Abstract

Numerous self-report questionnaires have been used in pain research to explore patients' experiences. However, these questionnaires often employ negatively worded items that can potentially worsen patients' distress. In response to the emergence of positive psychology, this thesis aimed to develop a new questionnaire that adopts a positive and strengths-focused approach, incorporating resilience, to replace the negative items found in existing tools such as the Pain Catastrophizing Scale (PCS). First, the effectiveness of the Connor-Davidson Resilience Scale (CD-RISC) in measuring resilience following trauma was assessed through a systematic review using the COnsensus-based Standards for the selection of health status Measurement INstruments (COSMIN) checklist. The review revealed that the CD-RISC may not adequately capture resilience in the context of trauma. Consequently, a new tool called the Post-traumatic Resilience Scale was theorized and developed to address these limitations. In line with the potential benefits of positive psychological factors such as optimism in mitigating the effects of trauma, the 2nd and 3rd studies of this thesis aimed to explore these factors within the framework of Post-traumatic Resilience and Optimism (PTRO). In developing the initial items for the prototype Pain Resilience and Optimism Scale (PROS), researchers reversed the polarity of 13 items from the widely used PCS, transforming them into positively worded items. Feedback from three patients with chronic pain contributed to the creation of the 13-item test version of the PROS. Validation of the PROS involved a sample of Canadian military veterans with chronic pain. The refined version of the scale consisted of eight items categorized into two subfactors: Pain Optimism (5 items) and Pain Resilience (3 items). The reduction in items aligns with previous findings that a shorter version of the PCS adequately measures pain catastrophizing. In conclusion, this thesis proposes the PROS as a new measurement tool for research and clinical use. The validation analyses demonstrate promising psychometric properties, although further research is needed for replication. Incorporating advanced measurement models such as Item Response Theory may enhance the reliability and validity of the PROS in evaluating pain resilience and optimism.

Keywords

Pain, self-report questionnaires, negative valence, positive psychology, strengths-focused approach, resilience, Pain Catastrophizing Scale (PCS), Connor-Davidson Resilience Scale (CD-RISC), trauma, systematic review, psychometric properties, COSMIN checklist, optimism, Post-traumatic Resilience and Optimism (PTRO), Pain Resilience and Optimism Scale (PROS), chronic pain patients, validation, Pain Optimism, Pain Resilience.

Summary for Lay Audience

Pain is a widespread issue that affects many people, and researchers use questionnaires to understand how people experience and cope with pain. However, most of these questionnaires ask questions in a negative way, which can make people recall and relive their painful experiences, causing more distress. This thesis aimed to develop a new questionnaire that focuses on positive aspects and strengths, such as resilience, to replace the negative questions found in existing tools such as the Pain Catastrophizing Scale (PCS). The Connor-Davidson Resilience Scale (CD-RISC) is commonly used to measure resilience, but it may not be effective in capturing resilience after a traumatic event. Thus, a systematic review was conducted to assess the CD-RISC's ability to measure resilience in post-trauma situations. The review found that the CD-RISC has limitations in this context, which led to the development of a new tool called the Post-traumatic Resilience Scale. Optimism has the potential to lessen the impact of traumatic events. The new questionnaire, called the Pain Resilience and Optimism Scale (PROS), was developed based on the idea that resilience and optimism can influence how people experience pain. To create the PROS, researchers transformed negative questions from the PCS into positive ones. We also gathered feedback from people living with chronic pain to ensure the questionnaire was relevant and meaningful. The PROS was then tested with a group of Canadian military veterans to validate its effectiveness. The results showed that the PROS is reliable and valid tool to assess pain resilience and optimism. In summary, this thesis reveals the limitations of the CD-RISC in measuring resilience after MSK trauma and introduces the PROS as a better alternative. The development and validation of the PROS offer a new way to understand how people cope with pain. By focusing on positive aspects such as resilience and optimism, this questionnaire provides valuable insights into the experiences of people dealing with pain and trauma.

Co-Authorship Statement

The studies in this thesis were co-designed, analyzed, interpreted, and written by Wonjin Seo with collaboration and guidance from Dr. David Walton.

Acknowledgments

I am sincerely grateful to my supervisor, Dr. Dave Walton, whose support and humor have been a constant source of cheer throughout my doctoral journey. His guidance in navigating my studies and managing my mental health has been invaluable, playing a significant role in the successful completion of this crucial chapter in my life.

I express my gratitude to Dr. Marnin Heisel, a clinical psychologist, for his valuable insights during my comps. examination and doctoral thesis. His supportive nature and meticulous proofreading greatly enhanced the quality of my manuscript.

The perpetual challenge of navigating academic English writing was made manageable with the assistance of Dave, Marnin, the Writing Center at Western, and Grammarly. Together, they enabled me to articulate my ideas clearly and concisely in this thesis.

Acknowledging my PIRL family, both past and present, is essential as their unwavering support has been instrumental in achieving this significant milestone. My heartfelt thanks go to Josh Lee, Moe Fakhereddin, Dorota Klubowicz, Maryam Ghodrati, Mike Lukacs, Shirin Modarresi, Shahan Salim, Iyad Al-Nasri, Stacey Guy, Helen Phan, Michelle Kleiner, Lauren Straatman, Kaitlin Turner, and Joe Putos for their support on my academic and personal journey.

Lastly, to my parents, I express profound gratitude for their unwavering support and constant presence by my side. Despite facing challenges during my PhD journey, their enduring support has been a wellspring of strength and encouragement.

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Chapter 1

1 Paradigm shift from psychopathology-focused to positive, strengths-focused approach in the field of pain.

1.1 Introduction

Pain is a common issue. Typically, pain is classified as chronic when its persistence or recurrence exceeds a timeframe of 3 to 6 months (Treede et al., 2015). Steglitz and colleagues (2012, p. 6) state, "*chronic pain is defined as persistent pain, which can be continuous or recurrent. The duration and intensity can adversely affect a patient's wellbeing, level of function, and quality of life*."

According to a report by the Institute of Medicine (IOM), the prevalence of chronic pain among American adults is estimated to impact approximately 116 million people, surpassing the combined prevalence of heart disease, cancer, and diabetes (Steglitz, Buscemi, & Ferguson, 2012). In addition, in a population-based study by Yong and colleagues (2022), that included a nationally representative sample obtained through household surveys, the authors identified an annualized prevalence rate of 20.5%, indicating that chronic pain affects approximately one-fifth of the American adult population on an annual basis. Moreover, within this American adult group, a substantial proportion of 24.4 million people (equivalent to 10% of all U.S. adults) experienced high-impact chronic pain, which significantly impeded their ability to carry out work-related activities. This corresponds to 21.0% of the general Canadian population afflicted by chronic pain in 2011/2012 (Shupler, Kramer, Cragg, Jutzeler, & Whitehurst, 2019).

The economic burden of chronic pain is of considerable magnitude. A 2010 report published by the Institute of Medicine (IOM) presented an estimation that approximately one in three Americans are affected by chronic pain, resulting in a substantial financial burden ranging between US$560 billion and US$635 billion annually in terms of medical expenses. A newer report identified that among the 15.4% of Australians living with chronic pain, the average annual cost ranged from AU$22,588 to AU$42,979 per person when factoring in non-financial costs (Cohen, Vase, & Hooten, 2021).

In terms of personal burden, Hadi et al. (2019) conducted a convergent parallel mixed-methods cohort design of seventy-nine patients with pain from a community-based pain clinic in the North of England. The results revealed that chronic pain had a significant adverse impact, leading to a decreased quality of life when compared to both the general population and patients with other chronic conditions.

In the recent and unforeseen era of the COVID-19 pandemic, patients with chronic pain have faced substantial challenges, both psychologically and physically. A study conducted by Fallon et al. (2021) utilized an online methodology to examine the impact of COVID-19 circumstances, such as lockdown measures and social/physical distancing, on people living with chronic pain. This situation necessitated swift adaptation of treatment and care strategies. The sample consisted of people with chronic pain (N=431) in comparison to a healthy control group (N=88) from the United Kingdom. Through hierarchical regression analysis, it was determined that pain catastrophizing played a crucial role in the self-perceived escalation of pain severity during lockdown, while also mediating the relationship between decreased mood and pain levels. In line with the fear-avoidance model proposed by Vlaeyen and Linton (2000), pain catastrophizing intensifies fear associated with pain, leading to avoidance behaviors, hypervigilance, disuse, depression, and ultimately, disability. This cyclic pattern of escalating fear and avoidance is perpetuated by the people's pain-related beliefs, experiences, and attitudes.

1.2 State of evidence for treating chronic pain

Some treatments have been employed to address the complexities of chronic pain; however, timely access to appropriate care often presents challenges. In a systematic review conducted by Lynch et al. (2008), the relationship between waiting times, health status, and health outcomes for patients awaiting treatment for chronic pain was examined. The findings revealed that patients experience a considerable decline in health-related quality of life (HRQL) and psychological well-being during a wait period of six months for chronic pain treatment. Consequently, the authors concluded that wait times exceeding six months for chronic pain treatment are medically unacceptable.

As for treatment for chronic pain, opioids have increasingly been used. Although opioids may be effective in short-term treatment of acute pain, the evidence supporting the benefits for the treatment of chronic pain is less well established (Warner, 2012). About 80% of all opioid users experience at least one side effect (Warner, 2012). Addiction is a feared consequence of long-term opioid treatment of chronic pain patients (Højsted, Nielsen, Guldstrand, Frich, & Sjøgren, 2010). Even nonopioid pharmacologic treatments for chronic pain tend to show small positive effects (Cohen, Vase, & Hooten, 2021; McDonagh, et al., 2020).

1.3 The link between psychology and pain persistence.

Numerous diseases impose significant financial and temporal burdens upon people once they are afflicted. The most effective approach to alleviate such burdens is to proactively prevent the onset of any ailments. Similarly, chronic pain presents considerably greater challenges in comparison to acute pain. During the acute pain phase, it becomes imperative to anticipate the prognosis of the pain, thereby enabling the prevention of patients transitioning from the acute phase to the chronic phase. This anticipation equips clinicians with the means to devise suitable treatment plans for patients, thus ensuring optimal care. However, assessing the prognosis of pain presents inherent challenges and complexities. For example, early symptoms of postinjury stress predict poor recovery (Rabinowitz, et al., 2015) making the experience of (dis)stress following new injury or pain a relevant area of focus in the field. However, it should be noted that the evidence of a direct causal link between post-trauma distress and recovery is growing but remains unconvincing. For example, Sterling and colleagues (2019) conducted a study utilizing a randomized controlled trial of a combined psychological/physical intervention for acute whiplash-associated disorder – Physiotherapist-delivered stress inoculation training integrated with exercise, called ‘StressModex,’ and recruited only those with high self-ratings of post-trauma distress in their sample (Sterling, Smeets, Keijzers, Warren, & Kenardy, 2019). Despite an intervention that directly targeted the potential causal mechanism (distress), the results were statistically significant though of generally low overall effect and of questionable clinical importance. This suggests that post-trauma

distress, fear, or catastrophic beliefs may indeed have a direct causal link with pain and recovery, though either the link is weak, is not direct (e.g., it is mediated or moderated by other variables), or the measurement tools used to quantify those experiences are not well-targeted to the population of people with MSK trauma.

1.4 Prognosis in acute pain

In a systematic review conducted by Rosenbloom, Khan, McCartney, and Katz (2013), it was observed that certain psychologically predictive factors were frequently cited in relation to persistent pain. These factors included symptoms of anxiety and depression, as well as cognitive avoidance of distressing thoughts. Furthermore, Edwards and colleagues (2011) performed a longitudinal study that indicated a connection between depression, catastrophizing, and an increased risk of long-term pain. The study found that higher baseline catastrophizing scores prospectively predicted more intense pain among patients diagnosed with Osteoarthritis (OA) and Rheumatoid Arthritis (RA) over a 12-month period. Additionally, in longitudinal studies involving adults residing in the community, depression and catastrophizing at baseline were robust predictors of the onset of new musculoskeletal pain during a follow-up period ranging from 6 months to 3 years (Edwards, Cahalan, Mensing, Smith, & Haythornthwaite, 2011).

As previously mentioned, pain catastrophizing assumes a pivotal role in the assessment and prognostication of pain levels in people suffering from pain. The Pain Catastrophizing Scale (PCS), developed by Sullivan, Bishop, and Pivik in 1995, has been widely used in studies about pain. In a series of relevant studies, Kristiansen and colleagues (2014) constructed a comprehensive model proposing the influence of catastrophizing on the experience and perception of pain. The model outlines how the experience of pain catastrophizing can be separated into two distinct groups: Catastrophizers and Non-catastrophizers, identified based on their PCS scores. According to the author’s perspective, people who fall into the non-catastrophizers category face pain with strength and tend to recover quickly, avoiding any negative impacts on how they perceive pain. On the other hand, those who are categorized as catastrophizers tend

to experience pain-related limitations due to their fearful attitude towards pain, thus leading to an ongoing harmful cycle.

1.5 Positive Psychology as an alternative to psychopathology in pain research

Taking a positive psychological perspective, certain factors are introduced to counteract the negative effects associated with a psychopathological approach. One of the positive variables is optimism. Coronado and colleagues (2017) conducted a study investigating if optimism moderates the influence of pain catastrophizing and fear avoidance on 3-month clinical outcomes in patients with shoulder pain. The findings shows that optimism was associated with decreases in the negative influence of pain catastrophizing on shoulder function. Hanssen and colleagues (2013) sought to test the causal status by experimentally inducing a temporary optimistic state by means of writing about and visualizing a future best possible self. In addition, the authors explored pain expectations and pain catastrophizing as possible underlying mechanisms of the link between optimism and pain with seventy-nine undergraduate students participating in a cold pressor task (CPT). This study is novel in that it confirms the causal status of optimism towards pain. Additionally, the results reveal that positive interventions might provide a useful alternative in reducing pain catastrophizing as a relevant target in pain treatment.

A study conducted by Pulvers and Hood (2013) explored the role of positive traits and pain catastrophizing in pain perception. Extensive research has consistently associated pain catastrophizing with negative psychological experiences, including depression and anxiety. Notably, a smaller yet significant body of research has demonstrated an inverse relationship between pain catastrophizing and positive traits such as optimism, hope, and self-efficacy. Recent investigations have proposed an integrated psychological model that examines the combined influence of positive traits and pain catastrophizing on pain perception (Pulvers, & Hood, 2013). Specifically, each of the three dimensions of pain catastrophizing (rumination, magnification, and helplessness) partially mediated the relationship between hope and optimism and how people perceive pain.

The Pain Catastrophizing Scale (PCS)

The Pain Catastrophizing Scale (PCS; Sullivan, Bishop, & Pivik, 1995) has been extensively utilized to assess levels of pain catastrophizing among patients experiencing pain. The PCS comprises three subscales: Magnification, Rumination, and Helplessness, all of which encompass negative valence. Considering that patients with pain may have undergone traumatic experiences related to their pain, the participation of such people in a survey raises concerns about the potential impact of questionnaire contents that contain distressing or traumatic elements (e.g., ‘I feel I can’t go on’). Such content has the capacity to evoke recollection or re-experiencing of past traumatic events, undermining the well-being and benefits of the participants engaged in the survey.

