

Université de Montréal

**Coping et participation sociale à la suite d'un traumatisme craniocérébral léger :
une étude observationnelle de cohorte en réadaptation**

par
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Résumé

Objectif : Évaluer l'association entre le coping et la participation sociale en fonction de la symptomatologie de l'anxiété, de la dépression et de la douleur, avant et après la réadaptation dans une population TCC légers bénéficiant d'un programme de réadaptation ambulatoire. **Méthodes :** Soixante-dix adultes âgés entre 18 à 78 ans, ayant tous reçu un diagnostic de TCC léger ont reçu des services de réadaptation interdisciplinaires en consultation externe dans un programme de traumatologie majeure de la région du Grand Montréal, minimum trois mois post-accident. Les mesures administrées avant et après l'intervention comprenaient le Rehabilitation Survey of Problems and Coping (R-SOPAC), le Mayo-Portland Adaptability Inventory-4 (MPAI-4), le Depression Anxiety Stress Scale 21 (DASS-21) et le Brief Pain Inventory-Short Form (BPI-SF). Des analyses de médiation ont été effectuées afin d'explorer les relations entre les différentes variables à l'étude. **Résultats :** Au terme de l'intervention, l'évolution du groupe sur toutes les mesures était positive. Les analyses de médiation ont indiqué un lien indirect partiel entre le niveau de coping, l'anxiété et la douleur sur le niveau de participation sociale pré-intervention. Après l'intervention, des relations médiatrices significatives concernant l'anxiété et l'impact perçu de la douleur sur le lien entre le coping et la participation sociale furent trouvées. **Conclusion :** Ces relations suggèrent qu'un faible niveau de coping semble conduire à un niveau plus élevé d'anxiété et de douleur autodéclarée, ce qui entraîne une participation sociale plus faible. Ces résultats suggèrent qu'il pourrait être bénéfique de prêter une attention particulière au niveau de l'anxiété et de l'impact perçu de la douleur pendant la réadaptation, en appliquant des interventions ciblées à ces niveaux, notamment pour améliorer le coping.

Mots clés : traumatisme crânien léger, coping, participation sociale, détresse émotionnelle, réhabilitation.

Abstract

Purpose: This present study aimed to investigate the association between coping and social participation according to anxiety, depression, and pain symptomatology, before and after rehabilitation in a mild TBI population benefiting from an outpatient rehabilitation program.

Methods: Seventy adults aged between 18 and 78, all of whom were at least three months post diagnosis of mild TBI, having received interdisciplinary outpatient rehabilitation services at a major trauma program in the Greater Montreal area. Measures administered pre and post intervention included the Rehabilitation Survey of Problems and Coping (R-SOPAC), the Mayo-Portland Adaptability Inventory-4 (MPAI-4), the Depression Anxiety Stress Scale 21 (DASS-21) and the Brief Pain Inventory-Short Form (BPI-SF). Mediation analyses were performed to explore the relationships between the different variables under study

Results: At the end of the intervention, group evolution on all measures was positive. Mediation analyses indicated a partial indirect link between coping, anxiety, and pain on the level of social participation at the pre-intervention time point. Post-intervention, significant mediating relationships regarding anxiety and the perceived impact of pain on the link between coping and social participation were found.

Conclusion: These relationships suggest that low levels of coping appear to lead to a higher self-reported level of anxiety and pain, resulting in lower social participation. These results suggest that paying close attention to the level of anxiety and perceived impact of pain during rehabilitation, and applying targeted interventions at these levels, in particular to improve coping, may be beneficial.

Keywords: mild traumatic brain injury, coping, social participation, emotional distress, rehabilitation.

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Liste des abréviations

mTBI: mild traumatic brain injury

R-SOPAC : Rehabilitation Survey of Problems and Coping

MPAI-4: Mayo-Portland Adaptability Inventory-4

DASS-21 : Depression Anxiety Stress Scale 21

BPI-FR : Brief Pain Inventory-Short Form

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Article

Coping and social participation following mild TBI: an observational rehabilitation cohort study

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Abstract

Purpose: This present study aimed to investigate the association between coping and social participation according to anxiety, depression, and pain symptomatology, before and after rehabilitation in a mild TBI population benefiting from an outpatient rehabilitation program.

Procedure: Seventy adults aged between 18 and 78, all of whom were at least three months post diagnosis of mild TBI, having received interdisciplinary outpatient rehabilitation services at a major trauma program in the Greater Montreal area. Measures administered pre and post intervention included the Rehabilitation Survey of Problems and Coping (R-SOPAC), the Mayo-Portland Adaptability Inventory-4 (MPAI-4), the Depression Anxiety Stress Scale 21 (DASS-21) and the Brief Pain Inventory-Short Form (BPI-SF). Mediation analyses were performed to explore the relationships between the different variables under study

Results: At the end of the intervention, group evolution on all measures was positive. Mediation analyses indicated a partial indirect link between coping, anxiety, and pain on the level of social participation at the pre-intervention time point. Post-intervention, significant mediating relationships regarding anxiety and the perceived impact of pain on the link between coping and social participation were found.

Conclusion: These relationships suggest that low levels of coping appear to lead to a higher self-reported level of anxiety and pain, resulting in lower social participation. These results suggest that paying close attention to the level of anxiety and perceived impact of pain during rehabilitation, and applying targeted interventions at these levels, in particular to improve coping, may be beneficial.

Keywords: mild traumatic brain injury, coping, social participation, emotional distress, rehabilitation.

Impact and implications statement

- Anxiety and pain are associated with coping and with social participation outcome following mTBI.
- Low levels of coping appear to lead to a higher self-reported level of anxiety and pain, resulting in lower social participation.
- Clinicians should consider monitoring anxiety and perceived impacts of pain more systematically early on after a mTBI to provide preventive interventions and coping strategies.

