Adapting the Physical Activity Self-Regulation Scale (PASR-12) for Rock Climbers

Thesis

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Abstract

Rock climbing is an alternative full-body exercise to mainstream forms of physical activity. It involves diverse avenues of engagement that challenge participants both physically and mentally. Such appeal, along with increased access to climbing through a rise in the number of indoor gyms and "airtime" on platforms such as the Olympics, has resulted in significant increases in climbing participation in recent years. Likewise, research in the field is expanding to meet the increased interest and address the abundant circumstances unique to study in climbing.

This study was designed to adapt the Physical Activity Self-Regulation Scale (PASR-12), originally validated to assess physical activity-related self-regulatory behavior in the older adults, to the climbing population and explore the initial validity of this modified version of the scale for climbers. Both the PASR-12 and its adapted form to climbers, the Adapted Self-Regulation Scale for Climbers (ASRS-C), were administered. Additionally, a previously validated scale for the climbing population addressing another behavioral construct linked with self-regulation, self-efficacy, was also administered in the form of the Climbing Self-Efficacy Scale (CSES). A final, general physical activity self-efficacy scale was administered, the Multidimensional Self-Efficacy Scale (MSES), to compare the 2 valid and reliable assessments in the climbing population. Additional information was collected on the background/demographics of the sample, their climbing level and experience, as well as their amount of engagement in other physical activity.

Results

A total of 147 climbers took the survey (male n= 74, female n=65, non-binary n=8; *M* age = 32.56 years). Respondents average experience bouldering, top-roping, lead climbing, and traditional (trad) climbing was 16.7, 12.0, 15.3, and 13.7 years respectively. According to the International Rock-Climbing Research Association (IRCRA) ranking system by gender, on average, both male and female identifying participants could be categorized as advanced in the bouldering, top-roping, and lead climbing disciplines, and intermediate at trad climbing. Responses to the ASRS-C were analyzed using Principal Component Analysis (PCA) to form initial determinations of the adaption's validity. With no imposed/fixed number of factors, 5 potential factors explaining 61.9% of variance were interpreted with Eigenvalues greater than 1 (3.2, 1.6, 1.5, 1.3, 1.1 from the factors explaining most to least variance respectively). However, a corresponding scree plot denoted a distinct bend after one factor (see figure 2). Inter-scale item correlations indicated correlations within the two "sets" of cognitive-behavioral constructs measured – self-regulation (0.663 between ASRS-C & PASR-12) and self-efficacy (0.323 between CSES & MSES). The CSES was the only scale to correlate moderately with female lead climbing level (0.304) and climbing experience in all disciplines (0.335, 0.301, 0.385, 0.341 for bouldering, top roping, lead climbing and traditional (trad) climbing respectively). Intra-scale item correlations indicated no overlap in highly correlated items in responses to both the ASRS-C & PASR-12 self-regulation scales, whereas for the self-efficacy scales, highly correlated items in the MSES mimicked in more detail a continuum of constructs (managing potential interruptions to training, continual preparation for demanding climbing, and confidence in training) outlined by the CSES. Finally, comparisons of average summary scores for all the scales indicate higher levels of self-regulation in general physical activity (66.80% for the PASR-12) than climbing (62.30% for the ASRS-C), but the reverse for the cognitive-behavioral construct of self-efficacy, higher levels in climbing (76.10% for the CSES) than general physical activity (66.10% for the MSES).

Conclusions

Findings from the present study suggest the ASRS-C is a single component measure of self-regulation that demonstrates acceptable psychometric properties. Given the initially promising findings of the scale's factor structure and psychometrics properties, the modified ASRS-C, has potential to measure the progression of this important social cognitive construct in relation to changes in climbing level over time in future translational research targeted at developing self-regulatory behavior in the promotion of climbing participation. The study also further validated the CSES in measuring self-efficacy in climbers, revealing how the MSES can further break down these constructs and could be an applicable tool in targeting changes in self-efficacy for the climbing specific population as well. Given the underdeveloped nature of climbing literature in the cognitive-behavioral realm, such work lays the foundation for the measurement of two constructs key to future intervention – self-efficacy and self-regulation.

Acknowledgments

There is a trope about climbing being a way of life. For me, climbing seems to succinctly and repeatably remind me of the song and dance between me and mine.

When I started graduate school, the world was upside down from the pandemic. In the middle of it, I was deployed overseas with the Air Force. I started to the top of this mountain not sure if I would ever summit, but that didn't discourage me. Much like how the seasons and environment carve holds into rock, mine did the same for my path; I just had to keep my eyes open, get solid footing and trust that something would be there when I reached for it. Sometimes I met these experiences with fear.. of the unknown, of falling, of failing. But I learned pretty quickly, those who aim high are going to take big falls, again, and again, and again. It is through paying attention to those instances, I learned the most about myself. You can't have an ego and reach your highest highs; it takes seeking conditions that challenge you, exploiting your weaknesses for growth, and scuffing time and time again. It is the antithesis of this day and age. There is no fast track to growth, no filter for skill, no main character moment to gain momentum. I am a supporting role in a larger ecosystem, supported by all those around me and the idea that I can return the catch some day. There are lessons in the landscape, guidance in the group, reason just within reach. Most importantly, I've learned to forage my own path. We may be on the same route, but the style of how we ascend, and the importance tied to it is deeply personal. From the outside perspective, I go up a wall only to come right back down. It is what you don't see between the start and the anchors that is everything. And because of this, I will always be in search of my next climb, grounded with my feet far from the ground.

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Chapter 1. Introduction

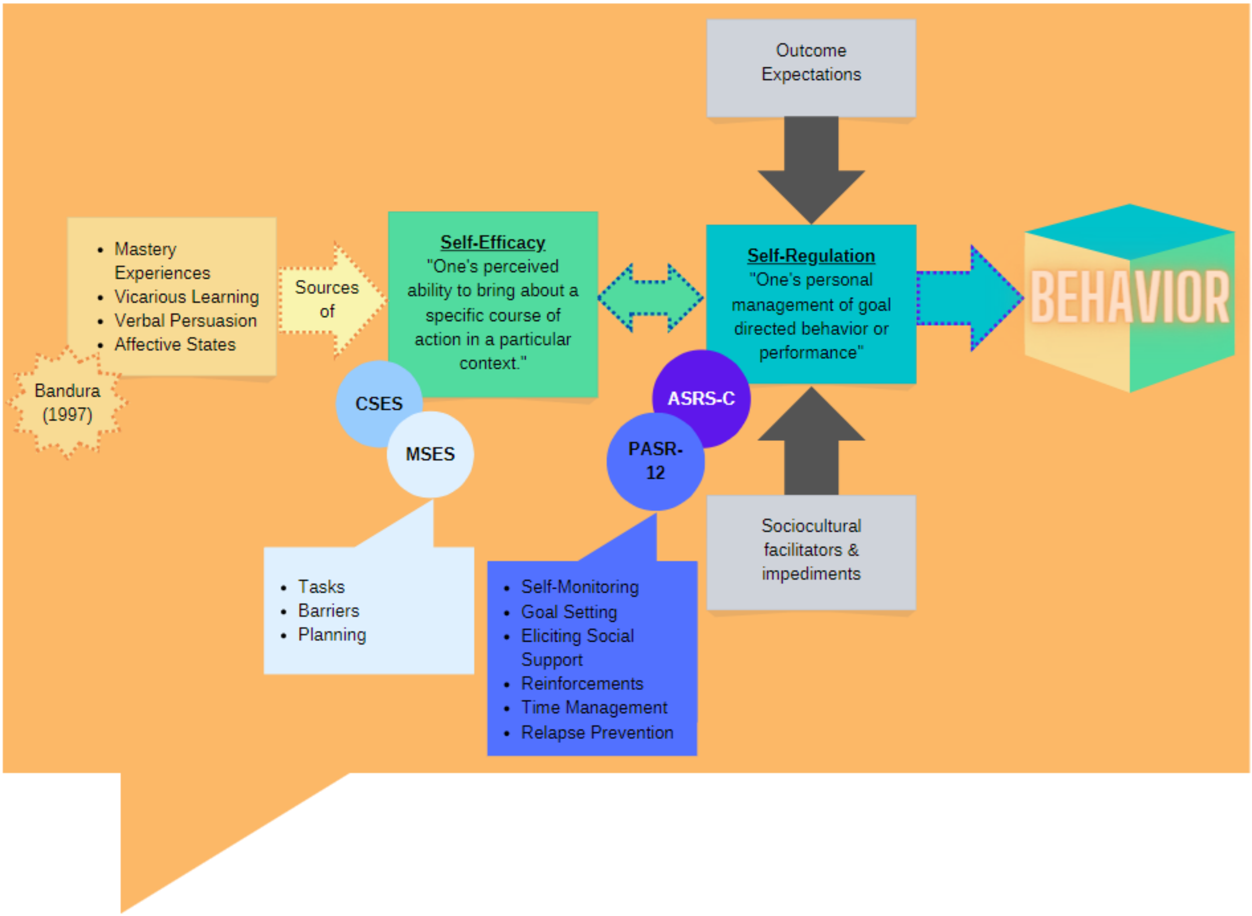
In recent years, rock climbing has seen a significant growth with an estimated 10.4 million people participating in several forms of the activity each year (*2022-Outdoor-Participation-Trends-Report-1.Pdf*, n.d.). For the first time in Olympic history, it was added to the schedule for the 2021 Tokyo Summer Olympics, expanding its reach to all levels of competition. With the increase of interest, it becomes of paramount importance that the activity is studied in a way that most accurately addresses the needs of its consistently rising number of participants. As Nicita, Shaw & Signorello (2018) explains, "rock climbing definitely involves the risk of injury and death and participants know this, but the sport is likely very much misunderstood by those who do not participate"(Nicita et al., 2018). As a historically revered counterculture movement, rock climbing was established by its participants and is instructed, and, arguably exclusively understood thoroughly by those within the climbing community. Therefore, it is important that in the early stages of systematic research on this topic, that focal attention is devoted upon defining and validating assessment of key constructs relevant to rock climbing participation within this population. This approach is essential so that researchers can best build on and address the multitude of relevant areas of inquiry to explore in climbing in accordance with their prevalence to various and diverse participants. In this sport especially, pushing for such specificity can greatly mitigate the risks associated with an enjoyable, yet inherently dangerous, activity.

From a health promotion and disease prevention perspective, regular participation in a variety of modes of physical activity should be encouraged as physical inactivity and associated health conditions such as heart disease, stroke, type 2 diabetes and certain cancers continue to be some of the leading causes of preventable and premature death (Ansari et al., 2020). While mounting evidence consistently demonstrates that people are aware of the overarching health benefits of regular physical activity and generally aware of the national physical activity guidelines, statistics regarding the adherence to regular physical activity in the U.S. remain alarmingly poor. According to research by Ryan et al. (1997), adherence relates to "enjoyment, competenc[y], and social interaction," aspects that are at the cornerstone of rock climbing (Ryan et al., 1997). These intrinsic motivators for exercise coincide with self-esteem and mental health factors, another widespread struggle as an estimated 50% of people in the United States are diagnosed with a mental illness or disorder in their lifetime (*Mental Health*, 2021). Rock climbing is unique in that both mental and physical factors are at the forefront of the activity. The current literature ranges from analyzing the effect of such mental and physical stress on biomarkers like heart rate, cortisol, and lactate concentrations to documenting the physiological determinants and psychophysiological benefits of rock climbing (Gallotta et al., 2015; MacKenzie et al., 2020; Magiera et al., 2018). Researchers are exploring the implications the sport could have on promoting physical health for those with diabetes and promoting mental health as it relates to self-efficacy and depression (Luttenberger et al., 2015; Allen et al., 2020; Boudreau & Gibbons, 2019). The relevance of building a systematical line of inquiry upon these emerging studies is integral to advancing knowledge critical to promoting rock climbing participation and expanding understanding of the physical and psychological wellbeing benefits of this unique mode of exercise. Until researchers begin to understand the wide array of concerns for climbers, the substantive gaps in evidence will persist that undermine knowledge in this important area of inquiry. Its impact, however, is again dependent on acknowledging critical gaps in the knowledge base and tailoring future research to address them with the required specificity to climbers.