With the emergence of Positive Psychology, there has been a notable shift towards adopting a positive and strengths-focused approach. Rather than solely focusing on pathological phenomena, positive psychology directs attention towards identifying and harnessing the inherent strengths and capabilities of patients experiencing pain, as these factors may contribute to their resilience in the face of adversity. Research performed by Korean scholars such as Kim and Eun (2010) and Min, Kim, and Kim (2014) has shown that exposure to positive sentences, referred to as "well-being cognitive techniques," that are infused with positive valence can yield beneficial outcomes in terms of reducing job-related stress, overall stress response, negative affect, and promoting an increase in life satisfaction.

I believe that it is advisable to incorporate a positive and strengths-focused approach when designing questionnaires specifically aimed at assessing pain experiences. Building upon the insights gained from those Korean studies, it is anticipated that the inclusion of items with a positive valence in the questionnaire will have a positive impact on patients with pain when they participate in survey studies.

Resilience and Optimism

Bonanno (2004) described the prototypical patterns of disruption in normal functioning over time that occur following interpersonal loss or what was called “potential traumatic events” (PTE). That model described four distinct trajectories - chronic, delayed, recovery, and resilience - experienced by people who undergo traumatic events such as interpersonal loss. It is worth noting that the model as depicted in that manuscript suggests that different people have different reactions to trauma (that are likely influenced by other factors, including personality, characteristics, coping, past history, etc.). Specifically, resilient people commence their trajectory with a relatively minor disruption in normal functioning, which smoothly progresses over time (e.g., 1 and 2 years). Conversely, some people initiate their trajectory with a severe disruption in normal functioning and follow a path of chronic severe post-traumatic disruption. Interestingly, there were two trajectories that included people who experience PTE both starting with a moderate disruption in normal functioning but diverge into two distinct pathways: recovery or delayed response. The recovery trajectory appears to align closely with the pathway of resilience at the 2-year point, whereas the delayed trajectory exhibits similarities to the chronic pathway. Bonanno (2004) suggests that people who demonstrate resilience effectively navigate adversity by harnessing positive emotions.

Cousins and colleagues (2015) conducted a survey-based investigation involving 58 youths, aged between 8 and 17 years, who were attending a chronic pain clinic along with their parents. The primary aim of the study was to explore the complex relationship between risk factors, optimism, and their impact on functional outcomes. The results of the study revealed that the youths displaying greater levels of optimism reported an enhanced Quality of Life (QOL). This improvement in QOL was attributed to a reduction in fear of pain and catastrophizing tendencies (Cousins, Cohen, & Venable, 2015).

A tool measuring resilience and some challenges to using it in MSK trauma.

The Connor-Davidson Resilience Scale (CD-RISC; Connor & Davidson, 2003) has gained global recognition in the field of resilience research. It consists of 25 items designed to assess levels of resilience in people, encompassing five subfactors. However, a significant concern has emerged regarding the scale's ability to measure "trauma-related resilience" as opposed to a more general resilience construct. Upon examination of the subfactors and content of the scale's items, it appears that the CD-RISC may have limitations in accurately assessing resilience, particularly in the context of musculoskeletal (MSK) trauma. Some studies have attempted to validate different versions of the CD-RISC in various populations, including those with fibromyalgia (Notario-Pacheco et al., 2014) and chronic MSK pain (Sharma, Pathak, Abbott, & Jensen, 2018). However, it should be noted that these studies focused on the mathematically-derived factor structure of the shorter CD-RISC-10 and did not focus on content validity. Therefore, it cannot be definitively concluded that the CD-RISC-10 is a comprehensive measure of resilience in traumatic contexts. There are also questions about the non-English versions of the CD-RISC-10 used in these studies that raise concerns regarding translation accuracy and equivalence.

The initial development of the CD-RISC incorporated certain characteristics associated with resilient people, such as hardiness, clear goals or objectives, and strong self-esteem. However, while the inclusion of items assessing the ability to endure stress or pain does touch upon pain-related resilience, it comprises only a limited number of items. Consequently, the concepts utilized to construct the CD-RISC were not originally intended to address musculoskeletal (MSK) trauma or pain specifically. It is necessary to establish whether the CD-RISC is indeed adequate for measuring resilience in these contexts.

The reason why a different tool that takes a positive psych perspective is needed.

When investigating pain experiences within a study, the inclusion of people who are personally affected by pain becomes imperative. People living with chronic pain often endure associated negative symptoms in their daily lives. Consequently, it is essential to ensure that patients with chronic pain receive advantages when participating in such studies. It is worth noting that the mere act of reading items from specific questionnaires that are saturated with negative experiences or phenomena can evoke traumatic memories of pain within patients (Brodhun, Borelli, & Weiss, 2021). Fava and Tomba (2009) found and indicated that positive psychological variables such as flourishing and resilience can be bolstered by certain interventions such as a positive self-evaluation, a perception of ongoing growth and development, a belief in the purpose and meaningfulness of life, the cultivation of meaningful relationships, effective life management skills, and a sense of self-determination. Drawing upon evidence from positive psychology and well-being cognitive techniques, it is evident that exposure to items imbued with positive valence from certain assessment tools can prove advantageous for participants experiencing pain. Thus, there is a need for a different assessment tool that adopts a positive psychological perspective.

1.6 Thesis Layout

This thesis aims to undertake a comprehensive series of studies outlined as follows: Firstly, in Chapter 2, the psychometric properties of the Connor-Davidson Resilience Scale (CD-RISC) will be scrutinized using the COSMIN checklist. Given the research hypothesis that the CD-RISC may not adequately capture resilience in a post-traumatic context, subsequent chapters will focus on the development of a new measurement tool.

Chapter 3 will introduce a novel framework termed "Post-traumatic Resilience and Optimism (PTRO)," which will serve as the foundation for the forthcoming tool. This chapter will involve three distinct studies aimed at proposing and refining the PTRO framework. Additionally, utilizing the PTRO framework, initial items will be generated and further refined based on feedback and comments received from three people living

with chronic pain and through concept mapping of each item with the framework and against the PCS, conceptually the ‘opposite’ scale to the PROS. The objective is to ensure that the items accurately represent the experiences, thoughts, and emotions pertaining to pain from the perspective of those who are intended users of the scale.

Lastly, in Chapter 4, the validation process will be conducted employing factor analysis. This phase will focus on validating the initial items developed in Chapter 3, assessing their reliability, and exploring the underlying factor structure. This rigorous analysis will contribute to establishing the psychometric properties of the newly proposed measurement tool within the PTRO framework. The proposed measurement tool is named the Pain Resilience and Optimism Scale (PROS).

1.7 Thesis Purpose

The purpose of this thesis is to develop and validate a new tool to measure pain experiences as an optional alternative to the widely used Pain Catastrophizing Scale (PCS). This will be achieved by reversing the negative valence of PCS items and conducting concept mapping, aligning the new tool with a positive and strengths-focused approach.

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Chapter 2

2 A Systematic Review of Psychometric Properties of the Connor-Davidson Resilience Scale (CD-RISC)

2.1 Introduction

Population-level data provides compelling evidence that most North American adults experience at least one traumatic event in their lifetimes (Benjet et al., 2016), which often imposes grave distress. Trauma can be defined as "exposure to actual or threatened death, serious injury, or sexual violence" by the Diagnostic and Statistical Manual for Mental Disorders, 5th Edition (DSM-5; American Psychiatric Association, 2013, p. 271). The American Psychiatric Association defines traumatic events as actual or threatened death or serious injury or threat to the physical integrity of self or others and that the person's response involved intense fear, helplessness, or horror (American Psychiatric Association, 2013). For some people, the physical and emotional effects of trauma appear to be short-lived, and some may even experience post-traumatic growth, although for a significant proportion of people experiences of trauma can lead to long-term social or health effects (Walter & Bates, 2012).The long-term effects of trauma can be diverse, from interfering with social connections to chronic psychiatric morbidities such as depression, anxiety, or post-traumatic stress disorder (Dahm & Ponsford, 2015). Such conditions are highly burdensome in terms of time and cost for not only the sufferer but also those who provide support and the broader social and healthcare systems (Davis et al., 2022).

The reasons why some people may overcome trauma seemingly easily while others develop long-term adverse outcomes are very likely the result of a wide range of personal and socioenvironmental influences. One such factor may be referred to as 'resilience.' Although the term resilience is broad in its definition, resilience can be defined as a capacity to "bounce back" or quickly overcome distress in the face of adversity (Herrman et al., 2011). A study showed that those who score higher on indicators of resilience after trauma also reported earlier and more fulsome recovery compared to those who rated themselves as less resilient (Bonanno & Mancini, 2008). In this sense, resilience may

play a key role to prevent traumatized people from adverse chronic mental health outcomes. Although resilience can be considered in both physical (e.g., genetics, muscle condition) and mental/emotional terms, in this study, we will focus on psychological resilience following traumatic experiences.

There have been several instruments published intended to measure resilience, of which the Connor-Davidson Resilience Scale (CD-RISC; Connor & Davidson, 2003) is the most widely used self-report tool in this field (Bezdjian, Schneider, Burchett, Baker, & Garb, 2017). The CD-RISC was created based on established constructs of resilience, including hardiness and protective factors identified in research on resilient people. The items of the CD-RISC were tested in various populations, including typical American community members, primary care and psychiatric outpatients, and people with anxiety disorders or PTSD. The CD-RISC comprises five subscales, each representing different components of resilience: i) personal competence and tenacity, ii) trust in one's instincts and stress-strengthening effects, iii) positive acceptance of change, iv) control, and v) spiritual influences. Participants rate how much they agree with each statement, using a five-point Likert scale. The total range of the scale is 0-100, with higher scores indicating greater resilience (Connor & Davidson, 2003). While prior work supports some aspects of its validity, there have been inconsistences described across research studies that render clear statements on its psychometric properties difficult.

Campbell-Sills and Stein (2007) developed the 10-item version of the CD-RISC through a series of analyses of the original 25-item CD-RISC. The authors conducted exploratory factor analyses (EFA) on the 25-item CD-RISC in two subsamples consisting of over 1700 college students, but the EFA did not support the five factors originally proposed by Connor and Davidson (2003). Issues arose, including inconsistent item loading across the EFAs, an item failing to load on any factor, one factor being defined by too few items, and factors being difficult to interpret because the items focused on more than one construct. Thus, the authors examined shorter versions of the CD-RISC and arrived at a unidimensional 10-item CD-RISC. A confirmatory factor analysis (CFA) supported the construct validity of the 10-item CD-RISC. The 10-item CD-RISC exhibited acceptable internal reliability ($\alpha = .85$) and concurrent validity. The authors concluded that the 10-

item CD-RISC measures a characteristic that distinguishes people who are functioning well after adversity from those who are not (Campbell-Sills & Stein, 2007).

The CD-RISC has been endorsed as a tool to measure 'general' resilience across a range of life events, though its properties for measuring resilience to specific types of traumas have yet to be systematically reviewed and synthesized. If the tool is to be used for screening those who are at risk of a mood disorder following a traumatic event or injury, a reliable and well-validated scale to estimate resilience is necessary. Given that the CD-RISC has already been administrated in many studies, the aim of the present study was to critically appraise and summarize the quality of the psychometric properties of the CD-RISC in adult populations with a specific focus on its use in people experiencing musculoskeletal trauma.

Thus, the purpose of this study was to conduct a structured systematic review to examine and synthesize the psychometric properties of the CD-RISC utilizing the COSMIN checklist.

2.2 Methods

This systematic review protocol adhered to the guidelines outlined in the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) (Moher et al., 2015).

Study registration

In accordance with the PRISMA-P guidelines (Shamseer, et al., 2015), the present systematic review protocol was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO) on 28 August 2018, under the registration number CRD42018090942.

In this study, the COnsensus-based Standards for the selection of health Measurement Instruments (COSMIN) checklist was applied to structure the review and synthesis of psychometric properties of the CD-RISC. The COSMIN classification system categorizes

psychometric properties into three domains, namely reliability, validity, and responsiveness (Prinsen et al., 2018; Mokkink, et al., 2018). Reliability, the degree to which an instrument is free from measurement error, is comprised of three properties, namely internal consistency, measurement error, and reliability. Internal consistency refers to the level of interrelatedness among items in an instrument and is usually evaluated using Cronbach's alpha. Measurement error is systematic and random error that is not attributable to true changes in the underlying construct. Reliability reflects the proportion of the total variance that reflects true differences between people and can be assessed using intraclass correlation coefficients (ICCs), Cohen's Kappa, or test-retest correlations.

Validity pertains to the extent to which an instrument measures the intended construct. COSMIN groups three properties under the validity domain, namely content validity, construct validity, and criterion validity. Content validity involves the face validity, comprehensiveness, and relevance of the items in an instrument for its target population and purpose. Construct validity is composed of structural validity, hypothesis testing, and cross-cultural validity. Structural validity pertains to the evidence supporting the dimensionality of an instrument, while hypothesis testing refers to the extent to which relationships between an instrument and other measures conform to expectations, including differences between known groups. Pearson correlation coefficient (r) is often used to assess these relationships. Criterion validity assesses the extent to which an instrument correlates with an accepted "gold standard." Each of these types of validity require a clear theoretical framework for the construct being evaluated against which the validity indicators can be compared. Finally, cross-cultural validity examines the extent to which the items of a translated or adapted version of an instrument statistically and conceptually perform as they do on the original instrument.

The third and final domain, responsiveness, pertains to an instrument's ability to detect changes in the underlying construct. To assess responsiveness, researchers propose hypotheses about expected correlations between the change score on the target instrument and change scores on other instruments for the same or other constructs. Responsiveness

is essentially a measure of longitudinal validity; thus, we did not include Responsiveness to examine in this paper.

Eligibility criteria

The titles and abstracts of collected publications were screened and each full article was assessed according to the inclusion and exclusion criteria. Inclusion criteria were: 1) full-text available, 2) written in English, 3) studies that included only adults (ages from 18 to 65), 4) studies that were designed specifically to explore at least one psychometric property, and 5) peer-reviewed articles. Exclusion criteria were: 1) non-measurement properties research, 2) translating and validating study into other languages, 3) original study of CD-RISC-25 and CD-RISC-10 development and 4) CD-RISC-2 (2 items). The methodological quality of the selected articles was evaluated by two reviewers (WS and DW) independently using the COSMIN checklist.

Search strategy for identification of relevant studies

Electronic searches of MEDLINE, EMBASE, CINAHL, and PsycINFO databases were employed to retrieve relevant peer-reviewed articles published between 2003, when CD-RISC was developed, and June 2018, using the keywords [“CD-RISC OR Connor-Davidson OR CD-RISC-10” AND “psychometric* OR valid* OR reliab* OR properties OR Rasch OR Item Response Theory OR IRT”].

Selection of the studies

The study selection process was conducted in three distinct stages. Initially, comprehensive searches were conducted in various databases, and the retrieved records were saved and managed using Excel software. In the second stage, reviewers screened the titles and abstracts of the identified records to determine their eligibility, removing any duplicate entries. During the third stage, full-text articles of the selected studies underwent a thorough screening process to assess their eligibility. The studies that were excluded, along with the reasons for their exclusion, were documented.

