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Personality, Mental Health and Performance Anxiety in Outdoor Sports: The Case of Rock-Climbing

SUMMARY OF THE PH.D. THESIS

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1. THEORETICAL FRAMEWORK

1.1. Introduction and Motivation

Are not the mountains, waves, and skies, a part

Of me and of my soul, as I of them?

— Lord Byron (pp. 30, 1881)

There are only three sports: bullfighting, motor racing, and

mountaineering; all the rest are merely games.

— (mis)attributed to Ernest Hemingway

The secret for harvesting from existence the greatest fruitfulness and

greatest enjoyment is: to live dangerously!

— Friedrich Nietzsche (1889)

Sport significantly shapes human behaviour, fostering life skills in children and adolescents, and promoting health and well-being among older adults. It also serves as a “living laboratory”, providing insights into the extremes of human potential. The COVID-19 pandemic emphasized the crucial role of sports in society. Given this context, it is pertinent to explore high-risk sports as a subject of investigation.

Researchers have been striving for decades to comprehend why individuals engage in extreme or high-risk sports. Recently, they have endeavoured to formulate a *‘blueprint’* for achieving outstanding athletic performance in these sports, which includes physical capabilities as well as psychological attributes such as personality and emotional processes, notably anxiety. One significant limitation of prior research is characterised by the lack of clear understanding of the performance aspects involved in these sports, often focusing primarily on exploring the motives for participating in such sports. Another notable limitation is the tendency to focus either on the antecedents or consequences of these sports, rather than providing a comprehensive overview of both phenomena.

In order to address these limitations, the current thesis investigates both psychological antecedents involved in rock-climbing performance, including personality traits and anxiety, and consequences of participating in these sports, such as improvements in mental health, quality of life, and gains in affective and cognitive functions following exposure to rock-climbing or outdoor sports.

Subsidiarily, this research stems from my personal curiosity, fuelled by over 20 years of involvement in rock-climbing, and by the bewilderment often caused by its practitioners. It originated from Thoreau's 'Walden; or, Life in the Woods' and the profound contributions of historically significant rock-climbers, including Wolfgang Güllich, Ben Moon, Fred Rouhling, Fred Nicole, Josune Bereziartu, Bernabé Fernandez, Chris Sharma, Angela Eiter, Adam Ondra, and many more, who played pivotal roles in the development of modern climbing.

1.2. Research Relevance

In recent decades, there has been a surge in high-risk sports' popularity, notably seen in the addition of sport climbing to the Olympic disciplines in 2020. Studies have linked Five Factor Model (FFM) personality traits like openness, conscientiousness, and extraversion with high-risk sports participation (McEwan et al., 2019; Steinmetz et al., 2022), while neuroticism shows a negative association (Tok, 2011). However, understanding of how FFM traits impact performance remains limited, and grit's role in rock-climbing performance is understudied.

Outdoor physical activity, including climbing, is linked to mental health benefits, but previous reviews focused narrowly on clinical populations and conditions, overlooking broader aspects like wellbeing and stress management (Gassner et al., 2022; Liu et al., 2022; Zieliński et al., 2018). Additionally, anxiety's role in high-risk sports like rock-climbing is poorly understood, despite its significance in sports psychology (Cox et al., 2003; Jones et al., 2019; Martens et al., 1990; Smith et al., 2006), with existing measures failing to capture the complexity of the ‘vertical world’ and to differentiate between two major forms of climbing, lead climbing and top-rope. In terms of the benefits derived from practicing physical activities in the outdoors, current studies lead to notable cognitive and emotional advantages for both exposure to nature and simulations of nature (Bowler et al., 2010; McMahan, & Estes, 2015; Pasanen et al., 2014), but none of these studies controlled for the potential confounding effect of physical exertion/effort.

