA (AVOIDANCE AND DANGEROUSNESS SUBSCALES) AND THE HEADACHE, AVOIDANCE, AND COGNITION MEASURES

	Full sample (n=80)		MSVT fails excluded (n=60)	
	Avoidance	Danger	Avoidance	Danger
Headache measures				
BC-PSI Headache Frequency Past Week	0.363**	0.289**	0.331*	0.278*
BC-PSI Headache Intensity Past Week	0.365**	0.294**	0.324*	0.291*
Brief Pain Questionnaire-Head/skull	0.348**	0.362**	0.357**	0.361**
Avoidance measures				
FABQ-Physical Activity	0.588***	0.515***	0.497***	0.418**
PCL-Avoidance	0.394***	0.419***	0.315*	0.282*
BRIQ Limiting	0.426***	0.151	0.413**	0.057
MSVT				
Immediate Recognition	−0.230*	−0.237*	— [^]	— [^]
Delayed Recognition	−0.254*	−0.202	— [^]	— [^]
Consistency	−0.262*	−0.290*	— [^]	— [^]
NIHTB-CB				
Flanker	−0.155	−0.171	0.006	0.005
List Sorting	−0.085	−0.098	0.060	−0.058
Dimensional Change Card Sort	−0.243*	−0.206	−0.215	−0.120
Pattern Comparison	−0.024	−0.046	0.065	0.038
Picture Sequence Memory	−0.376**	−0.202	−0.335**	−0.261*

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

[^]Correlations were not computed because of a profoundly restricted range on the MSVT variables, with 62.3–78.7% achieving the ceiling score.

BC-PSI, British Columbia Postconcussion Symptom Inventory; FABQ, Fear Avoidance Beliefs Questionnaire; PCL, PTSD Checklist; BRIQ, Behavioral Response to Illness Questionnaire; MSVT, Medical Symptom Validity Test; NIHTB-CB, National Institutes of Health Toolbox Cognition Battery.

the Picture Sequence Memory Test would remain after adjusting for headache severity. In linear regression modeling with the sample who passed the MSVT, Cogniphobia-Avoidance significantly predicted Picture Sequence Memory Test performance when it was the only predictor ($\beta = -0.335$, $t = -2.632$, $p = 0.011$). When headache intensity during the assessment ($\beta = -0.241$, $t = -1.571$, $p = 0.122$) and headache severity (frequency \times intensity) over the past week ($\beta = 0.023$, $t = 0.151$, $p = 0.880$) were added to the model as covariates, the coefficient for Cogniphobia-Avoidance remained significant ($\beta = -0.384$, $t = -2.13$, $p = 0.043$).

Finally, to appreciate the relative contribution of cogniphobia to cognitive test performance (Picture Sequence Memory Test), we ran a linear regression that included other candidate predictors of MTBI outcome.^{34,35} In this model, Cogniphobia-Avoidance ($\beta = -0.322$, $t = -2.821$, $p = 0.006$) and performance validity (MSVT) failure ($\beta = -0.384$, $t = -3.281$, $p = 0.002$) independently predicted Picture Sequence Memory performance, but a history of mental health treatment, history of prior mTBI(s), presence of loss of consciousness with the index mTBI, time since index mTBI, and current post-concussion symptom severity (BC-PSI Total Score) did not significantly contribute to the prediction model.

Discussion

A number of factors other than brain injury may influence neuropsychological test performance and daily functioning in post-acute mTBI. Intentional underperformance for secondary gain is one well-established example.³⁶ Other examples may include performance anxiety induced by creating an expectation of low performance by drawing attention to the subjects' mTBI diagnosis ("diagnosis threat"),^{37,38} or exerting extra effort by deploying top-down control over automatic skills, as when a golfer "chokes" on a high-stakes short putt.^{12,39} The present study suggests that cogni-

phobia may also be relevant to understanding chronic problems after mTBI. Given that fear-avoidance is common in various pain and headache disorders,^{1,9,32} it can also be expected in people with post-traumatic headaches following mTBI. Theoretically, phobic anticipation of headache pain may motivate some patients to withhold mental effort and restrict their participation in mentally taxing activities, contributing not only to reduced neuropsychological test performance but potentially to functional disability, above and beyond the headache pain itself.