In accordance with the PRISMA 2020 statement (Page et al., 2021), a study flow diagram was constructed to depict the information flow across the various stages of this

systematic review. The diagram provided a visual representation of the selection process, ensuring transparency and facilitating a clear understanding of the study's progression.

The COSMIN checklist allows researchers to select items based on the purpose of a study. For this study, four criteria of COSMIN checklist were selected: structural validity, internal consistency, criterion validity, and hypotheses testing. As for content validity, the COSMIN checklist evaluates studies in a process of development stages. It does not meet the aim of this study because the retrieved papers dealt with a validation of the CD-RISC rather than the initial development.

A three-step process was implemented to evaluate the quality of studies that reported the psychometric properties of the CD-RISC. Initially, the methodological quality of each study was examined using the COSMIN risk of bias checklist, which encompasses four COSMIN measurement properties (Mokkink et al., 2018). Subsequently, a 4-point rating scale was applied to assess each of the COSMIN properties of the CD-RISC. The ratings were determined through a "worst-score-counts" analysis, which assigned priority to the lowest rating among the gradings for each section (Terwee et al., 2012). Two independent reviewers (WS and DW) conducted the methodological quality appraisal of each study, and any disagreements were resolved through consensus.

Mokkink et al. (2018) proposed new labels for the four-point rating system in response to concerns about the original labels' lack of alignment with the descriptions provided in the rating scale. The original labels, namely 'excellent,' 'good,' 'fair,' and 'poor,' were deemed inadequate as they did not precisely correspond to the descriptions used in the scale boxes. The category 'fair' frequently employed terms such as doubtful and unclear, necessitating the introduction of a more fitting label, namely 'doubtful.' Furthermore, the asymmetry between the labels 'good' and 'poor' led to their replacement with 'adequate' and 'inadequate,' respectively. Finally, a different category was introduced to acknowledge studies that exhibited exceptional performance. To better represent the distinction between the response categories, the label 'excellent' was replaced with 'very good.' This revision aimed to enhance clarity for users and highlight the differences

between the original COSMIN checklist and the updated version (Table 1).

Table 1. Proposed labels for the four-point rating system

New labels for the four-point rating system proposed by Mokkink et al. (2018)				
Old labels	Excellent	Good	Fair	Poor
New labels	Very good	Adequate	Doubtful	Inadequate

Data Synthesis

To synthesize the extracted data, I came up with an algorithm. High confidence in any property will be reserved for a property in which 3 or more moderate-to-high quality manuscripts all report the same or a similar finding. Moderate confidence will be when less than 3, or no high-quality manuscripts, report a similar finding. Low confidence will be when no moderate-quality, or inconsistent results regardless of quality, are reported for a specific property. The strength of effects/evidence as strong will be dependent on the statistic used, but examples would be ICC > 0.85, EFA with factors that explain at least 75% of scale variance, or meaningful concurrent correlations/hypotheses at coefficient values > 0.70. Weak effects / evidence will be small and barely significant findings for ICC, EFA explaining < 35% of scale variance, or tests of association/hypotheses that are either weak or not in accordance with the theoretical relationships posed in the article. Moderate evidence will be anything in between.

2.3 Results

The PRISMA flow diagram is shown in Figure 1. The search returned a total of 433 articles of which 153 were duplicates. Of the remaining, 251 were excluded because they were original development studies of CD-RISC-25 and 10 (n=2); CD-RISC-2 (n=3); out

of age range (n=18); they were not written in English (n=10); not related to the purpose of this study (n=214); not full-text available (n=1); and not peer-reviewed (n=3). Furthermore, 18 papers were excluded due to their reporting on the translation of the CD-RISC into non-English languages. A total of 11 articles remained. Two of them examined both 25-item and 10-item versions of the CD-RISC for validity. Only one of the articles included a sample with traumatized people. Table 2 presents the description of each retained study and the population studied.

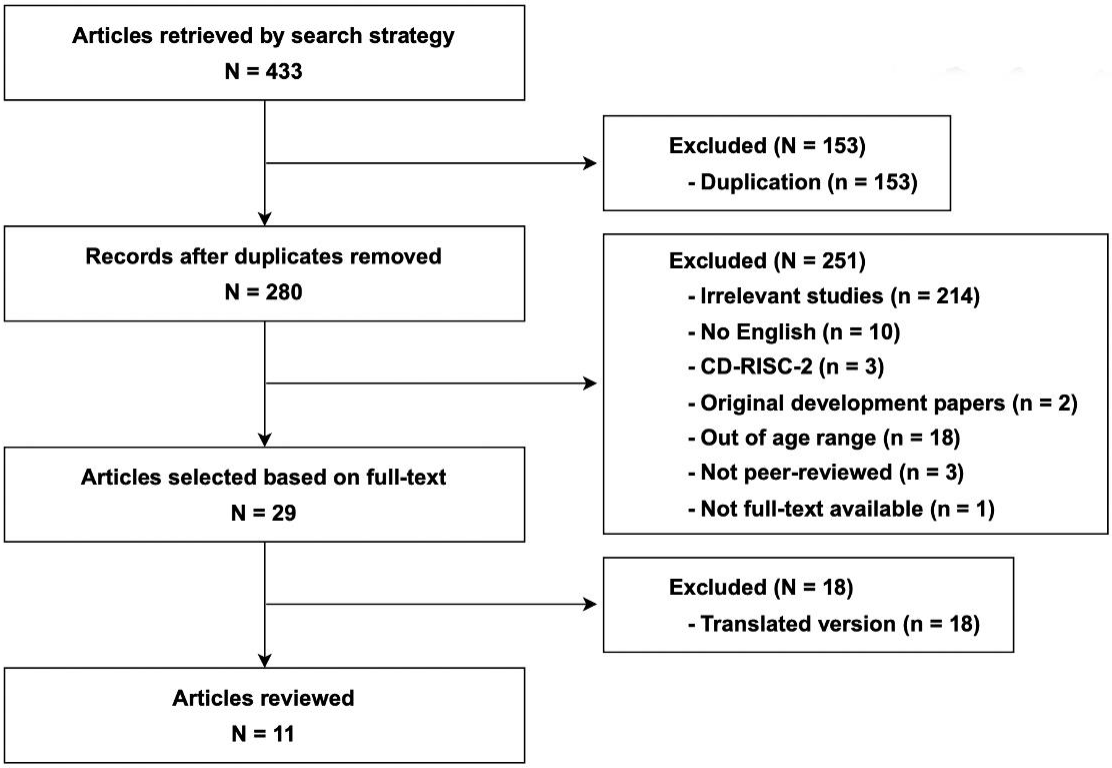

Figure 1. Flow chart of systematic review

Table 2. Description of the retrieved studies

Authors	Year	CD-RISC-10/25	Sample (N)
#1. Aloba et al	2016	CD-RISC-10	Nigerian nursing student (N = 449)
#2. Bezdjian et al	2017	CD-RISC-25	US Air Force (N = 53,692)
#3. Burns et al	2010	CD-RISC-25	Australian young adults (N = 1,775)
#4. Coates et al	2013	CD-RISC-10	Low-income, African American Men (N = 127)
#5. Gonzalez et al	2016	CD-RISC-25 & CD-RISC-10	American distance runners (N = 405)
#6. Green et al	2014	CD-RISC-25	U.S. veterans with military service since 9/11 2001. (N = 1,981)
#7. Hartley	2012	CD-RISC-25 & CD-RISC-10	Undergraduate students in general in US (N = 605) & Undergraduate students in the waiting rooms of campus mental health offices (N = 121)
#8. Madewell et al	2016	CD-RISC-25 & CD-RISC-10	Emerging Adulthood (EA) college students in US (N = 451)
#9. Mealer et al	2016	CD-RISC-25	Critical care nurses in US (N = 744)
#10. Perera et al	2018	CD-RISC-25	Postsecondary students with disabilities (N = 274)
#11. Sharma et al	2016	CD-RISC-25	IT industry in India (N = 160)

Table 3. GRADE rating based on COSMIN checklist.

	Structural Validity				Internal Consistency					Criterion Validity			Hypotheses Testing						
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q1	Q2	Q3	Q4	Q5	Q6	Q7
#1	vG	NA	vG	InA	vG	vG	NA	NA	vG	NA	NA	vG	vG	vG	vG	vG	NA	NA	NA
#2	InA	NA	vG	InA	InA	vG	NA	NA	vG	vG	NA	vG	InA	InA	Db	vG	NA	NA	NA

#3	vG	NA	vG	vG	InA	InA	NA	NA	vG	NA	NA	vG	NA	NA	NA	NA	Db	Ad	vG
#4	vG	NA	vG	vG	vG	vG	NA	NA	vG	NA	NA	vG	vG	vG	vG	vG	NA	NA	NA
#5	vG	NA	vG	vG	vG	vG	NA	NA	vG	NA	NA	vG	vG	vG	vG	vG	NA	NA	NA
#6	vG	NA	vG	vG	vG	vG	NA	NA	vG	NA	NA	vG	vG	vG	vG	vG	NA	NA	NA
#7	vG	NA	vG	vG	vG	vG	NA	NA	vG	NA	NA	vG	vG	vG	vG	vG	vG	vG	vG
#8	vG	NA	vG	vG	vG	vG	NA	NA	vG	NA	NA	vG	-	-	-	-	-	-	-
#9	vG	NA	vG	vG	vG	vG	NA	NA	vG	NA	NA	vG	-	-	-	-	Db	vG	vG
#10	vG	NA	vG	vG	InA	InA	NA	NA	vG	NA	NA	vG	vG	vG	vG	vG	-	-	-
#11	vG	NA	Ad	InA	vG	vG	NA	NA	vG	NA	NA	vG	InA	InA	InA	InA	-	-	-

1. Aloba (2016) / 2. Bezdjian (2017) / 3. Burns (2010) / 4. Coates (2013) / 5. Gonzalez (2015) / 6. Green (2014) / 7. Hartley (2010) / 8. Madewell (2016) / 9. Mealer (2016) / 10. Perera (2018) / 11. Sharma (2016).

** vG: very good, NA: Not applicable, Ad: Adequate, Db: Doubtful, InA: Inadequate.

Table 4. Final grading

Article	Version	Structural Validity	Internal Consistency	Criterion Validity	Hypotheses Testing
#1	10	Inadequate	Very good	Very good	Very good
#2	25	Inadequate	Inadequate	Very good	Inadequate
#3	25	Very good	Inadequate	Very good	Doubtful
#4	10	Very good	Very good	Very good	Very good
#5	25 & 10	Very good	Very good	Very good	Very good
#6	25	Very good	Very good	Very good	Very good
#7	10	Very good	Very good	Very good	Very good
#8	25 & 10	Very good	Very good	Very good	NA
#9	25	Very good	Very good	Very good	Doubtful

#10	25	Very good	Inadequate	Very good	Very good
#11	25	Inadequate	Very good	Very good	Inadequate

Overall evaluation

Of the 11 retained studies, 8 received a 'very good' rating for structural validity, 8 were rated 'very good' for internal consistency, 11 'very good' for criterion validity, and 6 'very good' for hypothesis testing (Table 4). Of those rated inadequate, common reasons were: inappropriate application of statistical procedures, such as extraction method or rotation for EFA that was not in accordance with the type of data, or exploring criterion validity without adequate a priori hypotheses. There were 6 or more 'very good' papers for each property evaluated, those served as the primary sources for the synthesis statements with the remaining papers serving as secondary sources.

Table 5. Results of each of the CD-RISC-25 studies

Authors	Region	Sample	Sample Size	N of factors	Items on each subfactor	Total items
Bezdjian	The US	Enlisted basic trainees in the US Air Force	53,692 (M=82%)	Unitary factor	25	25
Burnz	Australia	Community youngest adult	1,775 (M=45.9%)	Unitary factor, χ^2=2874.72***; CFI=.85; TLI=omit; RMSEA=.081(.078~.083)	25	25
Gonzalez	The US	Competitive post-collegiate long-distance runners	405 (M=54.8%)	Five subfactors, χ^2=837.62***; CFI=.838; TLI=.816; RMSEA=.073 (.068~.097)	The same with original version of CD-RISC-25	25

				Unitary factor, χ^2=1150.41***; CFI=.75; TLI=.73; RMSEA=.089 (.083~.094)	25	
Green	The US	U.S. veterans with military service since Sep 11, 2001	1,981 (M=80%)	Two subfactors, χ^2=789.81***; CFI=.96; TLI=omit; RMSEA=.07(omit); AIC=875.81(compared to original 25-item five-factor solution=3060.29)	Adaptability=8 Self-efficacy=6	14
Hartley	The US	Undergraduate students	Mental Health Participants (MHP): 121 (M=28%) Classroom Participants (CP): 605 (M=29%)	Five-factor structure invariance across the two groups: χ^2=1461.30***; CFI=.88; TLI=.86; RMSEA=.07(.066~.074). 25-item poor fit, no further analysis in this paper (only 10-item version going forward)	N/A	
Madewell	The US	College Students	Total 451; 384 from a large rural university (M=23.7%) / 67 from two regional universities (M=28.4%)	Assumed unitary factor at first, χ^2=1040.56***; CFI=.79; TLI=.77; RMSEA=.07(.067~.077)	All Modification indices, 13 covariances with a coefficient larger than 20 occurred.	25
Mealer	The US	Critical care nurses	744 (M=9%)	Three subfactors, (n=373) χ^2=243.14***; CFI=.94; TLI=omit; RMSEA=.062(omit)	Personal Competence (6) Perseverance (6) Leadership (4)	16

Perera	Australia	Postsecondary students with Disabilities	274 (M=64.6%)	Unitary factor, χ^2=800.18; CFI=.94; TLI=.93; RMSEA=.083 (.077~.090)	25	25
				Five-Factor CFA, χ^2=633.14; CFI=.96; TLI=.95; RMSEA=.071(.064~.078)	The same with original one	
				Higher order CFA, χ^2=638.35; CFI=.96; TLI=.95; RMSEA=.071(.064~.078)		
				Five-factor ESEM, χ^2=304.82; CFI=.99; TLI=.98; RMSEA=049(.039~.058).		
				Higher order ESEM, χ^2=300.36; CFI=.99; TLI=.98; RMSEA=.046(.036~.056)		
				Bifactor-ESEM, χ^2=249.62; CFI=.99; TLI=.98; RMSEA=.043(.032~.054)		

Table 6. Results of each of the CD-RISC-10 studies

Authors	**Region**	**Sample**	**Sample Size**	**N of factors and model fits**	**Items on each subfactor**	**Total items**
Aloba	Nigeria	Student Nurses	449 (M=12.5%)	Two subfactors, χ^2=87.50(omit); CFI=.95; TLI=omit; RMSEA=.062(omit)	Toughness (6), Motivation (4)	10

Burns	Australia	Community youngest adult	1775 (M=45.9%)	Unitary factor, χ^2=200.11***; CFI=.97; TLI=omit; RMSEA=.052(.045~.059); AIC=240.11 compared to 25 items, 2966.72	-	10
Coates	The US	Low-income African American Men	127 (all men)	Unitary factor, χ^2=52.82*; CFI=.99; TLI=omit; RMSEA=.063(omit)	-	10
Gonzalez	The US	Competitive post-collegiate long-distance runners	405 (M=54.8%)	Unitary factor, χ^2=69.45**; CFI=.97; TLI=.96; RMSEA=.049(.032~.066)	-	10
Hartley	The US	Undergraduate students	Mental Health Participants (MHP): 121 (M=28%) Classroom Participants (CP): 605 (M=29%)	MHP: Unitary factor, χ^2=48.56; CFI=.97, TLI=.97, RMSEA=.06 (.00~.09) CP: Unitary factor, χ^2=107.62***; CFI=.96, TLI=.95, RMSEA=.06 (.05~.07)	-	10
Madewell	The US	College Students	451 a)384(M=23.7%) b)67(M=28.4%)	Unitary factor, χ^2=116.09***; CFI=.94; TLI=.92; RMSEA=.075(.06~.09)	-	10

Structural Validity

Included papers explored either the original CD-RISC (25 items), the shortened CD-RISC-10, or both. Of those, 6 very good quality studies evaluated the factor structure of the original CD-RISC. Only one (Gonzalez et al., 2016) recreated the same factor structure and items per factor of the original development paper. Another very good

paper (Perera et al., 2018) also found support for the 5-factor structure but found a bifactor structure a better fit to the data. Mealer et al. (2016) found strongest support for a 3-factor model (factors termed: Personal Competence, Perseverance, and Leadership). Of the papers who reported properties for a single unifactorial structure, none reported adequate fit indicators.

