Psychology & Health

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/gpsh20

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To cite this article: Simon Kunz , Corinne Stadler , Claudio Peter & for the SwiSCI Study Group (2020): Longitudinal course and predictors of posttraumatic stress symptoms after spinal cord injury, Psychology & Health, DOI: 10.1080/08870446.2020.1826483

To link to this article: https://doi.org/10.1080/08870446.2020.1826483

PSYCHOLOGY & HEALTH
https://doi.org/10.1080/08870446.2020.1826483

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Longitudinal course and predictors of posttraumatic stress symptoms after spinal cord injury

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ABSTRACT

Objective: This study examined longitudinal changes in post-traumatic stress symptoms (PTSS) in individuals newly diagnosed with spinal cord injury (SCI) and tested various psychosocial and injury-related characteristics as predictors for interindividual differences in symptom courses.
Design: Longitudinal data from the larger Swiss Spinal Cord Injury Cohort Study were used. The sample consisted of 269 patients (70.6% male; $M_{age} = 53.21$) admitted for inpatient rehabilitation to SCI rehabilitation centers.
Main Outcome Measure: PTSS were measured at one and six months after injury using the Impact of Event Scale-6.
Results: Latent change score modelling revealed no average change in PTSS in the sample, but significant variability in the individual symptom courses. Reliable change index analyses suggest that among individuals with an initial PTSS severity of clinical concern ($n = 65$), only 27.7% showed clinically significant decreases over time. Predictors explained 34% of the variance in PTSS change. Loss appraisals ($\beta = .30$, $p < .001$) and cause of injury ($\beta = .16$, $p = .018$) emerged as unique predictors.
Conclusion: Clinically elevated PTSS one month after SCI typically remain across the following months highlighting the need for early screening and intervention. Low loss appraisals were related to decreases in symptom severity and might therefore be a suitable intervention target for reducing PTSS after SCI.

ARTICLE HISTORY
Received 8 April 2020
Accepted 16 September 2020

KEYWORDS
Post-traumatic stress disorder; spinal cord injuries; appraisals; self-efficacy; meaning in life

Introduction

A spinal cord injury (SCI) is a serious physical injury characterised by a damage of the spinal cord which typically results in permanent, partial or complete, loss of autonomic, motor, and sensory functions below the injury level (World Health Organization, 2013). Causes for the injury include, for example, motor vehicle accidents and falls – so called traumatic causes – or vascular disorders and neoplastic tumours – so called

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Supplemental data for this article is available online at https://doi.org/10.1080/08870446.2020.1826483.

non-traumatic causes (World Health Organisation, 2013). Individuals with SCI are at risk for various secondary health conditions with chronic pain, spasticity, and urinary tract infections being most common (Jensen et al., 2013). The severe physical impairments resulting from SCI often entail disruption in daily life activities, reduced autonomy, and restrictions in social and occupational activities (Noreau & Fougeyrollas, 2000). Taken together, the onset of an SCI confronts the individual with various life-changing consequences that can act as extreme stressors. As a result, individuals with SCI are at risk for mental health issues (Post & van Leeuwen, 2012). For instance, they may experience post-traumatic stress symptoms (PTSS) including intrusive thoughts, avoidance, hyperarousal, and negative thoughts and emotions (e.g., Martz, 2005; Nielsen, 2003). These symptoms can be so severe to meet the criteria of a post-traumatic stress disorder (American Psychiatric Association, 2013). Prevalence estimates of post-traumatic stress disorder diagnoses in individuals with SCI typically range from 7–27% (Post & van Leeuwen, 2012).

Little is known with regards to longitudinal changes in the severity of PTSS after SCI. Cross-sectional studies found higher levels of PTSS to be related to shorter time since injury which may indicate that, on average, PTSS severity decreases over time (Pollock et al., 2017). However, longitudinal studies supporting this finding are lacking (Post & van Leeuwen, 2012). Accordingly, there is a need for longitudinal studies that examine changes in PTSS after the injury. Besides focusing on average changes, such studies should also test whether there are interindividual differences in symptom severity courses, as observed after the onset of other potentially traumatic events (Visser et al., 2017), to gain a comprehensive picture of the psychological adjustment process to SCI. Moreover, in particular the initial time after the injury deserves study because this period represents the most crucial phase in the formation of a post-traumatic stress disorder (Galatzer-Levy et al., 2013). Hence, corresponding results may not only contribute to a better understanding of the pathogenesis of the disorder, but can also help to plan the timing of screening and interventions in the clinical rehabilitation setting.

From a clinical perspective, it is also crucial to identify factors, which can explain interindividual differences in the severity and in longitudinal changes in PTSS after SCI onset, since corresponding findings can serve as a basis for designing interventions. Previous research examining predictors of PTSS following SCI has been almost exclusively cross-sectional and has focused primarily on demographic and injury-related characteristics, trauma and psychiatric history, as well as social support (e.g., Martz, 2005; Nielsen, 2003). Corresponding findings were summarised in a recent review and meta-analysis by Pollock et al. (2017): Effect sizes of demographics, injury-related variables (i.e., level and completeness, time since injury), and trauma and psychiatric history were identified as being weak and typically non-significant in the pooled analyses. The exceptions were that female sex, not being married, lower education, shorter time since injury, and a higher number of previous life traumas were significantly, but still weakly, related to higher levels of PTSS. Larger effects sizes were observed with regards to pain intensity and negative appraisals, which were related to higher PTSS, and with regards to social support, which was related to lower symptomatology (Pollock et al., 2017).

With the exception of social support, factors exhibiting a protective effect regarding PTSS have rarely been studied in the SCI context. In particular, few studies have assessed whether psychological resources such as hope or sense of coherence (e.g., Livneh & Martz, 2014) are related to PTSS. However, an identification of modifiable psychological resources may give important insights into which factors could be targeted in clinical interventions aiming to reduce PTSS in individuals with SCI.