Patients with more severe post-traumatic headaches reported greater avoidance of mental exertion so as to not elicit or worsen a headache, confirming that the phenomenon of cogniphobia applies to mTBI in a clinic sample. The origin of beliefs regarding the dangerousness of mental exertion after MTBI may come from early experiences with activity-related symptom exacerbations,^{1,40–42} inappropriate application of the "rest until asymptomatic" maxim by health professionals,⁴³ or media misinformation. Although likely adaptive in the acute phase of recovery, avoiding mental exertion is not necessary to achieve a good clinical outcome from mTBI.^{40,44} It may be reinforced by relief from pain and/or other symptoms, and come to unduly restrict a patient's return to pre-injury activities and exacerbate their emotional distress. Also, avoiding activity and other headache triggers can over time make those triggers more potent.⁴⁵

Our primary hypothesis was that cogniphobia would be associated with lower cognitive performance. We found that avoidance of mental exertion was associated with objectively assessed cognitive effort (performance on the "easy" subtests of the MSVT), despite a severely restricted range on these variables. It is possible that withholding effort motivated by cogniphobia accounted for reduced effort test performance, but it is also possible that other factors (e.g., compensation seeking) explained both reduced effort test performance and high scores across questionnaires, including the cogniphobia scale. Of the five NIHTB-CB fluid cognition tests,

avoidance of mental exertion was significantly related to one (the Picture Sequence Memory Test), even after removing participants who failed the MSVT and adjusting for multiple testing. A supplementary analysis also found that this relationship held after controlling for headache severity (current and over the past week). Participants who reported high avoidance of mental exertion were two to four times more likely to have a low score (< 1 SD) on the Picture Sequence Memory Test than those reporting low avoidance. It is unclear why avoidance of mental exertion correlated less strongly (and nonsignificantly) with other measures of fluid cognition. The Picture Sequence Memory test requires examinees to reproduce the sequential order of 15–18 pictures. Because a high information load (intended to exceed the capacity of working memory) is presented on the first trial, this task may be perceived as especially taxing and therefore sensitive to cogniphobia. Future research demonstrating that examinees rate their perceived exertion as higher during the Picture Sequence Memory test relative to the other NIHTB-CB tests would support the theory that subjective effort mediates the effects of fear-avoidance beliefs on cognitive performance.⁹

The present study demonstrated that avoidance of mental exertion was associated with other forms of avoidance in mTBI, including avoidance of physical activity and traumatic stress. Cogniphobia may be a specific manifestation of avoidant coping, a broader psychological construct that negatively influences behavioral engagement in daily activities. Exposure-based treatments have been shown to successfully target avoidance in other health conditions,^{1,2} and even to decrease sensitivity to headache triggers,⁴⁶ and, therefore, should be considered for chronic mTBI. It is also shown in Table 1 that participants with high scores on the Cogniphobia-Avoidance scale were somewhat less likely to have a college degree. Low education and health literacy might also contribute to cogniphobia.

The cross-sectional design limits us from drawing conclusions about the causal nature of the relationship between cogniphobia and neuropsychological performance. Patients may perform poorly on cognitive testing because they are avoiding mental exertion and/or they may avoid mental exertion because they accurately perceive having limited cognitive capacity (or other reasons). Further research is required to better understand the clinical implications of our findings. Patients with greater cogniphobia were more likely to produce an impaired score on one test in a five test battery. This effect may not be sufficient to significantly alter treatment recommendations. The present study was also limited by not having medical records available to document the mTBI in many cases. We relied on a structured interview of the injury event, signs of altered mental status, and potential confounds of altered mental status to determine whether participants met mTBI diagnostic criteria. The optimal cutoff score for the Cogniphobia-Avoidance scale used in the relative risk analyses and for stratification in Table 1 may be specific to the present sample and might not replicate in future studies. It should be cross-validated before it is applied clinically. Fear of headache may motivate other maladaptive behaviors not measured in the present study, such as analgesic overuse³ and restricted head movement.³² Another limitation of the present study is that participants were not medically evaluated for specific headache disorders common after mTBI, such as migraine versus tension type. We did, however, find an effect of cogniphobia in a subgroup that probably did not have migraine-type headache based on their reporting relatively mild or absent nausea and phonophobia, suggesting that cogniphobia is not restricted to the migraine phenotype of post-traumatic headache. Finally, our findings should generalize to patients who are seeking treatment for persistent problems related to mTBI, but not to those seen in other settings.

The risk for false negative and false positive findings should be considered. Our sample may have been too small to detect true differences in cognitive domains other than memory. With effect size estimates derived from the present work, future studies on cogniphobia can prospectively calculate sample size requirements necessary to achieve adequate power. We conducted a number of supplementary (post-hoc) analyses to explore the robustness of the cogniphobia–memory performance relationship. Given the purpose of these supplementary analyses and the modest sample size, we did not further adjust for multiple testing, which could have resulted in spurious findings. These novel findings require replication.