Introduction

Mild traumatic brain injury (mTBI) is one of the most common neurological conditions, constituting 80–90% of all traumatic brain injuries (Levin, H. S. & Diaz-Arrastia, 2015). While most patients return to fully normal functioning in the first three months following the incident (Hiploylee et al., 2016; Levin & Diaz-Arrastia, 2015), a significant proportion of individuals with mTBI remain at risk for developing persistent symptoms that impact many facets of their lives. Approximately 15-20% continue to report a variety of persisting symptoms that may require rehabilitation interventions (Ponsford et al., 2012). These include primarily physical (headaches, dizziness), cognitive (memory and poor concentration), or behavioural/affective (irritability, mood instability) complaints (Cassidy et al., 2014). Therefore, mTBI is a significant and increasing public health problem globally (James et al., 2019).

The impact of persistent post-mTBI symptoms can be profound, causing significant disruptions in well-being, functioning and quality of life (Agtarap, et al., 2021; Ahman et al., 2013; Carroll et al., 2020; Zahniser et al., 2019). The range of cognitive, emotional, behavioural and

physical symptoms that can result from mTBI raises challenges in many areas of their daily lives and social participation. In rehabilitation, the level of social participation is considered among the most relevant outcomes (Kersey, McCue & Skidmore, 2020; Piškur et al., 2014). Reduced social participation often extends beyond the acute recovery period and continues to be associated with lower quality of life for many months after mTBI (Voormolen et al., 2019). Specifically, a person with mTBI is 3.5 times more likely to be unemployed one year after the incident compared to the general population, controlling for age, gender, and education levels (Emanuelson et al., 2003). Consequently, understanding the factors that contribute to the development of persistent symptoms post mTBI is of importance.

Coping has been described as essential, especially in populations with mTBI, to decrease physical symptoms, have better psychological health, and increased social participation (Vos et al., 2019). Coping can also directly impact the prognosis for social participation by promoting a return to previous life activities and responsibilities (Wardlaw et al., 2018). The concept of coping, as defined by Lazarus and Folkman (1984), represents the set of cognitive and behavioural efforts that an individual interposes between them and the perceived threatening event in order to control, tolerate, or lessen the impact of the event on their physical and psychological well-being. Adaptive coping is generally associated with reduced anxiety and depressive symptoms, as well as improved quality of life (Wardlaw et al., 2018). Less adaptive coping would predict greater anxiety and more depressive symptoms, which in turn would predict increased symptoms associated with mTBI (Anderson & Fitzgerald, 2020; Tomberg et al., 2007). It is therefore essential to focus on understanding the factors contributing to social participation in this clinical population, including coping, to optimize their recovery.

There is strong evidence that psychological factors significantly impact recovery following mTBI (Broshek et al., 2015; Nelson et al., 2019; Ponsford et al., 2012; Scott et al., 2016). Perceived stress, depression, and hope variables appear to be directly and indirectly related to mild post-TBI adjustment in life satisfaction and return to work (Strom & Kosciulek, 2007). Post-TBI psychological functioning, particularly depression and anxiety, are indeed important predictors of social participation outcomes (Kreutzer et al., 2016; Ponsford, 2013). It has been found that in individuals with persistent symptoms after mTBI, anxiety or depression (i.e., psychological distress) is associated with reduced social participation. Anxiety and depressive symptoms would thus be predictive of post-TBI prognosis (Grubenhoff et al., 2016; Wood et al., 2014). Subsequently, the combination of anxiety factors and coping behaviours would also impact an individual's psychosocial adjustment following mTBI (Strom & Kosciulek, 2007). Consequently, identifying psychological mechanisms that contribute to symptom persistence following mTBI could also inform psychological treatments and result in more efficacious recovery.

Furthermore, it has been reported that 72,6 % of individuals with mTBI report pain 1-year post injury (Hoffman et al., 2007). A greater percentage of individuals with mTBI report chronic pain as compared to individuals with more severe TBIs (Hoffman et al., 2007; Weyer Jamora, Schroeder & Ruff, 2013). A meta-analysis found the prevalence rates for individuals with mTBIs to be higher (75.3%) as compared to their more severely impaired counterparts (32.1%) (Nampiarampil, 2008; Weyer Jamora, Schroeder & Ruff, 2013). Possible explanations include the fact that people with mTBI have less cognitive impairment and are therefore more able to remember their symptoms and express them clearly, in addition with a tendency to over-exert themselves which can have a negative impact on their recovery (Weyer Jamora, Schroeder & Ruff, 2013).

This could have a negative impact on the recovery of these individuals. Indeed, in populations with chronic pain, the negative impact of pain on cognition is correlated with several emotional factors. These include higher levels of somatic awareness, anxiety, depression, emotional distress and fatigue (Weyer Jamora, Schroeder & Ruff, 2013). Adaptive coping strategies and addressing pain avoidance beliefs can help to better manage the emotional difficulties associated with pain and result in less self-reported pain in mTBI population (Regier et al., 2015; Weyer Jamora, Schroeder & Ruff, 2013).

Given these implications and the growing concern for mTBI as a potentially disabling and chronic medical condition, it is important to focus on identifying the processes that can lead to persistent symptoms and related preventive interventions that can be applied. Considering the important role of emotional distress and pain in psychological adjustment and rehabilitation in individuals with mTBI, there is a need to further examine these variables in relation to coping and social participation. In addition, although emotional distress and pain have been associated with coping and social participation in mTBI, the mediating role of emotional distress and pain on the relationship between coping and social participation remains unknown. To our knowledge, this is the first study to explore these relationships in mTBI.

The purpose of the present study was to verify the association, at the beginning and at the end of rehabilitation, between the level of coping and the level of social participation according to symptoms of anxiety and depression, and pain, in a population having sustained a mTBI and presenting persistent symptoms at rehabilitation intake. Identifying the interactions between these factors would make it possible to promote better adapted intervention approaches.