Two psychological resources which may be particularly relevant in exhibiting such a protective function are meaning in life and self-efficacy. Meaning in life is typically conceptualised as being composed of a cognitive (comprehensibility, i.e., having a coherent mental model of the self, the world, and their interactions) and a motivational component (sense of purpose, i.e., having aspirations, goals, and pursuits; Steger, 2012). The relevance of meaning in life in the etiology of PTSS is especially highlighted in the work of Janoff-Bulman (e.g., Janoff-Bulman & McPherson Frantz, 1997). She proposes that traumatic events have the potential to shatter an individual's fundamental assumptions about the self and the surrounding world (i.e., meaning in life) which in turn causes PTSS. Accordingly, it has been argued that the ability to maintain or regain meaning in life in the aftermath of a potentially traumatic event might be key to successful adjustment and recovery (Feder et al., 2016; Steger, 2012). This hypothesis was supported by cross-sectional and longitudinal studies (e.g., Aiena et al., 2016; Feder et al., 2016; see also Steger, 2012) showing that having more meaning in life was negatively related to the severity of PTSS after different types of potentially traumatic events.

Self-efficacy refers to one's sense of control over the environment and beliefs that one is able to deal with challenging events (Bandura, 1997). Self-efficacy is proposed to reduce the severity and persistence of PTSS through several processes, such as more benign appraisals or mobilising and sustaining coping efforts (Benight & Bandura, 2004). Indeed, higher general and situation-specific aspects of self-efficacy beliefs were identified as being linked to lower PTSS after different types of potentially traumatic events in several cross-sectional and longitudinal studies (Simmen-Janevska et al., 2012).

Present study

Aiming for reducing the identified knowledge gaps with regards to longitudinal changes and predictors of PTSS after SCI, the aims of the present longitudinal study were twofold: (1) to examine changes in PTSS from one to six months after SCI onset in a sample of patients attending inpatient rehabilitation and (2) to investigate which socio-demographic (sex, marital status, household income), injury-related (cause of injury, presence of pain, number of other secondary health conditions), psychological (general self-efficacy, meaning in life, negative appraisals, substance abuse), and social (social support) characteristics predict changes in PTSS from one to six months. The selection of these potential predictors was based on previous cross-sectional research in the SCI context, psychological theory, findings from other populations and clinical considerations. Based on the literature outlined above, we hypothesised that the average severity of PTSS decreases over time, but we also expected some interindividual variability in the symptom severity courses. Regarding the predictors, we expected negative appraisals to be associated with increases in PTSS and general self-efficacy, meaning in life, and social support to be related to decreases in PTSS. In contrast, we expected that socio-demographic and injury-related characteristics (with the exception of pain) are at best weakly related to changes in PTSS.

Method

Participants and procedures

In this observational study a secondary data analysis was conducted using data from the larger, ongoing inception cohort of the Swiss Spinal Cord Injury Cohort Study (SwiSCI; Post et al., 2011). Within SwiSCI, clinical and questionnaire data (in German, French, and Italian) on biomedical and psychosocial characteristics in the initial time after SCI onset were collected at several measurement time points. To reduce participant burden, the assessment of these characteristics was distributed across the different measurement time points. As a result, not all characteristics were assessed repeatedly or at each of the time points (see measures section about the specific timing of the assessment of the variables used for the present study). Included in SwiSCI were individuals who were newly diagnosed with traumatic or non-traumatic SCI and who were admitted for inpatient rehabilitation to one of the four Swiss SCI rehabilitation centers. Further inclusion criteria were an age of 16 years or older and a permanent residence in Switzerland. Exclusion criteria were: congenital conditions leading to para- or tetraplegia, new SCI in the context of palliative care, and neurodegenerative disorders such as multiple sclerosis. SwiSCI was approved by all regional ethics committees involved (Ethics Committee northwest/central Switzerland (EKNZ): PB_2016-00183, Ethics Committee Vaud (ECVD): CCVEM 032/13, Ethics Committee Zurich (KEKZH): 2013-0249) and all participants gave written informed consent. For participants under the age of 18, parental consent was obtained too.

Assessment time points within SwiSCI

During inpatient rehabilitation, the four assessment time points within SwiSCI were scheduled at one (T1), three (T2), and six months (T3) after SCI onset and at discharge from rehabilitation (T4). To determine SCI onset, the corresponding entry from a patient's medical records was used. However, the envisioned procedure did not necessarily represent clinical reality due to variability in the rehabilitation duration. For example, some individuals were discharged from inpatient rehabilitation after four months, in which case T3 and T4 assessments were both completed at this time point (i.e., measurement occasions collapsed).

Present study sample

For the present study, we used data collected at T1, T2, and T3. All SwiSCI participants who completed their rehabilitation until April 15, 2019, and who gave consent for the data collection ($n = 520$) were considered. We excluded all SwiSCI participants who did not complete T1 ($n = 97$) or T3 ($n = 53$), who had the PTSS scale at T1 ($n = 19$) or T3 ($n = 7$) completely missing, and for whom the T3 assessment collapsed with the T1 assessment ($n = 48$). Following the procedure of Galatzer-Levy et al. (2013), we also

Table 1. Sample characteristics and distributional properties of the study variables ($N = 269$).