1.3. The Realm of High-Risk Sports

1.3.1. Defining Outdoor Sports

Outdoor sports refer to a wide range of physical activities and sports that are primarily conducted in natural settings or outdoors (Eigenschenk et al., 2019). These activities can vary significantly in intensity, type, and environment, encompassing everything from traditional team sports played on outdoor fields, individual or group activities such as hiking, rock-climbing, kayaking, and road cycling or mountain biking, to water-based sports like surfing and sailing.

1.3.2. Defining Risk and High-Risk Sports

Human evolution has been significantly shaped by the willingness to take risks. However, we now find ourselves in an era where safety is paramount, with advancements in technology and medicine seen as hallmarks of societal improvement. Despite this, or perhaps because of it, the temptation of danger grows stronger for many, sparking a heightened interest in activities like high-risk sports (Woodman et al., 2020).

Risk is defined as the “(exposure to) the possibility of loss, injury, or other adverse or unwelcome circumstance; a chance or situation involving such a possibility” (Oxford English Dictionary, 2017). High-risk sports refer to “all sports where you have to reckon with the possibility of serious injury or death as an inherent part of the activity” (Breivik, 1999, p. 10), such as mountaineering, rock-climbing, skydiving, white-water kayaking, BASE-jumping, etc.

Rock-climbing

Rock-climbing encompasses various disciplines, distinguished by criteria such as the type of protection employed by climbers, the nature of the terrain, the length of the routes, and the climbing styles. Examples include: bouldering, characterized by short climbs over crashpads for protection and typically not exceeding heights of 5–7 meters; and sport climbing, where climbers ascend routes with pre-placed anchors and rope for protection. Each of these styles represents a unique approach to engaging with the vertical world.

Jones and Sanchez (2017) noted the uniqueness of climbing, attributing it to multiple factors: physiologically (isometric contractions of forearm muscles), biomechanically (primary use of the upper limbs and vertical motion), and psychologically (new and difficult paths daily, fostering an extreme mindset). The practice is done in a variety of environments (outdoors on natural rock, indoors on various artificial surfaces), has different scales to measure self-report difficulty (e.g., French/sport scale, Yosemite Decimal System – YDS, and UIAA scale; see Draper et al., 2015), different characteristics of climbing and competition formats (lead climbing, bouldering, speed and para-climbing), and encompass multiple modalities (onsight, flash, redpoint). Redpoint, originally called *Rot-Punkt* (from German) is the act of successfully climbing a route using a rope, without resorting to any artificial aids, after allowing oneself ample time to familiarize with the route. Flash involves successfully completing a route with a rope, without prior physical engagement with the climb, but with some foreknowledge of its specific sequence of the holds. Onsight is characterized by ascending a route using a rope, without the use of artificial aids or prior knowledge about the route's features (Jones & Sanchez, 2017).

1.4. Antecedents: Personality in Sports

The interconnection between personality traits and their influence on health, occupational, and athletic achievements has consistently interested researchers (Laborde et al., 2019; Roberts et al., 2018; Waleriańczyk & Stolarski, 2021). The Five Factor Model (FFM) has emerged as the primary framework for examining the relationship between personality and athletic performance, identifying key traits like neuroticism, extraversion, openness, agreeableness, and conscientiousness (Allen et al., 2013; McCrae & John, 1992). Studies have linked these traits to various aspects of athletic performance, including preparation and coping strategies, indicating a direct correlation between certain personality traits and sports-related achievements (Kaiseler et al., 2012; Woodman et al., 2010). Despite these insights, significant gaps remain regarding the application of these insights to high-risk sports.

1.4.1. Personality in High-Risk Sports

The fascination with high-risk sports is partly due to their potential positive impact on psychological well-being and emotion regulation (Allman et al., 2009; Willegers et al., 2023; Woodman et al., 2020). Studies highlight the significant association of extraversion, conscientiousness, and openness with high-risk sports participation, whereas neuroticism is inversely related (McEwan et al., 2019; Rumbold et al., 2021; Tok, 2011). Individuals engaged in these sports tend to exhibit higher extraversion and openness and lower conscientiousness and neuroticism compared to those in lower-risk sports (Allen et al., 2011; Tok, 2011).