Conclusion

In conclusion, patients who reported avoiding mental exertion because of concerns about headache performed worse on memory testing, but not on other cognitive tests. They also reported worse headaches and greater avoidance of physical activity and psychological trauma. The results partially support our hypothesis that cogniphobia contributes to cognitive difficulties in some patients with chronic symptoms after mTBI. Future research is warranted on cogniphobia and its potential role in a biopsychosocial model of poor outcome from mTBI.

Acknowledgments

The authors thank research assistants Mary Ellen Johnson and Sabrina Khan as well as the clinical staff at our recruitment sites, including Kelsey Davies, Jennifer Loffree, and Grace Boutilier (GF Strong Rehab Centre); Deanna Yells, Heather MacNeil, and Rod Macdonald (Fraser Health Concussion Clinic); Denise Silva and Lesley Norris (Back in Motion); and Karilyn Lao, Wayne Tang, and Cyrus Huang (LifeMark). This study was funded by a Specific Priorities Research Grant from WorkSafeBC (#RS2014-SP03). N.D.S. receives salary support from a Clinician-Scientist Career Development Award from the Vancouver Coastal Health Research Institute.

Author Disclosure Statement

G.L.I. has been reimbursed by the government, professional scientific bodies, and commercial organizations for discussing or presenting research relating to mTBI and sport-related concussion at meetings, scientific conferences, and symposiums. He has a clinical practice in forensic neuropsychology involving individuals who have sustained mTBIs. He has received honorariums for serving on research panels that provide scientific peer review of programs. He is a co-investigator, collaborator, or consultant on grants relating to mTBI funded by several organizations. N.D.S. has a clinical practice in forensic neuropsychology and W.P. has a clinical practice in forensic neuropsychiatry involving individuals who have sustained mTBIs.

References

1. Vlaeyen, J.W.S., and Linton, S.J. (2000). Fear-avoidance and its consequences in chronic musculoskeletal pain: a state of the art. *Pain* 85, 317–332. doi:10.1016/S0304-3959(99)00242-0.
2. Nijs, J., Roussel, N., Van Oosterwijk, J., De Koning, M., Ickmans, K., Struyf, F., Meeus, M., and Lundberg, M. (2013). Fear of movement and avoidance behaviour toward physical activity in chronic-fatigue syndrome and fibromyalgia: state of the art and implications for clinical practice. *Clin. Rheumatol.* 32, 1121–1129.
3. Peres, M.F.P., Mercante, J.P.P., Guendler, V.Z., Corchs, F., Bernik, M.A., Zukerman, E., and Silberstein, S.D. (2007). Cephalalgia: a possible specific phobia of illness. *J Headache Pain* 8, 56–59.