Characteristic	n (%)	n (%) missing	α	M (95% CI)	SD	Skewness	Kurtosis
Sex		0					
Male	190 (70.6)						
Marital status		0					
Married	147 (54.6)						
Household income		43 (16.0)					
Less than 1500 CHF	9 (3.4)						
Between 1500 and 3000 CHF	16 (6.0)						
Between 3000 and 4500 CHF	39 (14.5)						
Between 4500 and 6000 CHF	43 (16.0)						
Between 6000 and 7500 CHF	29 (10.8)						
Between 7500 and 9000 CHF	35 (13.0)						
More than 9000 CHF	55 (20.5)						
Language of questionnaire		0					
German	211 (78.4)						
French	52 (19.3)						
Italian	6 (2.2)						
Cause of injury		0					
Traumatic	162 (60.2)						
Type of injury		14 (5.2)					
Incomplete paraplegia	123 (45.7)						
Complete paraplegia	38 (14.1)						
Incomplete tetraplegia	82 (30.5)						
Complete tetraplegia	8 (3.0)						
Intact	1 (0.4)						
Not testable/ unknown	3 (1.1)						
Presence of pain		7 (2.6)					
Yes	192 (71.4)						
Alcohol use pre SCI		10 (3.7)					
Never	52 (19.3)						
1 to 3 times a month	62 (23.1)						
1 to 3 times a week	89 (33.1)						
4 to 6 times a week	29 (10.8)						
daily	27 (10.0)						
Drug use pre SCI		8 (3.0)					
Yes	63 (23.4)						
Drug use post SCI		6 (2.2)					
Yes	20 (7.4)						
Age at injury in years		0		53.21 [51.22, 55.20]	16.58	−0.36	2.22
Number of other SHCs		27 (10.0)		1.56 [1.36, 1.76]	1.66	1.66	7.69
PTSS (T1)		13 (4.8)	.74	6.65 [6.11, 7.20]	4.56	0.36	2.24
PTSS (T3)		16 (6.0)	.76	6.19 [5.64, 6.74]	4.54	0.71	3.49
General self-efficacy		13 (4.8)	.81	15.80 [15.48, 16.12]	2.68	−0.46	2.93
Meaning in life		10 (3.7)	.85	23.01 [22.52, 23.50]	4.09	−1.13	4.34
Threat appraisals		34 (12.6)	.91	9.00 [8.04, 9.96]	8.03	0.89	2.91
Loss appraisals		22 (8.2)	.83	5.85 [5.23, 6.46]	5.12	0.77	2.78
Social support		14 (5.2)	.85	8.43 [8.22, 8.64]	1.76	−1.80	7.07

Note. *M*, *SD*, Skewness and Kurtosis rely on imputed data. SHCs = secondary health conditions; CI = confidence interval; PTSS = post-traumatic stress symptoms.

excluded 28 participants for whom the timing of T1 or T3 deviated substantially from the envisioned schedule in SwiSCI (*inconsistent timing of assessments* as determined by being more than 2 *SD* away from the average timing of data collection at T1 or T3 in the sample). This was done to ensure a more homogeneous sample in terms of timing of the assessments. More detailed information on participation can be found in the Supplemental material Figure S1, which depicts the participant flow. In the final sample ($n = 269$), T1 took place on average 39.05 ($SD = 14.95$), T2 79.91 ($SD = 10.77$) and T3 130.02 ($SD = 41.95$) days after SCI onset. Demographic and injury characteristics of the final sample are shown in Table 1.

To examine potential selection effects, we compared the final sample with the excluded SwiSCI participants in terms of demographic and injury-related characteristics and baseline PTSS (if available). First, the final sample did not differ from the participants who did not complete the T1 assessment regarding sex, age at SCI, language of the questionnaire, and cause of injury. However, individuals in the final sample were less likely to have tetraplegia, $\chi^2(5) = 13.11$, $p = .022$, $V = .20$. Second, the final sample did not differ from the participants for whom the T1 and the T3 assessment time point collapsed regarding language of the questionnaire, type of injury and PTSS at T1. However, individuals in the final sample were more likely to be female, $\chi^2(1) = 7.90$, $p = .005$, $V = .16$, younger, $t(315) = 1.97$, $p = .050$, $d = .31$, and to have had a non-traumatic cause of the injury, $\chi^2(1) = 11.96$, $p = .001$, $V = .19$. Third, the final sample did not differ from the participants who did not complete T3 (drop outs) in terms of age at SCI, language of the questionnaire, cause of injury, type of lesion, and PTSS at T1. However, individuals in the final sample were more likely to be male, $\chi^2(1) = 5.49$, $p = .019$, $V = .13$. Finally, no significant differences emerged when comparing the final sample with participants who were excluded due to inconsistent time intervals between SCI and T1 or T3. In sum, these analyses suggest a slight selection bias in the final sample.

Measures

PTSS (T1, T3)

To measure PTSS as a response to SCI onset, the Impact of Event Scale–6 (IES-6; Thoresen et al., 2010) was used. The IES-6 is a brief self-report measure which covers the PTSS clusters intrusions, avoidance, and hyperarousal with two items each. A sample item, which measures intrusions, is: “I thought about the event [SCI] when I didn’t mean to”. To indicate symptom severity, respondents were asked to select one of five response options ranging from 0 (*not at all*) to 4 (*extremely*) in all six items. The sum score (possible range = 0–24) of the IES-6 demonstrated acceptable internal consistency ($\alpha = .80$) in individuals after various types of potentially traumatic events (Thoresen et al., 2010) as well as in the present study sample ($\alpha = .74$ and .76 at T1 and T3, respectively). The IES-6 showed validity in form of moderate to strong correlations with other measures of mental health (Hosey et al., 2019). Sum scores >10 indicate a PTSS severity that is likely to be of clinical concern (Hosey et al., 2019).

Presence of pain (T1)

Presence of pain was measured with a dichotomous item of the International Spinal Cord Injury Basic Pain Data Set (ISCIBPDS; Widerström-Noga et al., 2008). Respondents reported whether they had any pain in the past week (0 = *no*, 1 = *yes*).

General self-efficacy (T1)

General self-efficacy was measured with a modified version of the General Self-Efficacy Scale (GSES; Peter et al., 2014). The scale consists of five Likert-type items with response options ranging from 1 (*not at all*) to 4 (*exactly true*). For example, individuals rated the item: “I can usually handle whatever comes my way”. The individual scores of the five items were summed with higher sum scores (possible range = 5–20) indicating greater general self-efficacy. The GSES demonstrated satisfactory reliability (PSI = 0.82) in an SCI sample (Peter et al., 2014). In the present sample, Cronbach's α was .81. In terms of validity, GSES scores have been shown to be moderately to strongly related to a broad range of psychosocial outcomes after SCI (van Diemen et al., 2017).

Meaning in life (T1)

Meaning in life was assessed using the short form of the Purpose in Life Test (PIL-SF; Schulenberg et al., 2011). The four items which make up the PIL-SF have different anchors but are all answered on a Likert scale ranging from 1 to 7. For example, for the item "My personal existence is:" the anchors 1 and 7 stand for "*utterly meaningless, without purpose*" and "*very purposeful and meaningful*", respectively. The four items were aggregated into sum scores that can range between 4 and 28. Higher sum scores indicate more meaning in life. Good reliability ($\alpha = .86$) and validity have been demonstrated (Schulenberg et al., 2011). Cronbach's α in the present study was .85.