For the shortened CD-RISC-10, four 'very good'-quality papers reported adequate support for a unifactorial structure, while Aloba et al. (2016) reported that a two-factor structure was a better fit.

Summary Statement: Based on findings from 6 'very good'-quality papers, we find moderate confidence that the original CD-RISC does not conform to a single unifactorial structure. Beyond that, we find inconsistent evidence that any of the 2-, 3-, or 5- factor structures offer adequate model fit or that any one is superior to the others. For the CD-RISC-10, based on findings from three of four 'very good'-quality studies, we find consistent evidence of acceptable model fit for a unifactorial structure.

Internal Consistency

The included papers provided a calculation of internal consistency for either the original CD-RISC with 25 items, the shortened CD-RISC-10 item version, or both. Three of the five studies ('very good' quality) of the original CD-RISC reported a Cronbach's alpha of 0.85 or greater for the whole scale, with values for the subscales ranging from 0.81 (Spiritual; Sharma et al., 2016) to 0.90 (Personal Competence; Sharma et al., 2016). The other two studies (both 'very good' quality) reported internal consistency for subscales different than those originally reported. Mealer et al. (2016) reported an alpha of > 0.90 for the full scale and subscale values of 0.72 (Leadership) to 0.83 (Perseverance). Green et al. (2014) reported subscale values of 0.91 (Adaptability) and 0.90 (Self-efficacy).

Five papers (all 'very good' quality) reported Cronbach's alpha for the full scale of the shortened CD-RISC-10. All papers reported an alpha value of between 0.81 (Aloba et al.,

2016) to 0.90 (Hartley, 2012). One study (Aloba et al., 2016) showed 2-factor solution and subscale alpha values were 0.77 (Toughness) and 0.62 (Motivation).

Summary Statement: Based on the findings of 5 papers ('very good' quality), we find consistent evidence of good to excellent internal consistency (alpha 0.85 to 0.91) for the overall CD-RISC-25 with alpha for the subscales ranging from moderate (0.72) to excellent (0.91) dependent on the factor structure evaluated. Based on the findings of 5 'very good' quality studies, we find consistent evidence of good to excellent internal consistency (alpha 0.81 to 0.90) for the 10 items of the shortened CD-RISC-10.

Criterion Validity

In one very good-quality paper, Bezdjian et al. (2017) tested the ability of CD-RISC scores to predict attrition (leaving the service) or receiving a new mental health diagnosis within 6 months of entering military service as a criterion standard. Using a sample of over 53,000 military members, they found area under the receiver operating characteristic curve (AUC) of 0.64 for both outcomes, suggesting small to moderate predictive accuracy.

Summary Statement: Based on findings from 1 very good-quality paper, we find low confidence in small-to-moderate accuracy of the full CD-RISC for discriminating between military service members who do and do not leave the service within 6 months for reasons of mental ill-health.

Hypothesis Testing

We identified 6 papers that explored concurrent strengths of association between the two CD-RISC versions and several other established self-report sales. None provided a priori hypotheses regarding direction and magnitude of association, though all papers are included here as the analytic techniques and interpretation were similar across the studies.

Of those, 3 very good-quality studies compared the original CD-RISC against other self-report measures of affect, worry, competence, or psychopathology. In accordance with theory, Gonzalez et al. (2016) reported small-to-moderate significant negative correlations of the full CD-RISC with measures of somatic anxiety (r = -0.14), worry (performance anxiety) (r = -0.21) and performance concentration (r = -0.27) in a sample of athletes. They found the full CD-RISC had significant positive correlations with negative affect (r = 0.13) and positive affect (r = 0.33), the former of which did not support theory. They found a similar pattern of associations with the same comparator measures and 4 of the 5 CD-RISC subscales with significant associations ranging from r = -0.12 (somatic anxiety v CD-RISC positive acceptance of change) to r = -0.34 (performance concentration v positive acceptance of change). The fifth subscale (spirituality) showed no significant association with any of the performance-related metrics. All 5 subscales were also significantly and positively correlated with a measure of positive affect (r = 0.20 to 0.40), though contrary to theory the only significant correlation with negative affect was in the positive direction with the CD-RISC factor of 'competence' (r = 0.19). No other CD-RISC subscale showed an association with negative affect. Green et al. (2014) used regression to explore explanation of variance in self-rated psychopathology as measured using the Symptom Checklist Revised-90 (SCL-90-R; Derogatis, 1983). Using their two-factor structure of the original CD-RISC, they found that both factors (Adaptability: $\beta = -0.74$, $p = 0.03$; Self-Efficacy: $\beta = -0.78$, $p = 0.03$) explained significant unique variance in psychological symptoms in the direction supported by theory. Perera et al. (2018) evaluated the associations of a set of factors derived from bifactor-exploratory structural equation modeling (assuming both a 'general resilience' general factor and three specific behavioral or cognitive resource resilience sub-strategies: competence, control, and spirituality) against a measure of career optimism and one of general well-being. Using a sound theoretical framework, they found the general resilience factor (r = 0.57) and the specific competence (r = 0.48) and control (r = 0.64) sub-factors significantly and positively associated with career optimism in 274 post-secondary students with disabilities. Using an LVM-based approach, expressed as completely standardized estimates, they found the general resilience ($\gamma = 0.42$) and control ($\gamma = 0.53$) factors positively, and contrary to theory the competence

factor negatively (γ = -0.22), explained 55.1% of variance in general well-being. Again, the spirituality factor did not explain significant variance after parceling out the effects of the other variables.

Four very good-quality studies explored associations of the single-factor CD-RISC-10 against other established measures. Gonzalez et al. (2016) compared scores on the CD-RISC-10 against scores on The Sport Anxiety Scale – 2 (Smith, Smoll, Cumming, & Grossbard, 2006) and the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). In accordance with theory, they found CD-RISC-10 scores explained significant variance in performance anxiety (R^2 = 0.76), with negative coefficients for somatic anxiety (r = -0.24), cognitive anxiety (r = -0.58), cognitive disruption (r = -0.38) and negative affect (r = -0.57) and a positive coefficient with positive affect (r = 0.67). Aloba et al. (2016) found significant associations between CD-RISC-10 and related variables such as Rosenberg Self-Esteem Scale (r = 0.34), General Health Questionnaire-12 (r = -0.24), Patient Health Questionnaire (r = -0.32), and Religious Orientation Test (r = -0.18). Coates et al. (2013) found that CD-RISC-10 had a significant relationship with the Religious Well-Being Scale (r = 0.60). Finally, Hartley (2012) reported small-to-moderate significant correlations with the Mental Health Inventory-5 (MHI-5; r = 0.16) and Social Support Questionnaire-6 (SSQ-6; r = 0.40) in a sample of post-secondary students.

Summary Statement: Based on findings from 3 very good-quality studies, we find moderate confidence that the full CD-RISC score is associated with other metrics of general psychological well-being, positive affect, or (inversely) psychopathology. We find low-to-very low confidence that the full CD-RISC score is associated with negative affect. We find inconsistent evidence that the subscales of the CD-RISC are associated with any one outcome, owing largely to differences in how the subscales have been constructed across studies. However, based on findings from two very good-quality studies, we find moderate confidence that the CD-RISC ‘Spirituality’ subscale is not associated with other measures of optimism, resilience, or general well-being.

Based on findings from four very good-quality studies, we find moderate confidence (bolstered by consistency of effects but hampered by differences in comparator measures) that the CD-RISC-10 is associated in the directions expected by theory at a small-to-moderate magnitude with other measures of positive or negative affect, self-esteem, or mental wellness. Based on two very good-quality studies, we find moderate confidence that the CD-RISC-10 is associated with other measures of religious or spiritual orientation at a small-to-moderate magnitude. On the basis of only single studies, we find low confidence in associations with other metrics of constructs like performance anxiety or social support.

Discussion

Traumatic events are a common experience, and resilience may serve as a protective factor against the negative effects of these experiences. It is of importance for clinicians and researchers to be able to measure levels of resilience in order to intervene effectively with patients who have experienced trauma. This study aimed to evaluate the psychometric properties of the CD-RISC, a commonly used measure in resilience research. To achieve this goal, the COSMIN checklist was used to assess the psychometric properties of 11 articles identified through this study.

Studies pertaining to people who have experienced trauma have been challenging to conduct, as evidenced by their scarcity in the literature. In fact, out of the 11 articles retrieved in the present study, only one article included people with a history of trauma. This lack of literature on traumatized people could be attributed to the difficulties encountered by researchers in recruiting people who have been exposed to traumatic events.

Out of the studies conducted on the 25-item CD-RISC, only one study revealed a five-factor structure that was identical to the original. On the other hand, the remaining studies exhibited inconsistent factor solutions when compared to the original CD-RISC. When the factor structures obtained from subsequent confirmatory factor analyses (CFAs) are

not consistent with the original version of the questionnaire, it suggests that the questionnaire may not be measuring what it was intended to measure or that the theoretical foundation of the construct was not adequately defined. This can lead to several problems. Firstly, if the factor structure does not match the original questionnaire, it may indicate that the questionnaire does not accurately measure the construct it is intended to measure. Inconsistent factor structures may indicate that the questionnaire has poor reliability or may show measurement variance across potentially important clinical subgroups of people (e.g., by sex, age, race, etc.). This can lead to inconsistent results and reduced confidence in the questionnaire. Thirdly, if different factor structures are obtained for different samples, it can be difficult to compare results across studies. This can make it challenging to draw meaningful conclusions from the research. Lastly, when the factor structure is inconsistent with the original questionnaire, it can be challenging to interpret the results of the analysis. This can make it difficult to draw accurate conclusions about the construct being measured and the relationships between variables.

The CD-RISC-10, which was created by Campbell-Sills and Stein (2007), displayed a unitary factor structure in its original publication. However, resilience is a comprehensive and intangible concept, making it difficult to construct using a single factor. The presence of latent variables in psychology is due to its abstract nature, and so it is reasonable to expect those studies employing the 10-item CD-RISC frequently yield non-unitary factor solutions. However, in comparison to the original CD-RISC, the CD-RISC-10 appears to show more consistent and acceptable measurement properties across studies.

This study has several limitations that must be noted. Firstly, we only included the English version of the CD-RISC due to cross-cultural validity concerns and did not consider versions in other languages. Even some non-English studies may have conducted rigorous statistical analyses, it was challenging for us to determine the quality of the translation and validation based solely on the information presented in the papers. Secondly, the majority of the studies included in our analysis did not involve people who had experienced trauma. For example, Green and his colleagues (2014) conducted a study with a sample of US veterans who had served in the military since the 9/11 attacks in 2001. The study's ultimate factor structure revealed a two-factor solution, incorporating

only 14 of the original 25 items from the CD-RISC. The two subfactors identified were Adaptability, consisting of eight items, and Self-efficacy, which consisted of six items. Without more studies that include people with prior experiences of trauma, it is difficult to assess the suitability of this tool as a measure of response to specific situations rather than a measure of general ‘trait’ resilience. Although we cannot claim that the factor solution and some items in the original CD-RISC are unsuitable for measuring "post-trauma resilience," we recommend that researchers take great care in selecting questionnaires to be used in their studies, particularly when studying people who have experienced trauma.

2.4 Conclusion

Although the CD-RISC has widely been used in trauma-related studies, the findings indicate that the tool may not possess adequate factorial stability to measure resilience in traumatic situations. We have identified only one analysis after the original development paper that recreated the initial factor structure, and only a single paper that included people with known traumatic histories in the sample. Accordingly, and despite widespread use of the CD-RISC, our findings appear to indicate that cautious interpretation of scale scores is warranted. Based on the findings, it seems that the CD-RISC may effectively measure a construct resembling ‘general resilience.’ However, further information on content validity is needed before endorsing its use in research focusing on specific types of traumas.

Our findings could be partly explained by a lack of a universally accepted operational definition for ‘post-traumatic resilience (PTR).’ Researchers and clinicians are encouraged to use the CD-RISC with proportional caution and consider supplementing it with other tools related to resilience and to positive affect.

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Chapter 3

3 Development of the Pain Resilience and Optimism Scale (PROS) from Post-traumatic Resilience and Optimism Frameworks in Musculoskeletal Trauma

3.1 Introduction

No one lives a life free of adversity, but not everyone responds in the same way. Some are resilient in the face of adversity, able to cope with the threat and return to a state of relative routine or homeostasis. Others struggle to cope with the threat and perceived stress, with decades of research revealing the negative effect of chronic stress and inability to cope on both mental and physical health (Bonanno, Galea, Bucciarelli, & Vlahov, 2007; Bonanno, 2005; Mancini & Bonanno, 2009; Maschi, Baer, Morrissey, & Moreno, 2013). In some cases, the experience of a trauma and resulting mental stress can manifest as a chronic form of psychopathology, termed PTSD (Carmassi et al., 2020).

Work emerging from the field of positive psychology is revealing more powerful influences on post-trauma distress including a concept that has become known as resilience (Ahmed, 2007). Resilience is a personal trait that can be described in terms of coping resources, optimism, and a willingness to view adversity as a contributor to personal growth, that can mitigate the effects of trauma (Polk, 1997). Of relevance to rehabilitation, the current state of knowledge in the field of post-traumatic pain and disability suggests that those who catastrophize about pain, are highly anxious or fear avoidant, are at greatest risk of developing chronic problems (Sullivan et al., 2009). I propose that a better and more therapeutic strategy is to flip the discourse such that clinicians and researchers focus less on quantifying how terrible the patient rates their experience of pain or trauma, and rather capture their beliefs in their own post-traumatic resilience and optimism. Although several patient-reported tools currently exist to measure the ‘terribleness’ of a condition such as the Pain Catastrophizing Scale (PCS; Sullivan, Bishop, & Pivik, 1995) and Traumatic Injuries Distress Scale (TIDS; Walton et al., 2016), there are very few if any specifically targeted at measuring trauma-related resilience and optimism that can be meaningfully applied to musculoskeletal (MSK)

trauma. Those that are available, such as the Connor-Davison Resilience Scale (Connor & Davidson, 2003) were neither designed nor intended to predict outcomes following MSK trauma. As sound measurement must be based on clinically and theoretically meaningful constructs, having a clear and well-developed framework or model for the construct is critically important for supporting validity of a scale. With the field of musculoskeletal pain and trauma dominated by negatively-oriented models for recovery (e.g., the Fear-Avoidance model; Vlaeyen & Linton, 2000), it seems a new theoretical model that prioritizes resilience from which meaningful measurement tools can be developed is sorely needed.