One pressing gap in the rock-climbing literature is a dearth of research addressing cognitive-behavioral determinants of climbing participation. In this regard, Llewellyn et al. was the first to explore the cognitive behavioral measure of self-efficacy by developing and validating a climbing specific self-efficacy (CSES) scale (Llewellyn et al., 2008). Self-efficacy (SE) can be defined as "one's perceived ability to bring about a specific course of action in a particular context" (Rejeski & Fanning, 2019).

Numerous other SE scales for general physical activity exist, such as the Multidimensional Self-Efficacy Scale (MSES), which addresses various domains of exercise-related SE that are relevant to the climbing population but have yet to systematically evaluated. While SE is clearly an important cognitive-behavioral measure, one’s self-efficacy partly influences, and in turn is influenced by, various subfunctions of self-regulatory (SR) practices such as self-monitoring, personal performance assessment, goal setting, and one’s valuation of activities (Boudreau & Gibbons, 2019). It is important to acknowledge the reciprocal determinism between SE and SR. Self-regulation is defined as one’s personal management of goal-directed behavior or performance and has been theorized to manifest itself in numerous dimensions to include: self-monitoring, reinforcements, goal setting, corrective self-reactions, performance self-guidance and preparation to reach or avoid specific outcome expectancies (Bandura, 2004). Rejeski & Fanning (2018) illustrated from the earlier work of Bandura (2004), how self-efficacy and sources of efficacy are linked with self-regulation that ultimately impacts behavior. As illustrated in Figure 1, measuring self-regulatory skills is an integral consideration in promoting physical activity behavior (Bandura, 2004; Rejeski & Fanning, 2019).

Figure 1. Social Cognitive Theory



Adapted from Rejeski & Fanning (2019)

Petosa et al. originally developed and validated the physical activity self-regulation scale in obese and overweight adults with type 2 diabetes (Patrick Petosa, 1993). It was subsequently modified for use among older adult population yielding a reduction in total scale items from 43 questions to 12 by Umstattd et al. (PASR-12) (Umstattd et al., 2009). Although these physical activity-related self-regulatory behaviors are relevant in the climbing population, a climbing-specific measure of self-regulation has yet to be developed. Adapting the PASR-12 to climbers will aid in advancing research in this population further into the cognitive behavioral domain and provide a greater understanding of the social cognitive factors associated with motivation for adoption and maintenance of regular climbing participation. Thus, the primary purpose of this study was to advance understanding of the self-regulatory behaviors among rock climbers by adapting the physical activity self-regulatory scale (PASR-12) and exploring its initial validity in a climbing population. Additionally, a secondary aim of the study was to explore the associations between self-regulatory scales (PASR-12 & ASRS-C), and the self-efficacy scales (CSES & MSES) as evidence supporting initial convergent validity of the modified measure. Finally, responses to background/demographic information as well as climbing level, experience, and other physical activity engagement aimed to define characteristics of our sample from the climbing population. Therefore, this study was designed to outline the general categorizes of research-acquired knowledge in the field to date, illustrate how the modified scale addresses a pressing gap in the cognitive-behavioral realm of research through validating tools for future measure, and explore associations of select demographic factors in this sample of experienced climbers in order to develop a more comprehensive understanding of social cognitive correlates of climbing participation.

Chapter 2. Literature Review

The body of research in rock climbing, paralleling involvement in the sport, has grown exponentially in recent years. Over 70% of the climbing-specific research mentioned in this review has been published in the last 10 years. The research on the population can be most broadly divided into two groups: intra-disciplinary and inter-disciplinary studies. The former describes studies analyzing means specific to the activity of climbing and contains subgroups of physiological, psychological, psychophysiological, and cognitive-behavioral based research directives. The latter explores how rock climbing connects with realms outside the activity, including economic and communal outreach. Through the present review of the literature, pressing gaps in the extant research will be identified in order to develop priorities for future studies in this line of inquiry.

Intra-disciplinary Physiological Research

Physiological Research

As with most research pertaining to a physical activity, a considerable amount of existing studies in the literature have focused upon understanding the various physiological components central to the activity. In this regard, the research on climbing is similar to other modes of physical activity with focal emphasis of studies placed upon evaluating the physiological responses to climbing as well as the energy systems fueling these processes (Bertuzzi et al., 2007). Bertuzzi et al. (2007) identified the anaerobic glycolytic and creatine phosphagen systems as the source of power production while oxidative phosphorylation fueled endurance components of training (Bertuzzi et al., 2007). The aerobic system of oxidative phosphorylation was found to be engaged more frequently, suggesting focusing on lower intensity, longer duration endurance training along with sessions of training power output; through these endurance session, climbing economy can be improved as well, which seems to be more important for performance than improved energy metabolism (Bertuzzi et al., 2007). Oxidative capacity particularly became an interest of measurement for the forearm muscle. Fryer et al. (2016) examined forearm oxidative capacity and compared differences in oxygenation kinetics between the dominant and non-dominant arm flexor digitorum profundus (S. Fryer et al., 2016; Giles et al., 2017). It was found that measuring forearm flexor oxidative capacity could serve as a useful indicator of training status, especially for elite climbers, and that such measurement was indicative of notable differences in oxygenation kinetics between arms (Giles et al., 2017). Finger flexors also became a point of interest in their contribution to recovery capacity for handgrip strength. Results demonstrated that lower grade climbers and boulderers had less finger flexor endurance, but all climbers could extent their maximal contraction time until failure by eliciting hand shaking techniques during recovery phases (Baláš, n.d.). Different disciplines of the sport tax the body in different ways, leading to research objectives aiming to distinguish forearm strength and hemodynamics kinetics by comparison among boulderers and lead climbers (S. Fryer et al., 2017). The study found that the more power intensive discipline of bouldering had athletes with greater maximal volitional contraction, whereas the more endurance based discipline of lead climbing had athletes with greater oxidative capacities, reaffirming the need for analysis between climbing disciplines. Hemodynamics re-emerged as a study interest in cardiorespiratory predictors of sport climbing performance (S. M. Fryer et al., 2018). The study reiterated the importance of sport-specific training, illustrating that general cardiorespiratory activities, like running, do not translate to greater oxidative capacities for climbing. Callender et al. (2020, 2021) also expanded on the unique nature of the sport, by collecting blood pressure values to help inform risk stratification for new climbers and documenting tidal volume constraint as a product of bouldering sets (Callender et al., 2020, 2021). Such efforts aim to understand the various energy and organ systems at work during the distinctly taxing forms of the activity (i.e., bouldering and sport climbing) in order to help direct insights into training for each discipline's distinct performance demands.

Evidence suggest that a variety of factors related to how or what individuals climb when participating in climbing activity can significantly impact the physiological responses and demand of climbing. The speed at which an individual climbs is one of the most pertinent of these factors. Notably, Watts et al. (1995) studied this using a treadwall (a short, vertical wall of continuous holds set up similar to the rotating belt of a treadmill), where heart rate, maximal oxygen consumption (VO2) and energy expenditures were measured at slow, moderate and fast paces. Results suggested climbing requires moderate to high VO2 and energy expenditure capacities, where climbing pace influences energy requirements in a positive linear manner and absolute energy expenditure is a function of one's body mass and total distance climbed (Watts et al., 1995). Rosponi et al. (2012) observed a significant association between climbing speed and economy, demonstrating that climbers around the same level preferred a similar speed of climbing (Rosponi et al., 2012). Furthermore, although energy expenditure was better managed with increased pace, this did not necessarily promote more economical climbing as it forced climbers to find a balance between climbing speed and economy (Rosponi et al., 2012). The treadwall has also been used to explore the influence of the wall angle, another relevant factor in rock climbing that could impact the physiological response to the activity. Measures of heart rate (HR), VO_2 max, handgrip force (HG), rate of perceived exertion (RPE) and blood lactate (BL) were used to determine the effect of wall angles upon workload. Additionally, physiological responses during climbing were directly compared to those observed during running in order to compare climbing workload at applicable wall angle differences with a common, well-established mode of exercise (Watts & Drobish, 1998). Results revealed that HR, BL and RPE increased with the climbing wall angle, but VO_2 did not vary significantly, and HG actually decreased. Moreover, steady state running versus climbing elicited a higher VO_2 max overall. Another study by Baláš et al. (2014) explored the impact of different wall angles and route difficulties on performance with results demonstrating a relationship between wall inclination and physiological demand that can be offset by movement economy and fitness level (Baláš et al., 2014). Looking at the breadth of scenarios that can be elicited in a climb helps create a complete picture of the subsequent variability in physiological responses.

With a wide breadth of climbing modalities and circumstances, it is necessary to develop an appropriate span of tools to measure them. MacKenzie et al. (2020) specified the physical and physiological characteristics that most supported climbing to be shoulder power and endurance, followed by the secondary determinants of finger, hand, and arm strength, core-body endurance, aerobic endurance, flexibility, and balance (MacKenzie et al., 2020). Additionally, Binney and Cochrane (2003) developed testing protocols in the process of characterizing physiological functions of climbers. More specifically, they developed a forearm endurance specific test, finding it to be a significant predictor of performance in elite climbers, but crimp grip strength, as a function of itself, as a function relative to one's body mass and as a function of endurance, not significant (Binney & Cochrane, 2003). Another group of researchers conducting some of the earliest studies on climbers, Grant et al. (1996) created a testing battery that compared differences in strength, endurance, flexibility and anthropometric measures among elite and recreational climbers (Grant et al., 1996). Results revealed that finger strength, shoulder strength and endurance, as well as hip flexibility accounted for the significant differences between the two populations (Grant et al., 1996). However, it wasn't until recent years that researchers began attempts to validate such sport-specific measures and batteries in climbers. In this regard, recent research has focused upon validating specific measures for climbing strength components, such as isometric finger strength, that can then be used to determine all-out finger flexor critical force and subsequently prescribe optimal training programs (Giles et al., 2020). Measures like these have led to studies asking if finger flexor strength or exhaustive whole-body climbing are better assessments of endurance in sport climbers. Baláš et al. (2021) found both assessments to accurately determine climbing-specific endurance and be interrelated, allowing individual access to drive the usage of assessment type without compromising measurement validity (Baláš et al., 2021). The aim of the performance assessment resulting from the International Rock-Climbing Research Association (IRCRA) conference in 2020 was to determine the validity and reliability of a battery of climbing-specific tests. They measured performance factors including strength, power, endurance, flexibility, and core stability, finding the continuous finger hang and the powerslap to be the most reliable and valid measures tested, whereas planking and leg raises were not sufficiently sport-specific to measure core stability (Draper et al., 2020). The IRCRA also released a position statement as a function of their 2015 conference on comparative grading scales for ability grouping (Draper et al., 2015). This allows stratification by climbing level to be standard across all future studies. Such assessments are incredibly important to building the foundation of research in this area. As an activity that could have great applicability, the development of such physiological measures can be used to compare and determine climbing's relevancy to desired improvements in various populations.