Social support (T1)

Social Support was measured with six survey questions taken from the Swiss Household Panel (Tillmann et al., 2016). These questions assessed the extent to which respondents perceived that they would receive practical and emotional support from three different sources (partner, family, friends), if needed (e.g., "If necessary, in your opinion, to what extent can your family provide you with practical help, this means concrete help or useful advice?"). The response format was a Likert-type scale ranging from 0 (*not at all*) to 10 (*a great deal*). The items were combined into a mean score (possible range = 0–10) with higher scores indicating more social support ($\alpha = .85$).

Negative appraisals (T2)

Negative appraisals were measured with the Appraisal of Life Events Scale (ALE; Ferguson et al., 1999). The scale consists of 16 adjectives covering the dimensions threat (six items, e.g., "terrifying"), challenge (six items, e.g., "stimulating") and loss (four items, e.g., "pitiful"). Each of these items was rated separately on a six-point scale ranging from 0 (*not at all*) to 5 (*very much so*). Participants were instructed to refer to living with an SCI when rating the items. Acceptable to good internal reliability of the three subscales (α range between .74 and .87) and validity have been reported (Ferguson et al., 1999). For the present study, only the subscales "threat" and "loss" were used with Cronbach's α of these subscales being .91 and .83, respectively.

Substance use pre and post SCI (T2, T3)

Alcohol use before SCI onset (T2) was assessed using a single item asking individuals to report how often they were drinking alcoholic beverages in the year before SCI onset on a scale from 0 (*never*) to 4 (*daily*). Further, two dichotomous items (0 = *no*, 1 = *yes*) were used to identify whether individuals have ever used non-pharmaceutical drugs (e.g., marijuana, cocaine) before (T2) and after SCI onset (T3).

Finally, marital status (0 = *married*, 1 = *not married*) and household income were assessed as part of a short demographic questionnaire (T1) and information on sex

(1 = *male*, 2 = *female*), cause of injury (0 = *traumatic*, 1 = *non-traumatic*), and number of secondary health conditions (e.g., muscle spasms, urinary tract infections, pressure ulcers) was retrieved from the patient's medical records (T1).

Data analyses

Descriptive statistics were calculated using Stata, Version 14. Using the mice package in R (van Buuren & Groothuis-Oudshoorn, 2011), missing data was handled by multiple imputation with chained equations based on the assumption that data were missing at random. Data was imputed at the item level and 20 imputed data sets were created (Enders, 2010). All variables used in subsequent analyses and four auxiliary variables (type of injury, age at injury, and time from SCI until T1, and until T3) were included in the imputation model.

To examine changes in PTSS over time (aim 1), a latent change score (LCS) model (McArdle, 2009) was employed. This model was built following a stepwise procedure in which longitudinal measurement invariance (i.e., intercept invariance) of the PTSS measure was established first to ensure a meaningful interpretation of corresponding change scores (Gollwitzer et al., 2014). In the LCS model, the six observed PTSS items each loaded on a latent PTSS factor at T1 and T3, respectively. Further, a second-order LCS factor for PTSS was included in the model, the variance of the T3 latent factor was fixed to 0, and the T3 factor was regressed on the LCS factor and the T1 factor using structural weights constraint to be 1.0. As a result, the intercept of the LCS factor (μ_Δ) indicate the average intraindividual change in the severity of PTSS from T1 to T3 in the sample whereas the variance of the LCS factor (σ_Δ) indicate potential heterogeneity in the patterns of intraindividual changes. The main advantage of estimating intraindividual changes in such a latent variable framework is that measurement error is partialed out. This leads to more accurate estimates of change. Moreover, the random errors cannot cause regression to the mean (McArdle, 2009). Further strengths of LCS models are that they allow to establish longitudinal measurement invariance and that they can easily be extended by including categorical or continuous predictors of change (Gollwitzer et al., 2014).

As LCS models do not allow to determine the significance of change in PTSS from T1 to T3 at the individual level, the reliable change index (RCI; Jacobson & Truax, 1991) was calculated to do so. The RCI was calculated by dividing the raw PTSS change score by its standard error (estimated by using the T1 standard deviation and internal reliability). An RCI above 1.96 was considered as indicating significant change in an individual. A change was considered as *clinically* significant, if the individual additionally passed the cut-off of $>$10 on the IES-6 over time (in one or the other direction; Jacobson & Truax, 1991).

To identify predictors of changes in PTSS (aim b), the LCS model was extended by including the different socio-demographic, injury-related, psychological and social variables as predictors of the PTSS LCS factor. They were added as observed variables to ensure parsimony and an adequate ratio of number of variables included in the model and sample size (Weston & Gore, 2006). The T1 PTSS factor was also included as a predictor of the PTSS LCS factor to control for autoregressive effects (King et al., 2006).

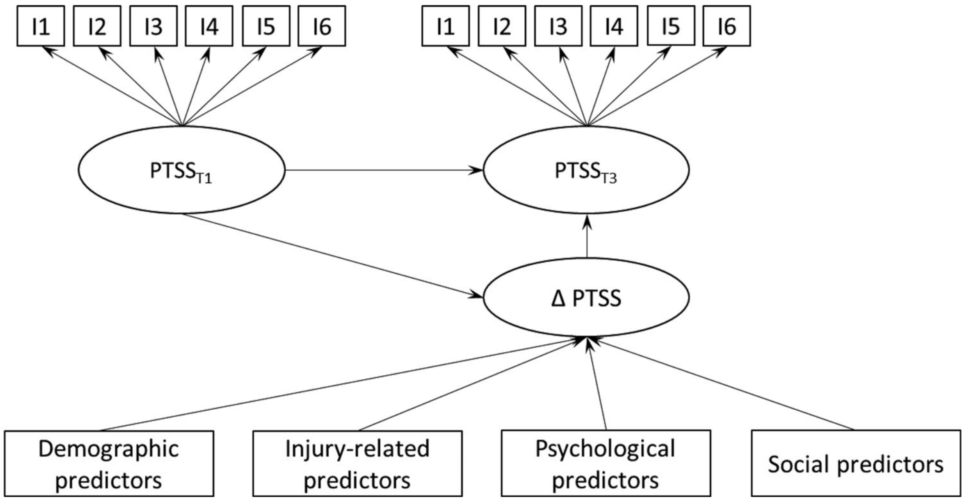

Figure 1. Model to examine risk and protective factors for changes in the severity of post-traumatic stress symptoms (PTSS). I1-I6 = Item 1–Item 6.
Note that intercepts, equality constraints on factor loadings and item intercepts across time for the same item, restrictions required to estimate the LCS model for PTSS, correlations of the residuals of the same item across time, and correlations of the predictors with each other and with the latent PTSS factor at T1 are not depicted to facilitate graphical illustration.