I believe that a research program exploring the protective effects of post-traumatic resilience and optimism (PTRO) will result in a paradigmatic shift in the field of trauma rehabilitation and recovery, where clinicians focus less on resolving what is wrong with the patient and more on building personal resources and coping skills to manage adversity.

Introduction to the Post-traumatic Resilience and Optimism (PTRO)

This chapter discusses the need for a new model of post-traumatic resilience and optimism in the context of musculoskeletal (MSK) trauma, which includes resilience as a factor that has not been previously emphasized in MSK recovery models. The chapter reviews three existing models of resilience related to distress (e.g., trauma), including the TBI Resiliency Model (Nalder, Hartman, Hunt, & King, 2019), the Resilience Model in Operating Room Nurses (Gillespie, Chaboyer, Wallis, & Grimbeek, 2007), and Models of Resilience (Fergus & Zimmerman, 2005). These models are reviewed to create a new model of post-traumatic resilience and optimism in MSK trauma by incorporating parts of the three resilience models.

Overview of the models

The TBI Resiliency Model (Nalder et al., 2019) is a process-oriented resiliency model following traumatic brain injury (TBI). It highlights the affective, cognitive, and behavioral self-regulatory processes that people with TBI can use, as well as the physiological, personal, and person-in-environment factors that affect TBI-related adversity and initial response. The model further describes how personal characteristics (affective, cognitive, and behavioral) and external resources (social support and family resiliency) moderate the progression from initial response to self-regulatory processes. Ultimately, positive beliefs are enabled, which lead to positive outcomes and facilitates the recovery process.

The Resilience Model in Operating Room Nurses (Gillespie et al., 2007) identifies six components that contribute to resilience: self-efficacy, hope, coping, competence, collaboration, and control. The authors conducted concept analysis and literature review to identify these factors and hypothesized that moderation variables such as age, education, and years of employment would affect the relationship between explanatory variables and resilience. The final model was created after collecting data of 2,860 Australian Operation Room nurses and conducting regression analyses. The findings indicate that hope, self-efficacy, and coping were the strongest explanatory variables for predicting resilience.

Finally, the Models of Resilience proposed by Fergus and Zimmerman (2005) provide three models of resilience, including the compensatory, protective, and challenge models. The protective model suggests that protective factors may function to affect outcomes and decrease the correlation between a risk and an outcome. Specifically, the Protective-Reactive model indicates that when the protective factor is absent, the relationship between a risk and an outcome is stronger.

Consistent across these three established models are the importance of perceived coping resources, whether those be social supports or available personal strategies, as effective means of countering the threat to personal safety or stability. Also consistent are factors related to the person experiencing the adversity, alternately described as hope, self-

efficacy, cognitions, or personal protective factors. Combined, there appears to be a consistent thread indicating that resilience in the face of adversity, possibly such as MSK trauma, is the result of some combination of beliefs in one's own personal internal resources and the supports of external factors in response to, and mitigating, the threat to stability.

A new model focused on resilience in MSK trauma

Based on these models, I propose a new model of post-traumatic resilience and optimism (PTRO) in MSK trauma, which highlights the importance of resilience in the recovery process (Figure 2). The proposed model incorporates the TBI Resiliency Model's self-regulatory processes, personal characteristics, and external resources, as well as the Resilience Model in Operating Room Nurses' factors of self-efficacy, hope, and coping. Additionally, the model incorporates the Protective-Reactive model from the Models of Resilience, emphasizing the protective factors that can decrease the correlation between a risk and an outcome. Ultimately, this new model aims to provide a framework that professionals and clinicians can use to make treatment plans and anticipate prognosis of MSK trauma.

The new model consists of three phases: 'Adversity', 'Response', and 'Outcome', with a focus on the transition from acute pain to chronic pain, either persisting in a state of relative hopefulness in those likely to recover or moving from a state of relative hopefulness a state of relative hopelessness in those likely to report persistent problems. In the 'Adversity' phase, people face MSK trauma, which is described as a physical injury and related psychological distress. In the 'Response' phase, people respond to their trauma, and may either be vulnerable to trauma or resilient to trauma. Protective factors such as self-efficacy, perceived social support, and optimism can buffer against chronic pain, while fear of pain and pain catastrophizing can make the person more at risk of chronic pain. The 'Outcome' phase describes the results of the MSK trauma trajectories, with some people experiencing recovery or even post-traumatic growth and others experiencing exacerbated distress and pain. The model suggests that building positive

psychological factors such as optimism can enhance resilience and buffer against chronic pain. Below are suggestions for further research to test the model.

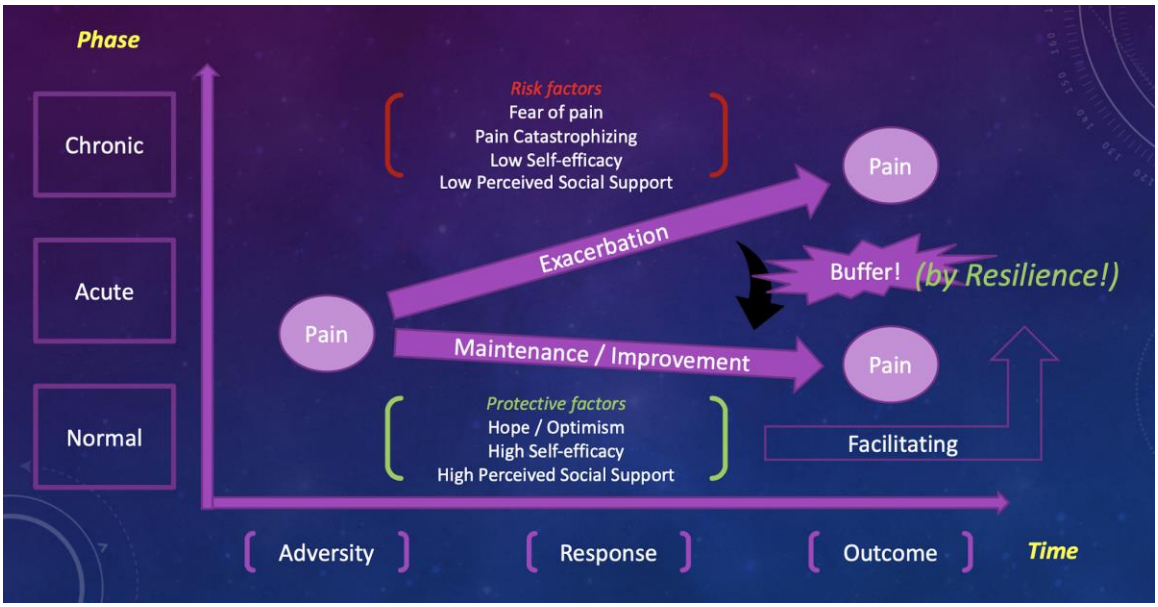

Figure 2. The Post-traumatic Resilience and Optimism Framework

Positive effects of exposure to sentences infused with positive valence.

The term "well-being cognition techniques" has been employed in various studies conducted in South Korea. These techniques involve presenting participants with sentences infused with positive valence. For instance, Min, Kim, and Kim (2014) observed an enhancement in well-being among bus drivers over a six-week period through the implementation of well-being cognition techniques. This improvement encompassed a reduction in job-related stress, overall stress response, negative affect, and an increase in life satisfaction. Similarly, Kim and Eun (2010) found a positive correlation between the frequency of recalling biblical verses in daily life among Christians and positive states such as life satisfaction along with a negative correlation with negative states such as depression and anxiety.

Min, Kim, and Kim (2014) described that the mechanism underlying well-being cognition techniques can be explained as follows: When people encounter stressful

situations, they typically experience negative affect, which subsequently triggers negative thoughts. This negative cognitive process sets in motion a detrimental cycle that amplifies stress. Although positive cognition is crucial when confronting negative affect, the mood-congruency effect often highlights and reinforces negative cognition. This is especially prominent in people who are susceptible to stress, as their tendency to ruminate on negative cognition in negative circumstances prolongs and intensifies their stress levels. In response to this, well-being cognition techniques aim to counteract these effects by exposing people to phrases that frequently evoke well-being cognition in their everyday lives. By doing so, these techniques facilitate the emergence of well-being cognition during stressful situations, effectively competing with negative cognition. Consequently, the process of rumination on negative cognition is impeded, contributing to a reduction in stress levels and promoting overall well-being.

The Pain Catastrophizing Scale (PCS) has widely been used in pain research. The items of the PCS represent a negative phrasing about thoughts describing the respondent's pain. According to the well-being cognition theory, the PCS may in fact function to exacerbate the pain experience as a respondent may experience increased risk for getting worse by just reading the negative valence of items.

The remainder of this chapter describes the process I followed to move from the theoretical PTRO framework to create a prototype scale intended as a conceptual 'oppositive' of negatively-worded scales like the PCS.

3.2 Methods & Results

Initial Item Generation and Revision

The PCS is a sound tool on which to base the genesis of the new resilience and optimism scale, partly because it enjoys a wealth of published evidence indicating that it has value as a risk-screening tool for prognosis in MSK trauma, and partly because catastrophizing

as a construct can be interpreted as the theoretical opposite of resilience and optimism, I start with an acknowledgement that, like many pain-focused scales.

PCS items represent pain-related phenomena in negative valence. Accordingly, the first step in developing items saw the two authors thematically interpret each PCS item for its core construct, translate the construct into positive terms against the PTRO framework, and then rewrite the item using positive phrasing. Table 7 presents the original PCS item, the initial result of reverse-phrasing, and the PTRO concept this item was mapped to.

Table 7. Original items from the Pain Catastrophizing Scale (verbatim), initial reverse-worded items, and concepts from the PTRO those items can be mapped onto.

The original version of the PCS	Reverse-worded items	Concepts mapped to the PTRO framework
I worry all the time about whether the pain will end.	I hope to be free from the pain in the end.	'hope'
I feel I can't go on.	I believe I can continue my life as usual.	'resilience'
It's terrible and I think it's never going to get any better.	It's tolerable and I believe it's going to get better soon.	'resilience' & 'optimism'
It's awful and I feel that it overwhelms me.	It's not a big deal and I feel that I can cope with it.	'optimism' & 'resilience'
I feel I can't stand it anymore.	I feel I am strong enough to endure the pain.	'resilience'
I become afraid that the pain will get worse.	I become hopeful that the pain will get better.	'hope' & 'optimism'

I keep thinking of other painful events.	I can easily keep away from thinking about other painful events.	‘resilience’ & ‘self-efficacy’
I anxiously want the pain to go away.	I have no doubt that the pain will go away.	‘optimism’
I can’t seem to keep it out of my mind.	I can easily keep it off of my mind.	‘resilience’ & ‘self-efficacy’
I keep thinking about how much it hurts.	I believe this hardship will make me stronger.	‘optimism’
I keep thinking about how badly I want the pain to stop.	I believe I will be the one who has a strong belief that I can overcome any painful experiences.	‘optimism’ & self-efficacy
There’s nothing I can do to reduce the intensity of the pain.	I believe there’s something that I can do to control the intensity of the pain.	‘resilience’ & ‘self-efficacy’
I wonder whether something serious may happen.	I believe that something good will happen to me.	‘optimism’

For item #1, 'worry' was reframed as 'hope'. In item #2, the original 'I feel I can't go on' was transformed into 'I believe I can continue my life as usual' to imbue a more positive perspective on coping with pain. For item #3, 'terrible' became 'tolerable,' and 'never' was omitted from the revised version. In item #4, 'it's awful' was changed to 'it's not a big deal,' and 'it overwhelms me' was substituted with 'I can cope with it.' In item #5, 'I can't stand it anymore' suggested weakness in enduring pain, so it was revised to 'I am strong enough to endure the pain.' Item #6 saw 'afraid' and 'worse' replaced by 'hopeful' and 'better' to instill a more positive outlook. In item #7, 'keep thinking' was transformed into

'can easily keep away from. 'For item #8, the original PCS item conveyed obsession and nervousness about pain cessation. It was revised to 'I have no doubt that the pain will go away.' In item #9, the PCS item indicated difficulty in stopping thoughts about pain, which was turned into 'I can easily keep it off my mind.' In item #10, the PCS item's fear of pain magnitude was rephrased as 'I believe this hardship will make me stronger,' emphasizing the potential for personal growth through facing and conquering fear. Item #11 continued in the same vein, shifting from 'keep thinking about how badly I want the pain to stop' to 'I am strong enough to overcome the pain,' highlighting resilience. For item #12, the PCS implied an inability to reduce pain intensity. This was modified to include the word 'control,' emphasizing the ability to manage pain intensity. Lastly, for item #13, the original negative expression 'something bad occurs' was transformed to 'something good occurs' reflecting a more positive perspective.

This resulted in a prototype 13-item scale that was then presented to three patient partners who live with chronic pain. Their responses were used to refine the items prior to formal testing of the scale. Following the application and modification of the items with support of the three patients, we developed a new tool, the 13-item of the Pain Resilience and Optimism Scale (PROS) (see Table 8).

Table 8. Prototype (column 1) and revised (column 2) items on the new scale based on feedback from patient partners.

Reversed 13-item of the PCS	**Pain Resilience and Optimism Scale (PROS)**
When thinking about the pain that resulted from my injury or trauma…	*When thinking about the pain that resulted from my injury or trauma…*
#01. I hope to be free from the pain in the end.	#01. I am confident that the pain will get better.
#02. I believe that I can continue my life as usual.	#02. I am optimistic about my future.
#03. It’s tolerable and I believe that it’s going to get better soon.	#03. Even though the pain may be bad, I can tolerate it at this level.

#04. It's not a big deal and I feel that I can cope with it.	#04. Even when the pain is bad, I can still do the important things that I need to do in my day.
#05. I feel I am strong enough to endure the pain.	#05. I can endure this much pain without requiring extra help from others.
#06. I become hopeful that the pain will get better.	#06. I remain optimistic even when the pain gets bad.
#07. I can easily keep away from thinking about other painful events.	#07. I do not tend to dwell on other painful experiences from my past.
#08. I have no doubt that the pain will go away.	#08. I can patiently wait for the pain to get better.
#09. I can easily keep it off of my mind.	#09. I can ignore my pain for a short time when I need to.
#10. I believe this hardship will make me stronger.	#10. By confronting and understanding the pain, I will get stronger.
#11. I believe I will be the one who has a strong belief that I can overcome any painful experiences.	#11. I can reassure myself that the pain will get better.
#12. I believe there's something that I can do to control the intensity of the pain.	#12. I have strategies I can use to reduce the intensity of the pain when I need to.
#13. I believe that something good will happen to me.	#13. Despite the pain, I am confident that nothing serious is going to happen to my body.

