EXAMINING CONDITIONED PAIN MODULATION IN NON-ELITE AND ELITE ROCK CLIMBERS: THE INFLUENCE OF PAIN COPING STRATEGIES AND COGNITIVE APPRAISAL

by

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Abstract

The physical demands of rock climbing combined with climber’s verbal reports suggest that this sport requires participants to cope with pain. Recent athlete pain studies have used Conditioned Pain Modulation (CPM), a measure of pain that quantifies the amount that one painful sensation downregulates other painful sensations. This research has focused on traditional-sport athletes such as runners and has neglected adventure sport athletes such as climbers. Furthermore, the influence of pain coping strategies and appraisals on CPM have not been clarified. This study examined how elite and novice climbers experience, cope with, and appraise pain by examining CPM in a laboratory test. In addition, coping and appraisals for the pain during the CPM test were compared to coping and appraisals of a recent painful climb to examine if the situations elicited similar responses. Elite climbers (n=27) demonstrated higher CPM (p<.01) and higher baseline pain tolerance (p<.05) than novice climbers (n=26). Novice climbers reported using higher distraction coping strategies than elite climbers in both the CPM test and during a recent painful climb (p<.05). Elite climbers reported more control over pain during a recent painful climb (p<.01). Despite group differences, distraction coping was not linearly correlated to CPM. Intraclass correlation analysis showed that most pain coping strategies and appraisals were moderately to highly correlated across the two conditions, suggesting similarities in how climbers appraised and coped with the pain during the CPM test and climbing. Results suggest that elite climbers have better pain tolerance than non-elite climbers. However, the role of coping and appraisals of pain was unclear. Future research should consider longitudinal studies to examine the factors that lead to an elite climber’s higher pain tolerance, as well as examining climbers of all skill levels to elucidate the link between the stress process and rock climbing.
Lay Summary

Elite and non-elite rock climbers pain tolerance, pain coping strategies, and pain appraisals were compared in this study. Elite climbers had better pain tolerance, used less distraction coping in lab settings. However, the difference in distraction coping did not directly contribute to the differences in pain tolerance. Elite climbers also reported more control and less distraction than non-elite climbers in a recent painful climb. Findings suggest that pain is experienced and viewed differently by elite and non-elite athletes, but the causes of these differences are not known.
Preface

This research was approved by the University of British Columbia’s Behavioural Research Ethics Board (H17-00330). A version of this work will be submitted for publication and presented in poster form at a conference. I conceptualized, designed, and carried out this research with the support of my supervisor, Dr. Peter Crocker. I was responsible for developing the research questions, participant recruitment, testing and data collection, analysis, and thesis preparation. Dr. Peter Crocker, Dr. John Kramer, and Dr. Anita DeLongis are co-authors on this thesis. The co-authors provided guidance, comments, and feedback on study design, literature review, data interpretation, and final thesis preparation.
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Chapter 1: Introduction

Rock climbing is a demanding sport that gives participants an opportunity to test themselves – psychologically and physically – in risky, demanding, and often painful situations. The sport is growing rapidly in popularity, however research into the sport is still lacking. As a climber, there are many things about the sport that interest me that research has not fully explored. Why do we climb? What about the sport has drawn me, and so many others, to it? And most of all, why do we revel in and search for the intense, painful situations that climbing involves? To me climbing can be almost masochistic in nature, as climbers willingly endure often very painful situations that are then boasted about later, with scars and bruises being shown off with pride. The painful aspect of climbing has not yet been explicitly examined in research, and to me the pain aspect of climbing is often downplayed or not acknowledged. We use euphemisms to describe common pains in climbing, such as “pump” for the forearm flexor muscle fatigue often felt after a hard climb, “flapper” being a very painful piece of skin that gets torn off the hands, and “screaming barfies” for the very unique painful reaction that occurs in the extremities in response to extreme cold during mountaineering or ice climbing. And there are many pains in climbing that seems to be just accepted: generating incredible amounts of force through the fingertips (force that routinely exceeds pressure pain thresholds; Vigouroux, Quaine, Paclet, Colloud, & Moutet, 2008), jamming limbs into cracks, holding onto miniscule, razor-sharp edges with fingertips, and shoving feet into shoes that are 2 sizes too small. Is being able to endure these pains important in the sport? Do elite climbers appraise and cope with this pain better than those who are new to the sport?

Pain has physical, cognitive, emotional, and social components, meaning the pain experience depends upon a person’s thoughts, memories, biology, and their surroundings (Williams & Craig, 2016). This subjectivity of pain leads to large differences between people, and there has long been a search for an objective measure of pain that would account for all of these components. Recently, Conditioned Pain Modulation (CPM) has been used to examine pain. CPM is thought to be a more objective measure of
pain that is influenced by emotions and cognitions (Lewis, Rice, & McNair, 2012), and may help account for some of the between-person variations in pain tolerance. Elite athletes typically have higher CPM than non-elite athletes (Tesarz, Schuster, Hartmann, Gerhardt, & Eich, 2012), and some of these differences may be due to differences in cognitions and emotions (Nahman-Averbuch, Nir, Sprecher, & Yarnitsky, 2016).

Athletes need to be able to cope with pain in order to continue in their sport. Injury pain is common; however, athletes are expected to deal with a wide range of non-injury pains as well. Non-injury pain has not been the topic of much research, but it appears that those at the elite level may appraise and cope with this pain differently than those at a non-elite level (Lind, Welch, & Ekkekakis, 2009). Potentially, the coping strategies elite athletes use allows them to better tolerate pain, and potentially has helped them excel at their sport. Research has generally focused on endurance athletes (eg. Deroche et al., 2011; Hutchinson & Tenenbaum, 2007; Lind et al., 2009), and the pain coping strategies and appraisals of rock climbers are not known. As rock climbing is a sport that routinely involves pain, it could be that elite climbers are coping with and appraising pain in ways different from non-elite climbers. Therefore, the purpose of this study was to extend current knowledge on pain in sports to rock climbers by testing and comparing elite and non-elite rock climber’s CPM. Secondly, this study aimed to examined how rock climbers coped with and appraised pain to see if there were differences between elite and non-elite climbers, and if these coping and appraisal differences contributed to CPM. Thirdly, coping and appraisals made during a CPM test were compared to a recent painful climb, to assess the stability of these constructs across experimental and non-experimental situations.
Chapter 2: Literature Review

In the following sections the stress process, rock climbing, and pain will be discussed, closing with the gaps in the literature that led to this study.

2.1 Stress and Coping in Sport

Stress in sport is a complex process and involves demands or situations that an athlete perceives to be taxing or exceeding their resources, thereby endangering their well-being (Lazarus 2000a; Lazarus & Folkman, 1984). In rock climbing stressors include possibilities of falls, rock or snow slides, failure of safety equipment, or human errors (Schoffl, Morrison, Schwarz, Schoffl, & Kupper, 2010). Such stressors are appraised by an athlete to determine the relevance to them (primary appraisal) and their potential coping options (secondary appraisal). Emotions influence, and are influenced by, these appraisals (Lazarus, 1991). An appraisal of a situation as stressful can impact an athlete’s cognitions, behaviours, and emotions, and subsequently influence their sport performance and well-being (Lazarus, 2000a).

How an athlete responds to an identified stressor is determined by the appraisal process (Lazarus & Folkman, 1984). Stressful situations are appraised as harm/loss, threat, or challenges/benefits (Lazarus, 1991; Lazarus & Folkman, 1984). Harm/loss situations have already caused some irreparable damage, such as a fall from a great height or the recognition that a climber cannot reach their goal of completing a climb. Threat appraisals are anticipated harms or losses. Some damage may have already occurred, and the athlete anticipates needing to cope with damages or losses that may occur in the future (Lazarus, 1999). Examples include watching an impending thunderstorm encroach while partway up an exposed climb, or continually falling off the crux of a climb, indicating the athlete may not have the skills needed to complete it. Challenge/benefit appraisals are seen in situations that a person perceives to be potentially beneficial, or achievable (Lazarus, 1999). The climb may be the hardest one they have ever attempted, but the climber believes that they can complete it. In this situation there could be a dual challenge and threat appraisal, as a challenging situation, such as a climb that is at the top of one’s abilities, can easily turn
into a threatening one (Lazarus & Folkman, 1984). These primary appraisals are influenced by beliefs a person holds regarding the situation, such as feelings of control. Control refers to the extent to which a person feels that they can influence or control the outcome of a situation. Appraising a stressor as either a harm, loss, or a challenge will bring about different coping strategies, and are influenced by the extent to which a person believes they have control over the situation.

Coping strategies are “the person's constantly changing cognitive and behavioral efforts to manage specific external and/or internal demands that are appraised as taxing or exceeding the person's resources” (Lazarus & Folkman, 1984, pg. 141). Coping is an ongoing process that is individualized and contextual; it relies on the specific appraisals of the demands of the situation. Coping strategies athletes have reported using in stressful situations include acceptance, increasing effort, seeking social support, avoidance, wishful thinking, confrontation, distractions, venting, seeking guidance, and others (Crocker et al., 2015; Hanin, 2010). How an athlete copes with specific stressors impacts, and are impacted by, their appraisals, cognitions, motivations, relations, and emotions.

Lazarus (1991) argued that stress, appraisals, and coping are involved in emotional responses. Emotions are cognitive in that they involve conscious and automatic appraisals and knowledge of a particular situation. A climber approaching a climb might consider their knowledge of the area and the route, their climbing skills, as well as any potential dangers or threats. Motivational refers to how acute emotions are often responses to goal status. How would completing or failing to complete the climb impact this person’s goals? Emotions are also relational, as they are the result of a transaction, or ongoing relationship, between the person and situation (Lazarus, 1991). A person may start a climb feeling very happy and confident, but partway up the weather and climbing conditions may change, causing them to appraise the situation as more threatening, resulting in increases in anxiety. Within Lazarus’ (1991, 1999) framework, emotions would be tied to an athlete’s appraisal of a situation. Threat appraisals are accompanied by negative emotions such as fear, worry, and anxiety. Harm/loss appraisals see anger, guilt,
shame, and sadness. Positive emotions such as hope, eagerness, and happiness are seen with challenge appraisals (Lazarus, 1999). If a situation is appraised as both a threat and challenge, often positive and negative emotions emerge (Lazarus, 2000b). For example, high levels of anxiety and positive affect are seen during rock climbing (Pijpers, Oudejans, Holsheimer & Bakker, 2003; Sanchez, Boschker, & Llewellyn, 2010). These emotions could reflect dual threat and challenge appraisals made in this high-risk sport, as rock climbers considers the cognitive, motivational, and relational aspects of the stressful situation.

2.2 Stress and Rock Climbing

Although sport has been the context for much stress and coping research the importance of the stress and coping process in the subcategory of adventure sports, which includes rock climbing, has not been examined. Rock climbing is a physically and psychologically demanding sport. It is a full-body, anaerobic and aerobically demanding sport characterized by short bursts of activity intended to propel the individual to a top of a climb, during which only minimal aspects of the hand and feet contact the climbing surface (Watts, 2004). Climbers, especially elite climbers, must endure incredibly high forces on the fingers and high levels of ischemia in the forearms, which regularly exceeds pain thresholds (Chesteron, Barlas, Foster, Baxter, & Wright, 2003; Vigouroux et al., 2008). Climbers must not only manage the high physical demands of climbing, they must also manage potentially high arousal levels and the risk and fear of falling or injury (Morrison & Schoffl, 2007) while managing a high cognitive load (Blakely, 2017). This “high-stress” sport is physically and psychologically demanding but has rarely been examined in the context of stress and coping theory. Examining one potential stressor in this sport – pain – and its corresponding appraisals and coping strategies, could lead to a greater understanding of rock climbing and its requirements.

Rock climbing is a demanding whole-body sport characterized by short bouts of high-intensity exercise and variable rest (Watts, 2004). On average, completing one climb takes 2-7 minutes, with VO₂
scores averaging about 20-25 ml·kg⁻¹·min⁻¹, although difficult climbs have shown to have VO₂
requirements above 30 ml·kg⁻¹·min⁻¹ (Watts, 2004). For a comparison, VO₂ requirements for a game of
tennis average 29.1 ml·kg⁻¹·min⁻¹. (Smekal et al., 2001). Movement economy improves with technique,
changing energy system demands from the anaerobic to the aerobic system and allowing elite climbers to
climb harder and for longer periods of time. Generally, an elite climber is shown to be of below average
stature, with low percent body fat, high upper body power, and moderate to high aerobic power (Watts,
2004; Laffaye, Levernier, & Collin, 2016). Climbing is a physically demanding sport, with the upper
body taking the brunt of the demand (Mermier, Janot, Paker, & Swan, 2000).

Although no study has explicitly examined pain in climbing, the high forces and high amount of
ischemia experienced during climbing suggest that pain is common in the sport. Forces of between 12 and
13N elicit feelings of pain when applied to the dorsal aspect of the hand (Chesteron et al., 2003), and
recorded forces at the fingertips in rock climbing regularly exceed this, reaching up to 124.1N of force
(Vigouroux et al., 2008). The anaerobic conditions and isometric contractions climbers regularly endure
can lead to ischemia, creating a buildup of metabolites and by-products that can be 4-7 times higher than
resting (Watts, 2004), triggering nociceptors (O’Connor & Cook, 1999). Forearm muscle endurance is a
limiting factor in climbing performance, suggesting that climbers who are able to endure this ischemia in
the forearms for longer periods of time perform better (Watts, 2004). This ischemia is so well-known in
the rock climbing community that it has its own nickname - “pump” (Climbing dictionary, 2017).

Climbers discuss other pain as well, such as “skin pain”. Often, hard climbs involve using the fingertips
so forcefully that layers of the skin begin to peel off, leaving fingertips red and sore. Also, some forms of
climbing involve using one’s own limbs as a hold, such as jamming a fist, knee, or foot into a crack in the
wall in order to gain purchase (Figure 1). These climbs are notoriously painful, with professional climbers
describing them as such. One climber in a video documentary described this type of route by saying
“you’re not going to have fun climbing [it], you might think you’re having fun off the routes, but not on
them. You hyperventilate, you vomit, you curl up into a little ball and cry, it’s a full battle” (0.22). One
route she was climbing required “one of the weirdest… moves – you jam your head in the roof – and it hurts!” (5:25-5:39) (Ziechmann, 2015). This is reinforced by the names of similar climbing videos, such as “Tour of Pain” and “Sufferfest”. Although there is little research on pain in climbing, its demands and descriptions suggest there are high levels of pain that must be managed in order to climb successfully.

Figure 1: The author demonstrating a type of climbing called crack climbing, in which a person’s limbs are used as the holds to propel the climber up a climb.

Climbing research has not focused on examined the stress and coping process, but research on emotional states during climbs allude to the importance of stress management in this sport. Climbing is very cognitively demanding, requiring planning, coordinated movements of all four limbs, reaching, and posture control (Blakely, 2017), all of which is processed alongside anxiety, fears, and risk analysis. Anxiety has been shown to be detrimental to climbing performance, as high anxiety is related to jerky
movements, rigid posture, and taking longer to complete a climb (Pijpers et al., 2003; Sanchez et al., 2010). Anxiety appears to be higher in climbs that have a possibility of a longer fall (Draper et al., 2012). But higher experience and skill level may mediate this relationship, as elite climbers show lower anxiety in all climbing types (Fryer, Dickson, Draper, Blackwell, & Hillier, 2013). Lower anxiety is likely related to higher self-confidence (Draper, Dickson, Fryer, & Blackwell, 2011) and high levels of positive affect (Sanchez et al., 2010), facilitating success in climbing (Giles et al., 2014). Lower anxiety and higher positive affect may be indicative of appraising situations as a challenge or feeling in control (Jones, Meijen, McCarthy, & Sheffield, 2009; Lazarus, 1999), suggesting experienced climbers see climbing as beneficial and less threatening than inexperienced climbers. Current research suggests that when examining climbing as a stressor, experienced and inexperienced climbers experience difference emotions that could be due to different appraisals or coping strategies. But how climbers of different skill levels approach and respond to specific stressors in the sport of climbing, such as pain, has not yet been examined. The next section will examine pain in sports in a stress and coping context, leading to a better understanding of how pain in rock climbing may be influencing a climber’s experience.