The primary hypothesis was that the level of coping predicts and partially modulates the level of social participation following a mTBI. Specifically, it was expected that the level of coping would be associated with the level of social participation following a mTBI. Less adaptive coping would result in lower social participation, whereas adaptive coping would be related to higher levels of social participation. It was also expected that the relationship between coping level and social participation would be mediated by emotional distress. A high level of psychological distress, i.e., anxiety and depression, was expected to result in lower social participation. Coping was also expected to significantly predict the level of anxiety and depression reported, where less adaptive coping was expected to result in greater psychological distress. Finally, pain was expected to also mediate the relationship between coping and social participation, where higher levels of pain would result in poorer social participation.

Methodology

Experimental design

A prospective longitudinal cohort study design was employed, with two-time points for outcome assessment (i.e., start and end of rehabilitation). This study is reported according to the STROBE statement for cohort studies (Von Elm et al., 2007).

Participants

This study included 70 adults who experienced a mTBI between February 2016 and January 2020 and received interdisciplinary outpatient rehabilitation services at a major rehabilitation centre in the Greater Montreal region (see Table 1 for sample characteristics). The study did not include additional exclusion criteria as it was a pragmatic cohort study conducted in

a clinical setting, but relevant clinical variables were documented (i.e., neurological or mental health diagnoses prior to mTBI, comorbid musculoskeletal diagnoses, history of alcohol/drug use). Standard sociodemographic variables were also obtained for the entire sample (i.e., age, biological sex at birth, education, pre-TBI employment status). End of rehabilitation measures were available for 28 individuals (see Table 1 for sample characteristics, which did not differ between pre- and post-intervention sub-samples). Since this study used data collected by clinicians in a clinical setting, the main reason for the loss of 42 study participants was the non-completion or non-return of the questionnaires by the users.

Table 1. Descriptive characteristics of the pre- and post- rehabilitation sub-samples

Variables	Pre-rehabilitation (n=70) M (SD; Range) or n (%)	Post-rehabilitation (n=28) M (SD; Range) or n (%)	Student's T- Test <i>p</i>
Age (years)	45.3 (13.7; 18-78)	45.5 (14.5; 19-78)	<i>p</i> = .95
Sex			<i>p</i> = .71
Men	30 (42.9)	13 (46.4)	
Women	40 (57.1)	15 (53.6)	
Education	13.3 (2.9; 10-19)	13.6 (2.3; 10-18)	<i>p</i> = .20
Pre-TBI work status			<i>p</i> = .60
Unemployed	3 (4.4)	1 (3.6)	
Employed	64 (91.2)	25 (89.3)	
Retired	3 (4.4)	2 (7.1)	
Time since injury (months)	7.4 (4.7; 1-22)	9.7 (5.0 -3-22)	<i>p</i> = .21
Length of stay (months)	6.9 (5.3; 1-32)	7.7 (6.1; 1-32)	<i>p</i> = .24
Severity of TBI			<i>p</i> = .42
Mild	69 (98.6)	28 (100.0)	
Mild-complex	1 (1.4)	0 (0.0)	
Previous neurological diagnosis	23 (32.9)	7 (25.0)	<i>p</i> = .27
Previous mental health diagnosis	30 (42.9)	14 (50.0)	<i>p</i> = .41
Anxiety disorder	9 (12.9)	4 (14.3)	<i>p</i> = .83
Mood disorder	11 (15.7)	6 (21.4)	<i>p</i> = .33
Comorbid musculoskeletal diagnosis	36 (51.4)	11 (39.3)	<i>p</i> = .32
History of substance abuse			<i>p</i> = .33
No history	66 (94.2)	26 (92.8)	
Alcohol or drugs	2 (2.9)	1 (3.6)	
Alcohol and drugs	2 (2.9)	1 (3.6)	

According to the specific interdisciplinary intervention approach for mTBI that was in place in this program, the intervention team was composed of a psychologist/neuropsychologist, occupational therapist, physiotherapist, kinesiologist, nurse and physician. The rehabilitation interventions consisted first of assessing the person's history in order to estimate their previous level of functioning and the gaps with their current situation, and to make them psychologically and cognitively available for rehabilitation. An interdisciplinary biopsychosocial conceptualization of their difficulties was then proposed. A succinct intervention plan, centered on the life habits (e.g., the various aspects of social participation) judged to be a priority by the person was developed and revised every six to eight weeks. Different strategies were put in place by the team clinicians to help the person deal with their symptoms. Behavioural activation and physical reactivation were central interventions within the program. The mean length of stay was approximately seven months (see Table 1). The interdisciplinary intervention was built on the individual's strengths and promoted the experience of success to enhance the sense of self-efficacy in resuming their social participation and to promote post-mTBI adjustment.

Measures

Social Participation

The Mayo-Portland Adaptability Inventory-4 (MPAI-4), a tool developed to measure the level of adaptation and social participation after brain injury, is commonly used for clinical rehabilitation and research purposes, including in Canadian, American, and European settings (translated into nine languages) and has strong psychometric properties, including very good clinical sensitivity (Eicher et al., 2012; Malec et al., 2003, 2015; Malec & Keane, 2016). The MPAI-4 and the User Manual have been translated and adapted French (McKerral et al., 2014a, b). Recent data obtained from 1,012 individuals with TBI at the beginning of rehabilitation show

acceptable to good internal consistency for all the scales of the MPAI-4 (Chronbach's alphas between .70 and .89) (Guerrette & McKerral, 2020). These data therefore support the structural validity and clinical sensitivity of the French-Canadian version of the MPAI-4. The MPAI-4 has 29 items measured by a Likert scale ranging from 0 for no difficulty to 4 for significant difficulty. It is broken down into three scales: Abilities, Adjustment, and Participation, resulting in specific indexes and a total score, which was used for this study.