Beyond climber-specific assessments, components thought to be central to climbing, but prevalent to other physical activities, such as grip strength, have been compared to other athletes to quantify how much greater this is in recreational climbers (Assmann et al., 2020; Grant et al., 2001). Upper body strength in advanced rock climbers, compared to resistance trained men (both with at least 2-3 years of training) is also greater, as measured by max pull-ups, relative pinch strength and relative grip strength (Macias et al., 2015). Aras and Akalan (2016) found improvements in VO2 max, body composition, muscular strength and muscular endurance could be elicited in sedentary adults from the training stimulus of top-roping for 60 minutes a session, 3 times a week over 8 weeks (Aras & Akalan, 2016). Cargo (2015) also found improvements could be elicited from a 7-week climbing course in grip endurance, pinch strength and time to ascend a pre-set route graded 5.8. However, no significant differences resulted for body mass and fat percentage, grip strength, upper body aerobic power or maximal heart rate (Cargo, 2015). Collectively, these findings suggest a need for further research to determine climbing's potential to improve certain physiological measures when prescribed to novel climbers.

For both novel climbers getting into the sport to promote physical activity and advanced climbers looking to elevate their performance to the next level, it is important to recognize the inherent dangers of the activity and sources of common injury. Wright (2001) conducted one of the first analyses on the profile of climbers getting injured indoors. Results demonstrated overuse injuries to be common, fingers to be the most frequent site of injury, and the probability highest in men, those who have climber more than 10 years, those climbing harder routes, and those bouldering or lead climbing more than top roping (Wright, 2001). Various researchers have investigated and curated comprehensive reviews of injury patterns, treatment, management and prevention tactics; these reviews have further specified flexor pulley tears as related to frequent finger injuries and mentioned how falls contribute to acute lower-extremity injuries such as ankle fractures (Cole et al., 2020; Wang & Dixit, 2020). Schoffl et al. (2013) conducted a translational study on over 500,000 visits of gym climbers to identify rates of injuring during 1,000 hours of climbing. Over the span of 5 years, 30 climbing injuries were observed, approximately half when lead climbing, and the rest evenly distributed between bouldering and top roping, with an overall incident rate of 0.02 per 1,000 hours (Schöffl et al., 2013). The identification of such frequent sites for injury have caused them to be targeted in other studies for mechanisms to strengthen performance and subsequently prevent injury. Deyhle et al. (2015) analyzed four muscle groups (i.e., digit flexors, shoulder adductors, elbow flexors and lumbar flexors) to evaluate their importance in climbing performance. The findings revealed muscular endurance of the digit and elbow flexors to be key, especially in specific terrains (Deyhle et al., 2015). Baláš et al. (2017) evaluated a more narrow focus on shoulder muscle activity in sport climbing for both naturally chosen and corrected shoulder positions, linking body positioning awareness with form improvements and subsequently lower risk of injury (Baláš, Duchačová, et al., 2017). Such awareness helps promote targeted and safe adaptations to various physiological factors with the potential to affect a diverse array of the population through climbing.

Psychophysiological Research

As climbing is a sport that combines many physical and mental components, it is not surprising how often these elements overlap in the literature. Physiological components of climbing link to psychological factors in the face of anxiety-inducing performances involving on-sighting, fall potentials, and demands of different safety rope protocols. Starting with pre-performance mental states, Xavier, Boschker and Llewellyn (2009) found that more elite athletes had higher levels of somatic anxiety and climbed the toughest part of the routes slower than less successful climbers (Sanchez et al., 2009). The act of route-reading reflects the translation of mental processing to physical action in order to ascend a route. Seifert et al. (2017) built off Grushko and Leonov's research (2014) on analyzing various strategies for route previewing for their effectiveness in translating to hold use, chaining movement and reducing anxiety (Seifert et al., 2017; Grushko & Leonov, 2014). Sanchez et al. (2019) focused on prediction parameters for performance in sport climbing by breaking down the process and decision making behind translating route reading to climbing performance (Sanchez et al., 2019). This research was an extension of previous work determining pre-ascent visual inspection to impact the number of rests and the duration one takes, but not their completion of climb (Sanchez et al., 2012). Some application has even been carried over to coaches' ability to analyze climbing movement, finding that eye tracking and retrospective think-aloud can capture coaches' cognitive-perceptual processes. Specifically, expert coaches have few fixations on their athlete's movements with longer durations on distinct areas that help them guide their athletes from a more informed manner (Mitchell et al., 2020). Whether as the climber, or the coach, it is clear that identifying and strengthening the various ties between psychological inputs and physiological outputs is key to performing at one's highest potential.

Other researchers have studied the psychological factors of on-sighting (a higher stakes scenario with one attempt to climb something correctly) versus red-pointing (a lower stakes scenario with unlimited attempts) (Limonta et al., 2020). The study found that red-pointing was less demanding, both psychologically and physiologically, meaning both factors should be targeted for training on-sighting. Draper et al. (2008) reaffirmed higher levels of pre- and post-climb measures of anxiety on on-sight routes compared to ones climbers have climbed, reaffirming a layer of 'pressure' that comes with first attempts (Draper et al., 2008). While the effects of on-sight on anxiety are consistently observed in the research, the larger, riskier falls in lead climbing as opposed to top roping, have variable effect on anxiety. In a study by Draper et al. (2012) examining plasma cortisol levels and reported self-confidence as they related to anxiety in on-sighting for intermediate climbers, results found low cortisol and anxiety levels with high self-confidence (Draper et al., 2012). This study found no difference when comparing these parameters to the style of accent (lead or top rope), indicating other individual characteristics may account for this variance. When analyzing plasma cortisol, oxygen volume, and heart rate, Fryer et al. (2012) found heart rate to be the only parameter increased toward the end of the route, indicated no physiological implications of increased stress of lead climbing compared with top roping in advanced climbers (S. Fryer et al., 2012). Dickson et al. (2012) measured pre-climbing anxiety, blood lactate, climbing time, and task load in addition to the measures of the prior study, again finding no physiological or psychological differences in elite climbers (Dickson et al., 2012). This differed from the earlier findings of Hodgson et al. (2009), whereby cortisol levels and self-reported levels of anxiety increased with the implementation of riskier rope safety protocol (Hodgson et al., 2009). Similarly, when measuring various physiological factors related to energy and oxygen consumption, Aras and Akalan (2014) found lead climbers generally exhibited higher levels of anxiety and energy expenditures when compared to top-rope climbers (Aras & Akalan, 2014). This variance could be due to experience level. In novice climbers, anxiety inducing conditions seem to have more of an impact. Pijpers et al. (2003) found in these climbers, climbing higher induced more anxiety, shown in elevated heart rates, muscle fatigue, and blood lactate concentrations, yielding negative impacts on climbing time and efficiency (Pijpers et al., 2003). Additionally, these researchers found that search rate decreased for novel climbers at higher levels off the ground (Nieuwenhuys et al., 2008). While hormones such as cortisol are a physiological measure, they can be indicative of stress and fear in response to the mental challenges imposed from managing height and fall potentials/risks that become more relevant when lead climbing. This was evident when Baláš et al. (2017) examined how such hormone levels, increased in response to fall distances (Baláš, Giles, et al., 2017). Another paper by Giles et al. (2020) explicitly examined the effect of chronic exposure to height on the psychological response to climbing as well (Giles, 2020). By examining the same factor, height, from the perspective of psychological factors, researchers were able to determine that habituation occurs over time that can help reduce height-induced anxiety for some (Giles, 2020). The study also reaffirmed on-sight leading to elicit the highest psychophysiological response compared to red-pointing and top-roping, highlighting oneself confidence, habituation to stressors and ability to perform well at higher anxieties as influences (Giles, 2020). A review of psychophysiological research by Giles et al. (2014) further explored stimuli that can impact climbing, current instruments for measuring their impact, and suggestions from the collection of studies included. It emphasizes continual research on the impact of these stimuli and the refinement of general psychophysiological methodologies, especially for their application in improving less experienced climbers (Giles et al., 2014).

Psychological Research

While there is considerable overlap in psychological and physiological parameters in climbing, there is a limited amount of research focusing upon how the activity may influence select psychological factors. Studies examining the psychological components to rock climbing have evaluated a range of topics, including pre-performance psychological states, various psychological components' impact on climbing, and even the potential of climbing as a modality for treating psychological disorders.

Early research examining psychological factors in climbing performance were focused upon defining the state and trait attributes of climbers, finding advanced athletes to exhibit higher levels of most state attributes in comparison to moderately skilled climbers (Feher et al., 1998). Additionally, climbers seem to parallel the psychological profile of individual and team activities, highlighting the duality of individualism and collectivism present in the sport (Feher et al., 1998). Other researchers have looked more closely at the impact of different psychological states during climbing. More specifically, Garrido-Palomino & España-Romero (2019) found that elite climbers decision-making while climbing is not affected by their emotional states as much as other climbers, which positively affects their performance (Garrido-Palomino & España-Romero, 2019). Additionally, select studies have assessed risk taking behaviors during climbing, finding that those high in self-efficacy and male climbers were more likely to take greater risks, and motivations behind risk taking derived from a “risk libido” or value of taking calculated risk, developed in the climbing community (Langseth & Salvesen, 2018; Llewellyn & Sanchez, 2008). Such pertinent decision-making, such as risk taking, may emerge from the state of mindfulness evident while rock-climbing; Wheatley (2021) considers mindfulness a potential attribute of climbing that makes it suitable as a resilience-building activity for therapeutic purposes (Wheatley, 2021).

Consistent with the well-established psychological benefits accompanying exercise, researchers have explored the effect of climbing on psychological responses. Luttenberger et al. (2015) has found climbing interventions to have positive impacts on improving depressive symptoms (Luttenberger, 2015; Luttenberger et al., 2015). Another group of researchers, Kleinstäuber et al. (2017) compared climbing with relaxation exercises as a remedy for coping with depression and found that, although participants could choose which activity, climbers coped better overall, with greater improvements in their positive and negative emotional states (Kleinstäuber et al., 2017). Together, these findings suggest that while climbing can be a psychologically challenging and/or stressful activity, it is also associated with meaningful psychological benefits. Additionally, these findings are consistent with well-established psychological benefits of exercise and extend these to rock climbing.

Cognitive-Behavioral Research

The application of climbing as a tool for well-being is evident in the cognitive-behavioral research realm as well. The foundation of psychological research in the field presents strong potential for cognitive-behavioral focused studies in climbing. With all the knowledge of climbing's benefits, ways to improve in skill, and its unique culmination of physical and mental/psychological demands, a logical direction for future inquiry is in behavior change aimed at applying the extant evidence to promotion of the adoption and maintenance of climbing participation. Unfortunately, to date, relatively few studies have explored behavioral aspects of climbing participation. Nonetheless, some groundwork has been laid by developing and validating a scale, the Climbing Self-Efficacy Scale (CSES) to measure the cognitive-behavioral concept of self-efficacy specifically in climbers (Llewellyn et al., 2008). A case study was also conducted looking at promoting self-efficacy through rock climbing programming in high school students, finding that meaningful, diversified, individualized, and progressively challenging activities in safe and collaborative spaces to be most effective (Boudreau & Gibbons, 2019). Allen et al. (2020) was the first to directly apply a cognitive-behavioral theory to a group of individuals to promote well-being. More specifically, utilizing rock climbing to promote wellness in youth with type 1 diabetes through the framework of Self-Determination Theory (SDT) (Allen et al., 2020). While these studies lay a strong foundation in the cognitive-behavioral aspect of self-efficacy and the framework of SDT, other concepts such as self-regulation and theories like the Social Cognitive Theory, have yet to be leveraged for their potential relevance to behavioral adaptation in the climbing population. Select studies have examined motivation and goal-orientation linked with these theoretical frameworks. One study found that climbers tend to be intrinsically motivated and task-oriented rather than goal-oriented, with age and other climbing-related factors influencing individuals motivation for engaging in the activity (Li et al., 1998). Another study analyzing motivation for engagement cited exercise balance, personal growth, and challenges to be the most common motivators, whereas injury and time were the most common barriers; participants were initially more motivated by external factors but continued climbing due to internal motivators (Dagnan et al., n.d.). Such research has laid the groundwork for further exploration of cognitive-behavioral constructs in this field of research.