2.3 Pain

Pain is a unique sensation that involves both physical and psychological aspects and has been redefined as research has progressed, however the pain experience is not well-understood. The reasons for variations in pain tolerances seen between people and groups, such as between athletes and non-athletes (Tesarz et al., 2012), are not well known. The discovery of Conditioned Pain Modulation (CPM) has allowed researchers to begin examining the differences in the pain system that may be responsible for the variation in pain measures between and within groups and individuals (Nir, Granovsky, Yarnitsky, Sprecher, & Granot, 2011). Factors that appear to influence CPM include age, sex, presence of chronic pain, and physical activity/athlete status (Flood, Waddington, Thompson, & Cathcart, 2016; Lewis, Rice, et al., 2012). Some relatively unexplored potential moderators include variables from the stress and coping process, such as appraisals and coping strategies. Elite and non-elite athletes appear to differ in
their CPM scores and in how they cope with pain, but little has been done examining the influence of coping and appraisals on CPM. Research has primarily focused on endurance sport athletes and it is unknown whether athletes in different sports, such as adventure sports, use similar coping strategies and have similar responses to CPM tests. Examining athlete’s appraisals and coping strategies surrounding pain could help improve our understanding of athletes’ pain experiences.

### 2.3.1 Pain Definition

Pain has been defined by the International Association for the Study of Pain (IASP) as an “unpleasant sensory and emotional experience accompanied by actual or perceived tissue damage” (Merskey & Bogduk, 1994, p. 211). This definition, however, may not capture the whole pain experience. This definition implies that pain is always a sensory experience with a strong emotional element, and that the perception of pain does not always reflect actual damage. This definition is unchanged from its original form from the 1970s when pain was still an emerging research area (IASP, 1979). Williams and Craig (2016) have updated the definition, describing pain as “a distressing experience associated with actual or potential tissue damage with sensory, emotional, cognitive, and social components” (p. 2420). This new definition includes previously neglected aspects (cognitive and social) that reflect our current understanding of the multifaceted nature of pain. The use of the word “distressing” reduces the potential trivialization of pain experiences, as distressing implies a stronger sensation than “unpleasant” (Williams & Craig, 2016). “Distressing” could also invoke inclusion of stress, coping and appraisals in the pain experience, which is neglected in the IASP (1994) definition. Examining the components in Williams & Craig’s (2016) definition suggests that the stress process is important to the experience of pain.

The sensory aspect of pain refers to the detection and transmission of pain through the body and is well understood (Julius & Bashaum, 2001). Different classes of nociceptors (pain sensory neurons) respond to different stimuli and help us distinguish between different types of pain. The two nociceptors specific to skeletal muscles and exercise are types III and IV, which are placed near muscle arterioles and
connective tissue to best detect damage to muscle (O’Connor & Cook, 1999). Once a nociceptor is activated, a signal is sent into the spinothalamic tract to the brain via the dorsal root ganglia (Millan, 2002). In the brain, different areas aid in the interpretation of the pain signal. For example, neurons from emotional and cognitive control areas of the brain synapse onto pain neurons allowing for emotional and cognitive influences on pain, and vice versa (Millan, 2002). This allows for interpretation and modulation of pain, showing that considering cognitions and emotions in the pain experience is important. As people are shown to respond to the same pain very differently, but have the same physiological pain system, it is clear that only considering the physical aspect of pain does not capture the whole pain experience.

2.3.1.1 Appraisals and coping in the pain experience

William & Craig’s (2016) definition of pain includes emotional, cognitive, and social components of pain, which introduce appraisals and coping to the pain experience and add an element of subjectivity. The emotionality of pain is often tied to how it is appraised, as pain is only distressing when it is appraised as important (Lazarus, 2000a). For example, injury pain is generally negatively perceived as a danger to the athlete’s goals and values (Taylor & Taylor, 1997), which can generate emotions of fear and anxiety (Lazarus, 2000b; Nicholls, Polman, & Levy, 2012). In the Williams & Craig (2016) definition, the cognitive aspect of pain was included to acknowledge that a painful sensation is influenced by previous knowledge, attention, and memories, making each person’s interpretation of pain unique. How one person appraises or copes with a pain (cognitive actions) will depend on their past experiences and knowledge, making how each person perceives and acts on pain different (Taylor & Taylor, 1997; Williams & Craig, 2016). Social contexts also dramatically impact pain, as the person’s surroundings and significant others will influence how they experience and communicate about their pain (Williams & Craig, 2016). This reflects the knowledge that the stress and coping process is context dependant; the context of the stressor (pain) greatly impacts concurrent cognitions and actions (Taylor & Taylor, 1997). Lazarus (1991) understood the important of emotions, cognitions, and social context in pain, and that this was a reciprocal relationship.
“Pain tolerance and possibly pain thresholds can be influenced by appraisal and by the anxiety about pain that it produces (cf. Beecher, 1956-1957), thereby dampening or enhancing both pain and pleasure. Although they are reflexes rather than emotions, pleasure and pain undoubtedly play a very important role in the development of the motivational structure on which appraisal and emotion depend. The infant and the young child learn to avoid pain and to seek pleasure. This idea has been at the center of emotion theory for centuries (Lazarus, 1991, p. 821).”

Lazarus (1991) postulates that pain can drive emotions and cognitions, and emotions and cognitions influence our perception of pain. Williams and Craig (2016) imbued their definition of pain with Lazarus’s (1991) thoughts, suggesting that pain is a multifaceted experience that can influence, and be influenced by, many different processes and systems of the body.

If we use Williams & Craig’s (2016) definition, we must consider all of the various components when examining pain; however, this is difficult within a single research project. By incorporating all components into one exploratory study we may only get a cursory examination of each, and miss out on understanding the richness and complexities of each component. Through controlling one or more components we may be able to get a better understanding of the others, such as controlling for a social context in order to examine the emotional and cognitive aspects in more detail. As this definition is new, research on each component which considers the others, is needed to support and broaden the area of pain research.

2.3.2 Appraising and Coping with Sport Pain

Pain is a central aspect of sport, and “the ability to tolerate it, endure it, inflict and absorb it, ignore it, play through it, [and] negotiate it … has long been associated with [sport] participation” (Bridel, 2010, p. 20). Research on coping with pain in sports has traditionally examined only injury pain, however pain associated with normal sport participation, such as fatigue and exertional pain, may be appraised and coped with differently than injury pain (Bridel, 2010). The appraisals, and therefore coping strategies,
athletes use in response to non-injury pain may be dependent on competition level (i.e. elite athletes may differ from non-elite athletes; Lind et al., 2009) and sport type (Meyers, Higgs, LeUnes, Bourgeois, & Laurent, 2015). Research on endurance sport athletes have dominated the coping with sport pain literature, whereas adventure sport athletes are notably absent; however, these athlete groups may use different strategies in response to sport pain (Meyers et al., 2015). Therefore, the specific coping strategies and appraisals used by adventure sport athletes to cope with pain is needing investigation.

How athletes cope with pain is dependent on their appraisal of pain, as pain viewed as negative and harmful is coped with differently than pain appraised as more positive or helpful. Injury pain in sport is overwhelmingly perceived as negative, overwhelming, and out of an athlete’s control (Bridel, 2010; Wiese-Bjornstal, 2010). Athlete’s coping strategies reflect this state, as common strategies include seeking social support, avoiding, catastrophizing, self-medicating, and reappraisal (Nicholls, Polman, Levy, Taylor, & Cobley, 2007; Tricker, 2000; Wiese-Bjornstal, 2010). On the contrary, pain related to fatigue and pushing oneself in sport is often viewed positively, leading to lowered perception of pain and allowing athletes to continue their sport participation (McDowell & LaChapelle, as cited by Potter, 2015). Elite runners often interpret pain as simply a physiological cue that gives them information about the race, such as pace or timing (Zepp, 2016). This use of associative, focusing techniques appears common when pain and physiological symptoms dominate attention (Hutchinson & Tenenbaum, 2007). Non-elite runners tend to attempt to diminish or ignore pain, through using dissociative coping strategies (Lind et al., 2009) or ignoring the pain (Deroche et al., 2011). This can lead to lowered perceived ratings of exertion, slower pace, and increased enjoyment (Lind et al., 2009). Pain viewed as injury-related or as part of normal sport participation is appraised, and therefore coped with, differently at the various levels of sport commitment (elite vs. non-elite). This suggests researchers should consider elite and non-elite athletes as separate when examining pain coping and appraisals in sport.
A few studies have suggested that adventure sport athletes, such as climbers, likely appraise and cope with pain differently than their endurance-sport counterparts. Meyers et al. (2015) found that female rock climbers (grouped with other non-traditional sport athletes) exhibited less pronounced coping strategy use in response to pain than traditional sport athletes. Potentially these athletes prefer a variety of coping strategies with none dominating over another, whereas traditional athletes have more distinct coping strategy sets (Meyers et al., 2015). The emotional profiles of climbers suggest experienced climbers tend to exhibit lower anxiety, have lower physiological measures of stress, and have higher confidence than amateur climbers (Draper et al., 2012; Fryer et al., 2013; Pijpers et al., 2003; Sanchez et al., 2010). These findings suggest that, like the athletes in McDowell & LaChapelle’s (2005, as cited in Potter, 2015) study, experienced climbers see climbing, and the accompanying pain, as a challenge and may therefore use different coping strategies than non-elite or inexperienced climbers. Considering the emotional differences between elite and non-elite climbers (highlighted in previous section) with Meyers et al.’s (2015) findings suggests rock climbers’ pain coping strategies need to be explicitly examined to clarify what strategies are being used by these athletes, and if these strategies differ between elite and non-elite climbers.

2.3.2.1 Coping as a Style or a Process in Pain Research

A key factor that has influenced pain research in sport is whether coping is conceptualized as a style or as a process. Coping style refers to typical coping responses that a person uses to manage stress. A strong version of coping style suggests coping is trait-like, in that people use the same types of strategies across multiple stressful contexts. A weaker version suggests people have preferred strategies for managing stressful demands. In contrast, examining coping as a process considers the differences within-people, and posits that their coping responses will vary according to the day, situation, and other measurement variables. Whether coping is conceptualized as a style or process will influence study methods as it determines the type of questions asked, the wording of questionnaire items, and how data is analyzed (Crocker, Kowalski, & Graham, 1998). Lazarus & Folkman (1984) emphasized the importance
of considering coping as constantly changing, and encourage measuring coping in different situations, times, contexts, and stressors. Lazarus (1999) encourages viewing coping as both a style and process, as people likely have coping strategies they prefer to use, but will change their strategies depending on the situations they are in. Pain coping research, especially sport pain coping research, has neglected the importance of identifying coping as a process (situation-specific) and a style (has consistencies over different situations), meaning there is uncertainty over whether coping with pain is similar, or different, across different pain scenarios.

Pain coping research in sport and non-sport settings has supported Lazarus & Folkman’s (1984) view that coping has style and process qualities; however, pain research has rarely explicitly tested this difference or considered this as a measurement concern. Longitudinal research has found coping with chronic pain changes over time and can influence, or even predict, future pain (Cruz-Almeida et al., 2013; Newth & DeLongis, 2004; Soderlung & Lindberg, 2003). This is also seen in injured athletes, where coping has been shown to change in response to levels of perceived stress over the course of an injury recovery period (Albinson & Petrie, 2003). However, most sport pain research has used single time point cross-sectional data inquiring about athletes’ usual or average coping strategy preferences, and there appears to be consistencies across athlete groups (See Deroche et al., 2011 or Sharma, Sandhu, & Shenoy, 2011). These findings suggest pain coping may exhibit some stability over time but that there is likely also variability across situations, suggesting the weak coping style format may apply. However, there are some concerns regarding how coping has been measured and defined in some of these studies. Lazarus & Folkman’s (1984) definitions of appraisals and coping were overwhelmingly used in these athlete studies, meaning they considered coping to be dynamic and situation dependent. However, not many studies have discussed how using this definition of coping impacts measurement (such as in the cross-sectional studies), and none have asked participants about their coping strategies in different situations. To correct this and examine the stability (or instability) of pain coping strategy use in athletes, researchers should examine athletes coping and appraisals in different situations. Specifically, considering how athletes pain
coping strategies differ in experimental lab conditions compared to sport situations can give researchers confidence that their findings translate to sport.

2.3.2.2 The Measurement of Coping with Pain in Sport

Measuring coping with pain in sports has proven difficult and has often involved adapting pain questionnaires from other areas. There is one sport-specific measure, the Sport Inventory for Pain (SIP) (Meyers, Bourgeois, Stewart, & LeUnes, 1992), but concerns have been raised regarding its validity (Bartholemew, Edwards, Brewer, Van Raalte, & Under, 1998). Some researchers have adapted chronic pain coping questionnaires, with the Coping Strategies Questionnaire (CSQ) appearing to be a useful measure of pain coping in athletes (Hastie, Riley, & Fillingim, 2004; Robinson et al., 1997). Quantitative measures of coping allow researchers to examine how athletes physically and mentally experience pain.

Recognizing the importance of developing a questionnaire for sport pain, Meyers et al. (1992) developed the Sport Inventory for Pain (SIP). The SIP was developed through a multistep process including using items from previous, non-sport specific measures and developing items based on interviews with injured athletes. The subscales include (1) direct coping, (2) cognitively mediated coping, (3) catastrophizing, (4) avoidance, and (5) body/somatic awareness (Meyers et al., 1992). The direct coping subscale measures the extent to which an athlete approaches and directly attempts to deal with pain (Meyers et al, 2008). Cognitively-mediated coping refers to the athletes use of “mental” coping strategies, such as imagery. The body awareness subscale is said to examine how sensitive a person is to a painful stimulus (Bourgeois, Meyers, LeUnes, 2009). The SIP does not profess to follow any existing stress and coping theory and, if one examines the subscales, there may be content validity issues as many of the items may not reflect the constructs claimed to be measured. For example, the catastrophizing scale includes the item “Pray for the pain to stop” which is similar to items in praying/hoping subscales of accepted pain questionnaires and is not related to the definition of catastrophizing (Riley & Robinson, 1997; Sullivan, Bishop, & Pivik, 1995). The avoidance subscale includes items such as “pain is probably a sign I’m doing damage to my body”, and “could perform as well as ever if pain would go away”. These
items do not reflect the definition or theoretical underpinnings of avoidance, which is generally considered cognitive or behavioural efforts a person uses to disengage from a situation (Nicholls et al., 2007). The cognitively-mediated coping scale contains items that may involve dissociation (“replay in my mind pleasant sport experiences”), suppression (“tell myself it doesn’t hurt”), and avoidance (“do anything to keep my mind off the pain”). The body awareness subscale appears to be a measure of physical pain symptoms, with items such as “seldom or never have dizzy spells or headaches”. A confirmatory factor analysis of the SIP found that the items do not fit the proposed subscales, and a respecification of the scale has been recommended (Bartholemew et al., 1998). The SIP was made to fill a gap in pain coping research, but its theoretical and empirical shortcomings mean it is not widely used.