Coping

To measure the level of coping, the Rehabilitation Survey of Problems and Coping (R-SOPAC) was used. This self-report questionnaire measured the severity of post-injury complaints and the individual's ability to cope with them (Salmon and Celinski, 2002). It is divided into 25 items focusing on health problems, symptoms and coping skills. Participants were asked to rate a wide range of physical (sleep, balance/vertigo, pain, headache, muscle tension, tinnitus), emotional (self-confidence, sexual activity, nightmares, depression, anger/irritability, fatigue, nervousness, feelings of helplessness, disturbing memories, fear of driving, embarrassment by appearance) and cognitive (concentration, reading, memory, decision-making, planning/organization) problems in terms of intensity. They were also asked to rate the extent to which they were able to cope with these symptoms, allowing scores to be calculated for both symptoms intensity and level of coping. The measure is divided into three components: physical, emotional and cognitive, which summed together constitute a global score that is useful in determining broad-based subjective ratings of changes person's status and may provide an indication of their overall response type (Salmon et al., 2007). The total score (intensity global + coping global) and the subscales (physical, emotional and cognitive coping) were used for this study. The R-SOPAC was first developed as a clinical

tool but has been used effectively in research (Hamilton et al., 2011). It was selected because of its methodological value and its ability to track symptom change over time. Because this measurement tool was only available in English, it was home-translated by the rehabilitation centre where the study took place. The internal consistency of the items, as verified with data from 45 individuals for whom pre-post intervention data was available, is excellent (Cronbach's alphas: intensity-pre .941; intensity-post .923; coping-pre .961; coping-post .928) and justified the use of this adaptation of the tool.

Depressive and Anxiety Symptoms (Emotional Distress)

The severity of depressive and anxiety symptoms was assessed by the Depression Anxiety Stress Scale 21 (DASS-21). This self-report questionnaire is a shortened form of the 42-item self-report measure by Lovibond and Lovibond (1995). It consists of 21 Likert-type questions ranging from 0 to 3, where 0 is "does not apply to me" and 3 is "applies entirely to me." This tool is able to distinguish between the characteristics of depression, physical and psychological agitation, and tension in clinical and non-clinical groups (Henry & Crawford, 2005). The questionnaire is broken down into three scales: Anxiety, Depression and Stress, which were all used in the analyses. The DASS-21 has been shown to have adequate construct validity, and the validity and reliability scores of the DASS-21 are high (Cronbach's alphas between .82 and .88) (Osman et al., 2012).

Pain

The Brief Pain Inventory-Short Form (BPI-SF) is one of the most widely used measures of clinical pain. This self-reported questionnaire allows users to assess the severity of their pain and the degree to which their pain interferes with their functioning. Specifically, it consists of nine

questions, the first two of which were used to establish the presence or absence of pain, as well as to locate pain using a body diagram. The next seven questions include a Likert-type response scale ranging from 0 to 10, with 10 being the most intense pain. These are intended to quantify the intensity of pain and capture its functional impact. Therefore, the questionnaire is divided into two subscales: Intensity, and Impact, which combined result in a total score. The total score and the subscales (Intensity and Impact) were used for this study. The BPI has been used in hundreds of studies and has thus become a standard for the assessment of pain and its impact. Cronbach's alpha for the BPI questionnaire was reported between 0.80 and 0.92 (Cleeland & Ryan, 1991). The similarity of factor loadings between language versions indicated that cancer and pain patients, living in different countries and speaking different languages, responded to the items in the same way (Cleeland & Ryan, 1991).

Procedure

In this rehabilitation framework, measures self-reported by users (i.e., R-SOPAC, DASS-21, BPI-SF) or completed by clinician consensus within (i.e., MPAI-4) were obtained prospectively pre- and post-intervention (within one week of admission and discharge) in order to measure the evolution of users and to guide intervention. All raters were trained and followed a specific protocol, ensuring a valid and standardized administration of the MPAI-4. The results of these measures were recorded in a local database and, in accordance with the ethical authorization obtained, were used to test our hypotheses. This research was approved by the Research Ethics Board of the Centre for Interdisciplinary Research in Rehabilitation of Greater Montreal (CRIR).

Statistical Analysis

All data were analyzed using SPSS version 27.0, and the significance level was set at 0.5. Demographic characteristics were analyzed using descriptive analyses and frequency distributions. Paired t-tests were used to measure the pre- and post-intervention evolution of measures (see Table 2). Associations between continuous variables were tested using Pearson's correlation (see Table 3). Lastly, a mediator transmits the effect of an independent variable on a dependent variable (MacKinnon, Fairchild & Fritz, 2007). Therefore, mediation analyses were conducted using the PROCESS macro for SPSS, models 4 and 6 (Hayes, 2013), to test whether coping was significantly correlated with emotional distress and pain (a path), whether emotional distress and pain were significantly associated with social participation (b path) and whether coping was related to social participation (c path). The direct effect of coping on social participation was also analyzed (c' path). Bias-corrected confidence intervals (CI) were estimated for the indirect effects based on 10,000 bootstrap samples of the data. Complete mediation would be detected if the inclusion of emotional distress or pain (mediator variables) reduced the observed association between coping (independent variable) and social participation (dependent variable) to zero. Partial mediation was indicated if the observed relationship between coping (independent variable) and social participation (dependent variable) become weaker after controlling for emotional distress and pain (mediator variables). In the mediation analyses, R-SOPAC (coping) total score and subscales scores (physical, emotional and cognitive) served as the independent variable, the three subscale scores of the DASS-21 (anxiety, depression and stress) and BPI-SF (pain) total score and subscales (intensity and impact) as the mediators, and MPAI-4 (social participation) total score as the dependent variable. Effect sizes were calculated using Cohen's d coefficient. An effect size is considered to have a large effect when the R^2 value is equal to or greater than .25 (Cohen, 1988).

Results

At the end of the intervention, there were significant improvements on all measures. More specifically, the scores corresponding to the level of coping, anxiety-depressive symptoms, pain, and social participation were all significantly reduced (see Table 2). Specifically, the level of clinically significant anxiety levels decreased from 37.3% pre-rehabilitation to 10.8% post-rehabilitation.