Thoughts and opinions from the three people living with chronic pain.

The partners identified issues related to all aspects of the scale, including the title. They noted potential issues of ableist language (e.g., that people in pain just need to 'push through') in the new scale and suggested alternatives. They also expressed potential concern that people in pain may be hesitant to endorse some items because it could give the impression that they do not in fact need help for their pain. These and other considerations were used to revise the items.

Response options

The PCS uses a five-point Likert scale ranging from 0 to 4, with 0 being “Not at all” and 4 being “All the time.” We note that the response structure of the PCS arguably conflates magnitude (to a slight degree, to a great degree) with frequency (all the time) in its options, potentially leading to ambiguity in selecting the appropriate response or interpreting scores. For the new scale we opted for an agreement-based scale instead, consistent with the theme of “beliefs and cognitions” being captured. It was important that the levels of distinction be meaningful and as unambiguous as possible, accordingly we reduced the number of options for 5 on the PCS to 4 on the new tool, as we were unable to identify a meaningful and clearly distinct level of agreement to sit between ‘slightly’ and ‘moderately.’ Accordingly, the new response structure is a 4-level scale with the options of “none (not at all)”, “slightly”, “moderately”, and “strongly” agree. The PROS begins with the prompt, "When thinking about the pain that resulted from my injury or trauma…" and in its prototype form summed scores can range from 0 (no sense of one’s resilience or optimism in the face of pain) to 39 (strong sense of one’s resilience and optimism in the face of pain).

3.3 Discussion

Since the emergence of positive psychology, significant attention has been directed towards a novel approach that emphasizes strengths rather than psychopathology. In pain research, the preponderance of scales is intended to capture how negative the experience of pain is perceived, with a clearly representative and popular example being the Pain Catastrophizing Scale (PCS). However, it is important to note that the PCS solely focuses on the negative aspects of pain experiences, thereby excluding potential benefits for people living with pain participating in clinical research. I have attempted to reorient the items of the PCS into a positive valence through a process of reverse-wording and mapping to a new theoretical framework of post-traumatic resilience. According to the models of positive psychology, I expect that presenting items with a more positive orientation will reduce the possibility of a respondent experiencing negative emotions just by reading the items of the PCS.

This chapter presents a novel framework, the Post-traumatic Resilience and Optimism (PTRO) framework, which has been proposed and summarized. This framework highlights that the trajectories of patients with pain differ based on their levels of positive psychological factors such as resilience and optimism, as well as psychopathological factors such as fear of pain and pain catastrophizing. The new framework was used to guide the development of items for the new scale, though it is important to note that the framework itself has yet to be subject to rigorous peer review. It was developed owing to a recognition that there were few existing resilience models that could be easily applied to MSK trauma, although what models were available in other fields did appear to contain some similar components that were then integrated into the PTRO model. Whether this is an accurate and testable model for predicting outcomes of MSK trauma remains to be seen and is a good direction for future research.

Regarding the development of an initial set of items for the PROS, two researchers (WS & DW) transformed the negative wording of PCS items into positive ones. Next, we engaged with three people with lived experience of chronic pain to identify potential issues in interpretation or acceptability of the items. Their comments, not intended to be formally analyzed but rather to guide the research development of the scale, contributed to a series of revisions that appear to retain the conceptual mapping to the PTRO while being potentially more acceptable to potential future respondents.

The process of creating the new scale also permitted some corrections to potentially problematic item structure on the original PCS. One example is the word ‘and’ in items 3 and 4, making those double-barreled questions, meaning respondents need to consider both statements when answering, and if they agree with one part and not the other it's hard to respond. Thus, we have removed the 'ands' and tried to think more about the conceptual meaning of the items - what are they getting at? We came up with the idea for the item 3 to capture the aspect of how people perceive their ability to tolerate pain, which influenced the way we worded it. It is essential to emphasize that we do not intend to be dismissive of the pain people experience. Therefore, we revised the item 3, ‘Even though the pain may be bad, I can tolerate it at this level,' to acknowledge that we

recognize the pain's severity while also aiming to understand people's confidence in managing it.

As for item #7, the PCS item is 'I keep thinking of other painful events', and in our conceptual interpretation the researchers were mapping that question to ruminating about prior painful experiences and how bad those were, and that thinking of those sorts of 'defeats' in the past makes the current pain experience worse. We tried to reverse this by phrasing it as though the person feels resilient because they have made it through prior painful events. Thus, the item is rephased as "I do not tend to dwell on other painful experiences from my past".

An important consideration for the next step of research on this tool is the possibility that this could come off as dismissive or patronizing, or in an unintended way it is possible that the reversed items could make people feel worse about themselves if they are disagreeing with these statements. This raises the possibility that people may feel worse because they disagree with all those positive statements and are being reminded of what they lack or have lost. One way to address the issue may be by reducing the number of items – it is recognized that the original PCS has a lot of redundant items in it (Walton, Mehta, Seo, & MacDermid, 2020); thus, it is possible this new scale could be reduced to as small as 4 or 5 questions in line with previous work with the PCS (Walton et al., 2020).

3.4 Conclusion

This chapter describes the initial development of a new 13-item instrument known as the Pain Resilience and Optimism Scale (PROS). In the subsequent chapter, the entire set of items will be administered to a large sample of people with chronic pain, and responses will be subjected to data analysis to determine its underlying factor structure. Important properties such as floor and ceiling effects, interpretability, factor structure, internal consistency, and convergent validity are described in the next chapter.

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Chapter 4

4 Validation of the Pain Resilience and Optimism Scale (PROS)

4.1 Introduction

Numerous measurement instruments are utilized in pain research, yet a substantial proportion of them primarily capture negative emotions and/or thoughts associated with pain such as the Pain Catastrophizing Scale (Sullivan, Bishop, & Pivik, 1995) and the Traumatic Injuries Distress Scale (Walton et al., 2016). To adopt a positive psychology perspective in assessing pain, the preceding chapter endeavored to develop a pain questionnaire that encompasses the positive aspects of pain. As part of this effort, an initial set of 13 items was constructed, giving rise to the Pain Resilience and Optimism Scale (PROS). However, it is imperative to subject these newly formulated items to rigorous validation procedures, employing a comprehensive range of scientific methodologies. This validation process is necessary to ensure the scale is providing information on the construct that it is intended to measure.

In this study, the items developed in Chapter 3 were explored for reliability and validity by conducting item-total correlation analysis, exploratory and confirmatory factor analysis, internal reliability and criterion-related associations using data provided by a sample of Canadian military veterans with chronic pain and comparing those results against predicted hypotheses.

The hypotheses for this study were as follows: (1) The initial 13 items of the PROS were expected to demonstrate a two-factor structure, one related to pain resilience (feelings related to coping with the current situation) and the other related to pain optimism (expectations for a positive future); (2) The two-factor structure would be confirmed through cross-validation using confirmatory factor analysis (CFA); (3) The PROS was expected to show a significant negative association with the 4-item PCS and BPI of magnitude -0.40 to -0.60, indicating a moderate negative (inverse) association; and (4) people living with chronic pain were qualitatively expected to express greater preference for the PROS over the PCS when participating in a pain survey.

4.2 Methods

Participants

The PROS was included as part of a battery of questions and other standardized self-report questionnaires administered through an online survey platform (Qualtrics Inc.). Not all questionnaires were included in this analysis (describe below).

Participants were recruited through targeted electronic advertisements to groups comprised entirely or partly of Canadian military veterans with chronic pain, including email lists, Facebook or other social media groups, and newsletters of groups or associations. Owing to the broad recruitment strategy, it was not possible to track how many totals, unique, members of the target population may have seen the advertisement and/or clicked on the link. Inclusion criteria were any former member of any branch of the Canadian military, at least 18 years of age who self-identified as having chronic pain (loosely defined as pain that occurred on most days of every week for at least the past 3 months). Participants needed to be fluent in English or French at a grade 6 level. Participants were able to save their progress and complete it later and completed the entirety of the survey independently without oversight by the research team. Participants could only complete the survey once. Ethics approval was obtained from the Research Ethics Board of Western University (London Ontario), and participants provided implied consent through survey participation. No remuneration was offered to participants.

Measurement tools

PROS (Pain Resilience and Optimism Scale). Development of the PROS was described in the prior chapter. Participants rated their agreement with each item on the tool using a four-point scale ranging from 0 (do not agree at all) to 3 (strongly agree), with higher scores indicating greater resilience and optimism towards pain.

PCS-4 (Pain Catastrophizing Scale). To examine concurrent validity, the Pain Catastrophizing Scale (PCS) was included in the study. The PCS was developed to gauge

a level of pain catastrophizing (Sullivan, Bishop, & Pivik, 1995). The PCS is a tool designed to assess this concept, encompassing dimensions of helplessness, magnification, and rumination in response to pain. Respondents rate each item on a 5-point Likert scale, with the options ranging from 0, indicating "not at all," to 4, representing "all the time." To reduce respondent burden, we utilized a shorter version of the PCS scale (PCS-4; Walton, Mehta, Seo, & MacDermid, 2020) in this study. The PCS-4 comprises four items (4, 9, 10 and 11 of the original PCS). Previous research has demonstrated the PCS-4's good content validity, construct convergent validity, and criterion validity in people with chronic pain, showing a correlation of $r = 0.94$ ($p < .01$) with the full version of the scale. The PCS-4 has been found to exhibit similar associations with disability and pain outcomes as the full-length scale (Walton et al., 2020).

BPI-SF (Brief Pain Inventory – Short Version). Initially, the Brief Pain Inventory (BPI) was designed to evaluate the severity of pain and its impact on cancer patients and to assess the efficacy of analgesic interventions in this population (Cleeland, & Ryan, 1994; Cleeland, 2009). However, research has demonstrated its validity in evaluating pain in non-cancer patients as well (Keller et al., 2004). There are two versions of the BPI scale available: a lengthy version (BPI-LF) utilized as a baseline measure in clinical trials and a shorter version (BPI-SF) that has been adopted as the standard for clinical and research purposes (Cleeland & Ryan, 1991). In the current study, we employed the short form of the BPI scale, providing two subscales of Pain Severity and Pain Interference each rated on a scale from 0 (no pain or interference) to 10 (worst possible pain or interference).

Statistical Analyses

Descriptive Analyses and Data Cleaning

Firstly, the researchers conducted descriptive statistics and item-total correlation analysis for the initial 13-item PROS. In this stage, outliers would be removed based on mahalanobis distance. Upon removing cases with missing data from the analysis, the remaining participants were randomly divided into two groups: one for conducting

exploratory factor analysis (EFA, n = 155) and the other for confirmatory factor analysis (CFA, n = 160).

Exploratory Factor Analysis

EFA was conducted using Maximum Likelihood Estimation (MLE) with oblimin rotation. Sampling adequacy was first determined through Kaiser-Meyer-Olkin factor adequacy (KMO) and Bartlett's Test of sphericity. Assuming adequate sampling, criteria for number of factors to retain were based on: a new criterion of > 0.7 (Jolliffe, 2002) instead of Kaiser's eigenvalue > 1.0 criterion (Kaiser, 1960), Horn's Parallel Analysis (Horn, 1965), and fit with the theoretical PTRO framework. Jolliffe (2002) proposed an adjusted Kaiser rule with a cutoff value of 0.7. This modification is recommended based on simulations, which indicate that the original Kaiser rule might result in the selection of too few variables. Parallel analysis is generally considered a more conservative approach to extracting factors compared to the eigenvalue > 1.0 criterion (Horn, 1965), though when both provide similar results confidence in the true factor structure is increased. The exploratory factor analysis (EFA) was carried out in R using the 'psych' and 'GPArotation' libraries (rotation: oblimin; fm: ml).

Cross-loaded items were identified as those with factor loadings of 0.32 or greater on more than one factor, while misfitting items were identified as those with very low commonalities or that did not load on any factor at > 0.32 (Tabachnick & Fidell, 2014). Where poor functioning items (cross-loaded or misfitting) were identified, those items were interpreted against the theoretical framework, and if appropriate were removed and the factor structure of the remaining scale retested in the same sample. Scale variance explained by the extracted factors and internal consistency (Cronbach's alpha; Cronbach, 1951, or McDonald's omega; McDonald, 1999) were also used as an omnibus indicator of fit to the latent construct. Alpha or Omega values of between 0.75 and 0.95 have been previously endorsed as indicating acceptable internal consistency for group-level comparisons while limiting redundancy. As for McDonald's Omega coefficient, the test of tau equivalence assesses whether the items in a test or scale are tau-equivalent,

meaning they have equal factor loadings and equal uniquenesses (Zhang & Yuan, 2016). The tau test was carried out in R using the 'coefficientalpha' library.

Confirmatory Factor Analysis

The factor structure identified in EFA was then brought forward for validation in CFA using the remaining N = 160 participants. Confirmatory factor analysis (CFA) was conducted in R using the 'lavaan' and 'semPlot' libraries. The first model tested was precisely mapped to the EFA findings. The goodness-of-fit was evaluated through various statistical measures, including the chi-square test of exact fit, the Root Mean Squared Error of Approximation (RMSEA), the Comparative Fit Index (CFI), and the Tucker-Lewis Index (TLI). In terms of model fit, Hu and Bentler (1999) suggested that lower value of RMSEA indicates a better fit, with values below 0.06 and 0.08 being deemed acceptable. Conversely, higher values of CFI and TLI, closer to 1, indicate a better fit, with values above 0.95 indicating a good fit. The ratio chi-square/degrees of freedom (Normed Chi-square; NC) was also calculated, and some researchers from their experiences proposed a chi-square/df ratio less than 2 or 3 indicates an acceptable model (Bollen, 1989; Kline, 1998). Where indicators were poor, modification indices (MI) were explored to determine if two or more items may be locally dependent and would therefore benefit from correlated residual (error) terms. If doing so significantly improved model fit, a decision was necessary regarding whether to retain both items, acknowledging that they are not independent observations, or to remove one and retest the model. This was determined on a case-by-case basis through collaboration between authors.

Concurrent Validity

Upon achieving adequate fit through EFA and CFA, the new scale was then tested against a priori hypotheses related to anticipated associations with other established questionnaires. Correlations between the PROS, including the full-scale score and any subscales scores, were calculated for the BriefPCS-4 and the BPI Severity and Interference subscales. Assuming at least one PROS subscale of 'Resilience' and one of 'Optimism,' I hypothesized a significant negative association with each of the BriefPCS-

4 and BPI subscales of magnitude -0.40 to -0.70, indicating a moderate to strong negative (inverse) association.

Patient Partner feedback

As an extra step to explore usability, a separate advisory group of people living with pain, were invited to review the PROS and the full PCS and to qualitatively indicate their preference. A simple one-or the other voting system was implemented, along with an open-ended question that was subsequently analyzed through simple qualitative interpretation. It was anticipated that a minimum of 50% of the respondents would express a preference for the PROS over the PCS.

The question was “The following pages contain two different questionnaires that a healthcare provider might use to start exploring the emotional impacts of your pain and that could be used to track change in your emotional state over time. You may note that they are both 13 questions long and are almost mirror opposites of each other. If a provider was going to use one of these, which would you prefer to complete and why? – Note: Q1 was the PCS, Q2 was the PROS.”