The lack of a valid sport-specific pain measure has led to researchers to adapt chronic pain questionnaires for their research, such as the CSQ. The CSQ was developed for use in chronic pain populations and ask participants the extent to which they use coping strategies when they feel pain (meaning the CSQ assesses coping style). The subscales of the CSQ include (1) distraction, (2) catastrophizing, (3) ignoring pain sensations, (4) distancing from pain, (5) coping self-statements, (6) praying, (7) increasing activity, (8) hoping, and (9) reinterpreting pain sensations (Rosenstiel & Keefe, 1983). In athlete studies the CSQ shows acceptable reliability (Deroche et al., 2011), with athletes who are in pain showing similar responses to chronic pain patients (Robinson et al., 1997). Deroche et al. (2011) found that the ignoring pain subscale of the CSQ was related to athlete’s ability to play through pain and suggested it could be a successful pain coping strategy. Also, previous athlete pain coping studies support the inclusion of the other subscales of the CSQ-R. Dissociation is theoretically similar to distraction - a commonly reported strategy used by non-elite runners - as both involve “focusing on distracting stimuli” (Lind et al., 2009, p. 745), and catastrophizing is commonly reported by athletes as a maladaptive means to cope with pain (Deroche et al., 2011; Lukins, Leicht, & Spinks, 2004). The CSQ is likely a valid and reliable way to examine pain coping in athletes.
Chronic pain coping questionnaires such as the CSQ appear useful tools for athlete populations, with subscales reflecting what is already known about pain coping strategies in athletes. Using the CSQ-R to examine pain coping strategies in adventure sport athletes is consistent with previous research, and in the future could allow comparisons to be drawn between the two groups. The SIP has been used to draw comparisons between traditional, endurance sport athletes and adventure sport athletes (Meyers et al., 2015), but has given us little information about adventure sport athletes coping strategy use. Using accepted pain coping questionnaires such as the CSQ in adventure sport athletes will help to further information on how athletes cope with pain. Also, measuring coping with pain may examine the cognitive, emotional, and social dimensions of pain, but neglects the sensory aspect. Therefore, including a measure of pain that acknowledges the physical aspect of pain in addition to pain coping measurements is important in considering the experience of pain as a whole; that is, as having emotional, cognitive, social and sensory components.

2.3.3 Conditioned Pain Modulation

Williams & Craig’s (2016) definition of pain reflects a growing body of research examining influences on pain, especially central influences such as emotions and cognitions. This more holistic approach to pain started with the Gate Control Theory in the 1960s, which stated that pain could be influenced by a “central” control in the brain. The Gate Control Theory opened the possibility that people could volitionally influence pain perception and has progressed into Conditioned Pain Modulation (CPM), which quantifies the amount that one pain sensation can be influenced by another pain sensation. CPM is a dynamic measure of pain thought to quantify the underlying physiology of static pain measures (pain tolerance, pain threshold), providing us with more information than taking one static measure (Tesarz et al., 2012). Examining CPM and the influences on CPM could help explain variations in pain tolerance and pain threshold by including the underlying psychological and neurobiological processes in pain research (Tesarz et al., 2012).
CPM is the idea that one noxious stimuli (pinch, poke, extreme temperatures) at one location can be inhibited by a second noxious stimulus applied at a different location (Lewis, Rice, et al., 2012), and has identified neural circuitry which includes physiological and psychological influences on pain. Both animal and human models show that CPM occurs supraspinally, likely controlled via a spino-bulbo-spinal tract that synapses in the subnucleus reticularis dorsalis in the brainstem (Le Bars, Villanueva, Willer, & Bouhassira, 1991; Youssef, Macefield, & Henderson, 2016). The subnucleus reticularis dorsalis receives input from prefrontal and anterior cingulate cortices, which are emotional and cognitive centres (Wilder-Smith, Schindler, Lovblad, Redmond, & Nirkko, 2004; Youssef et al., 2016). The input of these areas suggest CPM may be affected by emotional and cognitive factors, which is corroborated by the finding that using a placebo CPM test resulted in changes in CPM (Nir, Yarnitsky, Honigman, & Granot, 2012). The importance of these non-physiological factors is still being examined, as research has so far not been conclusive (Nahman-Averbuch et al., 2016).

2.3.3.1 Factors Influencing CPM

There are many factors that influence CPM, including presence of chronic pain syndromes, age, sex, training status, and some psychological factors (Flood et al., 2016; Lewis, Rice et al., 2012), however research surrounding athletes and psychological factors is still needed. Athletes appear to modulate pain better than non-athletes (Geva & Defrin, 2013), and within athlete populations, increasing levels of activity seems to be related to higher pain modulation (Umeda, Lee, Marino, & Hilliard, 2016). There have been few studies looking at athlete populations, and the research that has been done on athletes has overwhelmingly focused on endurance sport athletes, neglecting other sports that have prominent painful components such as rock climbing. Also, psychological factors have not been included in many athlete CPM studies, and as factors such as anxiety, depression, and catastrophizing may be important in other populations (Nahman-Averbuch et al., 2016), it is important to consider these factors in athletes’ pain experiences. Nahman-Averbuch et al. (2016) also recommend expanding the repertoire of psychological variables examined, as the importance of other psychological factors, such as appraisals and coping, has
rarely been examined in relation to CPM. As rock climbing is a painful, psychologically demanding sport that is growing in popularity, examining CPM and the stress and coping process in these athletes is important to expand our knowledge of the sport and the extant CPM literature.

Identified factors that influence CPM include presence of chronic pain syndromes, age, and sex (Lewis, Rice et al., 2012), and these factors have dominated the CPM literature. Females, older adults (>40 years old), and those with chronic pain show reduced CPM compared to healthy controls (Goodin et al., 2009; Lewis, Rice, et al., 2012), meaning these populations show less modulation compared to males and those without chronic pain. CPM is also reduced with age, meaning less pain modulation occurs as we age. These factors show large effect sizes, and are consistently seen (Lewis, Rice et al., 2012). As these factors are well-researched and well-understood researchers are now starting to expand the variables examined and are focusing on the role of exercise and psychological factors in CPM.

Exercise likely influences CPM and pain but there is still controversy surrounding the role exercise plays in pain perception. Exercise appears to impact pain perceptions, as it has been shown to have analgesic effects (termed exercise-induced hypoalgesia). This is reflected in athletes’ higher pain tolerances and thresholds than non-athletes (Tesarz et al., 2012). Athletes also appear to have better CPM compared to non-athletes, meaning they modulate pain better than people who are not regularly active (Flood et al., 2016). Also, elite athletes have been shown to have higher CPM scores than recreational and non-elite exercisers (Geva & Defrin, 2013; Umeda et al., 2016). There may be a large effect, as the average effect size from all identified athlete studies was d=.918 (calculated from Flood et al., 2016, Geva & Defrin, 2013, & Umeda et al., 2016). However there is still some controversy, as Tesarz et al. (2013) found no difference in CPM scores between athletes and non-athletes. Also, most research have been on endurance athletes (such as Flood et al., 2016, Geva & Defrin, 2013, Tesarz et al. 2013, & Umeda et al., 2016), neglecting sports that are not dominated by endurance and the aerobic system. Sports such as rock climbing appear to involve high levels of pain, but whether the findings on CPM in endurance athletes
can be extended to these athletes is unknown. Also, as most athlete studies did not examine many other variables besides physical activity, there may be other factors that are influencing this relationship, such as psychological variables. As sport and pain are both very psychologically demanding it is likely that psychological factors influence athletes’ pain experience. Examining psychologically-taxing sport such as rock climbing could help us further our knowledge into the psychology of sport. While elite athletes have shown higher CPM than non-athletes and recreational athletes, how psychology plays into this relationship is still unknown.

Psychological factors have been studied in relation to CPM in non-athlete populations, and the lack of inclusion of these variables in athlete studies limits our understanding of the sport pain experience. In non-athletes, commonly studied modulators of CPM include depression, anxiety, and catastrophizing, but a recent meta-analysis found no relation between overall CPM scores and these variables (Nahman-Averbuch et al., 2016). Coping strategies were examined alongside CPM by Cruz-Almeida et al. (2013) who found that osteoarthritis patients who had lower CPM scores were more likely to use passive coping strategies to deal with pain. These strategies involve relinquishing control over the stressful situation to others (such as avoidance, catastrophizing, praying/hoping). There have been few studies in athletes that examine psychological factors and CPM. Geva & Defrin (2013) examined CPM, catastrophizing, fear of pain, and perceived stress in elite triathletes and regular exercisers, and found differences in almost all variables between the two groups. Elite triathletes showed more efficient CPM, and had lower fear of pain and perceived stress than non-elite triathletes. Interestingly, there was no difference in catastrophizing between elite and non-elite athletes. This was the only study to date that examined both training status and psychological factors in CPM, although the influence of fear of pain, perceived stress, or catastrophizing on CPM score was not examined through any moderation or mediation analysis. This study suggests that in addition to the differences in CPM between elite and non-elite athletes there may be differences in how these groups of athletes are dealing with pain, indicating the stress and coping process may be important.
To further understand CPM in athletes, future research should include variables that account for how athletes deal with pain, including coping and appraisals.

CPM is understood to be influenced by many physical factors including age, sex, and chronic pain syndromes, but the effect of exercise and psychological variables are less clear and requires more research (Flood et al., 2016; Lewis, Rice, et al., 2012). Elite athletes appear to have better pain modulation than non-athletes, but evidence is divided and there may be other factors that influence the relationship (Geva & Defrin, 2013; Tesarz et al., 2013). The specific coping strategy of catastrophizing as well as perceived stress may be important in athletes’ CPM scores (Geva & Defrin, 2013); however, broader studies examining how athletes’ coping strategies and appraisals influence CPM have not been done. Also, most athlete studies have examined endurance sport athletes, and it is not known if athletes that don’t fall into this aerobic-sport category, such as rock climbers, will show similar CPM results. Examining CPM while considering the influences of coping and appraisals in rock climbing will help to expand our understanding of the relationship between training status, cognitive factors, and pain.

2.4 Concluding Summary of Literature Review

The differences in CPM scores between athletes and non-athletes, and elite athletes and non-elite athletes, are not fully understood but the stress and coping process may be an important variable that has not yet been examined. Geva & Defrin (2013), in their study of CPM in triathletes, acknowledge that psychological factors that they did not study may affect pain modulation, and that “evaluation of these and other traits will further unravel the factors underlying the unique capabilities of triathletes” (p. 2322), and potentially all athletes. The few CPM studies that have looked at coping and appraisals have found some evidence that these factors may influence CPM (Cruz-Almeida et al. 2013; Geva & Defrin, 2013), however the populations examined have been limited and there is a need for more research examining this link. As rock climbing is a painful sport that is physically and psychologically demanding, climbing may be a useful area to examine to help us understand pain and the psychological factors that influence pain in
sport, such as coping and appraisals. Also, comparing how athletes appraise and cope with pain in an experimental setting to a sports setting allows us to examine coping as a process; that is, it allows us to examine the changes (or similarities) in the appraisals and coping strategies made to a stressor (pain) in two different contexts. The current research will explore CPM, pain coping strategies, and appraisals of pain in elite and non-elite rock climbers in the hopes of increasing our understanding of rock climbing, pain management, and stress and coping theory.

2.5 Statement of Purpose and Hypothesis

The present study examined how CPM, pain coping strategies, and appraisal of pain were related to a rock climbers’ ability level. The purpose of the study was threefold:

1. To examine if elite and non-elite climbers differ in their CPM responses.

   Elite rock climbers were anticipated to have higher CPM and higher baseline pain tolerance scores than non-elite rock climbers, in line with previous research (Geva & Defrin, 2013, Tesarz et al., 2012).

2. To examine if the differences in CPM responses between elite and non-elite rock climbers is influenced by pain coping strategy use or appraisal of pain.

   Elite rock climbers were hypothesized to use “focusing on the task” and “coping self-statements” to cope with pain significantly more than non-elite rock climbers, reflecting that previous research that found elite athletes may use associative coping strategies to deal with pain (Sharma et al., 2011). Non-elite climbers were expected to use catastrophizing, distancing, and distraction significantly more than elite rock climbers, as previous research has found non-elite athletes tend to use dissociative coping techniques to deal with pain (Lind et al., 2009). For appraisals, it was expected that elite rock climbers would appraise pain as more challenging and would feel that they had more control over the pain in comparison to non-elite climbers, who were anticipated to appraise pain as
threatening. These coping and appraisals were expected to explain the difference in CPM scores between elite and non-elite rock climbers.

3. To examine if climbers coped with and appraised experimental pain in a similar manner to how they cope with and appraise pain during a rock climb. This was an exploratory purpose, as the literature does not demonstrate any consensus with regards to the stability of pain coping or appraisals.
Chapter 3: Methods

3.1 Participants

The final sample comprised of 53 male rock climbers, 27 elite rock climbers (aged 26.70, ±5.37, climbing grades ranging from V7-V13, and 5.13a-5.14b) and 26 non-elite rock climbers (aged 26.69, ±6.15, climbing grades ranging from V0-V3, and 5.9). Sample size was determined by a power calculation using previous CPM athlete studies. Previous CPM athlete studies have had a large effect size of d=.918 (calculated from Flood et al., 2016, Geva & Defrin, 2013, & Umeda et al., 2016). A more conservative d=.8 was used, alongside a significance level of p<.05 and a power of 80% to calculate a sample size of 52. The Yosemite Decimal System (YDS) was used to define sport climbing and the Hueco system for bouldering, as these are the most common systems used to define climbing grade in North America. Draper, Canalejo et al.’s (2011) climbing grade categorization (Appendix A) was used to determine the elite and non-elite climbing grade cutoffs, with those climbing above 5.13 (YDS)/V7 (Hueco) qualifying for the elite category and those climbing below 5.9 (YDS)/V2 (Hueco) qualifying for the non-elite category. The conversion chart for comparing Hueco to YDS grades can be found in Appendix B. Previous research has indicated there are little, or no, differences in emotional profiles and psychological states before and during different climbing types, meaning climbers of all types were recruited (Dickson, 2013). Self-reported highest climbing grade was used to determine categorization, as it appears to be a reliable and valid measure of climbing ability (Draper, Dickson, et al., 2011). Previous research has indicated that sex, age, and presence of chronic pain influences CPM (Lewis, Rice, et al., 2012), therefore study inclusion was limited to males aged 18-40 that were not suffering from pain that has lasted longer than 3 months.
3.2 Measures

3.2.1 Demographic Questionnaire

Demographic information was collected at the start of the experiment (Appendix L). Information collected included self-reported highest climbing grade, age, preferred type of climbing, presence of chronic pain, and exercise performed outside of rock climbing (present and past). As the sample was being stratified into elite and non-elite athletes, the author thought it important to record if a participant had been, or currently is, an elite athlete in a different sport, as this may influence CPM.

3.2.2 CPM

CPM is studied by examining the effects that a noxious conditioned stimulus has on the sensation of a noxious test stimulus and is generally done by comparing 2 measures of pain; a test and conditioned stimulus (Yarnitsky et al., 2010). The test stimulus was pressure pain induced by a pressure algometer (FPK 40 Algometer, Wagner Instruments, USA) on the dorsal aspect of the hand, between the second and third metatarsals, applied at a constant rate of approximately 1kg·s\(^{-1}\). Pressure pain is commonly used as a test stimulus in CPM studies (see Flood et al., 2016, Nahman-Averbuch et al., 2013, Tesarz et al., 2013, and Umedi et al., 2016). The conditioned stimulus was ischemic pain induced by a blood pressure cuff inflated to above 200mmHg. Using ischemic pain as the conditioning stimulus is a reliable and standard way to measure CPM (Lewis, Heales, Rice, Rome, & McNair, 2012).