Figure 1 represents a simplified illustration of this model. As change scores involve both magnitude and direction, a positive regression coefficient can be interpreted as higher predictor scores being related to higher change scores, that is, increases or less steep declines. A negative coefficient, in turn, means that higher predictor scores are related to lower change scores, that is, declines or less steep increases.

All models were fitted using the lavaan software package in R (Rosseel, 2012) and robust maximum likelihood estimation to account for potential non-normal distribution of the variables (Finney & DiStefano, 2006). Model fit was judged by chi-square (χ^2), comparative fit index (CFI), and root mean square error of approximation (RMSEA) including the 90% confidence interval (CI). A non-significant χ^2, a CFI value above .95, and an RMSEA value below .06 suggest good model fit though values above .90 and below .10 can indicate acceptable fit in complex models or when testing with small samples (Weston & Gore, 2006).

Results

Missing values and descriptive statistics of the study variables in the final sample are depicted in Table 1. With regard to PTSS, 65 (24.2%) and 48 (17.8%) individuals scored above the cut-off on the IES-6 at T1 and T3, respectively.

Changes in the severity of PTSS (Aim 1)

To examine changes in the severity of PTSS, we first inspected the LCS model. This model, in which a correlation between the T1 PTSS factor and the PTSS change score was allowed, fitted the data well, $\chi^2(51) = 71.72$, $p = .029$, CFI $= .98$, RMSEA $= .04$

(90% CI [.01; .06]). The mean change in PTSS from T1 to T3 was non-significant, $\mu_\Delta = -0.10$ ($SE = 0.06$), $p = .105$, indicating no average change in symptom severity over time in the sample. However, the variance of the LCS factor was significant, $\sigma_\Delta = 0.63$ ($SE = 0.13$), $p < .001$, suggesting that individuals differed with respect to the amount and direction of change. T1 PTSS were negatively related to subsequent changes ($r = -.43$, $p < .001$): Individuals with higher PTSS at T1 were more likely to show decreases or less steep increases in symptom severity over time.

Next, the RCI of the complete sample was inspected to illustrate the individual variability in PTSS changes over time. These analyses revealed that 22 individuals (8.2%) showed a significant decrease in the severity of PTSS over time, 18 individuals (6.7%) showed a significant increase, and the remaining 229 individuals (85.1%) did not show significant changes.

To determine the number of individuals showing *clinically* significant changes, the sample was split based on the IES-6 cut-off score (>10) into two subgroups with "no/low PTSS" ($n = 204$; $M = 4.63$, $SD = 3.03$) and "PTSS of clinical concern" ($n = 65$; $M = 13.02$, $SD = 1.96$) at T1. The RCI was then inspected in both subgroups separately. In the no/low T1 PTSS subgroup, the vast majority (90.2%) did not show significant changes over time. However, 4.9% showed significant increases in PTSS with T3 scores being above the cut-off, suggesting *clinically* significant deterioration. For another 2.9% a significant deterioration was observed, although T3 scores were still below the cut-off. In the subgroup with T1 PTSS of clinical concern, the majority (69.2%) did not show significant changes. However, 27.7% exhibited significant decreases in PTSS. All of these individuals ended up with PTSS scores below the cut-off at T3, which suggests *clinically* significant improvement.

Predictors of changes in the severity of PTSS (Aim 2)

Bivariate associations of the observed T1 and T3 PTSS scores with the potential socio-demographic, injury-related, psychological, and social predictors are depicted in Table 2. To ensure a parsimonious model, only the variables showing at least a weak bivariate association (i.e., $r > .10$) with either T1 or T3 PTSS were included as predictors in the extended LCS model. Accordingly, marital status, presence of pain, the number of other secondary health conditions, and alcohol use before SCI onset were not considered as predictors in the model. Also, due to the strong bivariate correlation ($r = .79$, $p < .001$) among the negative appraisal scales, separate models were run including either loss or threat appraisals to avoid any issues related to strong multicollinearity. The corresponding model including loss appraisals achieved an acceptable fit, $\chi^2(141) = 219.46$, $p < .001$, CFI = .94, RMSEA = .05 (90% CI [.03; .06]). The results of the parameter estimates from the regression of the PTSS LCS factor on the predictors in this model are shown in Table 3. Together, T1 PTSS, the socio-demographic, lesion-related, psychological and social predictor variables explained 34% of the variance in changes in PTSS over time. Yet, only loss appraisals ($\beta = .30$, $p < .001$) and cause of injury ($\beta = .16$, $p = .018$) appeared to be unique predictors of changes in the severity of PTSS while controlling for T1 PTSS. Individuals with higher loss appraisals and with a non-traumatic SCI cause were more likely to show increases or less steep declines in PTSS.

Table 2. Bivariate associations among the study variables ($N = 269$).