Inter-disciplinary Research

The latter overarching segment of research in rock climbing is interdisciplinary research or more explicitly, research addressing the universal value of climbing and how it interacts with factors outside of the activity. Qianru & Yuan (2021) have analyzed climbing as an economic driving force for tourism in rural mountainous areas (Qianru & Yuan, 2021). They emphasize using established sustainable tourism areas as models, establishing a coordinated mechanism between government and industry organizations, investing in infrastructure construction, and attaching importance to the fitness, leisure and economic value of rock climbing tourism in the targeted area (Qianru & Yuan, 2021). Other researchers are trying to explain the value and advantage of supporting the activity for the individuals partaking. Qiu (2011) explains that participants experience a connection to nature, improved physical and mental health, ability to adapt socially, improved self-concept and personality development; all valuable to society and communities as a whole (X. R. Qiu, 2011). In aiming to deepen people's awareness and understanding of rock climbing, Qiu hopes to promote participation in the activity, and thereby the prevalence of such positive attributes in the population (X. Qiu, 2011). Kulczycki and Hinch (2014) were able to express the value the indoor landscape of climbing gyms has provided people in its consciously artificial recreation of nature that emulates the outdoor desires distinct to climbing in an accessible form, promoting the core tenants of loyalty, skill development, physical fitness and camaraderie that are cornerstones of the climbing community (Kulczycki & Hinch, 2014). Dutkiewicz (2015) broke down the ethnography of one particular outdoor route for 8 different climbers, providing subjective experiences rather than objective quantifiers of grade, location, rock type, etc., and suggesting individuals have personal valuations of climbs beyond the rock itself (Dutkiewicz, 2015). Those who recognize participants valuation of the activity and its potential broad-span impact are working to develop appropriate platforms for teaching it in universities via coursework (Huang et al., 2021). Efforts like these will help expand the impact of climbing by reframing and distributing its benefits beyond its current captive audience, but also reaffirming the necessity for sustainability in an outdoor activity whose landscape is world-wide.

As evident by this dive into the climbing literature, physiological driven inquiries have received the most attention in publication. Climbing's connection to psychological focuses is widely recognized as well, but its limited application in the form of cognitive-behavioral research suggested a need for validated tools in said constructs that help mobilize the current body of knowledge to action. Similarly, for a sport rising in popularity, little data is available on its economic and societal value as an activity. As the majority of the foundation of research in the field is currently in physiological and psychological directives, future studies should aim to expand into the cognitive-behavioral and communal impact realms. Expanding into these new areas of interest will help build the knowledge and potential impact of the sport as it continues to grow in participation.

In summary, while there has been a substantive increase in rock climbing research, the majority has focused upon physiological responses during climbing, select physiological and psychological factors associated with climbing performance and/or expertise, and the psychological responses to climbing. As interest in rock climbing continues to expand, a pressing gap in the extant literature remains in systematic investigation of the behavioral aspects associated with the adoption and maintenance of climbing participation.

Chapter 3: Methods

Overview

The primary purpose of the present study was to evaluate the initial validity of the modified self-regulation for physical activity scale adapted for rock climbing. The present study employed a cross-section survey design gathering information on a sample of rock climbers' background including 1) demographic information (age, gender, race, education, income, and employment), 2) climbing specific measures such as climbing level and experience, 3) general physical activity engagement outside of climbing (aerobic, resistance, anaerobic, flexibility, balance, or other types of training), and 4) administered four surveys: the Adapted Self-Regulatory Scale for Climbers (ASRS-C), the Physical Activity Self-Regulation Scale (PASR-12), the Climbing Self-Efficacy Scale (CSES), and the Multidimensional Self-Efficacy Scale (MSES). The study used a convenience sampling approach to share the web-based questionnaire. It was delivered via email or social media messaging to climbing facility or climbing groups' accounts in the United States, with a particular focus in the Ohio area. Each of the participating sites received a recruitment flyer to be shared digitally or displayed in-person in the respective climbing facility that was embedded with a link and QR code to the survey. A total of 147 climbers responded to the survey.

Participant Eligibility

The inclusion criteria for the study are a) age ≥ 18; b) participated in bouldering, top roping, leading climbing and/or traditional climbing within the last month; c) have knowledge of the current level they climb at; and d) exhibit a willingness to take the questionnaire accurately and completely to reflect their personal experience.

Recruitment

Participants were recruited from climbing gyms and social media groups across the United States, with a particular focus on Ohio. Potential collaborators were sent an introductory email about the survey, with a flyer they could physically post in climbing facilities with a QR code to the survey or a flyer they could digitally post to their social media, with a link to the survey. Individuals who were interested in the study were self-selected and used their electronic device to either scan the physical fliers QR code or tap the digital flier's link from social media to access the survey. Participant completion of the survey through the online link or QR code was possible on any computer, phone, or tablet-based infrastructure.

Informed Consent

Informed Consent was obtained prior to the completion of the survey through the online survey platform using a document approved 11/9/2021 by the Ohio State University IRB (2021B0345).

Measures

The questionnaires were distributed using the online survey software Qualtrics (Qualtrics, Provo, UT, USA). As an online-data management system that is password protected, Qualtrics was also used to collect and store the data, such as participant's background information (demographics, climbing background and additional physical activity engagement), as well as their responses to the 4 scales administered (ASRS-C, PASR-12, CSES, and MSES).

Procedures

Outlets for potential participants, such as climbing gyms and climbing social media groups, were targeted and contacted with an introductory email about the survey. In addition to background information on the questionnaire, it included a flyer they could physically post in climbing facilities with a QR code to the survey (if applicable), or a flyer they could digitally post to their social media, with a link to the survey. Interested individuals exposed to these flyers decided to participate by following the link or QR code to the survey and completed it on their device.

He or she completed the informed consent form first and then continued to answer questions about demographic information, climbing background, additional physical activity engagement and the 4 questionnaire scales. Each questionnaire was presented separately, starting with the ASRS-C, followed by the PASR-12, CSES, and MSES. All participant data transferred from Qualtrics was stored in a secured, password-protected folder within the Ohio State University's OneDrive. Participants identity was only attached to acquiring access to the questionnaire (through their email or social media) and receiving proof of completion. Additionally, if participants were interested in participating in future research aimed at teaching climbing technique and skill in group-based programming, they could volunteer their contact information in a final question (email or phone) that would remain protected in both password-secured locations in Qualtrics and OneDrive.

Statistical Analysis

Questionnaire responses were inputted into IBM's Statistical Package for Social Sciences (SPSS). As the primary objective of this study was to adapt the PASR-12 to rock climbing (ASRS-C) and explore its initial validity in climbers, the primary analysis preformed was a principal component analysis (PCA) with a promax rotation to ascertain how many factors the adapted scale measured and the magnitude of these relations. Additionally, as two scales were administered for each cognitive-behavioral construct (i.e., self-efficacy and self-regulation), correlation analyses were run to evaluate the association among these conceptually related factors in each scale, determine the extent to which each construct compared when measured by a scale specific to climbers versus a more generalizable scale to physical activity, and provide initial evidence supporting convergent validity. Finally, demographic information, background on climbing level and experience, and participation in other forms of physical activity were evaluated using frequency distributions to evaluate means, frequencies, and percentages. This approach allowed for preliminary evaluation of differences in the demographic, climbing experience-related factors, and physical activity history in the sample and the extent to which they may be associated with the psychometric properties of the various administered scales.

Chapter 4: Results

The primary purpose of this study was to adapt the PASR-12 to rock climbing (ASRS-C) and explore its initial validity in climbers. Additionally, correlation analyses were run to evaluate the association among conceptually related constructs of exercise-related self-efficacy and self-regulation to determine the extent to which each construct compared when measured by a scale specific to climbers versus a more generalizable scale to physical activity, and provide initial evidence supporting convergent validity. Finally, demographic information, background on climbing level and experience, and participation in other forms of physical activity were evaluated using frequency distributions to evaluate means, frequencies, and percentages. This approach allowed for preliminary evaluation of differences in the demographic, climbing experience-related factors, and physical activity history in the sample and the extent to which they may be associated with the psychometric properties of the various administered scales.

In order to explore the initial validity of the adapted self-regulation scale (the Adapted Self-Regulation Scale for Climbers (ASRS-C) adapted from the PASR-12), a principal component analysis (PCA), was conducted to determine how many factors of self-regulation the ASRS-C was potentially measuring. Finally, bivariate correlations were conducted between scales (inter-scale item correlations) measuring similar, related cognitive-behavioral constructs of exercise-related self-regulation and self-efficacy, the 4 scales summary scores, and the specific climbing background qualifiers of experience and level. Intra-scale item correlations were also run within the 4 scales to identify patterns of strong positive correlations associated with specific items.

Demographic Characteristics

Of the 147 rock climbers sampled, participants' average age was 32.56 (Std. Dev. 10.82), with respondents ranging from 18 to 70. 50.3% identified as male, 44.2% as female, and 5.4% as non-binary. With regard to racial identification of the sample, the majority identified as White/Caucasian (n=128, 87.1%), with 1 Black/African American, 4 Latinos, 8 Asian/Pacific Islander, 4 Multi-/biracial, and 2 other. Most participants (76.2%) had a college education or above. The average income for this demographic was $35,000-49,999, with the largest percentage (42.2%), earning $75,000 or more annually. 72.8% of respondents work full-time, 19% work part-time, and 7.5% are retired.

On average, participants had 16.7 years of experience of bouldering, 12.0 years of top-roping, 15.3 years of lead climbing, and 13.7 years of traditional climbing. Respondents on average climbed at the advanced level for bouldering, top-roping, and lead climbing, but at the intermediate level for traditional climbing according to IRCRA categorization for men and women (see Appendix E). This sample of rock climbers engaged in physical activity outside of rocking to include aerobic training, resistance training, anaerobic training, flexibility, balance, and other activities (see Table 1 below).

Table 1. Frequency, Percent, and Mean Weekly Minutes Engaged in Additional Physical Activities

Activity	Frequency (*f*)	Percent (%)	Mean (*M*, min)
Aerobic	96.0	65.3	114.4
Resistance Training	85.0	57.8	83.0
Anaerobic	19.0	12.9	6.4
Flexibility	84.0	57.1	44.3
Balance	17.0	11.6	5.3
Other	13.0	8.8	28.3
None	13.0	8.8	0.0

Principal Component Analysis

As one of the main purposes of the present study was to adapt the PASR-12 to climbers and evaluate its initial validity and psychometric properties in a sample of experienced climbers in order to promote use of the scale in various climbing populations, a principal component analysis (PCA) with a promax rotation was conducted to explore all survey items interrelatedness under potential factors. When conducted with no imposed/fixed number of factors, the PCA initially yielded a potential 5 factor structure cumulatively explaining 61.9% of the variance. Each of these factors had associated Eigenvalues greater than 1 (3.2, 1.6, 1.5, 1.3, 1.1 from the factors explaining the most to least percentage of variance respectively). However, the corresponding scree plot included a distinct bend after the first component potentially indicating a unidimensional facture structure may be the best fitting model.