Yarnitsky et al. (2015) recommend reaching a pain rating of 6/10 when conducting CPM tests. A numerical rating scale (NRS) of 0 (no pain) to 10 (worst pain) was used to determine the rating. Verbal descriptive anchors for the NRS was given for 0 (no pain), 5 (moderate pain), and 10 (worst pain). An 11-point NRS interval scale is considered a reliable and valid interval measure of pain in many populations and appears to be more sensitive than a verbal rating scale or visual analogue scale (Williamson & Hoggart, 2005).
Two steps were used to determine CPM score. First, a baseline pressure pain score is determined using the test stimulus. This is the amount of pressure (in Newtons) equaling a pain rating of 6/10. Then a 10-minute break is taken to prevent the first stimulus from affecting the next step. Second, a conditioned pain score is determined. Ischemic pain is induced by applying the conditioned stimulus, a pressure cuff placed on the left upper arm, 5 cm above the cubital fossa for 2 minutes at a rating of 200mmHg. Ischemic pain was ensured not to exceed 4/10. Immediately following the 2 minutes of ischemic pain, pressure pain using the test stimulus was tested at the dorsal aspect of the right hand. The score in the conditioned step is the amount of pressure (in Newtons) equaling a pain rating of 6/10. The CPM score is determined by subtracting the pressure rating (in Newtons) found in the conditioned step from the value found in the baseline test step.

3.2.3 Pain Coping Strategies

Coping strategies used by the participant during the pain procedure and during a recent painful climb were assessed using a modified version of the Coping Strategies Questionnaire - Revised (CSQ-R) (Riley & Robinson, 1997). Participants were asked to recall a recent painful climb that was not injury causing. The modified CSQ-R was a 25-item questionnaire that consists of six subscales that is scored on a 7-point Likert scale that ranges from (1) “never do that” to (6) “always do that”. The subscales include catastrophizing (4 items; eg., “I feel like I can’t stand it anymore”), coping self-statements (4 items; eg., “I tell myself I can’t let the pain stand in the way of what I have to do”), ignoring pain (5 items; eg., “I don’t think about the pain”), distancing from the pain (4 items; eg., “I imagine the pain is outside of my body”), distraction (4 items; eg., “I try to think of something pleasant”), and a new subscale titled task engagement was developed for the study (4 items; eg., “I focused on the task at hand”). The author believed that focusing on the goal of completing the climb would be important and wasn’t adequately captured in the other scales. The original CSQ-R includes a praying subscale (3 items; eg., “I pray for the pain to stop”), but this was removed to reflect the authors understanding of climbing, as it was expected
that praying would not be reported. Reliability coefficients for original CSQ-R scales range from 0.72 to 0.91 (Hastie, Riley, Fillingim, 2004; Robinson et al., 1997).

The CSQ-R was originally developed to test coping strategies in response to chronic pain but has been used in athletic populations. Predictive validity of scores was reported by Deroche et al. (2011) who found that high pain catastrophizing predicted low ability to play through pain, but ignoring pain led to an increased ability to play through pain. This is similar to findings in chronic pain populations, where low use of catastrophizing and high use of ignoring pain is related to increased activity (Robinson et al., 1997). Lukins et al. (2004) found that catastrophizing correlated to perceived pain in canoe paddlers, which is similar to findings in chronic pain populations (Hastie et al., 2004). Reliability of scales in athletes appears reasonable, with Deroche et al. (2011) reporting coefficients ranging from 0.67 to 0.85. For this study, Cronbach’s alphas ranged from .737 to .882 (Table 1).

**3.2.4 Appraisal of Pain**

Participants completed the threat, control, and challenge subscales (4 items each) of the Stress Appraisal Measure (SAM; Peacock & Wong, 1990) that assessed their appraisal of (1) pain during the testing session and (2) pain during a recalled recent painful climb. Items included “I felt I had the ability to overcome the pain during the experiment/climb” (control), “I believed that managing the pain during the experiment/climb could have a benefit for me” (challenge), and “I perceived the pain as threatening”. and were answered on a 5-point Likert scale of 1 (not at all) to 5 (extremely). A previous study using the same subscales in athletes reported acceptable reliability, with coefficients ranging from 0.72 to 0.85 (Crocker, Gaudreau, Mosewich, & Kljajic, 2014). For this study, Cronbach’s alphas ranged from .613 to .821 (Table 1).
3.3 Procedures

Ethical approval for the study was obtained from the University of British Columbia prior to recruitment and testing. Posters were placed around local climbing gyms. The posters advertised a study examining pain tolerances in rock climbers, requiring elite and non-elite rock climbers, and included information about a stipend (a chance to win 1 of 3 25$ MEC gift cards). A table was also set up at local climbing gyms to find participants. Participation included a testing session at the participants local climbing gym, at the University of British Columbia, or a café of the participants choosing. Informed consent was collected from all participants following a description of the test protocols and goals of the study. Demographic information was then collected. Following this, a standard 2-step CPM protocol was followed (Yarnitsky et al., 2015).

Yarnitsky et al. (2015) recommend that the test and conditioned stimuli be presented sequentially to reduce the potential for distraction. First, the test stimulus pain rating was determined using pressure algometry (FPK 40 Algometer, Wagner Instruments, USA). Following this, the conditioned stimulus pain rating was determined. The conditioned step involved placing a pressure cuff around participants left upper arm, which was then inflated to 200mmHg. The cuff stayed inflated for 2 minutes. Pain ratings were taken at 15, 45, and 90 seconds to ensure the conditioning stimulus was painful enough to elicit the CPM response (Nir & Yarnitsky, 2015). If pain ratings exceed 4 or were below 2 at any time, the cuff was adjusted accordingly. Pain ratings of the conditioned stimulus were taken to ensure consistency between participants. Immediately following the 2-minute conditioned stimulus, the pressure test stimulus was repeated until a pain rating of 6 was reached, and this value was recorded as the conditioned stimulus pain rating. A 10-minute break separated the two steps to prevent the test stimulus from influencing the conditioned stimulus test. Immediately following the conditioned stimulus test, the CSQ-R and SAM were given, and participants were asked to rate their coping strategy use and pain appraisals for managing the test stimulus and for managing pain during a recent painful climb.
3.4 Data Analysis

3.4.1 Data Screening

Data were screened for missing data points and to determine if data conformed to assumptions of parametric analysis. Within-person median replacement was used to replace missing data. Data were screened for normality using histograms, box plots, and normal Q-Q plots. A priori it was decided that data that was not normal would be transformed and re-examined: data that had skewness values of >3 would be transformed. Z-scores were used to examine univariate outliers and Mahalanobis distances were used to examine multivariate outliers. Z-scores of ±3.29 or higher and Mahalanobis distances of $\chi^2(20) = 45.315$ were considered outliers.

3.4.2 Inferential Data Analysis

Data analysis was planned according to the specific research questions. First, group (elite and non-elite) differences on pain modulation were examined using a two (group) by two (pain test – baseline and conditioned step scores) mixed design ANOVA. Second, group differences in coping and appraisals were examined using one-way MANOVA, with follow-up ANOVAs done for each dependent variable. Third, correlation analysis examined the relationships between coping in the pain test and pain modulation. If a coping strategy or appraisal was correlated to CPM or baseline pain tolerance, it was to be a covariate in a one-way ANCOVA analysis which would examine group differences in pain modulation. For all of the above analysis, $p < .05$ was the criteria used to determine statistical significance. Finally, intraclass correlational analysis examined the consistency and absolute agreement of coping strategies and appraisals made in the two situations (CPM test and a recent painful climb).
4.1 Data Screening

Prior to formal analyses, data were screened for missing data points, normality, and for outliers. Three participants were missing data (accounting for 2% of total data), and within-person median replacement was used to replace these missing values. Data were screened for normality using histograms, box plots, and normal Q-Q plots. As shown in Table 1, all data appeared normal except for both catastrophizing scales, threat appraisals during the CPM test, and control appraisals during the CPM test, which were slightly skewed. Upon closer inspection, both catastrophizing scales and the threat scale were positively skewed, with 75% of the data for the climbing pain catastrophizing scale scoring 1.75/6 or lower, 75% of the data for the CPM test catastrophizing scale scoring 1.0/6 or lower, and 75% of the data for the CPM test threat scale scoring 1.5/6 or lower (Figure 1, Figure 2, and Figure 3 respectively). The CPM test control scale was negatively skewed, with 75% of the scores being 3.33/6 or higher (Figure 4). As these scales were only slightly skewed, no transformations were done. Q-Q plots showed data appeared normal. Univariate and multivariate outliers were assessed by Z-scores and Mahalanobis distances respectively; participants with a Z-score of ±3.29 on a higher-order subscale (n=3) were identified as potential univariate outliers, and no participants exhibited a Mahalanobis distance greater than $\chi^2(20) = 45.315$ (p<.001), suggesting no multivariate outliers. As the three univariate outliers did not appear to be atypical responses, they were included in the data analysis.
Table 1: Summary of descriptive statistics for study variables.

<table>
<thead>
<tr>
<th></th>
<th>Range</th>
<th>M</th>
<th>SD</th>
<th>Skewness (SE=.333)</th>
<th>Kurtosis (SE=.656)</th>
<th>α</th>
</tr>
</thead>
<tbody>
<tr>
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<td>-.410</td>
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</tr>
<tr>
<td>Conditioned Pain</td>
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<td>4.60</td>
<td>.608</td>
<td>.043</td>
<td></td>
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<tr>
<td>CPM</td>
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<td>-.54</td>
<td>2.14</td>
<td>.536</td>
<td>.877</td>
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</table>

**Recent, Painful Climb Scores**

<table>
<thead>
<tr>
<th></th>
<th>Range</th>
<th>M</th>
<th>SD</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>α</th>
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</thead>
<tbody>
<tr>
<td>Distraction</td>
<td>0-6</td>
<td>1.39</td>
<td>1.31</td>
<td>.833</td>
<td>-.126</td>
<td>.730</td>
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<tr>
<td>Catastrophizing</td>
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<td>1.10</td>
<td>1.08</td>
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<tr>
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<td>1.37</td>
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<td>-.558</td>
<td>.800</td>
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<tr>
<td>Distancing</td>
<td>0-6</td>
<td>1.53</td>
<td>1.55</td>
<td>.641</td>
<td>-.855</td>
<td>.855</td>
</tr>
<tr>
<td>Coping Self-Statements</td>
<td>0-6</td>
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<td>.792</td>
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<td>Task Engagement</td>
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<td>-.785</td>
<td>-.033</td>
<td>.789</td>
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<tr>
<td>Challenge Appraisal</td>
<td>0-5</td>
<td>3.85</td>
<td>.75</td>
<td>-.346</td>
<td>-.340</td>
<td>.616</td>
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<tr>
<td>Threat Appraisal</td>
<td>0-5</td>
<td>2.04</td>
<td>.77</td>
<td>.491</td>
<td>-.599</td>
<td>.743</td>
</tr>
<tr>
<td>Control Appraisal</td>
<td>0-5</td>
<td>3.97</td>
<td>.75</td>
<td>-.432</td>
<td>-.418</td>
<td>.613*</td>
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</table>

**Pain Test Scores**

<table>
<thead>
<tr>
<th></th>
<th>Range</th>
<th>M</th>
<th>SD</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>α</th>
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</thead>
<tbody>
<tr>
<td>Distraction</td>
<td>0-6</td>
<td>1.37</td>
<td>1.40</td>
<td>1.049</td>
<td>.796</td>
<td>.795</td>
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<tr>
<td>Catastrophizing</td>
<td>0-6</td>
<td>.57</td>
<td>.86</td>
<td>1.863</td>
<td>3.417</td>
<td>.849</td>
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<tr>
<td>Ignoring</td>
<td>0-6</td>
<td>2.21</td>
<td>1.37</td>
<td>.163</td>
<td>-.534</td>
<td>.807</td>
</tr>
<tr>
<td>Distancing</td>
<td>0-6</td>
<td>1.24</td>
<td>1.44</td>
<td>.955</td>
<td>-.170</td>
<td>.893</td>
</tr>
<tr>
<td>Coping Self-Statements</td>
<td>0-6</td>
<td>3.37</td>
<td>1.52</td>
<td>-.288</td>
<td>-.675</td>
<td>.801</td>
</tr>
<tr>
<td>Task Engagement</td>
<td>0-6</td>
<td>3.87</td>
<td>1.34</td>
<td>-.292</td>
<td>-.722</td>
<td>.739</td>
</tr>
<tr>
<td>Challenge Appraisal</td>
<td>0-5</td>
<td>3.20</td>
<td>.84</td>
<td>-.161</td>
<td>-.427</td>
<td>.611</td>
</tr>
<tr>
<td>Threat Appraisal</td>
<td>0-5</td>
<td>1.27</td>
<td>.48</td>
<td>2.554</td>
<td>8.166</td>
<td>.817</td>
</tr>
<tr>
<td>Control Appraisal</td>
<td>0-5</td>
<td>3.76</td>
<td>.86</td>
<td>1.094</td>
<td>1.321</td>
<td>.656**</td>
</tr>
</tbody>
</table>

*Original 4-item scale alpha was .524. Item 12 was dropped to improve alpha.

**Original 4-item scale alpha was .565. Item 12 was dropped to improve alpha.

Note: ranges for pain variables (baseline, conditioned, CPM) reflect range of scores achieved by participants, whereas ranges for all recent, painful climb and pain test scores reflect the range of scores possible.
Figure 2: Histogram of scores for the climbing pain catastrophizing scale.

Figure 3: Histogram of scores for the CPM test pain catastrophizing scale.
Figure 4: Histogram of scores for the CPM test threat appraisal scores.

Figure 5: Histogram of scores for the CPM test control appraisal scores.
4.2 Demographics

The average age for the elite rock climbers was 26.70 and 26.69 for non-elite climbers (F(1, 51) = .000, p=.994). Of the elite rock climbers, 52% completed their highest climbing grade on a bouldering route, 41% were “multi-type” climbers, meaning they had ascents that were of an “elite” classification on more than 1 style of climbing, and 7% completed their hardest climbing grade on a sport route. For the non-elite climbers 85% completed their highest climbing grade on a bouldering route. No participants were currently participating in any other sports at an elite level, but 4 (7.5%) had previously competed in a different sport at an elite level. None of the participants were currently suffering from chronic pain.

As climbing grades cannot be averaged to produce meaningful values, ranges and frequencies are reported (Figure 1). The elite group’s highest climbing grades ranged from V7-V13, and 5.13a-5.14b, with V7 & V8 having the highest frequencies (n=5). The non-elite group’s highest climbing grades ranged from V0-V3, and 5.9, with the highest frequency being V2 (n=9).

![Figure 6: Frequency distribution of participant's highest climbing grades. Total N is larger than sample size, as this includes data from participants who reported ascents in multiple types of climbing. Orange indicates elite group climbers, and blue indicates non-elite climbers.](image-url)
4.3 Scale Reliability

Scale reliability in this study was examined using Cronbach’s alpha. Both control appraisal scales showed low reliability (.524 and .565 for climbing and pain test versions respectively); dropping 1 item improve values to over 0.6. The item dropped on both control scales was the reverse scored item, “I believed the pain during the testing session/recent, painful climb was beyond my control.” All analysis using the control appraisal scale was done on the 3-item version. All other scales had acceptable scale reliability (Table 1).

4.4 Hypothesis Testing

4.4.1 Hypothesis 1

It was expected that elite rock climbers would have higher CPM and higher baseline pain tolerance scores than non-elite climbers, which was tested using a 2 (group) by 2 (pain tests – baseline and conditioned pain tests) mixed-design ANOVA. The main effect of the pain test (baseline vs. conditioned step pain tests) was not significant, F(1, 51) = 3.671, p= .061, Wilk’s Λ = .933, partial η² = .067 (Figure 7). The main effect of the groups (elite vs. non-elite climbers) was significant, F(1, 51) = 9.778, p<.01, partial η² = .161 (Figure 7). There was also a significant group by pain test interaction, F(1, 51) = 7.972, p = .007, Wilk’s Λ = .865, partial η² = .135, showing groups were significantly different at baseline and that the differences increased for the conditioned step pain test (Figure 7). Examining this closer, elite rock climbers had higher baseline pressure scores (F(1, 51) = 5.812, p<.05, η² =0.114) and higher conditioned step pressure scores (F(1, 51) = 12.992, p<.01, η² = 0.255) resulting in the higher CPM scores compared to non-elite climbers (F(1, 51) = 7.972, p<.01, η² = 0.156, Cohen’s d = 0.769;
Table 2). Appendix C contains raw baseline step, conditioned step, and CPM scores. These results provide support for hypothesis 1.