4. Martin, P.R., and MacLeod, C. (2009). Behavioral management of headache triggers: avoidance of triggers is an inadequate strategy. *Clin. Psychol. Rev.* 29, 483–495.
5. Hursey, K.G., and Jacks, S.D. (1992). Fear of pain in recurrent headache sufferers. *Headache* 32, 283–286.
6. Norton, P.J., and Asmundson, G.J.G. (2004). Anxiety sensitivity, fear, and avoidance behavior in headache pain. *Pain* 111, 218–223.
7. Schmidt, A.J.M. (2003). Does “mental kinesiphobia” exist? *Behav. Res. Ther.* 41, 1243–1249.
8. Martelli, M.F., MacMillan, P., and Grayson, R. (1999). Kinesiophobia and cogniphobia: Avoidance-conditioned pain-related disability (ACPRD). *Arch. Clin. Neuropsychol.* 14, 804.
9. Suhr, J., and Spickard, B. (2012). Pain-related fear is associated with cognitive task avoidance: exploration of the cogniphobia construct in a recurrent headache sample. *Clin. Neuropsychol.* 26, 1128–1141.
10. Lucas, S., Hoffman, J.M., Bell, K.R., and Dikmen, S. (2014). A prospective study of prevalence and characterization of headache following mild traumatic brain injury. *Cephalalgia* 34, 93–102.
11. Lucas, S. (2015). Posttraumatic headache, clinical characterization and management. *Curr. Pain Headache Rep.* 19, 48.
12. Potter, S., and Brown, R.G. (2012). Cognitive behavioural therapy and persistent post-concussional symptoms: integrating conceptual issues and practical aspects in treatment. *Neuropsychol. Rehabil.* 22, 1–25.
13. Holm, L., Cassidy, J.D., Carroll, L.J., and Borg, J. (2005). Summary of the WHO Collaborating Centre for Neurotrauma Task Force on Mild Traumatic Brain Injury. *J. Rehabil. Med.* 37, 137–141.
14. Todd, D.D., Martelli, M.F., and Grayson, R.L. (1998). *The Cogniphobia Scale (C-Scale): A Measure of Headache Impact*. Glen Allen, VA: Concussion Care Center of Virginia.
15. Lundberg, M., Grimby-Ekman, A., Verbunt, J., and Simmonds, M.J. (2011). Pain-related fear: a critical review of the related measures. *Pain Res. Treat.* 2011, 494196.
16. Iverson, G.L., and Lange, R.T. (2003). Examination of “postconcussion-like” symptoms in a healthy sample. *Appl. Neuropsychol.* 10(3), 137–144.
17. Sullivan, K., and Garden, N. (2011). A comparison of the psychometric properties of 4 postconcussion syndrome measures in a non-clinical sample. *J. Head Trauma Rehabil.* 26, 170–176.
18. Lange, R.T., Iverson, G.L., Brooks, B.L., and Rennison, V.L.A. (2010). Influence of poor effort on self-reported symptoms and neurocognitive test performance following mild traumatic brain injury. *J. Clin. Exp. Neuropsychol.* 32, 961–972.
19. Panenka, W.J., Lange, R.T., Bouix, S., Shewchuk, J.R., Heran, M.K., Brubacher, J.R., Eckbo, R., Shenton, M.E., and Iverson, G.L. (2015). Neuropsychological outcome and diffusion tensor imaging in complicated versus uncomplicated mild traumatic brain injury. *PLoS One* 10, e0122746.
20. Stulemeijer, M., van der Werf, S., Borm, G.F., and Vos, P.E. (2008). Early prediction of favourable recovery 6 months after mild traumatic brain injury. *J. Neurol. Neurosurg. Psychiatry* 79, 936–942.
21. Weintraub, S., Dikmen, S.S., Heaton, R.K., Tulsky, D.S., Zelazo, P.D., Bauer, P.J., Carlozzi, N.E., Slotkin, J., Blitz, D., Wallner-Allen, K., Fox, N.A., Beaumont, J.L., Mungas, D., Nowinski, C.J., Richler, J., Deocampo, J.A., Anderson, J.E., Manly, J.J., Borosh, B., Havlik, R., Conway, K., Edwards, E., Freund, L., King, J.W., Moy, C., Witt, E., and Gershon, R.C. (2013). Cognition assessment using the NIH Toolbox. *Neurology* 80(11, Suppl. 3), S54–S64.
22. Weintraub, S., Dikmen, S.S., Heaton, R.K., et al. (2014). The Cognition Battery of the NIH Toolbox for Assessment of Neurological and Behavioral Function: validation in an adult sample. *J. Int. Neuropsychol. Soc.* 20, 567–578.
23. Casaletto KB, Umlauf A, Beaumont J, Gershon, R., Slotkin, J., Akshoomoff, N., and Heaton, R.K. (2015). Demographically corrected normative standards for the English Version of the NIH Toolbox Cognition Battery. *J. Int. Neuropsychol. Soc.* 21, 378–391.
24. Green, P. (2004). *Green’s Medical Symptom Validity Test (MSVT) for Microsoft Windows: User’s Manual*. Green’s Publishing: Edmonton, Canada.
25. Carone, D.A. (2008). Children with moderate/severe brain damage/dysfunction outperform adults with mild-to-no brain damage on the Medical Symptom Validity Test. *Brain Inj.* 22, 960–971.