Correlations

Inter-Scale Item Correlations -

Bi-variate correlation analyses were conducted to evaluate the associations among the adapted self-regulation scale (ASRS-C) and the other valid and reliable exercise-related self-efficacy and self-regulation scales in order to explore evidence supporting initial convergent validity of the ASRS-C. Correlation analyses were also conducted within the two "sets" of scales administered – the two self-regulatory (ASRS-C & PASR-12) and the two self-efficacy (CSES & MSES) to evaluate the associations among these conceptually-related constructs. Additionally, each of these four scales' items were correlated with climbing level (categorized by gender) and climbing experience for all the disciplines studied: bouldering, top-roping, lead climbing, and traditional climbing.

Self-Regulation (ASRS-C & PASR-12)

The ASRS-C and PASR-12 correlations (see Table 2) featured similar scale items that generally were correlated positively and moderately. The items in each scale pertaining to mentally keeping track of climbing or physical activity (0.456), focusing on how good one felt after activity (0.328), reminding oneself of the health benefits of said activity (0.338), and rearranging one's schedule to ensure time for activity (0.316).

Table 2. ASRS-C & PASR-12 Scale Item Correlations

PASR-12	ASRS-C: 1. I mentally kept track of my climbing activity	2. I mentally noted specific things that helped me climb	3. I set short term goals that are focused on my health	4. I set climbing goals that are focused on my health	5. I asked acquaintances for climbing advice or demo	6. I asked a climbing instructor for climbing advice or demo	7. I asked a climbing guide for climbing advice or demo	8. I asked a professional climber for climbing advice or demo	9. After climbing, I focused on how good it felt	10. I reminded myself of climbing health benefits	11. I mentally scheduled specific times for climbing	12. I rearrange my schedule to ensure I had time for climbing	13. I purposely planned ways to climb when on trips away from home	14. I purposely planned to climb in bad weather
1. I mentally kept track of my physical activity	**0.456****	0.219	0.317**	0.178	0.223	-0.202	-0.170	0.149	0.144	0.256	0.084	0.185	0.225	0.153
2. I mentally noted specific things that helped me be active	0.209	**0.243**	0.304**	0.065	0.104	-0.136	-0.133	0.131	0.081	0.210	0.014	0.026	0.114	-0.021
3. I set short term goals for how often I am active	0.184	0.300**	**0.295**	0.289	0.076	-0.215	-0.026	0.016	0.158	0.146	0.057	-0.006	-0.036	0.049
4. I set physical activity goals that focused on my health	0.183	0.205	0.332**	**0.277**	0.214	-0.224	-0.097	0.015	0.001	0.106	0.041	0.100	0.000	0.012
5. I asked someone for physical activity advice or demo	0.047	0.018	-0.018	-0.028	**-0.053**	**-0.147**	**0.037**	**0.120**	0.104	0.080	0.117	0.093	-0.034	0.069
6. I asked a physical activity expert or health professional for physical activity advice or demo	0.254	0.054	0.249	0.133	0.218	**-0.075**	**0.251**	**0.144**	0.169	0.277	0.228	0.140	0.176	0.134
7. After physical activity I focused on how good it felt	0.163	0.174	0.118	0.065	0.115	-0.050	0.046	0.128	**0.328****	0.269	0.077	0.150	0.226	0.073
8. I reminded myself of physical activity health benefits	0.309**	0.051	0.147	0.090	0.044	-0.084	-0.053	0.037	0.325**	**0.338****	0.174	0.175	0.113	-0.006
9. I mentally scheduled specific times for physical activity	0.123	0.127	0.165	0.143	0.165	-0.076	-0.047	0.031	0.061	0.104	**0.122**	0.148	0.011	0.051
10. I rearranged my schedule to ensure I had time for physical activity	0.128	0.174	0.226	0.228	0.187	0.028	0.036	0.025	0.284	0.142	0.218	**0.316****	0.148	0.128
11. I purposely planned ways to do physical activity when on trips away from home	0.101	0.212	0.154	0.168	0.124	0.100	0.001	0.030	0.330**	0.285	0.193	0.199	**0.230**	0.084
12. I purposely planned ways to do physical activity in bad weather	0.012	0.163	0.142	0.271	0.096	0.057	0.036	-0.029	0.144	0.128	0.138	0.110	0.077	**0.206**

In accordance with Pearson's correlation, ** Correlation is moderately strong.

Self-Efficacy (CSES & MSES)

A single item from the MSES scale had moderately positive correlations with half the items of the CSES scale (see Table 3). The item of exercising with proper technique correlated with dealing with unexpected events, preparing physically for demanding routes, performing well, accomplishing what one sets out to do, and using appropriate climbing techniques.

Table 3. CSES & MSES Scale Item Correlations

	CSES: "My confidence in my ability to:"									
MSES: "How confident are you that you can…"	1. Deal with unexpected events	2. Maintain my concentration	3. Manage risks effectively	4. Manage my fears and anxieties	5. Prepare physically for demanding routes	6. Perform well	7. Avoid making mistakes	8. Prepare mentally for demanding routes	9. Accomplish what you set out to do	10. Use appropriate climbing techniques
1. exercise with proper technique	0.347**	0.199	0.141	0.253	0.316***	0.405**	0.279	0.297	0.304**	0.361**
2. follow any directions necessary to successfully complete your exercise	0.226	0.139	0.136	0.133	0.151	0.222	0.220	0.229	0.232	0.222
3. perform all the required movements to successfully complete your exercise	0.205	0.207	0.124	0.171	0.255	0.294	0.226	0.313**	0.256	0.307**
4. exercise when you feel discomfort	0.178	0.164	0.098	0.143	0.271	0.207	0.201	0.155	0.122	0.100
5. exercise when you lack energy	0.140	0.186	0.034	0.191	0.264	0.259	0.191	0.179	0.127	0.110
6. exercise when you don't feel well	0.108	0.044	-0.030	0.140	0.252	0.221	0.075	0.164	0.133	-0.017
7. include exercise in your daily routine	0.083	0.170	0.077	0.141	0.175	0.191	0.169	0.166	0.201	0.038
8. consistently exercise at least 3 times per week	0.050	0.254	0.062	0.207	0.208	0.146	0.182	0.170	0.214	0.091
9. arrange your schedule to include regular exercise	0.039	0.208	-0.066	0.156	0.197	0.183	0.081	0.092	0.157	-0.016

In accordance with Pearson's correlation, ** Correlation is moderately strong.

Summary Scores

The adapted self-regulatory scale for climbers (ASRS-C) elicited lower levels of self-regulation for climbing behavior than responses to the PASR-12 for general physical activity. Summary scores for the climbing self-efficacy scale (CSES) exhibited the opposite, whereby participants demonstrated higher levels of self-efficacy regarding climbing activity than general physical activity. Gross average summary scores and their relative percentages for comparison are in Table 4.

Table 4. Average Summary Scores & Relative Percentages

	M	%
1. ASRS-C	43.6	62.30%
2. PASR-12	40.1	66.80%
3. CSES	761.1	76.10%
4. MSES	72.7	66.10%

Note all scales had a different scoring system, only percentages are comparable.

According to Pearson's Correlation coefficient, summary scores from the ASRS-C & PASR-12 scales are strongly correlated to one another, and summary scores form the CSES & MSES are moderately correlated with one another (see Table 5).

Table 5. Inter-Scale Summary Scores

Scale	1	2	3	4
1. ASRS-C	--			
2. PASR-12	0.663***	--		
3. CSES	0.152	0.001	--	
4. MSES	0.125	0.270	0.323**	--

In accordance with Pearson's correlation coefficients, *** Correlation is strong, ** Correlation is moderately strong.

Climbing Level & Climbing Experience (by gender)

In accordance with Pearson's Correlation coefficient, the CSES scale is the only one administered that has a strong enough correlations to be notable; results show it has a moderately positive correlation with female level lead climbing (0.304) and all climbing disciplines (0.335, 0.301, 0.385, 0.341 for bouldering, top roping, lead climbing and trad climbing experience respectively) (see Table 7). Experience bouldering is strongly associated (0.579) with experience top roping, lead climbing (0.771), and trad climbing (0.578). Experience top roping is strongly correlated with experience lead climbing (0.792) and trad climbing (0.809). Experience lead and trad climbing are the most strongly correlated (0.948). The climbing level for each climbing discipline is strongly and positively associated with the climbing level scores for the other disciplines in both males and females, exhibiting a pattern of increased correlation strength progressing from more beginner-friendly disciplines (bouldering with top roping) versus those involving more risk/rope management skills (lead and trad climbing) (see Table 6).

Table 6. Climbing Level Correlations by Gender & Discipline

Climbing Level Correlations		***Male***		
Female	Boulder	TR	Lead	Trad
Boulder	–	0.874	0.936	0.904
TR	0.906	–	0.886	0.894
Lead	0.907	0.946	–	0.950
Trad	0.905	0.942	0.948	--

Table 7. Scale Summary Scores, Climbing Level & Experience Correlations

Modality	***Bouldering***			***Top-Roping***			***Lead Climbing***			***Trad Climbing***		
		Level			Level			Level			Level	
	5. Experience	6. Female	7. Male	8. Experience	9. Female	10. Male	11. Experience	12. Female	13. Male	14. Experience	15. Female	16. Male
1. ASRS-C	0.002	0.002	0.073	0.000	-0.039	0.065	-0.015	-0.029	0.087	0.039	-0.032	0.055
2. PASR-12	-0.095	-0.137	0.149	0.004	-0.150	0.172	-0.105	-0.123	0.165	0.097	-0.111	0.121
3. CSES	0.335**	0.256	-0.133	0.301**	0.278	-0.217	0.385**	0.304**	-0.081	0.341**	0.270	-0.102
4. MSES	0.136	0.023	0.077	-0.026	-0.007	0.065	0.102	0.047	0.096	0.176	0.033	0.064
5	--											
6	-0.079	--										
7	0.059	-0.753***	--									
8	0.579***	-0.027	-0.022	--								
9	-0.137	0.906***	-0.774***	-0.062	--							
10	0.046	-0.764***	0.874***	0.042	-0.786***	--						
11	0.771***	-0.035	0.076	0.792***	-0.109	0.115	--					
12	-0.119	0.907***	-0.769***	-0.081	0.946***	-0.781***	-0.104	--				
13	0.015	-0.763***	0.936***	-0.028	-0.785***	0.886***	0.114	-0.780***	--			
14	0.578***	0.068	-0.017	0.809***	0.076	-0.008	0.809***	0.064	0.007	--		
15	-0.109	0.905***	-0.812***	-0.048	0.942***	-0.824***	-0.143	0.948***	-0.822**	0.066	--	
16	0.055	-0.785***	0.904***	0.016	-0.807***	0.894***	0.128	-0.802***	0.950**	0.017	-0.846***	--

In accordance with Pearson's correlation, *** Correlation is strong, ** Correlation is moderately strong.

Intra-Scale Item Correlations -

Correlations were run between each item within the four scales to see how closely they related to one another.

ASRS-C

For the ASRS-C scale, three sets of items had strong, positive correlations with one another: 1) setting short term goals focused on one's health and setting climbing goals focused on one's health (items 3 & 4), 2) mentally scheduling times for climbing and rearranging one's schedule to ensure he or she has time for climbing (items 11 & 12), and 3) rearranging one's schedule to ensure he or she has time for climbing and purposely planning ways to climb when on trips away from home (items 12 & 13) (see Table 8).