Table 2. Results of paired sample t-test for study variables.

	M	ÉT	<i>t</i>	<i>ddl</i>
1. RSOPAC	-64.64	44.59	-7.67***	27
2. MPAI-4	-15.93	7.94	-10.61***	27
3. DASS-21 total	-7.86	12.50	-3.33*	27
4. DASS-21 anxiety	-3.29	8.81	-1.97*	27
5. DASS-21 depression	-7.07	10.01	-3.74***	27
6. DASS-21 stress	-5.36	9.35	-3.03**	27
7. BPI-SF total	-20.71	26.28	-4.17***	27
8. BPI-SF intensity	-5.52	10.93	-2.53*	27
9. BPI-SF impact	-15.32	17.47	-4.39***	27

Note. N=28. RSOPAC = Rehabilitation Survey of Problems and Coping; MPAI-4 = Mayo-Portland Adaptability Inventory-4; DASS-21= Depression Anxiety Stress Scales 21; BPI-SF= Brief Pain Inventory-Short Form

* $p < .05$. ** $p < .001$. *** $p < .0001$

Correlations between the study variables are presented in Table 3. Age and sex were not related to emotional distress, pain, coping, or social participation, and therefore were not used as covariates in mediation analyses. Pre-mTBI work status was positively correlated to rehabilitation time. The results also indicated that coping, social participation, emotional distress, and pain scores were all significantly intercorrelated.

Table 3. Correlations between the variables under study

	1	2	3	4	5	6	7	8	9	10
1. Age	-									
2. Sex ^a	.24	-								
3. Time since injury	.23	.13	-							
4. Rehabilitation time	.17	-.22	-.11	-						
5. Pre-TBI work status	.10	-.26	.03	.41*	-					
6. Education	-.14	.30	-.19	-.23	-.11	-				
7. Coping	.11	.17	-.06	.13	-.10	.08	-			
8. Social participation	.10	.15	-.17	.25	-.07	.05	.74**	-		
9. Emotional distress	.18	-.10	.15	.22	.13	-.14	.80**	.58**	-	
10. Pain	.17	-.04	.03	.26	-.08	-.06	.86**	.52**	.75**	-

Note. N=28. Pearson correlations are shown for continuous variables. ^aCoded 1 = male, 2 = female.

* $p < .05$. ** $p < .001$.

Mediation analysis pre-rehabilitation

Pre-rehabilitation mediation analyses included 70 participants, with no missing data. The first mediation analysis showed that the path between coping (total score) and emotional distress was statistically significant on all subscales of the DASS-21, namely anxiety ($a_1 = .15$, $se = .02$, $p < .0001$), depression ($a_2 = .09$, $se = .03$, $p < .001$) and stress ($a_3 = .07$, $se = .02$, $p < .001$). The relationship between anxiety level and social participation was the only one statistically significant. The significant total effect of coping on social participation wasn't reduced to non-significance in the direct model. The bootstrapping for the indirect effect showed significant results [$\beta = .06$, $SE = .03$, 95% CI: .01, .13], supporting a partial mediation (see Figure 1). According to Cohen's coefficients, the effect size of mediating anxiety on coping and social participation is large ($R^2 = .41$).

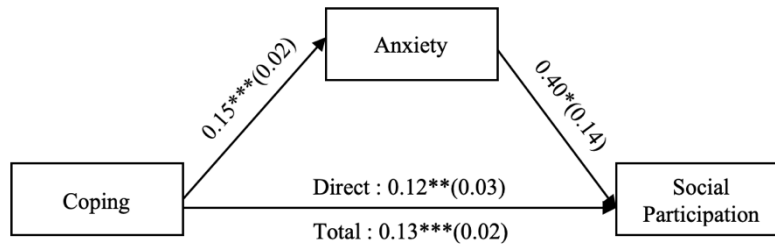


Figure 1. Mediation model of the effect of anxiety on coping and social participation pre-rehabilitation. $N= 70$. In parentheses: standard errors. * $p < .05$ ** $p < .01$ *** $p < .0001$.

The second mediation analysis only showed that the path between cognitive coping subscale (concentration, reading, memory, decision-making, planning/organization) and pain (total score) was statistically significant, as was the path between pain (total score) and social participation. The significant total effect of coping on social participation wasn't reduced to non-significance in the direct model. The bootstrapping for the indirect effect showed significant results [$\beta= .12$, $SE= .06$, 95% CI: .02, .24], supporting a partial mediation (see Figure 2). According to Cohen's coefficients, the effect size of mediating pain (impact and intensity) on cognitive coping and social participation is large ($R^2 = .25$).

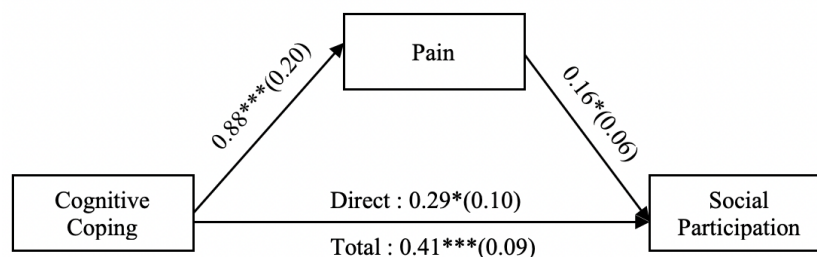


Figure 2. Mediation model of the effect of pain on coping and social participation pre-rehabilitation. $N= 70$. In parentheses: standard errors. * $p < .05$ ** $p < .01$ *** $p < .0001$.