26. Whitney, K.A., Shepard, P.H., Williams, A.L., Davis, J.J., and Adams, K.M. (2009). The Medical Symptom Validity Test in the evaluation of Operation Iraqi Freedom/Operation Enduring Freedom soldiers: a preliminary study. *Arch. Clin. Neuropsychol.* 24, 145–152.
27. Singhal, A., Green, P., Ashaye, K., Shankar, K., and Gill, D. (2009). High specificity of the medical symptom validity test in patients with very severe memory impairment. *Arch. Clin. Neuropsychol.* 24, 721–728.
28. Waddell, G., Newton, M., Henderson, I., and Somerville, D. (1993). A fear-avoidance beliefs questionnaire (FABQ) and the role of fear-avoidance in chronic low back pain and disability. *Pain* 52, 157–168.
29. Blevins, C.A., Weathers, F.W., Davis, M.T., Witte, T.K., and Domino, J.L. (2015). The Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5): development and initial psychometric evaluation. *J. Trauma Stress* 28, 489–498.
30. Spence, M., Moss-Morris, R., and Chalder, T. (2005). The Behavioural Responses to Illness Questionnaire (BRIQ): a new predictive measure of medically unexplained symptoms following acute infection. *Psychol. Med.* 35, 583–593.
31. Headache Classification Committee of the International Headache Society (2013). The International Headache Classification, 3rd edition. *Cephalalgia* 33, 629–808.
32. Martins, I.P., Gouveia, R.G., and Parreira, E. (2006). Kinesiophobia in migraine. *J. Pain* 7, 445–451.
33. Gil-Gouveia, R., Oliveira, A.G., and Martins, I.P. (2015). Assessment of cognitive dysfunction during migraine attacks: a systematic review. *J. Neurol.* 262(3), 654–665.
34. Silverberg, N.D., Gardner, A., Brubacher, J.R., Panenka, W., Li, J.J., and Iverson, G.L. (2015). Systematic review of multivariable prognostic models for mild traumatic brain injury. *J. Neurotrauma* 32, 517–526.
35. Lingsma, H.F., Yue, J.K., Maas, A.I.R., et al. Outcome Prediction after mild and complicated mild traumatic brain injury: external validation of existing models and identification of new predictors using the TRACKTBI Pilot Study. *J. Neurotrauma*
36. Binder, L.M., and Rohling, M.L. (1996). Money matters: a meta-analytic review of the effects of financial incentives on recovery after closed-head injury. *Am. J. Psychiatry* 153, 7–10.
37. Suhr, J.A., and Gunstad, J. (2002). “Diagnosis Threat”: the effect of negative expectations on cognitive performance in head injury. *J. Clin. Exp. Neuropsychol.* 24, 448–457.
38. Ozen, L.J., and Fernandes, M.A. (2011). Effects of “diagnosis threat” on cognitive and affective functioning long after mild head injury. *Int. J. Neuropsychol. Soc.* 17, 219–229.
39. Silver, J.M. (2012). Effort, exaggeration and malingering after concussion. *J. Neurol. Neurosurg. Psychiatry* 83, 836–841.
40. Silverberg, N.D., Iverson, G.L., McCrea, M., Apps, J., Hammeke, T., and Thomas, D.G. (2016). Activity-related symptom exacerbations after pediatric concussion. *J.A.M.A. Pediatr.* 170, 946–953.
41. Marsden, K., Strachan, N., Monteleone, B., Ainslie, P., Iverson, G., and Don, V. (2015). The relationship between exercise-induced increases in cerebral perfusion and headache exacerbation following sport-related concussion: a preliminary study. *Curr. Res. Concussion* 2, 17–21.
42. Covassin, T., Crutcher, B., and Wallace, J. (2013). Does a 20 minute cognitive task increase concussion symptoms in concussed athletes? *Brain Inj.* 27, 1589–1594.
43. Craton, N., and Leslie, O. (2014). Is rest the best intervention for concussion? Lessons learned from the whiplash model. *Curr. Sports Med. Rep.* 13, 201–204.
44. Brooks, B.L., Low, T.L., Daya, H., Khan, S., Migrogiannakis, A., and Barlow, K. (2016). Test or rest? Computerized cognitive testing in the emergency department after pediatric mild traumatic brain injury does not delay symptom recovery. *J. Neurotrauma* 33, 2091–2096.
45. McKinlay, A., Grace, R., Horwood, J., Fergusson, D., and MacFarlane, M. (2009). Adolescent psychiatric symptoms following pre-school childhood mild traumatic brain injury: evidence from a birth cohort. *J. Head Trauma Rehabil.* 24, 221–227.
46. Martin, P.R., Reece, J., Callan, M., MacLeod, C., Kaur, A., Gregg, K., and Goadsby, P.J. (2014). Behavioral management of the triggers of recurrent headache: a randomized controlled trial. *Behav. Res. Ther.* 61, 1–11.

Address correspondence to:

Noah D. Silverberg, PhD

Division of Physical Medicine & Rehabilitation

University of British Columbia

Rehabilitation Research Program

GF Strong Rehab Centre

4255 Laurel Street

Vancouver, British Columbia

Canada V5Z 2G9

E-mail: noah.silverberg@vch.ca