Table 2: Results of CPM test for elite and non-elite rock climbers.

<table>
<thead>
<tr>
<th></th>
<th>Elite Rock Climbers (n=27)</th>
<th>Non-Elite Rock Climbers (n=26)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Pressure (lbsf)</td>
<td>13.85 (3.76)</td>
<td>11.49 (4.04)</td>
<td>0.020</td>
</tr>
<tr>
<td>Conditioned Pressure (lbsf)</td>
<td>15.16 (4.24)</td>
<td>11.22 (4.14)</td>
<td>0.001</td>
</tr>
<tr>
<td>CPM (lbsf)</td>
<td>-1.31 (1.93)</td>
<td>0.27 (2.17)</td>
<td>0.007</td>
</tr>
</tbody>
</table>

Baseline Pressure: pressure that elicited a pain rating of 6/10 in the baseline step.
Conditioned Pressure: pressure that elicited a pain rating of 6/10 in the conditioned step.
CPM: difference between baseline and conditioned pressure (baseline-conditioned pressure).
lbsf: pounds of force.

1 Exploratory regression analysis was done to examine the influence of age and highest climbing grade on CPM. Age did not influence CPM, however highest climbing grade appeared to explain 6.5% of the variance in CPM scores (F(1,51) = 4.952, p = .031, R² = .065). Important to note is that highest climbing grade was highly correlated to group (elite or non-elite) membership (r=-.974, p<.01).
4.4.2 Hypothesis 2

It was expected that elite rock climbers and non-elite climbers would use different coping strategies and appraisals in response to pain, during both the CPM laboratory test context and the recent painful climb. Specifically, non-elite climbers were expected to use catastrophizing, distancing, and distraction significantly more than elite rock climbers, and would appraise pain as more threatening. This hypothesis was tested through a multi-step analytic strategy. The first step was to examine group differences in coping and appraisals scores using a one-way MANOVA, and was followed-up with ANOVAs for each dependent variable.

The MANOVA demonstrated a significant difference in coping and appraisal scores between elite and non-elite climbers (F(18,34) = 2.540, p=.009; Wilk’s Λ = .427, partial \( \eta^2 =0.573 \)). For the CPM test condition, distraction coping use was lower in elite rock climbers (F(1, 51) = 4.722, p<.05, partial \( \eta^2 =0.085 \); Table 3). For the recent painful climb condition, elite climbers used significantly less distraction (F(1, 51) = 6.088, p<.05, partial \( \eta^2 =0.107 \)) and had higher control appraisals (F(1, 51) = 22.101, p<.01, partial \( \eta^2 =0.302 \); Table 4) than non-elite climbers. Appendix D contains a table of complete results for the follow-up ANOVAs.

Table 3: Summary of means, standard deviations, and p-values of coping and appraisal scores for CPM test condition.

<table>
<thead>
<tr>
<th></th>
<th>Elite Rock Climbers (n=27)</th>
<th>Non-Elite Rock Climbers (n=26)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distraction</td>
<td>0.972(1.114)</td>
<td>1.779(1.559)</td>
<td>.034</td>
</tr>
<tr>
<td>Catastrophizing</td>
<td>0.565(0.792)</td>
<td>0.567(0.942)</td>
<td>.992</td>
</tr>
<tr>
<td>Ignoring</td>
<td>2.326(1.412)</td>
<td>2.085(1.023)</td>
<td>.527</td>
</tr>
<tr>
<td>Distancing</td>
<td>1.287(1.356)</td>
<td>1.192(1.556)</td>
<td>.814</td>
</tr>
<tr>
<td>Coping Self-Statements</td>
<td>3.222(1.628)</td>
<td>3.519(1.412)</td>
<td>.482</td>
</tr>
<tr>
<td>Task Engagement</td>
<td>3.787(1.508)</td>
<td>3.952(1.160)</td>
<td>.658</td>
</tr>
<tr>
<td>Challenge</td>
<td>3.130(0.850)</td>
<td>3.279(0.745)</td>
<td>.524</td>
</tr>
<tr>
<td>Threat</td>
<td>1.222(0.363)</td>
<td>1.327(0.582)</td>
<td>.434</td>
</tr>
<tr>
<td>Control</td>
<td>3.654(0.875)</td>
<td>3.859(0.839)</td>
<td>.389</td>
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</table>
Table 4: Summary of means, standard deviations, and p-values of coping and appraisal scores for recent painful climb condition.

<table>
<thead>
<tr>
<th></th>
<th>Elite Rock Climbers (n=27)</th>
<th>Non-Elite Rock Climbers (n=26)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distraction</td>
<td>0.97(0.91)</td>
<td>1.82(1.52)</td>
<td>.017</td>
</tr>
<tr>
<td>Catastrophizing</td>
<td>0.99(1.18)</td>
<td>1.22(0.97)</td>
<td>.442</td>
</tr>
<tr>
<td>Ignoring</td>
<td>2.96(1.28)</td>
<td>2.42(1.42)</td>
<td>.147</td>
</tr>
<tr>
<td>Distancing</td>
<td>1.58(1.57)</td>
<td>1.48(1.56)</td>
<td>.813</td>
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<tr>
<td>Coping Self-Statements</td>
<td>4.20(1.53)</td>
<td>4.07(1.29)</td>
<td>.727</td>
</tr>
<tr>
<td>Task Engagement</td>
<td>5.13(0.89)</td>
<td>4.63(1.02)</td>
<td>.065</td>
</tr>
<tr>
<td>Challenge</td>
<td>3.94(0.77)</td>
<td>3.77(0.75)</td>
<td>.428</td>
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<tr>
<td>Threat</td>
<td>2.10(0.74)</td>
<td>1.97(0.82)</td>
<td>.544</td>
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<tr>
<td>Control</td>
<td>4.37(0.52)</td>
<td>3.55(0.74)</td>
<td>.000</td>
</tr>
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</table>

The next step in the analytic strategy involved examining correlations between coping, appraisals, and CPM scores to determine if coping and appraisal scores could be considered as covariates in an ANCOVA to examine CPM group differences. Since there was no measure of pain during the painful climbing condition, only the CPM test condition was examined. As Table 5 shows, no coping or appraisal strategies correlated to CPM or baseline pain scores. Thus, no additional analysis was conducted since a basic assumption of ANCOVA is that the covariate (distraction) is correlated with the dependent variable (pain). Although the use of distraction coping was different across groups, there was no evidence that distraction coping mediated the differences between groups in their perception of pain.
Appendix E include a summary of within-group correlations. No coping strategy or appraisal correlated with CPM or baseline pain tolerance when examining elite and non-elite climbers separately.

4.4.3 Examining Stability of Coping and Appraisals Across Pain Test and Climb Contexts

Purpose 3 involved examining stability of coping strategies and appraisals made during a recent painful climb and during the CPM protocol. Intraclass correlations (ICC) were used to examine both consistency and absolute agreement between the two contexts (Table 6). Absolute agreement considers systematic differences in calculating its scores, whereas consistency only looks at the consistency between the two scores for each situation and does not consider systematic differences (Koo & Li, 2013). Values ranged from .252 to .827, suggesting some agreement between the recent painful climb and the CPM protocol versions of each scale. All coping scales and one appraisal scale (challenge) showed moderate stability (ICC > 0.5 (Koo & Li, 2013)) across contexts. There were, however, evidence of instability (ICC < .5) in threat and control appraisals. Unexpectedly, the task engagement, challenge, and threat scales had higher consistency than absolute agreement scores, suggesting some systematic differences between the CPM test and the recent painful climb (see Appendices G-I for figures). Overall,
ICC values showed moderate to high stability in pain coping and appraisals between the two situations, in line with hypothesis 3.

Table 6: Single measure intraclass correlations between CPM test and recent painful climb coping strategies and appraisals.

<table>
<thead>
<tr>
<th>Pain Coping Strategies &amp; Appraisals</th>
<th>Intraclass Correlation – Absolute Agreement</th>
<th>Intraclass Correlation – Consistency</th>
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<tr>
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<td>.824</td>
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<td>Ignoring</td>
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<td>.806</td>
<td>.812</td>
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<tr>
<td>Coping Self-Statements</td>
<td>.630</td>
<td>.684</td>
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<td>Task Engagement</td>
<td>.573</td>
<td>.709</td>
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<tr>
<td>Challenge</td>
<td>.566</td>
<td>.686</td>
</tr>
<tr>
<td>Threat</td>
<td>.252</td>
<td>.392</td>
</tr>
<tr>
<td>Control</td>
<td>.466</td>
<td>.474</td>
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</table>
Chapter 5: Discussion and Conclusions

5.1 Discussion

The differences in elite and non-elite athlete’s pain tolerances has been well-documented, but the reasons for these differences is largely unknown and research has not often examined adventure sport athletes such as rock climbers. Coping and appraisals may influence how a person approaches and deals with pain (Cruz-Almeida et al., 2013); however, data on non-injury sport pain is limited. This study examined if elite and non-elite rock climbers pain tolerance and pain modulation differed, and whether pain coping and appraisals influenced this difference. Results revealed that both pain tolerance and CPM differed between the two groups. But, neither coping or appraisals were related to either pain measure. Elite and non-elite climbers did differ in their coping strategies and appraisals, with non-elite climbers reporting higher distraction scores than elite climbers in both a laboratory setting and in a recalled recent painful climb. Elite climbers also reported higher use of control during the recalled recent painful climb. An interesting finding is the relative stability in coping and appraisals across a climbing setting and in the pain test, suggesting some stability in how climbers deal with pain. Although this study has a number of limitations, it adds to the growing body of literature and theory regarding pain in rock climbing, and has implications for future research in both the pain and climbing areas.

5.1.1 CPM Differences in Elite and Non-elite Rock Climbers

The first key finding was that elite climbers showed substantially higher pain tolerance and CPM than non-elite climbers, with 15.6% of the variance in CPM scores and 11.4% of the variance in baseline pain tolerance scores were explained by the group differences. These findings are similar to research in other athlete groups such as Geva & Defrin (2013) who found that elite triathletes had higher CPM than non-elite triathletes. The present findings suggest rock climbers have similar CPM responses as more traditional sport athletes. To the best of our knowledge CPM has not been examined in rock climbers before, making this study a unique contribution to the sport pain literature. Also, this study used a novel
CPM technique that was designed to be similar to the pain felt during the athlete’s sport, which has not yet been done. This study supports the finding that there is a relationship between a person’s level of sport involvement and their CPM, and extends our knowledge to include adventure sport athletes.

Although the effect size of the influence of group membership on CPM scores was moderate to large (d=.769), there is unexplained variance that is likely due to the subjective nature of pain and the many opportunities for measurement errors that exist when studying pain. Previous CPM studies that have compared athletes and non-athletes/novice athletes have found large effects (Flood et al., 2016, Geva & Defrin, 2018), suggesting rock climbers have similar CPM responses to other athletes. However, it is important to remember that pain is subjective and biological differences (e.g. genetic differences) exist between people alongside social and psychological differences creating large between-person variance in CPM. This study did explore two other possible influences on CPM (age and highest climbing grade) but these factors either did not predict CPM or were too highly correlated to other measures to explain additional variance. Pain is also measured using indirect methods such as self-reports, which has measurement error associated with it (Fillingim, 2017). Furthermore, there is a chance that the CPM protocol can differ between participants, adding more potential for measurement error.

The types of pain used in the CPM paradigm of this study may have led to improved internal validity, but it also impacted the comparison of results to other CPM studies. The modality of pain used has been shown to influence CPM, as there are low correlations between CPM found using different paradigms, such as electrical-, thermal-, or mechanical-based paradigms (Nahman-Averbuch et al., 2013). This may make it difficult to draw comparisons between studies that have used different noxious stimuli and influence how much CPM results can be extrapolated to non-experimental settings. This study considered this when pain modality was being determined: potentially it is more valid to experimentally study the type of pain athletes encounter in their sport, meaning a rock climbing study should use pressure and ischemic pain. Previous athlete CPM studies have used temperature pain (Geva & Defrin, 2013;
Naugle & Riley, 2014) and pressure pain (Flood et al., 2016), but there has not been much discussion regarding if these pain modalities are similar to the pain experienced in a specific sport. As such, directly comparing results from different CPM studies should be done with caution until there is more information on the influence of pain modality. Although this study is important in that it considers the type of pain athletes may encounter and attempted to recreate this in an experimental setting, it is important to remember that CPM found using different modalities may not be directly comparable.

Ever since it was first reported that athletes have higher pain tolerance than non-athletes (Scott & Gisbers, 1981), there have been questions regarding whether pain tolerance is learned through exposure in the sport or if high pain tolerance is an innate trait of athletes who choose to enter sport because of this tolerance. Rock climbers have not been considered in this debate. Unfortunately, this study was not set up to examine this issue. But this debate could be important in the sport as climbing, especially at the elite level, involves high physical demand. Elite climbers appear able to maintain high levels of physical effort on a rock climb for a longer period of time than non-elite climbers (Dickson, 2013), suggesting elite climbers may get more exposure to fatigue and pressure-related pain compared to non-elite climbers. However, potentially elite climbers are people who naturally have higher pain tolerances and are attracted to, and continue in, the sport because of this attribute. This causal argument is difficult to test, but O’Leary et al. (2017), Jones, Booth, Taylor, & Barry (2014), and Anshel & Russell (1994) conducted longitudinal studies that found exercise led to increased pain tolerances in a variety of populations regardless of baseline pain tolerance. As this study was cross-sectional it cannot contribute to this chicken-or-egg debate, but it does extend athlete pain tolerance findings to rock climbers. Future research could consider longitudinal studies, and look at the many potential factors that contribute to pain tolerance.
5.1.2 Coping Strategies and Appraisal Differences and CPM

The second key finding was that although elite and non-elite climbers differed in their coping strategy choice and appraisals, coping strategies and appraisals did not predict the differences in CPM or baseline pain tolerance across all individuals. Control appraisals during a recent painful climb and use of distraction during the CPM test and during a recent painful climb differed between the two groups, but these factors did not predict CPM or baseline pain tolerance in any climbers. Also, both groups reported moderate to high usage of coping self-statements, task engagement, and challenge appraisals, and very low use of catastrophizing. Previous research has found no differences in catastrophizing between elite and non-elite athletes (Geva & Defrin, 2013). Pain coping strategies has been examined alongside pain tolerance in knee osteoarthritis patients (Cruz-Almeida et al., 2013), with passive coping strategies found to correlate to lower pain tolerances. However, to the best of our knowledge no study has examined the influence of pain coping strategies and appraisals on CPM scores. This research extends this line of inquiry by finding that rock climbers coping strategies and appraisals may not influence their pain perception in direct ways, and may be difficult to examine in acute pain settings.

5.1.2.1 Differences in Coping Strategies and Appraisals Between Elite and Non-Elite Climbers

This study found that non-elite climbers used distraction significantly more than elite climbers during the experimental CPM test and during a recent painful climb which is consistent with research in other athlete groups such as runners (Lind et al., 2009). Non-elite and recreational runners seem to preferentially use dissociative coping strategies (such as distraction) in response to sport pain, whereas elite runners tend to use associative techniques. These contrasting coping choices may be linked to differences between elite and non-elite athletes in their sport goals; using associative techniques has been linked to improved performance and dissociative techniques to increases in positive emotions while running (Lind et al., 2009). Potentially, non-elite athletes (including climbers) use dissociative coping
strategies to ensure they are having positive experiences in the sport, as opposed to elite athletes who may be focused on obtaining performance gains and therefore may be more likely to use associative strategies such as coping self-statements and task engagement. These strategies did not significantly differ between elite and non-elite climbers; however, elite climbers did average slightly higher than non-elite climbers on the task engagement scale for the recent painful climb condition (5.130/6 for elite climbers vs. 4.634 for non-elite climbers, p=0.065, partial $\eta^2=0.065$). There is some evidence that elite climbers may use more associative strategies: one previous study found that elite climbers were able to tolerate a higher workload for much longer than intermediate climbers and suggested that “elite climbers are more accustomed to maximal effort and demonstrate an increased tolerance to the higher exercise intensity” (Dickson, 2013, p. iii). Also, an ethnographic study examining mountaineers found that elite mountaineers expected and, in some cases, embraced the pain and fear that comes with extreme mountaineering, and the opportunity to push through these adverse feelings seemed to motivate some. In contrast, recreational mountaineers paid less attention to how they felt, and instead focused on external goals such as successfully reaching a summit (Burke, Durand-Bush, & Doell, 2010). The preferential use of distraction by non-elite climbers is in line with previous research, and suggests adventure sport athletes may cope with pain in similar ways as traditional endurance-sport athletes.