Mediation analysis post-rehabilitation

Post-rehabilitation, 28 participants completed the various measures under study. The first mediation analysis showed that the path between coping and emotional distress was statistically significant on all subscales of the DASS-21, namely anxiety ($a_1 = .07$, $se = .02$, $p < .001$), depression ($a_2 = .10$, $se = .03$, $p < .05$) and stress ($a_3 = .08$, $se = .03$, $p < .05$). The relationship between anxiety level and social participation was also significant. The significant total effect of coping on social participation was reduced to non-significance in the direct model. The bootstrapping for the indirect effect showed significant results [$\beta = .03$, $SE = .01$, 95% CI: .01, .04], supporting total mediation (see Figure 3). According to Cohen's coefficients, the effect size of mediating anxiety on coping and social participation is large ($R^2 = .29$).

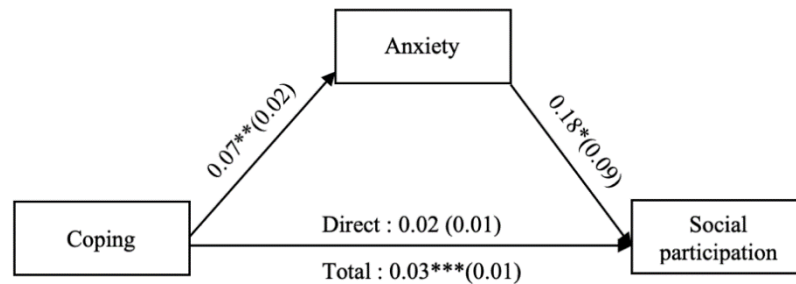


Figure 3. Mediation model of the effect of anxiety on coping and social participation post-rehabilitation. $N = 28$. In parentheses: standard errors. * $p < .05$ ** $p < .01$ *** $p < .0001$.

The second mediation analysis only showed that the path between coping (total score) and pain impact subscale was statistically significant, as was the path between pain impact and social participation. The significant total effect of coping on social participation wasn't reduced to non-significance in the direct model. The bootstrapping for the indirect effect showed significant results [$\beta = -.18$, $SE = .07$, 95% CI: -.29, -.03], supporting a partial mediation (see Figure 4). According to

Cohen's coefficients, the effect size of mediating pain impact on coping and social participation is large ($R^2 = .57$).

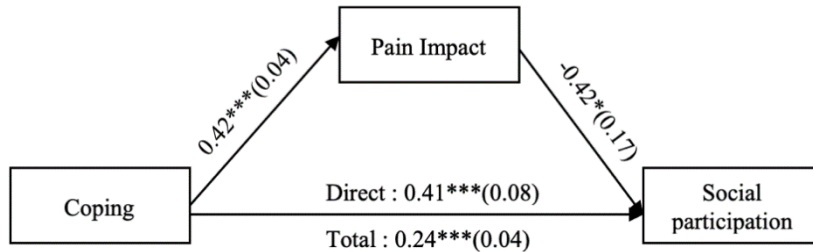


Figure 4. Mediation model of the effect of pain on coping and social participation post-rehabilitation. Note. $N= 28$. In parentheses: standard errors. * $p < .05$ ** $p < .01$ *** $p < .0001$.

Discussion

This study aimed to document the association, both at the beginning and at the end of rehabilitation, between the level of coping and the level of social participation according to the symptoms of anxiety, depression, and pain, in a population having sustained a mTBI and receiving rehabilitation services. Between the beginning and the end of the rehabilitation, participants showed positive changes on all variables. In particular, both coping and social participation improved, while levels of emotional distress and pain decreased. Overall, among our sample, the only variable specific to the measurement of emotional distress that significantly mediated the relationship between coping and social participation was the level of self-reported anxiety. Indeed, models specifically looking at indicators of psychological distress as moderators commonly pointed, both pre- and post- rehabilitation, to a significant relationship between coping, anxiety, and social participation. This would suggest that the anxiety experienced by our participants would have possibly greater predictive value compared to the level of self-reported depression and stress. In accordance with a study by Silverberg and colleagues (2015), when included in a multivariable model, early post-injury anxiety tended to be the strongest independent predictor regarding mTBI

prognosis. Our results suggest that the level of self-reported depression does not significantly mediate the relationship between the level of coping and social participation. Rather, we have replicated the finding by Schönberge et al. (2011) that depression did not seem to worsen functional status. Furthermore, in previous findings, it appears that poor functional status would precede depression (Pagulayan et al., 2008).

In parallel, pre-rehabilitation results suggest that the relationship between social participation and cognitive coping, referring to concentration, decision-making, organization/planning, and reading abilities, is partially mediated by pain, both in terms of intensity and functional impact. Related to our results, chronic physical pain has long been associated with emotional distress and emerging evidence suggests that it can also impact cognitive functioning in mTBI (Weyer Jamora, Schroeder & Ruff, 2013). Physical pain can alter cognitive functioning in the areas of attention, memory, speed of information processing, psychomotor ability and executive functioning (Weyer Jamora, Schroeder & Ruff, 2013). In a study looking at the implications of pain severity on emotional and cognitive functioning in a mTBI population, high pain group subjectively endorsed significantly more cognitive difficulties (Weyer Jamora, Schroeder & Ruff, 2013). Why this group misattributed their difficulties to being cognitively related may be related in part to a reinforced focus on everyday failures and a tendency to catastrophize their difficulties (Weyer Jamora, Schroeder & Ruff, 2013). Explanations can also involve attentional resource allocation where chronic pain stimulus often competes with other sensory inputs so that pain interferes with fully paying attention (Weyer Jamora, Schroeder & Ruff, 2013).

Regarding post-rehabilitation results, the relationship between coping level and social participation was only partially mediated by the functional impact of pain subscale, regardless of the intensity of the self-reported pain. These findings are consistent with the integrative biopsychosocial perspective, where perpetuating factors, which are cognitive, emotional, and behavioural responses to post-mTBI symptoms, interact with each other (Anderson & Fitzgerald, 2020; Whittaker, Kemp, & House, 2007). Particularly, the association between anxiety and persistent post-concussive symptoms is thought to be partially mediated by pain catastrophizing and limiting behaviour (i.e., avoidance) (Greenberg et al., 2020).