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. PTSS (T1)	–														
2. PTSS (T3)	.51***	–													
3. Sex	.08	.14*	–												
4. Marital status (T1)	−.09	.01	.02 [a]	–											
5. Household income (T1)	−.08	−.17**	−.16**	−.23***	–										
6. Presence of pain (T1)	.09	.03	−.08[a]	.16** [a]	−.01	–									
7. Number of other SHC (T1)	.00	−.06	−.09	.00	−.05	.04	–								
8. Cause of injury	.07	.14*	.19** [a]	−.10 [a]	−.07	−.18** [a]	−.03	–							
9. General self-efficacy (T1)	−.23***	−.26***	−.11	−.10	.11	−.07	−.13*	−.02	–						
10. Meaning in life (T1)	−.22***	−.26***	−.06	−.22***	.08	−.12	.00	−.02	.38***	–					
11. Threat appraisals (T2)	.34***	.41***	.20***	.10	−.06	.08	.05	−.04	−.34***	−.21***	–				
12. Loss appraisals (T2)	.37***	.43***	.17**	.10	−.07	.13*	.02	−.09	−.29***	−.33***	.79***	–			
13. Alcohol use pre SCI (T2)	.01	−.02	−.13*	−.08	.06	−.02	.12*	−.04	.03	.09	−.01	−.06	–		
14. Drug use pre SCI (T2)	−.18**	−.03	−.07 [a]	.16** [a]	.00	.01 [a]	−.19**	−.04 [a]	.07	−.14*	.09	.11	.06	–	
15. Drug use post SCI (T3)	−.16**	.00	−.10 [a]	.08 [a]	.04	.09 [a]	−.12*	−.02 [a]	.12	−.03	−.04	−.02	.07	.48*** [a]	–
16. Social support (T1)	−.18**	−.17**	−.01	−.22***	.19**	−.12*	−.04	−.10	.24***	.33***	−.23***	−.25***	−.03	.04	.04

Note: All values rely on imputed data. If not further specified, values represent Pearson (or point-biserial) correlation coefficients. Coding of dichotomous variables: sex (1 = male, 2 = female), marital status (0 = married, 1 = not married), presence of pain (0 = no pain, 1 = pain), cause of injury (0 = traumatic, 1 = non-traumatic), drug use pre SCI (0 = no, 1 = yes), drug use post SCI (0 = no, 1 = yes).

[a] Phi coefficient and significance of chi square test.

* $p < .05$, **$p < .01$, ***$p < .01$.

Table 3. Predictors of changes in PTSS from T1 to T3 ($N = 269$).

Predictors	Δ PTSS		
	b	*SE*(*b*)	β
Socio-demographic			
Sex	0.08	0.12	.05
Household income	−0.05	0.03	−.11
Injury-related			
Cause of injury	0.26*	0.11	.16
Psychological			
T1 PTSS	−0.52***	0.09	−.59
General self-efficacy	−0.03	0.02	−.09
Meaning in life	−0.01	0.01	−.04
Loss appraisals	0.05***	0.01	.30
Drug use pre SCI	0.03	0.14	.02
Drug use post SCI	0.33	0.21	.12
Social			
Social support	0.03	0.03	.08

Note: Δ = change from T1 to T3; PTSS = post-traumatic stress symptoms; SCI = spinal cord injury; *b* = unstandardised regression parameter; β = standardised regression parameter; Model fit: $\chi^2(141) = 219.46$, $p < .001$, CFI = .94, RMSEA = .05 [.03; .06]. R^2 regarding Δ PTSS = .34. Coding of dichotomous predictor variables: sex (1 = male, 2 = female), cause of injury (0 = traumatic, 1 = non-traumatic), drug use pre SCI (0 = no, 1 = yes), drug use post SCI (0 = no, 1 = yes).
*$p < .05$; **$p < .01$; ***$p < .01$.

The LCS model in which threat appraisals were included as a predictor (instead of loss appraisals) achieved essentially the same model fit, parameter estimates, and amount of explained variance in changes in the severity of PTSS. Higher threat appraisals were related to increases or less steep declines in symptom severity ($\beta = .28$, $p < .001$) over time.

Sensitivity analyses

First, distributional properties and parameter estimates in the imputed and the complete data were compared, because the iterative process in multiple imputation can go wrong (van Buuren & Groothuis-Oudshoorn, 2011). Suggesting a good fit of the imputation model, no remarkable differences in the distribution of imputed and observed data were detected and parameter estimates in the LCS models differed only minimally (i.e., Δ in relevant βs on average = .05) when rerun with complete cases only ($n = 169$).

Second, the data were inspected for potential univariate and multivariate outliers based on scores more than 3 *SD*'s from the mean of a variable and based on Mahalanobi's distance, respectively (Kline, 2011). 13 cases were identified as potential outliers and the LCS models were rerun with these cases excluded. No discrepancies were detected as compared to the analyses with those cases included (i.e., Δ in relevant βs on average = .05) and as such these cases were included in the main analyses.

Exploratory analyses

Contrary to our expectations, psychosocial resources (general self-efficacy, meaning in life, and social support) did not show a significant relationship with changes in the severity of PTSS in the multivariate analyses. As a potential explanation, we tested on

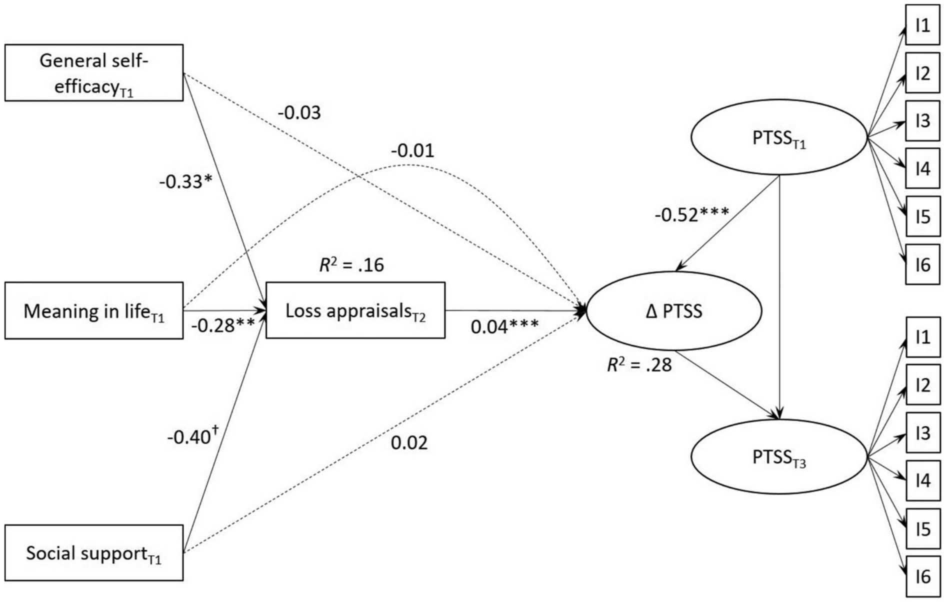

Figure 2. Mediation model examining indirect effects of general self-efficacy, meaning in life, and social support on changes (Δ) in post-traumatic stress symptoms (PTSS). Depicted are unstandardised regression coefficients. Model fit: $\chi^2(91) = 148.73$, $p < .001$, CFI = .95, RMSEA = .05 [.03; .06].