4.3 Results

Descriptive Analyses and Data Cleaning

The survey was started by 328 potentially eligible participants, of which 315 completed 100% of the PROS tool and were included in this analysis. Table 9 provides descriptions of the overall sample, and of the two randomly assigned samples for EFA and CFA, respectively.

Table 9. Demographic information and study data

		EFA (N = 155)	CFA (N = 160)
Age		M = 54.64 (SD = 10.15)	M = 54.14 (SD = 11.46)
Sex	Male	93 (62.8%)	107 (71.8%)
	Female	55 (37.2%)	42 (28.2%)
Pain Severity / 10 (mean, range)		6.81 (0 to 10)	5.89 (0 to 10)
Pain Interference / 10 (mean, range)		7.60 (0 to 10)	6.77 (0 to 10)
PCS-4 (mean, range)		3.41 (1 to 5)	3.37 (1 to 5)

The sample for EFA was predominantly male (62.8%) with a mean age of 54.6, and mean Pain Severity was 6.8/10 and Pain Interference was 7.6/10. The sample for CFA was predominantly male (71.8%) with a mean age of 54.1 and mean Pain Severity was 5.9/10 and Pain Interference was 6.8/10. Based on the frequency of each response option on each item, no ceiling/floor effect were detected (Table 10 and 11).

Table 10. PROS item descriptives - Frequency (%) on each item (Sample 1)

Sample 1	Response options (4-point Likert scale)				Mean	Median
N = 155	0	1	2	3	0	
Item #1	83 (53.6)	43 (27.7)	23 (14.8)	6 (3.9)	0.7	0
Item #2	28 (18.1)	59 (38.1)	58 (37.4)	10 (6.5)	1.3	1
Item #3	22 (14.2)	69 (44.5)	56 (36.1)	8 (5.2)	1.3	1
Item #4	46 (29.7)	62 (40.0)	33 (21.3)	14 (9.0)	1.1	1
Item #5	38 (24.5)	64 (41.3)	35 (22.6)	18 (11.6)	1.2	1

Item #6	41 (26.5)	65 (41.9)	35 (22.6)	14 (9.0)	1.1	1
Item #7	31 (20.0)	60 (38.7)	42 (27.1)	22 (14.2)	1.4	1
Item #8	42 (27.1)	72 (46.5)	32 (20.7)	9 (5.8)	1.1	1
Item #9	26 (16.8)	68 (43.9)	38 (24.5)	23 (14.8)	1.4	1
Item #10	33 (21.3)	57 (36.8)	47 (30.3)	18 (11.6)	1.3	1
Item #11	57 (36.8)	58 (37.4)	30 (19.4)	10 (6.5)	1.0	1
Item #12	18 (11.6)	62 (40.0)	53 (34.2)	22 (14.2)	1.5	1
Item #13	52 (33.6)	46 (29.7)	43 (27.7)	14 (9.0)	1.1	1

Table 11. PROS item descriptives - Frequency (%) on each item (Sample 2)

Sample 2	Response options (4-point Likert scale)				Mean	Median
N = 160	0	1	2	3		
Item #1	82 (51.3)	53 (33.1)	22 (13.8)	3 (1.9)	0.7	0
Item #2	32 (20.0)	72 (45.0)	45 (28.1)	11 (6.9)	1.2	1
Item #3	21 (13.1)	66 (41.3)	58 (36.3)	15 (9.4)	1.4	1
Item #4	52 (32.5)	52 (32.5)	44 (27.5)	12 (7.5)	1.1	1
Item #5	53 (33.1)	57 (35.6)	34 (21.3)	16 (10.0)	1.1	1
Item #6	43 (26.9)	66 (41.3)	40 (25.0)	11 (6.9)	1.1	1
Item #7	34 (21.3)	57 (35.6)	45 (28.1)	24 (15.0)	1.4	1

Item #8	42 (26.3)	64 (40.0)	48 (30.0)	6 (3.8)	1.1	1
Item #9	22 (13.8)	55 (34.4)	57 (35.6)	26 (16.3)	1.5	2
Item #10	29 (18.1)	65 (40.6)	44 (27.5)	22 (13.8)	1.4	1
Item #11	57 (35.6)	59 (36.9)	36 (22.5)	8 (5.0)	1.0	1
Item #12	18 (11.3)	56 (35.0)	63 (39.4)	23 (14.4)	1.6	2
Item #13	59 (36.9)	59 (36.9)	28 (17.5)	14 (8.8)	1.0	1

As for the item-total correlation coefficients of the PROS items, each correlation coefficient ranges from .53 to .76, which means that there are no problematic items in terms of the item appropriateness.

Exploratory Factor Analysis

From the initial sample of 166 participants in Sample 1, eight participants were excluded due to incomplete data with any missing values, while three participants were removed for being outliers based on the mahalanobis distance. Consequently, a total of 155 participants were included in the analysis of the EFA. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy was found to be 0.90 and Bartlett's test was significant (X^2 = 989.2972, df = 78, $p < 0.001$), indicating a sufficient sample for conducting factor analysis. A Scree plot of the eigenvalues as well as Parallel Analysis, suggested that a two-factor structure was appropriate for the sample (Figure 3).

The initial factor structure including all 13 items presented statistical and conceptual ambiguity. Items 9 ('I can ignore my pain for a short time when I need to'), 7 ('I do not tend to dwell on other painful experiences from my past'), and 6 ('I remain optimistic even when the pain gets bad'), in that order, each exhibited weak but potentially important cross-loading (loadings ≥ 0.32 and ≤ 0.47), suggesting that each may be

tapping more than one construct but not strongly. Owing to a desire for simplicity, those items were removed, one at a time, and the factor structure retested. This resulted in a 10-item scale with two meaningful factors explaining an overall 55% in scale variance. The final factor loadings are shown in table 12, with the factors labelled: Pain Optimism (37% of scale variance) including items 1, 2, 8, 10, 11, 12, 13; and Pain Resilience (18% of scale variance) including items 3, 4, 5. This structure showed good fit both statistically and with the theoretical framework. The correlation coefficient between two subfactors was r = 0.50 ($p < .01$).

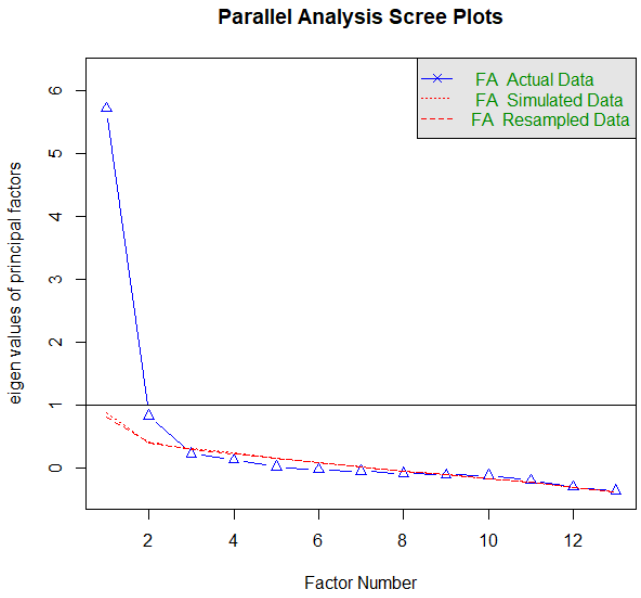

Figure 3. The result of Parallel Analysis

Table 12. Final factor loadings of EFA

	Factor 1	Factor 2	Communality
Item #11	0.92	-0.05	0.80
Item #10	0.73	-0.06	0.50

Item #1	0.70	-0.09	0.44
Item #8	0.63	0.19	0.55
Item #12	0.63	-0.02	0.38
Item #13	0.62	0.10	0.46
Item #2	0.62	0.21	0.56
Item #4	-0.06	0.86	0.69
Item #5	0.05	0.71	0.55
Item #3	0.28	0.54	0.52

Reliability

The robust F statistic was calculated to be 1.525 (p = .03). These findings suggest that the items do not exhibit tau equivalence. The Omega coefficient was 0.91, indicating acceptable internal consistency.

Confirmatory Factor Analysis

The factor structure from the EFA was then tested again using the independent data from Sample 2 (n = 160).

The model fits exhibited poor fit, with the exception of the NC (less than 3), for which the TLI was 0.848, CFI was 0.885, and RMSEA was 0.095. The Modification Indices (MI) suggested that the model fit could be improved by correlating the residuals between item #1 and #11 (MI = 18.062), as the two items shared similar content, relating to patients' confidence in their pain improving over time. After setting covariance between

item #1 and #11 of the data, we reconducted CFA and the model fit remained inadequate (TLI = 0.897; CFI = 0.924; and RMSEA = 0.078). None of the MIs indicated that further residual correlation would lead to meaningful change in model fit. When no covariance settings, the standardized path coefficients for these items are 0.522 and 0.752, respectively, and their R-squared values are 27.3% and 56.6%, respectively. As a result, we opted to exclude item #1. After conducting the analysis without item #1, the model fit improved, but it remained below an acceptable level. Further examination of the modification indices indicated potential issues with the local independence of items #10 and #11. Given that both items displayed similar path coefficients and R-squared values, we decided to introduce a correlation between the error terms for item #10 and item #11.

However, introducing covariance between each error term makes it challenging for clinicians and practitioners to interpret the results of the tool, particularly in determining the appropriateness of summing up all the items, even with covariate variables. Therefore, we explored an additional model in which one of the items, either #10 or #11, was removed. Item #10, which reads, "By confronting and understanding the pain, I will get stronger," may not be well-understood by people living with chronic pain when they attempt to confront it. Consequently, we considered removing item #10 based on the modification indices. The final, two subfactor model with removals of item #1 and #10 showed good model fits which were: TLI = 0.958, CFI = 0.972, and RMSEA (90% C.I.) = 0.052 (0 – 0.092) (Table 13). This was considered the final factor structure, based on statistical and conceptual alignment.

Table 13. Model fit indices on each model

Pain Optimism	Pain Resilience	NC (χ^2/df)	TLI	CFI	RMSEA (90% C.I.)
#1, 2, 8, 10, 11, 12, 13	#3, 4, 5	82.662*** / 34 / p < .001 / 2.43	0.848	0.885	0.095 (0.069, 0.121)
#2, 8, 10, 11, 12, 13	#3, 4, 5	50.097** / 26 / p = .003 / 1.93	0.908	0.934	0.076 (0.043, 0.108)

Corr. 10 & 11 above	#3, 4, 5	37.624 / 25 / p = .05 / 1.50	0.950	0.965	0.056 (0, 0.091)
Removal of #10	#3, 4, 5	27.083 / 19 / p = .103 / 1.43	0.958	0.972	0.052 (0, 0.092)

Table 14. The final version of the PROS (eight items in total)

Subfactor 1: Pain Optimism (five items)
#02. I am optimistic about my future.
#08. I can patiently wait for the pain to get better.
#11. I can reassure myself that the pain will get better.
#12. I have strategies I can use to reduce the intensity of the pain when I need to.
#13. Despite the pain, I am confident that nothing serious is going to happen to my body.
Subfactor 2: Pain Resilience (three items)
#03. Even though the pain may be bad, I can tolerate it at this level.
#04. Even when the pain is bad, I can still do the important things that I need to do in my day.
#05. I can endure this much pain without requiring extra help from others.

Construct and Criterion Validity

To assess the concurrent validity, three variables were included in the dataset for computing correlation coefficients. The findings revealed significant correlations among PROS, PCS, and BPI, including within the subfactors of each variable. The PROS exhibited statistically significant negative correlation coefficients with the PCS-4, the prototype tool of the PROS ($r = -0.57$, $p < 0.01$). Consequently, it can be concluded that

the concurrent and convergent validity of the PROS construct have been supported (Table 15).

Table 15. Correlation among relevant variables

	PROS (Total)	PROS (Pain Optimism)	PROS (Pain Resilience)	PCS-4	BPI (Pain Severity)	BPI (Pain Interference)
PROS (Total)	1					
PROS (Pain Optimism)	.91**	1				
PROS (Pain Resilience)	.82**	.50**	1			
PCS-4	-.57**	-.50**	-.49**	1		
BPI (Pain Severity)	-.29**	-.24**	-.27**	.53**	1	
BPI (Pain Interference)	-.48**	-.34**	-.52**	.64**	.66**	1

Patient Preference

A total of 16 partners each living with pain of various etiologies for 5 years or longer, discussed the new PROS and the original PCS. The discussions revealed complicated relationships with pain scales for many of the partners, resulting in no clear single preference for one over the other.

The general consensus from the group was that standardized patient-reported scales can be useful components of a pain-related healthcare visit, especially ones that allow the patients to report on the more emotional aspects of their experience. However, the partners also acknowledged limitations, notably that not all items were relevant (e.g.,

items related to pain ‘getting better’ felt irrelevant or even marginalizing to those with progressive conditions), and that they felt as though there were ‘right’ answers they were expected to select and some expressed concern about how not selecting those may impact their care. That some respondents indicated that their preference of positive or negatively-worded scales would depend on their own mood at the time and the information they wanted their doctor to hear, indicates a potential for new thinking about how standardized scales are selected, applied, and interpreted for individual patients (Table 16).

Table 16. Group discussion

Group	**Group Discussion** (Q1: the PCS, Q2: the PROS)
Grp i	Prefer Q2. Q1 is a downer, which makes the pain feel worse and makes you dwell on your pain. Centre ‘ability’ rather than ‘disability.’
Grp ii	Prefer Q1. Q2 feels demeaning or dismissive. Q1 seemed more authentic to capture actual experience but was almost too negative. Neither were good, neither capture the experience of struggling to exist and get through the next day.
Grp iii	Q1 may be better when at a time when you are in a darker place, but Q2 may be better when you are in a more positive mood. Pain does not ‘get better.’ Q10 of the PROS asks two things on the questionnaire. (*Q10 is removed in the final version of the PROS)
Grp iv	Q2 was the better one but had never been encouraged to get in touch with bodies to reflect upon actual impacts of living in a painful body.

	No option for capturing experiences about taking time off to manage pain – what are we doing to manage pain?
	General Discussion
	Both questionnaires assume an episode of pain that is going to go away – not relevant for those with long term progressive conditions. Confronting – a phrase worth exploring further. (Q10 is removed) Not so much intended for the person asking the questions but were perhaps overly leading. ‘I feel I can’t go on,’ and ‘I feel I can’t stand it anymore’ – maybe good to include in Q2 as they should be used as flags for clinicians.

4.4 Discussion

Ensuring the well-being of patients with pain is an important objective in healthcare. Numerous tools have been utilized in pain research to better understand and address this challenging issue. Many of these tools consist of items with negative valence, potentially leading survey participants to experience negative effects solely by reading them. Adopting a positive psychology perspective, we have endeavored to address this limitation by developing a novel instrument called the Pain Resilience and Optimism Scale (PROS). To achieve this, we have reversed the items of the widely used Pain Catastrophizing Scale (PCS) to imbue them with a positive valence. By employing this innovative approach, we aim to enhance the participant's experience during survey completion, promoting a more positive outlook on pain resilience and optimism.