Table 8. ASRS-C Intra-Scale Item Correlations

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. I mentally kept track of my climbing activity	--													
2. I mentally noted specific things that helped me climb	0.323 **	--												
3. I set short term goals that are focused on my health	0.175	0.220	--											
4. I set climbing goals that are focused on my health	0.136	0.317 **	0.566 ***	--										
5. I asked acquaintances for climbing advice or demo	0.076	0.189	0.179	0.150	--									
6. I asked a climbing instructor for climbing advice or demo	-0.092	-0.116	0.006	0.104	0.087	--								
7. I asked a climbing guide for climbing advice or demo	-0.031	-0.042	0.054	0.040	0.074	0.423 **	--							
8. I asked a professional climber for climbing advice or demo	0.230	0.246	0.071	0.007	-0.058	0.142	0.248	--						
9. After climbing, I focused on how good it felt	0.102	0.204	0.167	0.090	0.123	0.111	0.207	0.082	--					
10. I reminded myself of climbing health benefits	0.170	0.168	0.212	0.277	0.193	0.111	0.098	0.027	0.349 **	--				
11. I mentally scheduled times for climbing	0.373 **	0.208	-0.016	0.146	0.214	0.100	0.082	0.067	0.293	0.334 **	--			
12. I rearranged my schedule to ensure I had time for climbing	0.367 **	0.253	0.060	0.191	0.140	0.102	0.191	0.160	0.150	0.217	0.569 ***	--		
13. I purposely planned ways to climb when on trips away from home	0.241	0.236	0.126	0.261	0.197	0.113	0.168	0.226	0.073	0.187	0.322 **	0.526 ***	--	
14. I purposely planned to climb in bad weather	0.014	-0.071	-0.008	0.085	0.021	0.021	0.058	0.004	0.051	.211*	0.117	0.149	0.197	--

In accordance with Pearson's correlation, *** Correlation is strong, ** Correlation is moderately strong.

PASR-12

For the PASR-12 scale, 2 items had moderately positive correlations with 1/3 of the other items: 1) item 3, “I set short term goals for how often I am active, and 2) item 4, “I set physical activity goals that focused on my health” (see Table 8).

Table 9. PASR-12 Intra-Scale Item Correlations

Item	1	2	3	4	5	6	7	8	9	10	11	12
1. I mentally kept track of my physical activity	--											
2. I mentally noted specific things that helped me be active	0.451**	--										
3. I set short term goals for how often I am active	0.377**	0.343**	--									
4. I set physical activity goals that focused on my health	0.277	0.336**	0.487**	--								
5. I asked someone for physical activity advice or demo	0.048	0.030	0.064	0.007	--							
6. I asked a physical activity expert for physical activity advice or demo	0.159	0.107	0.133	0.288	0.211	--						
7. After physical activity I focused on how good it felt	0.279	0.164	0.184	0.213	0.174	0.142	--					
8. I reminded myself of physical activity health benefits	0.462**	0.180	0.235	0.254	0.119	0.164	0.417**	--				
9. I mentally scheduled specific times for physical activity	0.26	0.180	0.383**	0.400**	-0.066	0.163	0.132	0.256	--			
10. I rearranged my schedule to ensure I had time for physical activity	0.193	0.183	0.250	0.316**	0.154	0.132	0.160	0.298	0.440**	--		
11. I purposely planned ways to do physical activity when on trips away from home	0.268	0.216	0.184	0.209	-0.010	0.087	0.191	0.237	0.250	0.480**	--	
12. I purposely planned ways to do physical activity in bad weather	-0.006	0.244	0.148	0.103	0.004	0.209	0.151	0.061	0.208	0.212	0.306	--

In accordance with Pearson's correlation, ** Correlation is moderately strong.

CSES

For the CSES scale, all items were at least moderately and positively correlated to one another. All items featured at least 1 strong, positive correlation, with items 1 (dealing with unexpected events), 5 (preparing physically for demanding routes), and 6 (performing well), exhibiting 5 moderately strong, positive correlations. For item 1, these were between items 4 (manage one's fears and anxieties), 5, 6, 9 (accomplish what one sets out to do), and 10 (use appropriate climbing techniques). For item 5, these were between items 1, 2 (maintain one's concentration), 6, 8 (prepare mentally for demanding routes), and 9. Lastly, for item 6, these were between items 1, 4, 5, 8, and 9 (see Table 10 below).

Table 10. CSES Intra-Scale Item Correlations

"My confidence in my ability to"	1	2	3	4	5	6	7	8	9	10
1. Deal with unexpected events	--									
2. Maintain my concentration	0.440**	--								
3. Manage risks effectively	0.494**	0.378**	--							
4. Manage my fears and anxieties	0.524***	0.545***	0.321**	--						
5. Prepare physically for demanding routes	0.530***	0.504***	0.340**	0.483**	--					
6. Perform well	0.595***	0.457**	0.286	0.601***	0.726***	--				
7. Avoid making mistakes	0.454**	0.511***	0.550***	0.345**	0.467**	0.440**	--			
8. Prepare mentally for demanding routes	0.499**	0.450**	0.417**	0.652***	0.611***	0.665***	0.431**	--		
9. Accomplish what you set out to do	0.572***	0.462**	0.485**	0.485**	0.634***	0.735***	0.480**	0.564***	--	
10. Use appropriate climbing techniques	0.511***	0.392**	0.343**	0.343**	0.479**	0.474**	0.564***	0.380**	0.521***	--

In accordance with Pearson's correlation, *** Correlation is strong, ** Correlation is moderately strong.

MSES

For the MSES scale, as with the CSES scale, all items were at least moderately and positively correlated to one another. All items also featured at least 1 strong, positive correlation, with item 5 (confidence in one's ability to exercise when lacking energy) exhibiting 5 strong, positive correlations to items 3 (perform all the required movements to successfully complete one's exercise), 4 (exercise when feeling discomfort), 6 (exercise when one does not feel well), 7 (include exercise in one's daily routine), and 8 (consistently exercise at least 3 times per week) (see Table 11 below).

Table 11. MSES Intra-Scale Item Correlations

"How confident are you that you can…"	1	2	3	4	5	6	7	8	9
1. exercise using proper technique	--								
2. follow any directions necessary to successfully complete your exercise	0.700***	--							
3. perform all the required movements to successfully complete your exercise	0.693***	0.747***	--						
4. exercise when you feel discomfort	0.380**	0.314**	0.434**	--					
5. exercise when you lack energy	0.351**	0.275	0.448**	0.661***	--				
6. exercise when you don't feel well	0.219	0.053	0.243	0.501***	0.721***	--			
7. include exercise in your daily routine	0.373**	0.355**	0.406**	0.419**	0.575***	0.488**	--		
8. consistently exercise at least 3 times per week	0.325**	0.284	0.374**	0.473**	0.508***	0.392**	0.610***	--	
9. arrange your schedule to include regular exercise	0.401**	0.328**	0.431**	0.427**	0.484**	0.390**	0.637***	0.766***	-

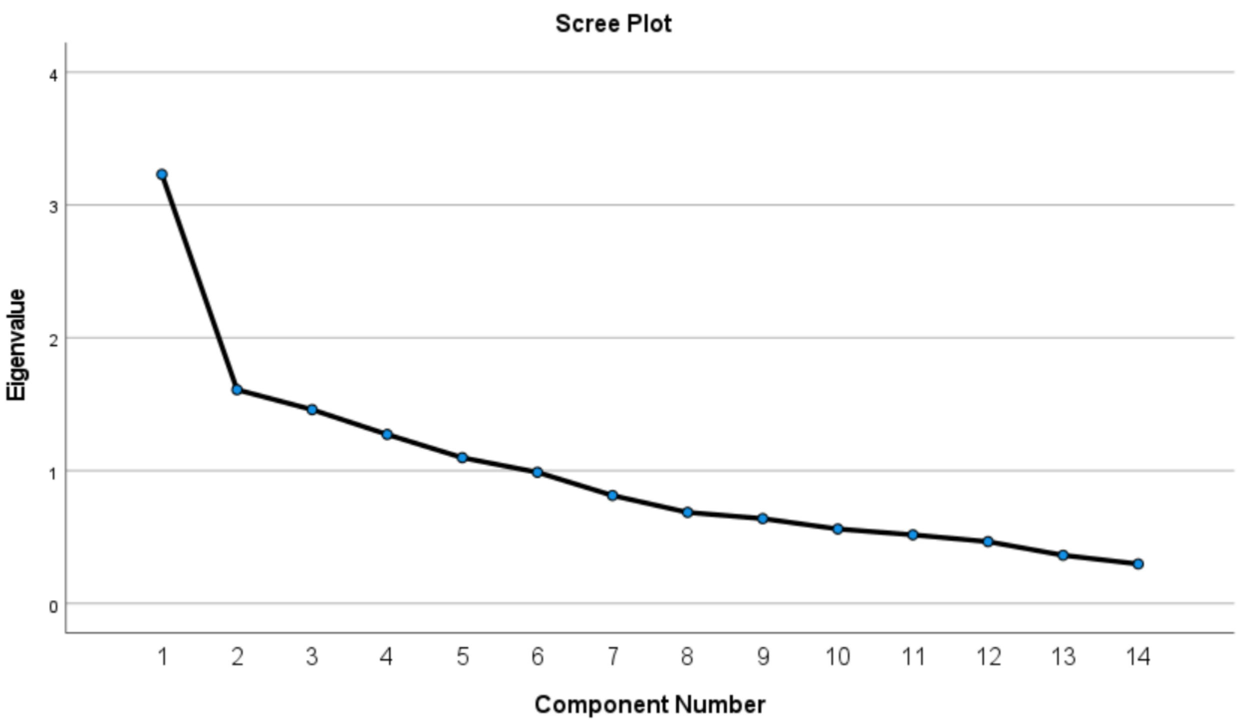
In accordance with Pearson's correlation, *** Correlation is strong, ** Correlation is moderately strong.

Chapter 5: Discussion

The primary purpose of this study was to adapt the PASR-12 to rock climbing (ASRS-C) and explore its initial validity in climbers. Additionally, correlation analyses were conducted to evaluate the association among conceptually related constructs of exercise-related self-efficacy and self-regulation to determine the extent to which each construct compared when measured by a scale specific to climbers versus a more generalizable scale to physical activity and provide initial evidence supporting convergent validity. Finally, demographic information, background on climbing level and experience, and participation in other forms of physical activity were evaluated using frequency distributions to evaluate means, frequencies, and percentages. This approach allowed for preliminary evaluation of differences in the demographic, climbing experience-related factors, and physical activity history in the sample and the extent to which they may be associated with the psychometric properties of the adapted self-regulation scale.

Results of the principal component analysis (PCA) conducted on the Adapted Self-Regulation Scale for Climbers (ASRS-C) with no imposed/fixed number of factors initially yielded a potential 5 factor structure cumulatively explaining 61.9% of the variance. Each of these factors had associated Eigenvalues greater than 1 (3.2, 1.6, 1.5, 1.3, 1.1 from the factors explaining the most to least percentage of variance respectively). This is distinct from the original Physical Activity Self-Regulation Scale (PASR-12), that was also administered, which was previously validated to have 6 factors of self-monitoring, goal setting, eliciting social support, reinforcements, time management, and relapse prevention in older adults (Umstattd et al., 2009). Results of the PCA analysis demonstrated that for the adapted version (ASRS-C) of the scale applied to a sample of experienced rock climbers, these subfactors did not emerge as distinct factors. Interestingly, the interpretation of the scree plot associated with the ASRS-C further supported a difference in the number of factors observed from the original scale (PASR-12). A distinct bend following the first component of the scree plot illustrates the ASRS-C appears to yield a single-component, unidimensional structure where all 14 items in the scale contribute to the measurement of one factor measuring self-regulation in rock-climbers. The similar results of the PCA analysis provide evidence supporting the interpretation of a single component, unidimensional measure of self-regulation for the adapted version of the scale in the present sample of experienced rock climbers.