Note that intercepts, restrictions required to estimate the latent change score model for PTSS, correlations between the same PTSS item over time, and correlations of the predictors with each other and with the latent PTSS factor at T1 are not depicted to facilitate graphical illustration.
$^{\dagger}p < .07$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

an exploratory basis whether the effect of those protective factors on changes in PTSS is (completely) mediated by negative appraisals (e.g., loss appraisals), as proposed, for example, by the Spinal Cord Injury Adjustment Model (SCIAM; Middleton & Craig, 2008). More specifically, the SCIAM suggests that psychosocial resources do not directly impact on psychological adjustment to the injury (e.g., PTSS). Instead, it proposes that individuals with higher levels of psychosocial resources appraise SCI and its consequences less negatively which in turn leads to the use of more adaptive coping strategies and thereby in the longer run to better psychological adjustment. Accordingly, we modified the extended LCS model to test these potential indirect effects of psychosocial resources on changes in PTSS (Figure 2). In this model, general self-efficacy, meaning in life, and social support did still not show significant direct effects on changes in PTSS. However, the indirect effects of general self-efficacy ($b = -0.02$, 95% CI [–0.039, -0.003]), meaning in life ($b = -0.01$, 95% CI [–0.024, -0.004]), and social support ($b = -0.02$, 95% CI [–0.044, -0.002]) on changes in PTSS through loss appraisals were significant, as indicated by the 95% confidence intervals calculated with bias-corrected bootstrapping with 1000 repetitions. Higher levels of general self-efficacy ($b = -0.33$, $SE = 0.14$), meaning in life ($b = -0.28$, $SE = 0.09$), and social support ($b = -0.40$, $SE = 0.21$) were related to lower levels of loss appraisals which were in turn associated with decreases or less steep increases in PTSS ($b = -0.04$, $SE = 0.01$).

Discussion

The present study examined the longitudinal changes in PTSS in individuals with SCI from one to six months after injury onset. The study further aimed to identify the factors that can explain interindividual differences in changes over time. One month post injury, a substantial minority (24.2%) of the study sample exhibited a severity of PTSS which can be considered to be of clinical concern. Partially supporting our hypotheses, analyses at the sample level revealed that the severity of PTSS was on average stable over time, but there was significant variability in the individual symptom courses. Analyses focussing on change at the individual level further uncovered that the majority of individuals was characterised by relatively stable symptom courses. However, on the one hand, 7.8% of the individuals without clinically elevated levels of PTSS one month post SCI showed a (clinically) significant increase in PTSS severity over time. This suggests (a trend to) a delayed onset of the symptoms. On the other hand, 27.7% of the individuals who had PTSS severity of clinical concern one month post SCI exhibited clinically significant decreases in symptom severity (recovery). In line with our hypothesis, we found that negative appraisals (i.e., loss and threat) were related to increases or less steep declines in the severity of PTSS. Against our expectations, the only other unique predictor of changes in PTSS was the cause of the injury.

Longitudinal changes in the severity of PTSS after SCI

As the present study is among the first to examine changes in PTSS after SCI onset, comparability of the results to other SCI research is limited. Extending the scope, however, no change, on average, in the severity of PTSS has also been observed in the first months or year after the onset of other severe chronic health conditions, such as cancer (Andrykowski et al., 2000; Costa-Requena et al., 2014). The presence of a chronic health condition and aspects of the long-term treatment in a hospital setting may act as a complex set of stressors, which confront the individual with repeated reminders of or re-exposure to different aspects of the traumatic event. This could interfere with successful cognitive processing which in turn may explain the relatively stable symptom severity courses observed among many individuals (Andrykowski et al., 2000).

While the present results are therefore comparable to observations after the onset of other chronic health conditions, they differ to some degree from findings in the trauma population in general. In particular, what stands out is that stability in PTSS severity over time was the modal response in the present SCI sample, as indicated by both, analyses at the sample and at the individual level. This is surprising as clinical manuals (American Psychiatric Association, 2013) as well as studies conducted in individuals after various other types of potentially traumatic events (Visser et al., 2017) report that PTSS severity typically decreases in the first months after the event. Moreover, it has been shown in a mixed trauma sample focusing exclusively on individuals with clinically elevated PTSS that the majority of individuals shows decreases in symptom severity in the first seven months after the event (Galatzer-Levy et al., 2013). In contrast, in the present SCI sample, only about one out of four individuals with an initial PTSS severity of clinical concern exhibited significant decreases over a comparable time span. Taken together, this may suggest that (clinically) elevated PTSS in the initial time after the onset of a chronic health condition such as SCI run a higher risk of becoming long lasting and potentially even chronic than after the onset of other potentially traumatic events.

Predictors of changes in the severity of PTSS after SCI

Previous cross-sectional research identified negative appraisals as one of the strongest correlates of the severity of PTSS in individuals with SCI (Pollock et al., 2017). Expanding this, the present study revealed in multivariate analyses that after controlling for initial PTSS, loss and threat appraisals demonstrated the largest effect size in predicting changes in PTSS from one to six months after SCI onset. The finding that higher levels of threat and loss appraisals were related increases or less steep declines in PTSS supports the cognitive model of PTSS by Ehlers and Clark (2000). In their model, these authors propose that negative appraisals (e.g., those involving threat or loss) of trauma and its sequelae lead to a sense of current threat and anxiety about the future, which in turn fuel PTSS. This is also reflected at the physiological level with negative appraisals being associated with an increased neuroendocrine stress response (Olff et al., 2005). Moreover, negative appraisals trigger selective attention to information consistent with these appraisals as well as maladaptive coping processes. As such, negative appraisals reinforce themselves which can result in a vicious circle leading to persistent or even increasing levels of PTSS over time (Ehlers & Clark, 2000).