Through the examination of responses from Canadian military veterans on a series of questionnaires aimed at validating the Pain Resilience and Optimism Scale (PROS), a two-subfactor structure emerged. The initial subfactor, denoted as "Pain Resilience,"

encompassed a distinct set of items, and the remaining subfactor was labeled as "Pain Optimism." It is worth noting that the model fits for this structure were deemed acceptable, indicating a favorable correspondence between the proposed theoretical framework and the observed data.

Consistent with the findings of the preceding study conducted by Walton et al. (2020), the Pain Resilience and Optimism Scale (PROS), which is the reversed version of the Pain Catastrophizing Scale (PCS), revealed statistically significant negative correlation coefficients with regard to both subfactors of the Brief Pain Inventory – short version (BPI-SF) ($r = -0.29$, $p < 0.01$ with Pain Severity and $r = -0.48$, $p < 0.01$ with Pain Interference, respectively).

In general, the Pain Catastrophizing Scale (PCS) and the Pain Resilience and Optimism Scale (PROS) were preferred over the pain groups. It is imperative to not only capture the positive facets of pain experiences but also to evaluate their genuine negative dimensions. The findings from the discussion further suggested that an excessive emphasis on negative valence could lead to unfavorable consequences, similar to the limited effectiveness of an excessive focus on positive valence in improving patient well-being. Consequently, there is a need to strike a balance between both positive and negative valence when constructing a new questionnaire specifically tailored for people suffering from pain.

Concept mapping

Table 17 shows comparison of the results of the PCS-13, PCS-4, and PROS. Among them and examine the factor structure of each scale.

Table 17. Concept mapping

Instruments	Rumination (Sub 1)	Magnification (Sub 2)	Helplessness (Sub 3)
PCS-13 (Sullivan et al)	#8, 9, 10, 11	#6, 7, 13	#1, 2, 3, 4, 5, 12
PCS-4 (Walton et al)	(Unitary) #4, 9, 10, 11 A three-item (#9, 10, and 11) is from Rumination, which deems it's important to represent pain catastrophizing. It makes sense because catastrophizing can be derived from rumination.		
PROS (Seo & Walton)	(Pain Optimism) #2, 8, 11, 12, 13 / (Pain Resilience) #3, 4, 5 All the items of #3, 4, 5 in Pain Resilience come from Helplessness, which means 'Helplessness' may be more (negatively) correlated to resilience than other subfactor of the PCS. On the other hand, Pain Optimism subfactor include one or two items of each subfactor of the PCS-13.		

Walton and colleagues (2020) conducted a study aimed at developing a concise version of the Pain Catastrophizing Scale (PCS) through the implementation of Rasch analysis. The resultant abbreviated version, known as the PCS-4, encompassed items #4, 9, 10, and 11, which were selected from the original PCS-13. Notably, three of the items in the PCS-4 were originally categorized under the 'Rumination' subfactor of the PCS-13. This decision was motivated by the acknowledged correlation between catastrophizing (the primary focus of the PCS) and rumination (a subfactor of the PCS-13) (e.g., $r = 0.45$, $p < .01$; see study Chan, Chan, & Kwok, 2015). The objective of Walton et al.'s investigation was to develop a shortened version of the PCS-13; hence it can be inferred that the PCS-4 includes items that predominantly capture the construct of 'catastrophizing,' which is also closely associated with rumination. It is important to note that while rumination pertains to the contemplation of past negative experiences and emotions, catastrophizing centers around apprehensions of future threats, differing in the aspect of 'tense' (Chan, Chan, & Kwok, 2015). However, both concepts share a common

characteristic of persistently engaging in negative thinking, which has implications for the mental well-being of people experiencing pain.

In terms of the relationship between the PCS-13 and the PROS, it was observed that all the items belonging to the Pain Resilience subfactor in the PROS were encompassed within the 'helplessness' subfactor of the PCS-13, specifically items #3, 4, and 5. The items comprising the PROS were formulated by transforming the negative valence of the PCS-13 into positive valence. Consequently, a negative correlation is presumed to exist between the PCS and the PROS. However, based on the findings, it is plausible to suggest that the notion of 'helplessness' can be considered as an absence of 'resilience.'

A discussion among the pain groups of the Pain Patient Advocacy Group (PPAG) highlighted the sentiment that "Pain does not get better." It is noteworthy that items #8 and #11 in the Pain Optimism subfactor encompass the phrase "get better." While it may be true that pain does not necessarily improve in reality, it is important to recognize that this particular tool aims to assess patients' optimistic thoughts and feelings regarding their pain.

Chronic Thoughts, Recovery Thoughts, and the PROS (Positive valence).

Following the successful development and validation of the Pain Resilience and Optimism Scale (PROS), our attention was drawn to the Challenging Chronicity Thoughts Form introduced by Dr. Sullivan during the PSA World Pain Summit. Dr. Sullivan is recognized for his work on the Pain Catastrophizing Scale (PCS). In contrast to chronicity thoughts, which entail negative valences, recovery thoughts encompass positive valences. Notably, efforts have been made to incorporate the negative valences of items within the scale. Table 18 provides a comprehensive overview of the items comprising the Chronicity thought, Recovery thought, and PROS for reference.

Table 18. A comprehensive overview of the items comprising the Chronicity thought, Recovery thought, and PROS for reference.

No.	Type	Items (A: Chronic thought, B: Recovery thought, and C: PROS (Positive valence)
6	A	I become afraid that my condition will get worse.
	B	I am confident that my condition will improve.
	C	I remain optimistic even when the pain gets bad.
5	A	I feel I can't stand it anymore.
	B	I will deal with this the same way I have dealt with other major challenges in my life.
	C	I can endure this much pain without requiring extra help from others.
9	A	I can't seem to keep (my condition/symptoms) out of my mind.
	B	If I stay busy, I can turn my attention away from my conditions/symptoms.
	C	I can ignore my pain for a short time when I need to.
12	A	There's nothing I can do to reduce the intensity of my symptoms.
	B	I am confident that I will learn ways of effectively managing the symptoms of condition.
	C	I have strategies I can use to reduce the intensity of the pain when I need to.
13	A	I wonder whether something serious may happen.
	B	I am confident that nothing serious will happen.
	C	Despite the pain, I am confident that nothing serious is going to happen to my body.
4	A	My symptoms are awful and I feel that they overwhelm me.
	B	My symptoms are challenging but I know that I will learn to deal with them.
	C	Even when the pain is bad, I can still do the important things that I need to do in my day.
1	A	I worry all the time about whether my symptoms will end.

	B	There are more important things to do with my time than worry about whether my symptoms will end.
	C	I am confident that the pain will get better.

Recovery thoughts and the PROS share notable similarities, as they both emphasize positivity. However, it is important to highlight that the PROS has undergone validation using rigorous scientific methods. Nevertheless, it is commendable that efforts have been made to transform certain negative aspects and psychopathology-focused elements into positive constructs. This approach holds promise in terms of benefiting study participants, particularly people experiencing pain.

In a study conducted by Walton et al. (2020), the Rasch model, also known as the one-parameter item response theory, demonstrated the effective assessment of pain catastrophizing using a concise four-item Pain Catastrophizing Scale (PCS). In a similar vein, the initial development of our Pain Resilience and Optimism Scale (PROS) comprised 13 items derived from the PCS, with their polarity reversed to reflect positive valences. As a result, it is logical that the final version of the PROS consists of only eight items.

The inter-correlation between the two subfactors, Pain Optimism and Pain Resilience, was found to be strong ($r = 0.5$, $p < .01$), indicating that optimism and resilience explain nearly 25% of the variance in each other. Previous research has consistently shown significant correlations between resilience and optimism, ranging from 0.38 to 0.48. However, it is important to note that the measurement tools used in each study were different. In this particular study, both 'pain' resilience and optimism were highly related. In fact, conceptually, they are quite similar as positively oriented psychological variables. They share common characteristics, and there is no clear distinction between the two.

Several limitations should be acknowledged within this study. Firstly, due to the utilization of data collected from a large-scale cohort study, the number of questionnaires that could be included for the examination of validity was constrained. Furthermore,

despite gathering data from over 300 participants, the dataset had to be divided into two subgroups for the purpose of conducting exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) separately. Although efforts were made to adhere to recommended sample size guidelines based on previous research, it is important to recognize the potential for the results of the factor analysis to be influenced by sample size-related considerations, leading to possible over- or underestimation.

However, the development of the PROS holds considerable utility, as it has been designed through the adoption of a positive psychological lens. By reversing the items of the Pain Catastrophizing Scale (PCS), a widely employed tool in pain research characterized by its negative valence, the PROS introduces a novel approach with a positive valence. This innovative instrument effectively measures both resilience and optimism towards pain within a single scale, delineating them as two distinct yet interconnected subfactors ($r = 0.5$, $p < .01$). Thus, the PROS offers a comprehensive assessment that encompasses both resilience and optimism, providing valuable insights into people's responses to pain experiences.

In pain research, it is important to minimize the burden on patients with pain when they participate in surveys. This new tool for assessing resilience and optimism in patients with pain is not only free, but also short, and convenient to use. The researchers hope this new tool helps measure and even enhance positive psychological components such as resilience and optimism of the patients with pain, who participated in a study.

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Chapter 5

5 Conclusion

5.1 Summary

Chronic pain imposes a significant burden on the people experiencing it, those who support them, and society at large. Pain specialists have exerted considerable efforts to comprehend and support people living with chronic pain. Self-report questionnaires serve as valuable tools for capturing patients' subjective experiences pertaining to their pain. Within the framework of psychopathology, various measures such as the Pain Catastrophizing Scale (PCS; Sullivan, Bishop, & Pivik, 1995) and the Traumatic Injuries Distress Scale (TIDS; Walton, et al., 2016) assess the adverse dimensions of pain. By virtue of the preponderance of negatively-worded pain scales, it is conceivable that participants in pain surveys may be prompted to recollect and relive traumatic experiences.

In South Korea, certain studies utilizing "well-being cognition techniques" have demonstrated that exposure to positive sentences or valence can cultivate a more positive mindset and alleviate distress (Min, Kim, & Kim, 2014; Kim, & Eun, 2010). Consequently, these findings indicate that incorporating positive stimuli in pain surveys can potentially benefit patients by promoting positive functioning.

The first objective of this thesis was to assess the psychometric properties of the Connor-Davidson Resilience Scale (CD-RISC). Although the CD-RISC, including both a 10-item and the original 25-item version, has been extensively employed in studies related to resilience, its ability to accurately measure resilience in MSK trauma has raised doubts. Consequently, a systematic review was conducted employing the COSMIN checklist, which serves as a tool for examining the psychometric properties of a specific measure.

Study 1 (chapter 2) presents findings that suggest the CD-RISC may not be efficient in measuring resilience within a trauma context. These results highlight the need for the development of a new tool, tentatively named the Post-traumatic Resilience Scale. In line with the emergence of positive psychology, optimism is also considered a promising

factor to explore in relation to trauma, as it can potentially mitigate the aftermath of traumatic events.

Study 2 (chapter 3) demonstrates the process of developing initial items for the newly proposed tool, the Pain Resilience and Optimism Scale (PROS), based on the theoretical framework of Post-traumatic Resilience and Optimism (PTRO), which was established in a previous work (Seo & Walton, in progress). The PTRO framework suggests that positive psychological variables, such as resilience and optimism, can moderate the trajectories of pain, leading to either exacerbation or mitigation. The Pain Catastrophizing Scale (PCS), widely used in pain research, consists of 13 items that reflect the negative aspects of pain phenomena. In the initial step of developing items for the PROS, the researchers (Seo & Walton) reversed the negative items of the PCS into positive valence. Subsequently, three people living with chronic pain reviewed all the items and provided feedback to the researchers. Incorporating the opinions of these people, a final version of the 13-item PROS in this phase was created.

Study 3 (chapter 4) focuses on the validation of the 13-item Pain Resilience and Optimism Scale (PROS). A sample of Canadian military veterans was used for a series of statistical analyses, including correlation analysis, exploratory factor analysis, and confirmatory factor analysis. Consequently, a refined version of the scale was derived, consisting of eight items in total, which were categorized into two subfactors: Pain Optimism (5 items) and Pain Resilience (3 items). It is worth noting that the initial items of the PROS were derived from the Pain Catastrophizing Scale (PCS) by reversing the negative valence into a positive valence. In a study conducted by Walton et al. (2020) aiming to develop a short version of the PCS, the findings indicated that a four-item version of the PCS adequately measured pain catastrophizing instead of the entire 13-item version. In line with this finding, the validation analyses of the PROS also demonstrated that the initial 13-item scale could be reduced to only eight items. Finally, the concurrent validity has been supported through a statistically significant negative correlation ($r = -0.57$, $p < 0.01$) between the PROS and the PCS-4.

5.2 Future Directions

Once a new questionnaire is developed, it is essential to establish its reliability and validity through replication. To further enhance the psychometric properties of the PROS, future studies may benefit from incorporating Item Response Theory (IRT) frameworks, such as 1-parameter models or Rasch analysis. By utilizing IRT models, the PROS can establish more rigorous psychometric properties, including item-level analyses, item difficulty, and discrimination parameters, which enable precise measurement of the latent construct being assessed. Integrating IRT into the evaluation of the PROS would offer valuable insights and improve the overall measurement precision of the questionnaire.

Numerous studies have provided compelling evidence that resilience and optimism can be cultivated, resulting in the enhancement of people's positive psychological attributes. The introduction of the Pain Resilience and Optimism Scale (PROS) holds significant promise as a valuable tool for identifying people who possess comparatively high levels of resilience and optimism. This, in turn, holds the potential to facilitate improved prognoses for people experiencing pain. Conversely, by employing the PROS to screen people with low levels of resilience and optimism, practitioners can promptly intervene and provide appropriate support. Armed with this valuable information, targeted interventions aimed at bolstering resilience and optimism can be devised for people exhibiting relatively lower levels of these qualities, thereby preventing further deterioration. Moreover, it would be worthwhile to explore the establishment of a "cut-off" score for the implementation of the PROS, as this could serve as a valuable means of identifying vulnerable people who stand to benefit the most from such interventions.

5.3 Conclusions

In this thesis, the primary objective was to assess the psychometric properties of the Connor-Davidson Resilience Scale (CD-RISC) in the context of post-trauma situations. The systematic review conducted using the COSMIN checklist revealed doubts about the CD-RISC's ability to accurately measure resilience in trauma settings. As a result, a new

tool, tentatively named the Post-traumatic Resilience Scale, was proposed for development.

It was expected for people living with chronic pain to prefer the PROS to the PCS; however, the findings showed that some people liked the PROS, and some preferred the PCS; and still others gave a response, ‘it depends on my mood at the time.’ Thus, since it is unclear which one between the PCS and the PROS is the more preferred tool for people living with chronic pain, further studies are needed. For example, researchers may conduct a series of experimental intervention to manipulate participants’ mood (e.g., being neutral).

In summary, this thesis has highlighted the limitations of the CD-RISC in post-trauma resilience measurement and proposed the development of a new tool, the PROS. The validation of the PROS demonstrated promising psychometric properties, paving the way for future research to enhance its reliability and validity through replication and the application of advanced measurement models in the field of pain resilience and optimism.

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