One possible explanation for the greater weight of the functional impact of pain compared to the perceived pain intensity could stand in a potentially disrupted neurocognitive anticipatory network that may result from damage to the endogenous pain modulatory system and underlie difficulties with regulatory pain processing following mTBI (Strigo et al., 2014). In other words, brain injury makes it more difficult to control acute pain (Strigo et al., 2014). Therefore, individuals with a reported history of mTBI, compared with healthy comparison subjects, showed increased brain response to pain anticipation and ineffective pain modulation after controlling for psychiatric symptoms (Strigo et al., 2014). This suggests a greater influence of brain injury on pain regulatory processes, that is, anticipation and modulation, rather than on actual pain perception, which could explain the mediating relationship of pain functional impact on coping and social participation (Strigo et al., 2014). It is also possible that the pre-rehabilitation mediation models could not be replicated due to the loss of power associated with the smaller sample size post-rehabilitation.

Individuals with high levels of post-morbid pain also report greater emotional distress than their lower pain counterparts (Weyer Jamora, Schroeder & Ruff, 2013). Clinically significant anxiety is a common issue after TBI and has been observed in studies including the full spectrum of TBI severity (Hammond et al., 2019). Onset of acute stress disorder within 5 days after injury was predictive of post- concussion syndrome at 3 months in both mild TBI and trauma control groups (Levin, H. S. & Diaz-Arrastia, 2015; Ponsford et al., 2011). Acute psychological distress has been found to be a robust risk factor for persistent symptoms following mTBI (Silverberg et al., 2015), supporting biopsychosocial modelling of mTBI recovery outcomes. In short, these models highlight the role of preinjury vulnerabilities, early physiological effects, and over time, an increasing role of psychosocial factors (Berrigan et al., 2011; Faulkner et al., 2021; Iverson, 2019; Krpan et al., 2011; MacMillan et al., 2002; McCrea et al., 2009; Polinder et al., 2018; Rickards et al., 2020). This idea also corroborates previous studies that have found symptom complaints in mildly injured patients stemming primarily from their emotional stress (Belanger et al., 2010; De Koning et al., 2016; Yehene et al., 2019), as well as with an earlier recommendation to understand the symptomatology post-mTBI via a patient-based approach focusing on the individual's subjective perception of the impacts of their mTBI (Ruff, 2005; Yehene et al., 2019).

Whether it leads to significant lifestyle changes or not, traumatic brain injury (TBI), in its varying degrees of severity, forces the affected individual to cope with changes to various abilities that were only available to them prior to the injury (Yehene et al., 2019). In this sense, coping with mTBI may not be different than coping with any other unpleasant life events that require adjustment to the injury event, as well as its subsequent consequences (Yehene et al., 2019). Furthermore, since emotional pain is known to aggravate physical pain, and vice versa (Lumley et

al., 2011; Yehene et al., 2019), it is highly possible that emotional outcome post-mTBI also contributes to the persisting physical symptoms and complaints (Yehene et al., 2019).

Our results are in line with a recent study by Lamontagne and colleagues (2022), where a significant reduction was found in the frequency of anxiety disorders between 4 and 12 months after mTBI. According to this study, the prevalence of anxiety disorders in the first year after mTBI is still 2.5 times higher than the rate in the Canadian population, which is 11.6% (Lamontagne et al., 2022; O'Donnell et al., 2016). Moreover, it appears that anxiety plays a role in the persistence of post-concussion symptoms, as longitudinal results suggest that participants who were significantly anxious at 4 months post-mTBI had a higher number of symptoms one year after the incident compared to those without anxiety (Lamontagne et al., 2022). Therefore, the first few months following mTBI represent a period of increased vulnerability to anxiety (Lamontagne et al., 2022; Osborn et al., 2017). In our study, the level of clinically significant anxiety decreased from 37.3 % pre-rehabilitation to 10.8 % post-rehabilitation.

In this regard, the proportion of mTBI post-anxiety symptoms, as well as the severity of these symptoms, would be significantly higher in participants with a history of anxiety disorders preinjury (Lamontagne et al., 2022). Indeed, a longitudinal study indicates that a pre-injury neuropsychiatric disorder is strongly related to the persistence of symptoms for 3 months or longer after mTBI (Levin, H. S. & Diaz-Arrastia, 2015). Consequently, the presence of a pre-injury anxiety disorder would have an important role in the presence of anxiety after mTBI (Gould et al., 2011; Karr et al., 2019; Vikane et al., 2019). One possible explanation would be that individuals who were vulnerable to anxiety before the accident have less effective coping strategies to manage

the stress and potential difficulties caused by mTBI (Ponsford et al., 2012). A second hypothesis would be that individuals with pre-existing anxiety sensitivity would pay more attention to physiological or cognitive symptoms experienced after the accident, which in turn would cause more anxiety, creating a vicious cycle (Broshek et al., 2015; Lamontagne et al., 2022).

In addition, several factors can be proposed to explain the predictive role of anxiety on the prognosis of social participation after mTBI. Firstly, the circumstances surrounding the accident, the experience of transportation to the emergency room or hospital, and the hospitalization itself may be the cause of anxiety for some individuals (Lamontagne et al., 2022; Moore et al., 2006). The physical limitations, pain (muscular, orthopedic or headache), cognitive difficulties (concentration), or emotional/behavioural regulation issues (irritability) potentially generated by or in concomitance with the mTBI could also be a source of anxiety since they limit the individual's ability to resume their activities, both on professional and personal levels (Lamontagne et al., 2022; Stergiou-Kita et al., 2016; Wise et al., 2010).