Besides negative appraisals, only etiology of the injury showed a direct effect on the PTSS course in the multivariate analyses. Individuals with a non-traumatic cause (e.g., disease) of the injury were more likely to show increases in PTSS over time than individuals with a traumatic cause (e.g., fall). A potential explanation might be that in contrast to traumatic causes, health conditions leading to non-traumatic SCI, such as vascular disorders or neoplasms, can persist after SCI onset. Prognosis for such health conditions is often uncertain, but it potentially includes further neurological losses or a relatively short life expectancy (New et al., 2017). Thus, these health conditions and the associated uncertainties may act as additional chronic stressors besides the onset of SCI. Accordingly, individuals with a non-traumatic cause of the injury may represent a particularly vulnerable subgroup, which might require specific attention in psychological care during inpatient rehabilitation.

Unexpectedly, we did not find psychosocial resources to be unique predictors of changes in PTSS. However, the results of our exploratory analyses indicate that meaning in life, general self-efficacy, and social support might be indirectly linked to a decrease in symptom severity through lower levels of negative appraisals. This is consistent with the SCIAM (Middleton & Craig, 2008) which proposes that more psychological resources allow individuals to appraise SCI less negatively, which in turn leads to a more effective coping process and ultimately to better psychological adjustment. However, as compared to the effects of meaning in life and general self-efficacy on other psychological sequelae of SCI, for example depressive symptoms (e.g., Peter et al., 2015), their effects on PTSS were comparatively weak.

Clinical implications

The most concerning result of this study are the early indications of chronicity: among the minority of individuals who reported a PTSS severity of clinical concern one month after SCI onset, only few showed significant decreases in symptom severity in the following months of inpatient rehabilitation. This stresses the need for early screening for PTSS in the rehabilitation setting to be able to provide individuals in need with psychological care. In this respect, there exist brief cognitive-behavioural and exposure-based interventions which have been shown to effectively decrease the severity of PTSS at early stages in specific primary care settings (e.g., Bisson et al., 2004; Bryant et al., 2008). Based on the present finding that high loss and threat appraisals were the strongest predictors of increases in PTSS, we can speculate that at least cognitive-behavioural interventions might be well suited to address PTSS in the SCI population too, as a central component of this type of interventions is to reduce negative appraisals (Watkins et al., 2018). However, what is needed now are studies which test in randomised clinical trials whether such early interventions are indeed appropriate for the SCI population.

Limitations

The present study is subject to several limitations. First, the IES-6 covers the three PTSS clusters, which are described in the DSM-IV. However, a fourth symptom cluster (i.e., negative thoughts and emotions), which is not covered by the IES-6, was added to the newer DSM-V. Second, the IES-6 can be used as a screening tool to identify individuals with a PTSS severity that is likely to be of clinical concern, but no formal post-traumatic stress disorder diagnoses can be made based on this instrument. Third, the longitudinal study design is a strength, but still limited in terms of the time span covered and frequency of assessments conducted. More specifically, the assessment of PTSS in SwiSCI was scheduled at one and six months after the injury. However, the psychological adjustment process to SCI may take longer than this. Therefore, the general trend in the course of PTSS may change in subsequent months or years after the injury. Therefore, future studies are needed which follow the PTSS severity course across a longer time span with more than two measurement time-points. The latter would also enable to model nonlinear change or different trajectories of PTSS across time. Fourth, some of the predictors of changes in PTSS (e.g., social support, meaning in life) were treated as time invariant in the analyses, although they might change over time too. Thus, future research could also test whether changes in these variables might predict changes in PTSS over and above the effects of their baseline levels. Fifth, number of previous life traumas and educational level, which were shown to be related to PTSS severity in cross-sectional studies (Pollock et al., 2017), were not assessed within SwiSCI and could therefore not be included as predictors of changes in PTSS in the present study. Also, the present results regarding pain as a predictor of changes in PTSS need to be interpreted cautiously as pain was assessed with a dichotomous item. Given the dimensional nature of the pain concept, more fine-grained measures such as pain severity could be more informative. Sixth, there was no information on the characteristics of the individuals who completely refused participation in SwiSCI. This limited our ability to determine the representativity of the final sample.

Conclusion

The present study revealed that the severity of PTSS including both, symptoms that are and that are not of clinical concern, remain relatively stable across the first months of inpatient rehabilitation of individuals newly diagnosed with SCI. Only few individuals showed (clinically) significant in- or decreases in symptom severity over time. Among a broad range of socio-demographic, injury-related, psychological and social characteristics tested, appraising SCI as loss or threat showed the strongest relationship with changes in the severity of PTSS. Accordingly, psychological treatment of PTSS in individuals with SCI could focus on a modification of such negative cognitive appraisals.

Acknowledgements

We thank the SwiSCI Steering Committee with its members Xavier Jordan, Fabienne Reynard (Clinique Romande de Réadaptation, Sion); Michael Baumberger, Hans Peter Gmünder (Swiss Paraplegic Center, Nottwil); Armin Curt, Martin Schubert (University Clinic Balgrist, Zürich); Margret Hund-Georgiadis, Kerstin Hug (REHAB Basel, Basel); Urs Styger (Swiss Paraplegic Association, Nottwil); NN (Swiss Paraplegic Foundation, Nottwil); Daniel Joggi (Representative of persons with SCI); Nadja Münzel (Parahelp, Nottwil); Mirjam Brach, Gerold Stucki (Swiss Paraplegic Research, Nottwil); Armin Gemperli (SwiSCI Coordination Group at Swiss Paraplegic Research, Nottwil).

Disclosure statement

The authors declare no conflict of interest.

Funding

SwiSCI is hosted and funded by Swiss Paraplegic Research.

Data availability statement

Owing to our commitment to SwiSCI study participants and their privacy, datasets generated during the current study are not made publicly available but can be provided by the SwiSCI Study Center based on reasonable request (contact@swisci.ch).

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