The finding that elite climbers had higher control appraisals than non-elite climbers (4.37/6 vs. 3.55/6) and that both groups had moderate challenge appraisals (averaging 3.85/6) during a recent painful climb builds on theory and previous research that has examined other components of the stress process in rock climbing. Research has found that athletes who make control and challenge appraisals often experience higher positive affect and feelings of achievement (Jones et al., 2009). In rock climbing elite climbers have been shown to experience lower levels of anxiety (Fryer, Dickson, Draper, Blackwell, & Hillier, 2013), higher self-confidence (Draper, Dickson, Fryer, et al., 2011), and higher levels of positive affect (Sanchez et al., 2010) compared to novice or non-elite climbers. These previous findings combined with the results in this study suggest that elite rock climbers view their recent, painful climb as a positive,
challenging experience that they were in control of. Non-elite climbers may have similar experiences, just to a lesser degree. However, previous to this study appraisals have not been examined in rock climbing and there has not been a study that considers both emotions and appraisals together in this sport. To confirm this link research should consider emotions and appraisals as interdependent constructs in rock climbing.

Both elite and non-elite climbers had similarly low levels of catastrophizing across both the CPM test and recent painful climb, which differs slightly from previous athlete studies and could reflect the type of pain examined and/or the unique demands of climbing. Previous CPM research found that non-elite and elite triathletes did not differ significantly in their pain catastrophizing, but that non-elite athletes did report marginally higher catastrophizing (16.5/52 for elite athletes, and 20.8/52 for non-elite athletes, p=.053; Geva & Defrin, 2013). In comparison, in this study catastrophizing levels were almost identical between elite and non-elite climbers in the CPM test condition (averages of 0.565/6 for elite climbers, 0.567/6 for non-elite climbers) and very similar in the recent, painful climb condition (averages of 0.991/6 for elite climbers, 1.221/6 for non-elite climbers). In Geva & Defrin’s (2013) study, catastrophizing in both groups was low to average (Sullivan, 1995), and was higher than averages reported in this study. These differences could be due to how the pain was assessed. Geva & Defrin (2013) asked participants to report catastrophizing in response to “past painful experiences” (p. 2319) and did not specify if participants were asked to recall injury or non-injury pain. In this study participants were asked to consider non-injury pain. Injury pain is often viewed as much more negative than non-injury pain (Bridel, 2010; Wiese-Bjornstal, 2010) and people may use different, and sometimes more maladaptive, strategies such as catastrophizing (Wiese-Bjornstal, 2010). Sport type could be another consideration. Meyers et al. (2015) found that female adventure athletes cope with pain differently than traditional-sport athletes, suggesting that something about adventure sports or athletes who participate in adventure sports leads them to cope with pain differently than traditional sport athletes. Interestingly, this study showed that there were similarities between how climbers coped with pain during the CPM test and a recent painful
climb, suggesting differences at the individual level may be more influential than the environment of rock climbing for coping with non-injury pain.

Rock climbing involves dealing with a high cognitive load, and this factor may have impacted the results. This sport involves planning, reaching, and posture control, all done while conducting an inherently risky task (see Blakely, 2017). This high cognitive load could mean that pain is considered less important and may lead to lower reports of specific coping and appraisals in response to pain. However, coping with pain may be intertwined with how a climber is coping with the other aspects of the climb. A few participants voiced thoughts surrounding this, with one participant commenting on their CSQ-R that “I don't know to what extent these are strategies to cope with pain while climbing, as opposed to an inseparable part of climbing a route: There is simply a lot more other stuff going on”. Potentially climbers see the pain of climbing as one of many stressors they must deal with in order to climb, and since this pain is not injury related, it may take lower priority than other stressors. Without explicit parameters in place in a study to separate out how climbers cope with pain as opposed to how they cope with the demands of the climb, this is difficult to ascertain. To fully understand the importance of pain and coping with pain in climbing, researchers may have to look at how other components of climbing influences, and is influenced by, pain.

**5.1.2.2 Impact of Coping Strategies and Appraisals on CPM**

An interesting finding was that no coping strategy or appraisal appeared to predict to the differences in CPM or baseline pain tolerance across all elite and non-elite climbers. The reasons for this are unknown, but some potential contributors could include (1) the type of pain used for the CPM test, (2) the inability of the questionnaires to capture participants’ coping and appraisal use, (3) that the pain intensity was not deemed “stressful” by participants, or (4) the nature of the design of the study (extreme group design) led to an inability to detect the relationship.
Pain modality may influence the impact of psychological constructs on CPM, however this is still being debated. Nahman-Averbuch et al. (2016) found that CPM was unrelated to anxiety, depression, and catastrophizing, but when a sub-analysis was done on each of the different types of pain used for the CPM test, anxiety was found to be related to pressure-based pain, depression to heat-based pain, and catastrophizing to electrical-based pain. Potentially, the different types of CPM pain modalities activate different pain-inhibitory pathways, and each pathway is influenced by different psychological factors (Nahman-Averbuch et al., 2016). This is seen in animal models, where electrical-based investigations of CPM are influenced by adrenoreceptor drugs but not opioids, whereas pain induced by formaldehyde is influenced by both classes of drugs (Wen et al., 2010). In humans, medications used to treat depression and anxiety appear to influence CPM; however, these studies have not controlled for pain modality (Nahman-Averbuch et al., 2016). These studies have almost exclusively used clinical populations and/or healthy controls and have not considered how coping and appraisals could be influenced by pain modality. The results of this study show that mechanical/pressure pain may be unrelated to coping and appraisals of pain in climbers, but potentially using a different pain modality we would find a different result.

The questionnaires used to measure coping strategies and appraisals also could have been a factor in the study’s findings, as neither were explicitly developed for the situations examined. This study asked participants to answer the questionnaires in response to an “in-vivo” pain test (the CPM test), and to recalled pain (the recent painful climb), and neither the CSQ-R or the SAM were designed to examine in-vivo pain or specific recalled pain scenarios. The catastrophizing scale of the CSQ-R was used to examine in-vivo pain and to recalled pain by Hirsh, George, Bialosky, & Robinson (2008), who found no difference in responses to the two situations. Also, the CSQ-R was not meant to assess acute pain situations; however, studies have found it to be valuable in measuring coping in response to acute pain in athletes (eg. Deroche et al., 2011; Lukins et al. 2004) and other populations (Hastie et al., 2004). Similarly, the SAM was not originally designed for athletes or acute pain. Nevertheless, previous athlete studies have found it to be useful in stress studies (Crocker et al., 2014). Unfortunately, it has not yet been
validated to study appraisals of pain. Despite these concerns, both the SAM and the CSQ-R were chosen as they were thought to be the most useful for this study population given the lack of questionnaires in this field. For this study, Cronbach’s alphas were acceptable, suggesting both questionnaires were reliable measures in this study. Nevertheless, results should be interpreted with consideration of the drawbacks of the questionnaires.

A third explanation for our findings could be that the pain wasn’t stressful enough to elicit strong reactions, something pain research has not fully researched. Stress is caused when a person encounters a situation that is perceived to be taxing or exceeding their resources (Lazarus & Folkman, 1984), and if a person’s resources exceed the requirements of the situation it will not be deemed stressful (Lazarus, 1999). It could be that participants found the CPM test to be well within their pain tolerance capabilities, and therefore perceived the pain situation as relatively low stress. Means on all coping and appraisal scales were low (Table 1), with the most-reported coping strategy being task engagement (with an average score of 3.8/6). For the CPM test, the high score on this scale could potentially indicate that participants were following instructions, as they were instructed to focus on the pain (i.e. engage with the task) and report when the pain reached a level of 6/10. Overall, participants seemed to appraise the CPM test as relatively non-threatening and felt that they had some control over the situation (Table 1), suggesting the climbers did not see the test as overwhelmingly stressful. Stress responsiveness has been shown to contribute to differences in pain perception with low stress situations equalling higher CPM (Geva & Defrin, 2018), but the influence of how stressful the pain is perceived to be has not been studied. Instead, studies examining pain coping seem to assume that pain itself is always stressful and have not reported on the perceived stressfulness of the pain. But as Bridel (2010) pointed out athletes often see pain as positive and useful and therefore the view of pain as always stressful may be inaccurate for some situations, especially for athletes. Accounting for how stressful the pain is perceived to be should be considered when examining pain coping and appraisals, especially in athletes, as this likely influences the coping strategies chosen to deal with the situation.
The study used an Extreme Group Approach (EGA) which comes with statistical advantages and disadvantages. The recommended uses for EGAs include when a study has limited resources, there is a desire to maximize statistical power and the chance of detecting the presence of an effect (especially in pilot or exploratory studies), if data is non-normal or if the study desires to examine lower-order interaction effects. However, limiting the sample to the extreme cases (in this case, those at the bottom and those at the top of the scale for climbing ability) means the sample is an incomplete set as it misses the middle data points. This may make it difficult to detect a linear relationship (Preacher, Rucker, MacCallum, & Nicewander, 2005). This might have been the case in this study: elite climbers used distraction significantly less than non-elite climbers to manage pain, which suggests coping is related to pain in explaining group differences. However, distraction did not explain differences in CPM across both groups. Potentially coping is related to CPM in non-linear ways, meaning EGA is an impractical design to use to examine this relationship. Potentially, the relationship between coping, pain, and level of rock climbing could have been different had the study included climbers across all climbing levels.

5.1.3 Similarities in Coping Strategies and Appraisals Between Laboratory and Real-World Climbing Situations

The third key finding in this study was the consistency between coping strategies and appraisals made during the CPM test and a recent painful rock climb. This was tested using intraclass correlations (ICC’s) to compare the coping and appraisal scales for the CPM test and the recent painful climb. All coping strategies and challenge appraisals had ICC’s above 0.5, whereas threat and control appraisals had ICC’s above 0.2 (Table 6). The high agreement of coping strategies and appraisals found between recalled and in-vivo pain builds upon previous conflicting research regarding the consistency of pain coping across the course of an injury. There has been a paucity of research looking at the coping strategies of non-injury pain. A potential reason for the similarities in coping and appraisals could have been the similarities between the pain modalities of the two situations (as the pain in the CPM test was chosen to be hypothetically similar to what is experienced during climbing). Alternatively, the method
might have induced a set response. The close temporal proximity of the questionnaires to the CPM test could have influenced the response of the participants. It should be noted that the consistency ICC’s were higher than the absolute agreement ICC’s for the task engagement, challenge, and threat scales (Table 6), suggesting that although participants responded to these scales in relatively consistent ways, the climb was viewed as more engaging, challenging, and threatening than the CPM test. These findings suggest some continuity within coping and appraising non-injury pain in different situations, and may suggest that examining coping with non-injury sport pain in controlled, experimental settings may produce results similar to real-world situations when using recalled pain questionnaires. Consistency of coping and appraisals across pain situations has not been well-studied, especially in athletes and sport, and this study is a step in leaning more about how pain is viewed and coped with in different scenarios.

The moderate to high stability of distraction, catastrophizing, ignoring, distancing, coping-self statements, task engagement, and challenge appraisals scales between the CPM test and a recent, painful climb builds upon previous research in non-athlete populations. Hirsh et al. (2008) examined the catastrophizing scale of the CSQ-R in healthy undergraduate students and found that catastrophizing was consistent (r=.62, p<.01) across an “in-vivo” pain test and recalled pain. No other scale of the CSQ-R was examined. However, this runs counter to previous research that found catastrophizing (as measured by the Pain Catastrophizing Scale) significantly differed between recalled and in-vivo pain situations (Dixon, Thorn, & Ward, 2004) in undergraduate students. To our knowledge the full CSQ-R has not been compared across in vivo and recalled pain scenarios. The results found here, as well as in Dixon et al.’s (2004) and Hirsh et al.’s (2008) studies suggest there should be additional work to clarify these results.

Previous pain coping research that has examined coping as a process has focused on injury recovery over time, and has neglected non-injury pain. Research into injury rehabilitation has found that appraisals and coping changed over the rehabilitation timeframe as the pain changed (Cruz-Almeida et al., 2013), and that athletes coping undergoes similar alterations (Albinson & Petrie, 2003). Albinson &
Petrie (2003) found that over an injury recovery period active behavioural coping and avoidance coping changed, and that appraisals made predicted these future coping changes. Although these studies have been informative regarding the process that is coping and appraisals of pain, they highlight a significant gap; how athletes appraise and cope with non-injury pain, and whether there are consistencies in these non-injury pain situations over time and situations. This study found similarities in coping and appraisals between an experimental pain setting and a sport pain setting, but did not examine if there were changes over time.

The similarities in coping and appraisals between the CPM test and a recent painful climb might have been an artifact of the intended similarities in the type of pain experienced in both scenarios, or may have been influenced by the exposure to the CPM test. In this study the pressure and ischemic pain used during the CPM test was chosen as it was thought to be similar to what a climber would experience during a climb. As shown in the previous section, different modalities of pain are associated with different emotions and cognitions (Nahman-Averbuch et al., 2016), so by using the same modalities of pain as a reference point for the experimental and climbing questionnaires we may have been triggering similar responses in the two situations. Also, both pains may have had similar meanings for the participants, as both were non-injury acute pain that could be stopped once the participant decided to stop (either by telling the tester to stop the pain or by coming off of the climb), and both were pressure/mechanical pain sensations. The meanings and affect surrounding a pain affects it’s recall: for example, birth – which generally has very positive meanings associated with it as it results in a child – is often recalled as less painful than how it actually was (the pain is underestimated) and the positive affect felt during birth is often overestimated (Babel, Pieniazek, & Zarotynski, 2015). As noted earlier, another potential influence was that the CSQ-R for the recent painful climb was filled out after the CPM test was completed, potentially participants unknowingly recalled the recent painful climb as similar to the pain they had just experienced. Recalled pain may have reliability issues, as different studies have reported pain as being recalled accurately, as more painful, or as less painful (see Babel et al., 2015). The types of pain used in
this study and the study protocol could have influenced the reported coping strategies and appraisals for both the recent painful climb and the CPM test.

Lazarus (1999) suggests that coping is situation dependent, but that people may have preferred strategies that they use. The findings in this study support this perspective, as rock climbers appeared to appraise and cope with pain in similar ways during a CPM test and a recent painful climb. The (in)stability of coping has not been the topic of much research in sport pain, meaning this study helps to bring these fields up to date with other areas, such as chronic pain (e.g. Cruz-Almeida et al., 2013) and acute injuries (Albinson & Petrie, 2003). This study also suggests that rock climbing pain coping strategies and appraisals might be able to be examined experimentally, and as rock climbing pain is difficult to control for this could help extend the field greatly.

5.2 Strengths and Limitations

5.2.1 Strengths

There were a number of features of this study that allows it to be a unique contribution to research and theory. The design of the study was theory based, drawing from Lazarus & Folkman’s (1984) CMRT. The sample was relatively homogeneous and sample size was decided using an a priori power calculation. The questionnaires used have demonstrated sound psychometric properties in prior studies (Crocker et al., 2014; Deroche et al., 2011), which were confirmed in this study. Also, the CPM protocol followed the most recent recommendations by Yarnitsky et al. (2015) and used a novel pain protocol, adding to the CPM literature. Finally, this study focused on non-injury pain, a type of pain that has not been examined often in the literature, especially quantitatively.