Figure 2. ASRS-C Scree Plot



Correlation analyses were conducted examining the associations among the 4 scales (ASRS-C, PASR-12, CSES, and MSES) and respondents' climbing level (categorized by gender) and experience (categorized by discipline – bouldering, top-roping, lead climbing, and traditional climbing), to identify potential secondary outcomes. Two specific "sets" of scales were administered, centering around different cognitive-behavioral constructs: self-regulation and self-efficacy. The two scales in each set were analyzed accordingly to see how inter-scale items related to one another or how closely responses aligned among the two scales attempt to measure the same construct. As the ASRS-C is adapted from the PASR-12, by adapting the terminology of "physical activity" to "climbing activity," and adding in two more specific sources or roles of climbing instruction for questions probing the elicitation of advice or demo, correlations between the two scales focused on results from the similar scale items (bolded in Table 2). Collectively, results of the correlation analyses provided evidence supporting the initial convergent validity of the modified self-regulation of climbing scale. Notably, these similarly worded constructs between the two scales were moderately and positively correlated for mentally keeping track of climbing or physical activity (0.456), focusing on how good it felt (0.328), reminding oneself of associated health benefits (0.338), and rearranging one's schedule to ensure time for physical activity or climbing (0.316). Although modest correlations were observed, these findings provide additional support for the initial validity, convergent validity, and sound psychometric properties of the modified scale for rock climbing. These findings could also suggest that those engaged in additional physical activity and climbing, while potentially inclined to engage in self-regulatory behaviors for one or both faucets, may not approach or prioritize it in the same way; emphasizing the need for distinct and specific measures validated by activity.

The second "set" of scales administered both aimed to measure the cognitive-behavioral concept of self-efficacy in the climbing population and included: the Climbing Self-Efficacy Scale (CSES) and the Multi-Dimensional Self-Efficacy Scale (MSES). The former has already been validated in the climbing population (Umstattd et al., 2009). Correlations between the two revealed 1 MSES item moderately correlated for half the items of the CSES scale. More specifically, the MSES item of exercising with proper technique correlated with dealing with unexpected events, preparing physically and mentally for demanding routes, accomplishing what one sets out to do, using appropriate climbing techniques, and performing well. Learning and executing proper technique for exercise is an intentional act that is preparatory in nature and logically could coincide with other means of preparing, practicing technical climbing and accomplishing performing well, even in the face of unexpected events.

In order to paint a clearer picture of how all 4 of these measures of cognitive-behavioral constructors relate to one another, each response was formulated into a summary score that was then correlated to the other scales. Responses to both sets of scales correlated to one another, more specifically the self-regulatory scales ASRS-C & PASR-12 exhibited strong positive correlations and the self-efficacy scales CSES & MSES exhibited moderately positive correlations (see Table 5). Of the summary score correlations, the ASRS-C and the PASR-12 had the largest correlation value (0.663). As a direct adaptation of one another, this being the strongest correlation is logical, but it not being closer to 1.00 (perfectly correlated), supports the validity of such adaptation in eliciting more specified results in the intended population its being adapted to – rock climbers. Self-regulation, as a dynamic construct feed into by self-efficacy (see figure 1), may explain why the correlations between the two sets of cognitive-behavioral construct scales are not stronger.

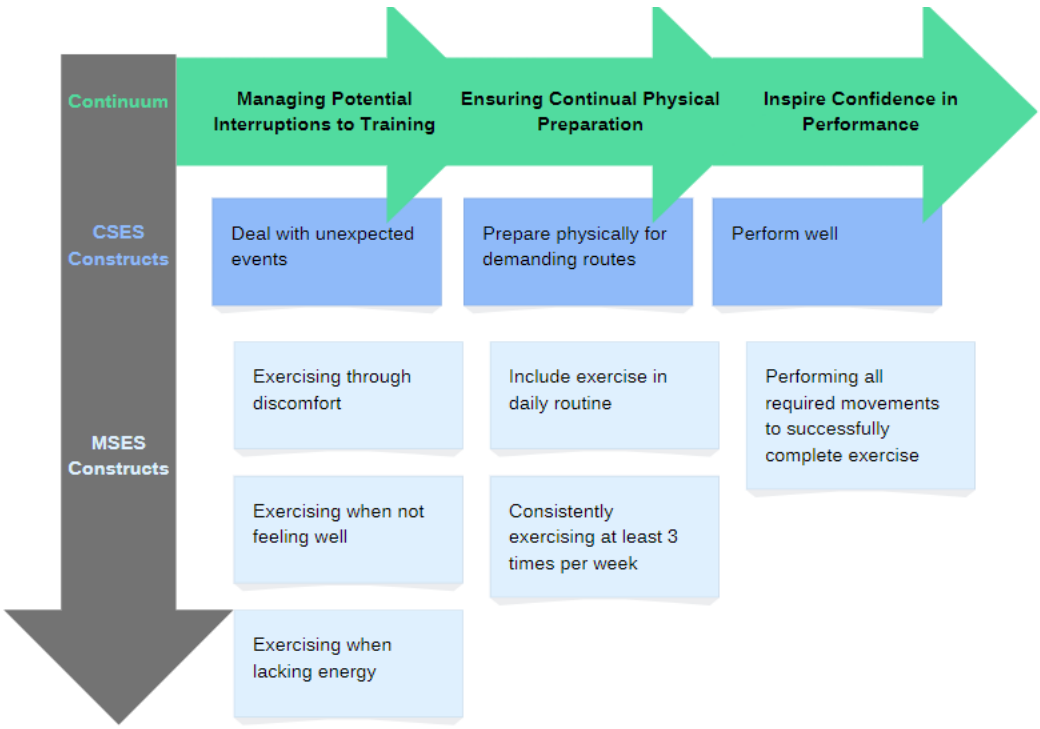
To further understand these scales relation to the participant's climbing level and experience recorded, as well as those facets to one another, correlations were run between the 4 scales, climbing experience and level (by gender) for the 4 disciplines presented in this study: bouldering, top-roping, lead climbing, and trad climbing (see Table 7). The CSES scale was the only one with notable correlations to these elements. For the climbing level of female lead climbers, CSES summary scale scores presented a moderately positive correlation. This single correlation could be indicative of the rope protocol in lead climbing being psychologically more demanding than top roping and influenced by levels of self-confidence (Hodgson et al., 2009). The CSES was also moderately correlated with climbing experience in all disciplines (0.335, 0.301, 0.385, 0.341 for bouldering, top roping, lead climbing and trad climbing experience respectively). As previously mentioned in the correlations between all 4 scales' summary scores, self-regulation is a dynamic construct reciprocally related to self-efficacy that may limit its potential to be interpreted in a static construct of the measure versus a quantification of its change over time. This could lend itself to why the CSES was also the only scale moderately correlated with the climbing levels for all disciplines.

When running bi-variate correlations for climbing experience and level between the disciplines, strong associations were observed between all climbing modalities (bouldering, top roping, lead climbing and trad climbing), with a general trend of higher correlations between disciplines requiring more skill and risk management (see Table 6). This potentially illustrates bouldering and top roping as two disciplines often introduced simultaneously to novice climbers, whereas lead and trad climbing require gaining additional skill over time that would overwhelm the average beginner climber building a foundation of fundamental skills. Such a 'building block' approach to climbing, where skills are stacked on top of one another over time could explain the very strong, positive correlations between climbing level scores of all climbing disciplines for both genders. It appears that with time and constant progressing of skill, climbing level development carries over into all disciplines.

The final correlations run were intra-scale correlations to determine which items' responses in each of the 4 scales related to one another. For the ASRS-C scale, 3 sets of items had moderately, positive correlations with one another: 1) setting short term goals focused on one’s health and setting climbing goals focused on one’s health, 2) mentally scheduling times for climbing and rearranging one’s schedule to ensure time for climbing, and 3) the latter item of set 2 with purposely planning ways to climb when on trips away from home. There are decently strong connections between items focused on one’s health in goal setting and adapting one’s schedule to ensure time for climbing. For the PASR-12 scale, 2 items had moderately positive correlations with one-third of the other items:1) setting short term goals for how often one’s active, and 2) setting physical activity goals focused on one’s health. Interestingly, none of the PASR-12 items mentioned are woven into the sets of items strongly correlated with one another into the ASRS-C. This suggests that even though the items within the original and adapted scale relate to one another, the most pertinent correlations of respondents differ, reaffirming grounds for a mechanism specific to the population it’s measuring to ensure its most accurate portrayal.

For the CSES scale, three items strongly correlated with half the other items in the scale. These include measuring one’s confidence in their ability to 1) deal with unexpected events, 2) prepare physically for demanding routes, and 3) perform well. For the MSES scale, the item pertaining to one’s confidence in their ability to exercise when lacking energy strongly and positively correlated to most/over half the items in the scale. These items included performing all required movements to successfully complete one’s exercise, exercising when feeling discomfort, exercising when one does not feel well, including exercise in one’s daily routine, and consistently exercising at least 3 times per week. Interestingly, the MSES scale seems to capture in more depth a continuum outlined by the CSES scale of managing potential interruptions to training in order to ensure continual physical preparation for demanding climbing, which inspires confidence in one’s performance. The primary MSES item of exercising when lacking energy, as well as the items strongly correlated to it, exercising through discomfort or times of not feeling well, address the management of potential disruptions to training. Additionally, the remaining strongly correlated items of including exercise in one's daily routine, and consistently exercising at least 3 times per week support the insurance of continual training that leads to confidence in one's ability to perform well/all necessary movements to successfully complete exercise (see Figure 3 below).

Figure 3. CSES/MSES Correlations Continuum



In addition to exploring the initial validity of the modified scale, the present study also illustrates characteristics that define the sample's demographic information, climbing background, and involvement in other physical activity outside of climbing. For this sample, the average participant is approximately 32.56 years old, with 50.3% identifying as male, 44.2% as female, and 5.4% as non-binary. They would most likely be White/Caucasian (87.1%), have an annual income above $75,000, and work full-time (72.8%). On average, participants' years of experience in top-roping, traditional climbing, lead climbing, and bouldering would be 12.0, 13.7, 15.3, and 16.7 years respectively. If they engaged in additional physical activity outside of climbing, it would most likely be aerobic, then resistance training, followed by flexibility for approximately 114.4, 83.0, and 44.3 minutes per week respectively. Additionally, their climbing level would be advanced in the top rope, lead climbing and bouldering modalities, and intermediate if they trad climbed. Finally, preliminary evaluation of select differences in self-regulation of these climbers' responses from the modified scale suggest, more self-regulatory behavior for general physical activity than climbing specifically, indicating the potential relevance for guidance in the future on applying this skill to climbing. Conversely, participants also reported higher levels of self-efficacy for climbing than general physical activity, which could be interpreted as being consistent with the behavior-specific nature of self-efficacy beliefs that have been consistently observed in prior social cognitive-physical activity studies evident in the extant literature.