In general, socio-psychological adjustment to the newfound impacts and persisting impairments are reflected in psychological reevaluation process, in which the severity of the physical disability is less prioritized than the main changes the individual experiences in their psychological values (Livneh & Antonak, 2005; Yehene et al., 2019). This may imply that individuals holding maladaptive cognitions, such as "what happened to me is overwhelming and beyond my capability to cope," may feel controlled by the ramification of the injury and assume a negative and distressing subjective experience (Yehene et al., 2019). Therefore, anxiety is an inevitable derivative of this psychological state. In addition, the feeling of not functioning quite "as before" can itself be a significant source of anxiety (Lamontagne et al., 2022). Many people

who have experienced mTBI report subtle after-effects, imperceptible to others, that may nevertheless prevent them from performing their daily tasks satisfactorily and have an impact on their social roles and relationships (Lamontagne et al., 2022). Thus, similar to individuals who capitulate to self-limiting cognitions and adopt an inflexible attitude, individuals with mTBI may potentially develop a vicious cycle that impedes their attempts to engage in challenging activities, thereby avoiding opportunities that may facilitate self-growth (Yehene et al., 2019). Though related to emotional distress, self-reported resilience also makes a unique contribution to predict outcomes over time following brain injury and may impact the relationship between stress and negative participation outcomes (Vos et al., 2019).

Therefore, the presence of anxiety and pain in the first few months following mTBI could play an important role in the adaptation process and how individuals experience other common symptoms after an mTBI. Our results suggest that it can be clinically relevant to systematically assess both anxiety symptoms and pain early after the accident, monitor their progression, as well as provide appropriate treatment. This could reduce anxiety and self-reported pain levels, and potentially other persistent symptoms, while promoting better social participation.

Results from the current study may also provide a preliminary direction relevant to clinical practice, in which early rehabilitation work with this population should be targeting coping, anxiety, and pain. Among promising rehabilitations for the mTBI population, Broshek et al. (2015) found that a single psychoeducational session covering common symptoms after an mTBI and the expected course of recovery reduces symptoms within the first month after the injury. In this sense, informing individuals early on that symptoms may take several months to subside, rather than a

few days as is commonly believed, may result in reduced anxiety. In fact, a recent study suggests that a brief and multidimensional psychoeducational and counselling intervention targeting four frequently reported symptoms following mTBI, including sleep and fatigue, attention and concentration, anxiety and mood, and memory and organization, might be beneficial in reducing overall post-concussion symptoms (Audrit et al., 2021). For individuals requiring more sustained interventions, cognitive behavioural therapy is known to be effective in reducing symptoms of anxiety and depression in individuals with TBI (Hsieh et al., 2012; Lamontagne et al., 2022; Potter & Brown, 2012). Specific pain-related coping strategies and addressing pain avoidance beliefs are other relevant treatment target for the treatment of chronic pain patients (Weyer Jamora, Schroeder & Ruff, 2013).

Drawing from cognitive behavioural therapies and the psychology of self-motivation (Al Sayegh, Sandford, & Carson, 2010; Geller, 2015), clinical rehabilitation should also focus on the narrative individuals communicate to themselves, and not only what they reflect to the outside world regarding their mTBI, while highlighting the role of choice and control they may have over the way they perceive their condition (Yehene et al., 2019). Furthermore, Tiersky et al. (2005) aimed to increase the use of effective coping strategies, reduce the level of stress, prevent relapse, and help individuals with mTBI face the sense of loss of physical or cognitive abilities. Their intervention included psychoeducation, self-recording of thoughts, cognitive restructuring, and behavioural exposure. They found that this treatment significantly improved emotional functioning, particularly by reducing anxiety and depression, compared with a wait-list control.

Study limitations

The results of the present study must be interpreted in the light of several limitations. Considering the clinical context, the sample size is relatively small, limiting the statistical power of the results. Another limitation is that, given the longitudinal nature of this study, there is also a nonnegligible proportion of missing post-rehabilitation data. Further, there were only two measurement times, whereas the inclusion of several measurement times would have widened the scope of the results, particularly by better targeting the specific effect of mTBI recovery with time. Additionally, most of the data was self-reported. A “good-old days” bias could have influenced the results, described as a tendency for persons with mTBI to underestimate the frequency or severity of certain symptoms that may have been present before the accident (e.g., headaches, fatigue, and anxiety), and overestimate those present after the accident (Iverson et al., 2010). Finally, the sample mainly represents francophone individuals from a midsized Canadian city where there is a good level of employment. As such, the sample may not represent mTBI cases seen in denser and socioeconomically different urban centres where more assault or violence-related accidents may occur. Despite these limitations, the present study also has several strengths, including the use of well-validated measures of emotional distress, social participation, and pain, as well as a longitudinal approach.

Conclusion

In conclusion, this observational rehabilitation cohort study demonstrates how anxiety and pain are associated with coping and social participation outcome following mTBI. Specifically, mediation analyses indicated a partial indirect link between coping, anxiety, and pain on the level of social participation at the pre- rehabilitation time point. Post-rehabilitation, a significant partial

mediating relationship regarding the impact of pain on the link between coping and social participation, was found. In addition, a statistically significant mediation relationship was found, where anxiety mediated the relationship of coping and social participation. These relationships suggest that lower levels of coping appear to lead to a higher self-reported level of psychological distress and pain, resulting in lower social participation. These results are quite pertinent for clinical purposes in that paying close attention to the level of anxiety and perceived impact of pain during rehabilitation, and applying targeted interventions at these levels, in particular to improve coping, may prove particularly beneficial.

Future research should examine the evolution of these mediators beyond the first year after mTBI, to characterize the evolution of the relationships documented in this study. Since anxiety and pain seem to mediate the relationship between coping and social participation, it would also be particularly informative to study the link between post-mTBI anxiety and pain. Variables such as anxiety sensitivity, tolerance to uncertainty, tendency to catastrophize, social support, and cognitive fatigue could be of interest. Looking at the expression of mediation patterns according to the presence or absence of premorbid anxiety disorder would also be relevant. Future studies could also examine if these results are replicable within a larger sample size.

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