5.2.2 Limitations

Although this study attempted to control for or consider many influences, it does contain a number of limitations. First, there are concerns regarding the validity and objectivity of CPM. It is
possible that CPM reflects a diversion of attention or distraction as opposed to a physiological mechanism; potentially the change in perception of the test stimulus is due to the participant focusing attention away from the test stimulus and towards the conditioned stimulus. One study has shown CPM is independent of distraction (Moont, Pud, Sprecher, Sharvit, Yarnitsky, 2010); however, there were limitations to this study and a meta-analysis has suggested more research is needed to confirm the role of attention in CPM (Lewis, Rice, et al., 2012). Also, it has been suggested that CPM should be tested alongside other pain measures (Yarnitsky et al., 2015) to gain a more complete pain profile. This study considered the first test stimulus as a measure of baseline pain tolerance, but future research should consider adding other pain measures or a second CPM protocol to confirm results. However, changing pain modality may lead to different pain tolerances (Nahman-Averbuch et al., 2013), so comparing CPM and pain measures found by different types of pain should be done with caution. At the moment, CPM appears to be the most objective and thorough pain measure available, but it is important to remember that pain is still subjective and difficult to examine.

The second limitation is in regard to the sample characteristics. As sex has been shown to influence pain perception (Lewis, Rice, et al., 2012) only males were examined, meaning findings cannot be generalized to females. Also, the sample was very homogeneous in age, which limits the applicability of the results to other age groups. The sample was found using convenience sampling and recruiting mostly occurred in two climbing gyms, resulting in the sample consisting of mostly boulderers, especially in the non-elite group. This could affect the applicability of results to other types of climbing. Previous research, however, has found little differences in emotional profiles and psychological states across different climbing types (Dickson, 2013), although responses to pain was not included in this study. Findings may not extend to rock climbers that are not male, are outside of the age range of 18-40, and mainly participate in the climbing styles of trad, sport, or ice climbing.
Another limitation is that this study was not designed to fully assess the process-view of coping. Lazarus (1999) discusses the process view of coping as having 3 components: (1) a coping strategy is not universally bad or good, as it’s effectiveness depends on the person, situation, type of appraisal, and what the outcome is; (2) coping should be examined alongside the thoughts and actions that contribute and proceed coping as coping is not an independent process, and (3) the function of coping should be considered (is the coping problem-focused or emotion-focused?). This small, cross-sectional study treated coping and appraisals as separate distinct constructs and did not consider the function of coping, which runs counter to Lazarus’s (1999) recommendations. To fully capture coping changes a daily-process approach has been advocated (see DeLongis & Holtzman, 2005), and this approach has not yet been applied to coping with pain in sport. To fully examine coping with sport non-injury pain as a process, researchers should consider using a longitudinal study that examines the function of coping strategies used over time.

A fourth limitation is that no well-developed instruments to assess sport-pain coping and appraisals. The questionnaires chosen had sound psychometric properties, but neither were designed to be answered in response to acute non-injury pain in athletes and as such run the risk of missing key coping strategies or appraisals used by the participants. Also, whenever a recall questionnaire is used there are always concerns regarding the accuracy of the recalled situation. Errors can be introduced into memories during encoding, storage, retrieval, or reconstruction (Tourangeau, 2000), and can be influenced by the intensity and valence of the emotions surrounding the memory (Kihlstrom, Eich, Sandbrand, & Tobias, 2000), the time since the event occurred, and many other cognitive factors (Tourangeau, 2000). The participants were asked to recall a recent climb, but as they did not need to record any information regarding the climb there may have been a range of timeframes used between participants. Also, they did not record how pertinent the climb was to them, so the emotional valence and intensity was not recorded. Potentially, having participants describe their recalled pain could help aid the recall and give researchers more context and information regarding the pain situation. In addition, there should be efforts to develop
or validate pain coping and appraisal questionnaires in order to properly assess acute sport injury pain coping and appraisals.

A fifth limitation is the categorization of climbers’ ability, as rock climbing grades are somewhat subjective. Climbing grades are generally determined by the first person to climb the route, who assign it a grade which is then agreed on or challenged by others that climb the route. This means there is huge variations within each grade, making a V1 in one gym or climbing area potentially unequal to a V1 in a different gym or climbing area. Draper (2011) recognized this difficulty and created groups that should reflect these subjective differences. This protocol was used in this study. However, future research should consider collecting other measures of climbing ability, such as years climbing or days or hours per week spent climbing alongside highest climbing grade to more fully capture a climber’s ability level. Also, there were difficulties in recruiting non-elite climbers, meaning the non-elite climbing group’s climbing grades extended from Draper et al.’s (2011) “lower grade” (below 5.9/V0) category into the “intermediate” (5.9-5.11a/V0-V2) category. This may be because most climbers do not stay in the lower grade category for very long, and some even start climbing at an intermediate grade during their first climbing session. Also, the climbing grade conversion from Hueco to YDS is not validated, meaning the Hueco scale cut-offs used in this study may not be accurate. Efforts were taken to ensure the Hueco scale cut-offs were as accurate and realistic as possible, including consultation with climbers at all skill levels. From these consultations it was decided that V2, especially a V2 at an indoor climbing gym, could still be considered as a beginner’s level. Examining skill level in climbing is a difficult process that has been improved by using Draper et al.’s (2011) climbing categories; however, future research should look at how to incorporate boulder grades into these categories.

This study’s EGA design matched the exploratory nature of the study, however using EGA comes with several disadvantages. EGA can lead to overprediction of the statistical power especially with linear relationships, an inflation of the effect size, decreased reliability, and difficulties in detecting non-linear
relationships (Preacher et al., 2005). The difficulty in detecting non-linear relationships may be especially applicable in this study (as discussed in the above section), but it is important to consider the other impacts of using EGA. Most athlete CPM studies have used an EGA to compare elite athletes against novice or non-athletes, and have found large effect sizes. The moderate to large effect size found in this study (d=0.769) was lower than what has been seen in other studies that have used EGA, such as Geva & Defrin (2013) or Flood et al. (2016). In a CPM study that considered physical activity as a continuous variable, Naugle & Riley (2014) found that vigorous physical activity levels ($r^2=0.143$) and total physical activity levels ($r^2=0.146$) predicted CPM. These findings were lower than the variance explained in this study by group membership (elite vs. non-elite climbers) on CPM, as the partial $\eta^2$ was found to be 0.156. Comparing results of Naugle & Riley’s (2014) study to this and other EGA CPM studies suggests that CPM research may be over-estimating the effect of exercise and/or being an elite athlete on CPM due to the EGA design often used in this research. Future athlete pain studies should consider recruiting participants who are at a range of athletic abilities in order to confirm the impact of exercise on CPM.

Another limitation is that this study was underpowered to properly detect significant differences in coping strategies and appraisals between elite and non-elite participants. The power calculation done to determine sample size was based upon previous CPM studies that had found large effects, but the effect sizes of the coping strategies and appraisals were small to medium – partial $\eta^2$’s between 0.085-0.302. An estimated sample size of 620 (310 per group) would be required to detect a small effect of d=0.2, given a significance level of $p<.05$ and a power of 80%.

Finally, there was one variable that was not considered but may be important in a person’s pain experience: fear of pain. George, Dannecker, & Robinson (2012) found that fear of pain, and not catastrophizing, predicted acute pain intensity, but that neither predicted pain tolerance. Fear is a component of climbing (Morrison & Schoffl, 2007), and therefore may be worth investigating in future climbing pain studies. Elite climbers do appear to have lower levels of fear and anxiety than non-elite
climbers (Fryer et al., 2013), and this finding may extend to fear of pain. Considering this emotional factor in pain coping research is also consistent with the CMRT, as emotions are an integral part of the stress and coping process.

5.3 Future Directions

This study straddles two areas of research (climbing and pain), and as such has implications in both areas. In climbing research, this study was the first to examine non-injury pain, and the results indicate more research is needed to determine the role pain plays in the sport. The EGA design may have contributed to the null finding in the relationship between CPM and coping, suggesting researchers should consider using climbers of all ability levels in their samples. Given the subjectivity of climbing grades, it is likely still best practice to use the climbing grade categories as assigned by Draper et al. (2011) but researchers should strive to include at least one of the middle-range groups. Secondly, this study demonstrated that elite climbers coped with pain differently than non-elite climbers both in a CPM test and a recent painful climb. Potentially, teaching non-elite climbers to cope with pain in ways similarly to elite climbers may help them improve their climbing ability. However, more research should be done to confirm this link. Thirdly, it may be helpful to learn how pain is contextualized in the larger climbing experience. By studying how appraising and coping with climbing pain fits in with other psychological components of climbing (eg. attention, fear, anxiety, motivation), researchers may be able to get a more complete picture of the climbing experience. Finally, this study focused on males but rock climbing is not a single-gender sport, and research needs to consider how females experience pain in climbing.

5.4 Concluding Remarks

Examining rock climbing, much like examining pain, involves considering many personal and environmental factors. Understanding how and why someone chooses to withstand the many pains of climbing is a complex process. This study was able to demonstrate that pain is experienced differently by elite and non-elite climbers. Unfortunately, it was unable to determine if pain coping strategies or
appraisals impacted the differences in CPM between the two groups. However, climbers of each category did cope with pain differently, and this difference could be important for future climbing pain research. Findings were generally comparable to previous studies in other athlete groups, suggesting that potentially climbers and other traditional sport athletes experience pain similarly. However, understanding how pain fits into the sport of rock climbing is far from complete, and the sport could benefit from further analysis of the role of pain in climbing. Indeed, it may help unravel why so many people participate in and love the sport, and could shed light on how climbers are able to find pleasure in situations that can elicit so much pain.

“There is probably no pleasure equal to the pleasure of climbing a dangerous Alp; but it is a pleasure which is confined strictly to people who can find pleasure in it”. Mark Twain
References


IASP Subcommitteee on Taxonomy. (1979). The need of a taxonomy. PAIN, 6, 249–52.


Appendices

Appendix A – Climbing Grade Classification Chart

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<th>British Trad Tech</th>
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N.B. USA system is the Yosemite Decimal System (YDS). The French/European system is also known as the “Sport Grade System”. The Ewbank System is generally common to Australia, New Zealand and South Africa (with some minor differences).

## Appendix B – Climbing Grade Conversion Chart

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Appendix C – Raw Scores for Elite and Non-elite Climbers CPM, Baseline, and Conditioned Step Scores

Figure 8: Baseline step pain test scores for elite and non-elite climbers.
Figure 9: Conditioned step pain test scores for elite and non-elite climbers.

Figure 10: CPM scores for elite and non-elite climbers.
Appendix D – Follow-up Coping Strategies and Appraisals ANOVAs for Hypothesis 2

Table 7: Follow-up ANOVAs for the CPM test condition following the hypothesis 2 MANOVA.

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<td>.034</td>
</tr>
<tr>
<td>Catastrophizing</td>
<td>.000</td>
<td>.992</td>
</tr>
<tr>
<td>Ignoring</td>
<td>.405</td>
<td>.527</td>
</tr>
<tr>
<td>Distancing</td>
<td>.056</td>
<td>.814</td>
</tr>
<tr>
<td>Coping Self-Statements</td>
<td>.502</td>
<td>.482</td>
</tr>
<tr>
<td>Task Engagement</td>
<td>.198</td>
<td>.658</td>
</tr>
<tr>
<td>Challenge</td>
<td>.412</td>
<td>.524</td>
</tr>
<tr>
<td>Threat</td>
<td>.623</td>
<td>.434</td>
</tr>
<tr>
<td>Control</td>
<td>.755</td>
<td>.389</td>
</tr>
</tbody>
</table>

Table 8: Follow-up ANOVAs for the recent painful climb following the hypothesis 2 MANOVA.

<table>
<thead>
<tr>
<th></th>
<th>F Statistic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distraction</td>
<td>6.088</td>
<td>.017</td>
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<tr>
<td>Catastrophizing</td>
<td>.599</td>
<td>.442</td>
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<tr>
<td>Ignoring</td>
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<td>.147</td>
</tr>
<tr>
<td>Distancing</td>
<td>.057</td>
<td>.813</td>
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<tr>
<td>Coping Self-Statements</td>
<td>.123</td>
<td>.727</td>
</tr>
<tr>
<td>Task Engagement</td>
<td>3.544</td>
<td>.065</td>
</tr>
<tr>
<td>Challenge</td>
<td>.637</td>
<td>.428</td>
</tr>
<tr>
<td>Threat</td>
<td>.373</td>
<td>.544</td>
</tr>
<tr>
<td>Control</td>
<td>22.101</td>
<td>.000</td>
</tr>
</tbody>
</table>
### Appendix E – Correlations Between Coping, Appraisals, and Pain, Separated by Group

**Table 9: Correlations between coping, appraisals, and pain for elite climbers.**

<table>
<thead>
<tr>
<th></th>
<th>Baseline Pain</th>
<th>CPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>--</td>
<td>-.011</td>
</tr>
<tr>
<td>CPM</td>
<td>-.011</td>
<td>--</td>
</tr>
<tr>
<td>Test Distraction</td>
<td>.006</td>
<td>-.310</td>
</tr>
<tr>
<td>Test Catastrophizing</td>
<td>.162</td>
<td>.021</td>
</tr>
<tr>
<td>Test Ignoring</td>
<td>-.296</td>
<td>.205</td>
</tr>
<tr>
<td>Test Distancing</td>
<td>-.224</td>
<td>-.036</td>
</tr>
<tr>
<td>Test Coping Self-Statements</td>
<td>-.218</td>
<td>.050</td>
</tr>
<tr>
<td>Test Task Engagement</td>
<td>-.158</td>
<td>.145</td>
</tr>
<tr>
<td>Test Challenge</td>
<td>.012</td>
<td>.029</td>
</tr>
<tr>
<td>Test Threat</td>
<td>.198</td>
<td>.111</td>
</tr>
<tr>
<td>Test Control</td>
<td>.107</td>
<td>.024</td>
</tr>
</tbody>
</table>

Note: n=53. Sig. ranged from .933 - .087.

**Table 10: Correlations between coping, appraisals, and pain for non-elite climbers.**

<table>
<thead>
<tr>
<th></th>
<th>Baseline Pain</th>
<th>CPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>--</td>
<td>.217</td>
</tr>
<tr>
<td>CPM</td>
<td>.217</td>
<td>--</td>
</tr>
<tr>
<td>Test Distraction</td>
<td>-.028</td>
<td>-.122</td>
</tr>
<tr>
<td>Test Catastrophizing</td>
<td>.035</td>
<td>-.027</td>
</tr>
<tr>
<td>Test Ignoring</td>
<td>-.214</td>
<td>-.019</td>
</tr>
<tr>
<td>Test Distancing</td>
<td>-.047</td>
<td>.174</td>
</tr>
<tr>
<td>Test Coping Self-Statements</td>
<td>.173</td>
<td>.104</td>
</tr>
<tr>
<td>Test Task Engagement</td>
<td>.104</td>
<td>-.056</td>
</tr>
<tr>
<td>Test Challenge</td>
<td>-.028</td>
<td>-.210</td>
</tr>
<tr>
<td>Test Threat</td>
<td>-.008</td>
<td>-.200</td>
</tr>
<tr>
<td>Test Control</td>
<td>.084</td>
<td>-.132</td>
</tr>
</tbody>
</table>

Note: n=53. Sig. ranged from .933 - .087.
Appendix F – Single Measure Intraclass Correlations, Separated by Group

Table 11: Single measure intraclass correlations for CPM test and recent painful time in elite climbers.