With regard to specific types of climbing, bouldering is generally a more accessible form of climbing from a few different perspectives. First, it does not require as much equipment, rope-handling skill, and a network of belay-trained climbing partners. Additionally, bouldering-only gyms are more cost effective to build and practical for most building structures, making them more widespread. For these reasons, it is logical that bouldering exhibits the highest years of climbing experience by discipline on average. Top-roping, widely held as the transition modality to route climbing, exhibits the lowest number of years' experience by discipline. This is likely due to its nature as a progression towards lead climbing, a modality that can be practiced indoors and is commonly practiced outdoors. Lastly, trad climbing is the second lowest number of years' experience by discipline. As the modality that is only suitable for outdoors, requires further rope-handling skill for the individual as well as the network of climbing partners, and relies on acquiring additional expensive equipment, it is logical that this discipline exude one of the lowest amounts of experience and skill level on average.

Limitations

Although the present results are promising and suggest the modified version of the scale demonstrates strong psychometric properties, there are a few notable limitations of the present study to acknowledge. First, given this was a self-selected sample, not a randomly selected sample, the demographic information may not be reflective of the true climbing population. Additionally, as one of the primary aims was to adapt a pre-existing self-regulation scale to the rock-climbing community instead of constructing a completely novel instrument, some self-regulatory practices as they may relate to the climbing specific population may be lacking. As the PASR-12 model scale informed the adaptation of the ASRS-C, further fine-tuning of items language could have been helpful in condensing items 5-8, so they do not inquire for both advice and/or demo. Additionally, item 14 proved to be problematic due to an oversight of the exclusion of "ways" in purposely planning to climb in bad weather. This likely misconstrued the interpretation of the item from finding alternative strategies to climb in non-ideal conditions to intending to climb in said conditions. While peer-review was conducted on this scale prior to distribution, a formalized peer-review process, specific to the climbing population could have streamlined identifying potential flaws in scale adaptation.

When interpreting the results of the correlation analysis evaluating the association of the PASR-12 to the ASRS-C, it is important to recognize there was considerable variability observed in the mode and volume of physical activity participation. That is, some participants reported only participating in rock climbing whereas others in the sample reported various other modalities of physical activity participation (see Table 1). The extent to which these differences in physical activity participation may influence self-regulatory skills cannot be determined from the present study but warrants future inquiry. It is also presently unclear the degree to which the ASRS-C is strongly associated with climbing experience and/or skill. The extent to which the modified ASRS-C may be linked with significant differences in various aspects of climbing performance and/or experience warrants further systematic evaluation in future inquiry.

Future Directions

Given the relatively limited amount of research addressing climbing and the dynamic nature of self-regulation, there are numerous areas ripe for future rock climbing research. First, given the process of establishing the construct validity of a modified measure is a process that requires multiple studies, replicating and extending evidence of the scale's validity and reliability, further research replicating the present findings are required to draw more definitive conclusions regarding the scale's overall psychometric properties. Additionally, exploring the scale in larger, more diverse samples of climbers is needed to reinforce the present evidence of initial validity and expand the generalizability of implementing the measure within the broader, more representative, climbing population. Once the psychometric properties of the modified ASRS-C scale are confirmed through systematic future inquiry, the measure shows substantive promise to be effectively integrated in studies focusing upon measuring change in self-regulation through targeted, translational intervention trials. Streamlining problematic items with two conditions or that are open to misinterpretation should be addressed prior to future use of this scale and consulted with a pilot group within the climbing population (see Appendix F for recommended modified form for future distribution). As the gap in research on cognitive-behavioral constructs and interventions remains prevalent in the climbing community, such scale adaptation, through iteration and utilization, should be a focus in building the foundation of this realm in climbing research. Lastly, lower levels of self-regulation in climbing versus physical activity suggest applying self-regulatory behaviors in the climbing realm as a potential focus for future research; as self-efficacy feeds into self-regulation to direct behavior change, targeting incorporation and adherence to climbing as a non-traditional form of physical activity means targeting self-regulation in future study (see figure 1).

Conclusions

In summary, results from the present study provide evidence supporting the initial validity of adapting the established PASR-12 to rock climbing via the modified version of the ASRS-C. Specifically, the findings provide evidence that the adapted scale demonstrates a unidimensional structure, appropriate psychometric properties, and preliminary convergent validity given the associations observed in correlation analyses with established measures of self-efficacy and self-regulation. Future inquiry replicating evidence of the scale's validity and extending the present findings are needed to guide the implementation of the scale to advance further rock climbing research.

Appendix A. ASRS-C

14-Item Adapted Self-Regulation Scale for Climbers (ASRS-C)

Please **rate how often** you used each of the following strategies listed below to help you regularly climbing during **the past 4 weeks**

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Very Often (5)
1. I mentally kept track of my climbing activity					
2. I mentally noted specific things that helped me climb					
3. I set short term goals for how often I am climbing					
4. I set climbing goals that are focused on my health					
5. I asked acquaintances for climbing advice or demo					
6. I asked a climbing instructor for climbing advice or demo					
7. I asked a climbing guide for climbing instruction or demo					
8. I asked a professional climber for climbing advice or demo					
9. After climbing, I focused on how good it felt					
10. I reminded myself of climbing health benefits					
11. I mentally scheduled specific times for climbing					
12. I rearranged my schedule to ensure I had time for climbing					
13. I purposely planned ways to climb when on trips from home					
14. I purposely planned way to climb in bad weather					

Appendix B. PASR-12

12-Item Physical Activity Self-Regulation Scale (PASR-12)

Please **rate how often** you used each of the following strategies listed below to help you get regular physical activity during **the past 4 weeks**

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Very Often (5)
1. I mentally kept track of my physical activity					
2. I mentally noted specific things that helped me active					
3. I set short term goals for how often I am active					
4. I set physical activity goals that are focused on my health					
5. I asked someone for physical activity advice or demo					
6. I asked a physical activity expert or health professional for physical activity advice or demo					
7. After physical activity I focused on how good it felt					
8. I reminded myself of physical activity health benefits					
9. I mentally scheduled specific times for physical activity					
10. I rearranged my schedule to ensure I had time for physical activity					
11. I purposely planned ways to do physical activity when on trips away from home					
12. I purposely planned ways to do physical activity in bad weather					

Appendix C. CSES

Climbing Self-Efficacy Scale (CSES)

Please rate how **confident** you feel about your climbing abilities **at the moment.** In each case rate your degree of confidence from 0% (Not at all confident) to 100% (Extremely confident) using the scale given below:

0	10	20	30	40	50	60	70	80	90	100
Not at all confident					Moderately Confident					Extremely confident

My confidence in my ability to:

1. Deal with unexpected events	______%
2. Maintain my concentration	______%
3. Manage risks effectively	______%
4. Manage my fears and anxieties	______%
5. Prepare physically for demanding routes	______%
6. Perform well	______%
7. Avoid making mistakes	______%
8. Prepare mentally for demanding routes	______%
9. Accomplish what you set out to do	______%
10. Use appropriate climbing techniques	______%

Appendix D. MSES

Multidimensional Self-Efficacy Scale (MSES)

Many people report that it is more difficult to be physically active under some conditions than others. Please rate how confident you are that you could be physically active at the present time under EACH of the following conditions.

	Not at all Confident					Somewhat Confident					Completely Confident
How confident are you that you can....	0	1	2	3	4	5	6	7	8	9	10
1. Exercise using proper technique.											
2. follow any directions necessary to successfully complete your exercise.											
3. perform all the required movements to successfully complete your exercise.											
4. exercise when you feel discomfort.											
5. exercise when you lack energy.											
6. exercise when you don't feel well.											
7. include exercise in your daily routine.											
8. consistently exercise at least 3 times per week.											
9. arrange your schedule to include regular exercise.											

Appendix E. IRCRA Grades

Climbing Group		Vermin	Font	IRCRA Reporting Scale	YDS	French/sport	British Tech	Ewbank	BRZ	UIAA	Metric UIAA	Watts
				1	5.1	1	2	4	I sup	I	1.00	
				2	5.2	2		6	II	II	2.00	
				3	5.3	2+		8	II sup	III	3.00	
				4	5.4	3-	3		III	III+	3.50	
Lower Grade (Level 1) Male & Female				**5**	5.5	3		10	IV	IV IV+	4.00 4.33	
				6	5.6	3+	4	12	V	V-	4.66	0.00
				7	5.7	4		14		V	5.00	0.25
				8	5.8	4+				V+	5.33	0.50
		VB	< 2	**9**	5.9	5	5a	16	V sup	VI-	5.66	0.75
				10	5.10a	5+		18		VI	6.00	1.00
		V0-	3	**11**	5.10b	6a	5b	19	VI	VI+	6.33	1.25
	Intermediate (Level 2) Female	V0	4	**12**	5.10c	6a+				VII-	6.66	1.50
Intermediate (Level 2) Male		V0+	4+	**13**	5.10d	6b	5c	20	VI sup	VII	7.00	1.75
		V1	5	**14**	5.11a	6b+		21	7a			2.00
			5+	**15**	5.11b	6c	6a			VII+	7.33	2.25
		V2	6A 6A+	**16**	5.11c	6c+		22	7b	VIII-	7.66	2.50
	Advanced (Level 3) Female	V3	6B	**17**	5.11d	7a		23	7c	VIII	8.00	2.75
		V4	6B+	**18**	5.12a	7a+	6b	24	8a	VIII+	8.33	3.00
		V5	6C 6C+	**19**	5.12b	7b		25	8b	IX-	8.66	3.25
Advanced (Level 3) Male		V6	7A	**20**	5.12c	7b+		26	8c			3.50
		V7	7A+	**21**	5.12d	7c	6c	27	9a	IX	9.00	3.75
		V8	7B	**22**	5.13a	7c+		28	9b	IX+	9.33	4.00
	Elite (Level 4) Female		7B+	**23**	5.13b	8a		29	9c	X-	9.66	4.25
		V9	7C	**24**	5.13c	8a+		30	10a			4.50
Elite (Level 4) Male		V10	7C+	**25**	5.13d	8b	7a	31	10b	X	10.00	4.75
		V11	8A	**26**	5.14a	8b+		32	10c	X+	10.33	5.00
		V12	8A+	**27**	5.14b	8c		33	11a	XI-	10.66	5.25
		V13	8B	**28**	5.14c	8c+		34	11b	XI	11.00	5.50
	Higher Elite (Level 5) Female			**29**	5.14d	9a	7b	35	11c			5.75
Higher Elite (Level 5) Male		V14	8B+	**30**	5.15a	9a+		36	12a	XI+	11.33	6.00
		V15	8C	**31**	5.15b	9b		37	12b	XII-	11.66	6.25
		V16	8C+	**32**	5.15c	9b+		38	12c	XII	12.00	6.50

Appendix F. Modified ASRS-C

Modified 14-Item Adapted Self-Regulation Scale for Climbers (ASRS-C)

Please **rate how often** you used each of the following strategies listed below to help you regularly climbing during **the past 4 weeks**

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Very Often (5)
1. I mentally kept track of my climbing activity					
2. I mentally noted specific things that helped me climb					
3. I set short term goals for how often I am climbing					
4. I set climbing goals that are focused on my health					
5. I asked acquaintances for climbing ***guidance***					
6. I asked a climbing instructor for climbing ***guidance***					
7. I asked a climbing guide for climbing ***guidance***					
8. I asked a professional climber for climbing ***guidance***					
9. After climbing, I focused on how good it felt					
10. I reminded myself of climbing health benefits					
11. I mentally scheduled specific times for climbing					
12. I rearranged my schedule to ensure I had time for climbing					
13. I purposely planned ways to climb when on trips from home					
14. I purposely planned way to climb ***despite*** bad weather					

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