<table>
<thead>
<tr>
<th>Pain Coping Strategies &amp; Appraisals</th>
<th>Intraclass Correlation – Absolute Agreement</th>
<th>Intraclass Correlation – Consistency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distraction</td>
<td>.649</td>
<td>.641</td>
</tr>
<tr>
<td>Catastrophizing</td>
<td>.528</td>
<td>.567</td>
</tr>
<tr>
<td>Ignoring</td>
<td>.446</td>
<td>.488</td>
</tr>
<tr>
<td>Distancing</td>
<td>.445</td>
<td>.445</td>
</tr>
<tr>
<td>Coping Self-Statements</td>
<td>.554</td>
<td>.654</td>
</tr>
<tr>
<td>Task Engagement</td>
<td>.339</td>
<td>.532</td>
</tr>
<tr>
<td>Challenge</td>
<td>.356</td>
<td>.526</td>
</tr>
<tr>
<td>Threat</td>
<td>-.006</td>
<td>-.013</td>
</tr>
<tr>
<td>Control</td>
<td>.397</td>
<td>.589</td>
</tr>
</tbody>
</table>

Table 12: Single measure intraclass correlations between CPM test and recent painful climb for non-elite climbers.

<table>
<thead>
<tr>
<th>Pain Coping Strategies &amp; Appraisals</th>
<th>Intraclass Correlation – Absolute Agreement</th>
<th>Intraclass Correlation – Consistency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distraction</td>
<td>.691</td>
<td>.682</td>
</tr>
<tr>
<td>Catastrophizing</td>
<td>.148</td>
<td>.178</td>
</tr>
<tr>
<td>Ignoring</td>
<td>.601</td>
<td>.609</td>
</tr>
<tr>
<td>Distancing</td>
<td>.892</td>
<td>.904</td>
</tr>
<tr>
<td>Coping Self-Statements</td>
<td>.330</td>
<td>.349</td>
</tr>
<tr>
<td>Task Engagement</td>
<td>.543</td>
<td>.641</td>
</tr>
<tr>
<td>Challenge</td>
<td>.469</td>
<td>.550</td>
</tr>
<tr>
<td>Threat</td>
<td>.317</td>
<td>.440</td>
</tr>
<tr>
<td>Control</td>
<td>.454</td>
<td>.308</td>
</tr>
</tbody>
</table>
Appendix G – Task Engagement Scale Scores, Separated by Condition

Figure 11: Task engagement scale scores showing a systematic shift between the CPM test condition and the recent painful climb condition.
Appendix H – Challenge Appraisal Scale Scores, Separated by Condition

Figure 12: Challenge appraisal scale scores showing a systematic shift between the CPM test condition and the recent painful climb condition.
Appendix I – Threat Appraisal Scale Scores, Separated by Condition

![Threat appraisal scale scores showing a systematic shift between the CPM test condition and the recent painful climb condition.](image)

*Figure 13: Threat appraisal scale scores showing a systematic shift between the CPM test condition and the recent painful climb condition.*
Appendix J – Informed Consent Form

The influence of pain coping strategies and competition level on conditioned pain modulation in rock climbers

Consent Form

Dr. Peter Crocker  Jessie McDougall, BSc
School of Kinesiology  School of Kinesiology
The University of British Columbia  The University of British Columbia
Contact Number: 604-822-5580  Contact Number: 604-831-7706
peter.crocker@ubc.ca  jessie.mcdougall@ubc.ca

WHY ARE WE DOING THIS STUDY?
The purpose of the study is to learn how adult male rock climbers of different experience levels perceive, cope with, and tolerate pain. Pain has not been studied in rock climbers before, and this study will help us understand how these athletes deal with pain, potentially providing information on how to best cope with rock climbing pain. Findings from this study will help further information on how athletes cope with and tolerate pain.

WHAT HAPPENS IN THE STUDY?
If you agree to participate, you will be invited to take part in one testing session that will be conducted at either UBC or at your local climbing gym. The session will take up to 1 hour to complete. In the session, you will be asked to have your pain tolerance tested using pressure and a blood pressure cuff, up to a level of 6/10 (0 being no pain, 5 being moderate pain, and 10 being your highest level of pain). You will also be asked to fill out questionnaires regarding how you coped with the pain, and how stressful you perceived the pain to be.

As a participant in the study, you will be entered into a draw to win 1 of 3 MEC gift cards valued at 25$.

WHAT WILL BE DONE WITH THE RESULTS OF THE STUDY?
Any information you provide within the testing session will be made anonymous. In subsequent documents, you will be identified by a number, with all identifying information removed. All data will be kept in a locked cabinet in the office of the principal investigator and no one other than the researchers associated with this study will have access to this information. The information collected will be reported in a graduate thesis and written up for publication in a scholarly journal and/or presented at an academic conference.
WHAT IF YOU WISH TO WITHDRAW FROM THE STUDY?
Your participation in the research is entirely voluntary and you may withdraw from the study at any time without having to give any reason for doing so and without experiencing any negative consequences. Even if you wish to withdraw, you will still be entered into the draw to win a gift card.

ARE THERE RISKS TO YOU PARTICIPATING IN THE STUDY?
This study will not subject you to psychological or physical risk. The pain will be minimal, and can be stopped at any time. You can refuse to answer any question in the questionnaire package or withdraw from the study at any time without having to give a reason, and there will be no negative consequences. If you choose to withdraw, all data collected prior to this point will be omitted from the study and destroyed.

WHAT IF YOU HAVE COMPLAINTS OR CONCERNS ABOUT THE STUDY?
If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the Research Participant Complaint Line in the UBC Office of Research Ethics at 604-822-8598 or if long distance email RSIL@ors.ubc.ca or call toll free 1-877-822-8595.

QUESTIONS?
If you have any questions or want further information about the study, please contact Jessie McDougall by telephone at (604) 831-7706 or by email at jessie.mcdougall@ubc.ca

CONSENT
☐ I have read the above and I consent to being part of this study of rock climbers pain coping and pain tolerance.
☐ I have received a copy of this consent form for my own records.

Signature: __________________________________________
Printed Name: _______________________________________
Date: _______________________________________________
Appendix K – Letter of Introduction

The influence of pain coping strategies and competition level on conditioned pain modulation in rock climbers

LETTER OF INTRODUCTION

WHO IS DOING THE RESEARCH?
The principal investigator for this study is Dr. Peter Crocker, Professor in the School of Kinesiology at the University of British Columbia. Jessie McDougall is a second-year graduate student working under the supervision of Dr. Crocker.

WHAT IS THE RESEARCH ABOUT?
We are interested in learning about how rock climbers of different experience levels cope with and tolerate pain.

WHAT WILL PARTICIPATING IN THE STUDY INVOLVE?
If you agree to participate, you will be invited to take part in one testing session that will be conducted at either your local climbing gym or UBC. The session will take approximately 1 hour in length. In the session, pain tolerances using pressure and a blood pressure cuff will be taken. You will also be asked to fill out questionnaires asking about how you coped with and perceived the pain, and how you coped with and perceived a recent, painful climb. Please refrain from training, climbing, or ingesting caffeine or alcohol 3 hours prior to the testing session.

This study will not subject you to psychological or physical risk. You will be asked to tolerate pain up to a level of 6/10 (0 being no pain, 5 being moderate pain, and 10 being your worst pain). The pain sensation can be stopped at any time. You might develop a small bruise at the testing site, however this should not last longer than a day. You can withdraw from the study at any time without having to give a reason without suffering any negative consequences. We will accept participants for the study based on order of initial contact with the researcher. As a participant in the study, you will be entered into a draw to win 1 of 3 MEC gift cards valued at 25$.

WHAT WILL BE DONE WITH THE INFORMATION I PROVIDE?
Any information you provide within the testing session will be made anonymous. You will be identified by a number and identifying information will be removed. All data will be kept in a locked cabinet in the office of the principal investigator and no one other than the researchers associated with this study will have access to this information. The information collected will be written up for publication in a scholarly journal and/or presented at an academic conference.
WHAT IF I WISH TO WITHDRAW FROM THE STUDY?
Your participation in the research is entirely voluntary and you may withdraw from the study at any time without having to give any reason for doing so and without experiencing any negative consequences. Even if you wish to withdraw, you will still be entered into the draw to win a gift card.

HOW WILL THE RESEARCH BE USEFUL?
Findings from this study will help further knowledge on how athletes cope with and tolerate pain. This study will help us understand the relationship between rock climbers and pain, potentially providing information on how to best cope with this type of pain.

If you would like more information about this study or to learn how to become involved, please contact Jessie McDougall at (604) 831-7706 or jessie.mcdougall@ubc.ca

Thank you!

Dr. Peter Crocker
School of Kinesiology
The University of British Columbia
Contact Number: 604-822-5580
peter.crocker@ubc.ca

Jessie McDougall, BSc
School of Kinesiology
The University of British Columbia
Contact Number: 604-831-7706
jessie.mcdougall@ubc.ca
Appendix L – Demographics Questionnaire

Demographic Questionnaire

The following questionnaire will ask for some background information and will be used for research purposes only. Accurate information is greatly appreciated, however questions may be left un-answered if you do not feel comfortable providing certain information.

Date of birth (DD/MM/YYYY):

Have you been suffering from pain that has lasted longer than 3 months?

What is the highest climbing grade you have climbed? NOT INCLUDING TOP ROPE

What type of climbing was this done on? (eg: bouldering, trad, sport)

What other sports/activities do you do? How many days per week, and how seriously (recreationally, competitively, professionally, etc.), do you participate in this sport/activity?
Appendix M – Modified CSQ-R for CPM Test

Modified Coping Strategies Questionnaire – Revised

Name: _____________________________________________________ Date: _____________________

Individuals who experience pain have developed a number of ways to cope, or deal with, their pain. These include saying things to themselves when they experience pain, or engaging in different activities. Below are a list of things that people have reported doing when they feel pain. Try to recall the pain during the testing session and, using the scale below, indicate how much you engaged in that activity, where a 0 indicates you never did that when you experienced pain during the testing session, a 3 indicates you sometimes did that when you experienced pain during the testing session, and a 6 indicates you always did it when you experienced pain during the testing session. Remember, you can use any point along the scale.

0 1 2 3 4 5 6

Never do that Sometimes do that Always do that

During the testing session, when I felt pain…

____ 1. I tried to feel distant from the pain, almost as if the pain was in somebody else’s body.

____ 2. I tried to think of something else.

____ 3. It was terrible and I felt that it was never going to get any better.

____ 4. I told myself to be brave and carry on despite the pain.

____ 5. I told myself that I could overcome the pain.

____ 6. It was awful and I felt that it overwhelmed me.

____ 7. I thought about my goal of completing the task.

____ 8. I tried not to think of it as my body, but rather as something separate from me.
9. I didn’t think about the pain.

10. I told myself I couldn’t let the pain stand in the way of what I had to do.

11. I didn’t pay any attention to it.

12. I pretended it wasn’t there.

13. I replayed in my mind other experiences in the past.


15. I concentrated on what needed to be done.

16. I imagined that the pain was outside of my body.

17. I just went on as if nothing happened.

18. Although it hurt, I just kept on going.

19. I felt I couldn’t stand it anymore.

20. I ignored it.

21. I focused on the task at hand.

22. I felt like I couldn’t go on.

23. I thought of things I enjoy doing.

24. I pretended it wasn’t a part of me.

25. I increased my effort to get through it.
Appendix N – Modified CSQ-R for Recent Painful Climb

Modified Coping Strategies Questionnaire – Revised

Name: _____________________________________________________ Date: _____________________

Individuals who experience pain have developed a number of ways to cope, or deal with, their pain. These include saying things to themselves when they experience pain, or engaging in different activities. Below are a list of things that people have reported doing when they feel pain. Try to recall a recent painful climb and, using the scale below, indicate how much you engaged in that activity, where a 0 indicates you never did that when you experienced pain during the climb, a 3 indicates you sometimes did that when you experienced pain during the climb, and a 6 indicates you always did it when you experienced pain during the climb. Remember, you can use any point along the scale.

________________________________________________________________________________

0          1          2          3          4          5          6

Never do that          Sometimes do that          Always do that

During the climb, when I felt pain…

_____ 1. I tried to feel distant from the pain, almost as if the pain was in somebody else’s body.

_____ 2. I tried to think of something else.

_____ 3. It was terrible and I felt that it was never going to get any better.

_____ 4. I told myself to be brave and carry on despite the pain.

_____ 5. I told myself that I could overcome the pain.

_____ 6. It was awful and I felt that it overwhelmed me.

_____ 7. I thought about my goal of completing the task.

_____ 8. I tried not to think of it as my body, but rather as something separate from me.

_____ 9. I didn’t think about the pain.
10. I told myself I couldn’t let the pain stand in the way of what I had to do.

11. I didn’t pay any attention to it.

12. I pretended it wasn’t there.

13. I replayed in my mind other experiences in the past.


15. I concentrated on what needed to be done.

16. I imagined that the pain was outside of my body.

17. I just went on as if nothing happened.

18. Although it hurt, I just kept on going.

19. I felt I couldn’t stand it anymore.

20. I ignored it.

21. I focused on the task at hand.

22. I felt like I couldn’t go on.

23. I thought of things I enjoy doing.

24. I pretended it wasn’t a part of me.

25. I increased my effort to get through it.
Appendix O – Modified SAM for CPM Test

Name: _______________________________ Date: _______________________________

Respond to each of these questions with respect to how you typically thought and felt in regards to the pain experienced during the testing session.

Please use the following scale for each question:

1: not at all true  2: slightly true  3: moderately true  4: very true  5: extremely true

<table>
<thead>
<tr>
<th></th>
<th>Not at all true</th>
<th>Moderately True</th>
<th>Extremely True</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I felt I had the ability to overcome the pain during the testing session.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. I believed that managing the pain during the testing session could have a benefit for me.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. I perceived the pain during the testing session as threatening.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. I focused on the positive aspects when tackling the pain during the testing session.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. I felt the pain during the testing session could have been a negative experience for me.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. I believed I had the necessary skills to manage the pain during the testing session.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. I was excited about the potential outcome of this testing session.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. I believed I had what it takes to overcome the pain during the testing session.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. I felt the pain during the testing session would have negative consequences for me.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>10.</td>
<td>I believed I could become a stronger person after experiencing the pain during the testing session.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>I believed the pain during the testing session would negatively impact me greatly.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>I believed the pain during the testing session was beyond my control.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix P – Modified SAM for Recent Painful Climb

Name: _______________________________ Date: _______________________________

Respond to each of these questions with respect to how you typically thought and felt in regards to pain felt during a recent, painful climb.

Please use the following scale for each question:

1: not at all true  2: slightly true  3: moderately true  4: very true  5: extremely true

<table>
<thead>
<tr>
<th></th>
<th>Not at all True</th>
<th>Moderately True</th>
<th>Extremely True</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I felt I had the ability to overcome the pain during the climb.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2. I believed that managing the pain during the climb could have a benefit for me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3. I perceived the pain during the climb as threatening.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4. I focused on the positive aspects when tackling the pain during the climb.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5. I felt the pain during the climb could have been a negative experience for me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>6. I believed I had the necessary skills to manage the pain during the climb.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>7. I was excited about the potential outcome of this climb.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>8. I believed I had what it takes to overcome the pain during the climb.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>9. I felt the pain during the climb would have negative consequences for me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>10. I believed I could become a stronger person after experiencing the pain during the climb.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>11. I believed the pain during the climb would negatively impact me greatly.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>12. I believed the pain during the climb was beyond my control.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
Appendix Q – Recruitment Poster

Participate in our
CLIMBING STUDY

WIN
1 of 3
25$ MEC
Gift Cards

We’re conducting a study examining how rock climbers tolerate and cope with pain.

What is involved?
• A test of pain tolerance,
• 4 questionnaires,
• At the location of your choosing.

You can participate if:
• You are male
• Aged 18-40
• Climb BELOW 5.9/V1
  OR
• Climb ABOVE 5.13/V7

If Interested:
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