A pioneering study by Rumbold et al. (2021) on rock-climbing practitioners revealed diverse personality profiles, challenging the stereotype of uniform sensation-seekers among them. However, its implications for performance remain unexplored due to the absence of performance data on sport climbing or bouldering.

1.4.2. Grit in Sport

Grit is a specific personality trait characterized by a persistent commitment and passion for long-term objectives, it involves diligently overcoming challenges and sustaining effort and interest over years, even in the face of failures, obstacles, and periods of no improvement (Duckworth et al., 2007). Despite its importance, grit's similarity to conscientiousness poses a challenge, as they are closely related (Credé et al., 2017; Rimfeld et al., 2016). Nevertheless, perseverance of effort, known as a facet of grit, has been shown to be distinctively valid, even when controlling for conscientiousness (Credé et al., 2017).

Grit has emerged as a significant predictor of sports performance across various disciplines (Cormier et al., 2021), being linked to positive behaviours and outcomes, such as athletic identity and performance (Cormier et al., 2024; Larkin et al., 2016; Moles et al., 2017; Mosewich et al., 2021). Grit has also been associated with the psychological state of flow and the inclination towards deliberate practice (Smith et al., 2020; Tedesqui & Young, 2018), which is particularly relevant to the perseverance required in rock-climbing.

1.4.3. Personality in Sports: A Longitudinal Perspective

There is a lack of longitudinal research into how personality traits predict sports performance. Recent studies have revealed a positive association between grit and progressive performance in various sports disciplines (Cormier et al., 2021). For instance, Doorley (2020) found a notable link between grit and performance recovery among athletes following a day of underperformance. Additionally, grit has been linked to seasonal performance enhancement among junior skiers (DeCouto et al., 2019), with specific facets of grit – consistency of interests, perseverance of effort, adaptability to situations – predicting subjective performance, well-being, and satisfaction within sport in collegiate student-athletes (Cormier et al., 2024). However, in the emerging field of high-risk sports, longitudinal studies examining the relationship between personality traits and performance are yet to be conducted.

1.5. Consequences for Mental Health

1.5.1. “Climbing Therapy”: Psychological Intervention for Mental Health Conditions

The COVID-19 pandemic significantly impacted the mental health and well-being of the general population and athletes worldwide. The gap between the need for and supply of mental health services has been widening, highlighting the urgency for affordable and effective community-wide strategies (WHO, 2019). In recent years, physical activity, has been increasingly recognized as a means to mitigate mental health difficulties, particularly depression (Lubans et al., 2016), with climbing emerging as an effective form of such activity.

Climbing fosters psychological skills essential for combating mental health difficulties, such as problem-solving, coping with fear, goal setting, self-esteem, focus, motivation, and social connections, potentially translating these benefits into daily life (Frühauf et al., 2021; Young & Knight, 2014). It also promotes mindfulness, a state of presence that is linked with mental health benefits (Enkema et al., 2020; Wheatley, 2023). Climbing has been shown to reduce symptoms of depression and anxiety, while also enhancing positive mood, with these improvements lasting for up to 12 months after the intervention (Aras, & Ewert, 2016; Kleinstäuber et al., 2017; Schwarz et al., 2019).

Despite these promising findings, there is a recognized need for a more comprehensive review of the literature to outline common methodologies and identify gaps, as previous reviews were limited by their narrow focus and methodological approaches (Gassner et al., 2022; Liu et al., 2022; Zieliński et al., 2018).

1.6. Climbing Anxiety: Individual Factors impacting Climbing Performance

1.6.1. Conceptualizing Anxiety in Sport and Athletic Performance

The hazardous nature of high-risk sports and the pressure of competitive environments can lead to anxiety and fear among athletes. However, super-elite athletes and practitioners of high-risk sports often find value in these challenges, using them for emotional regulation and forming an 'attachment' to these sports (Woodman, & Hardy, 2001). Unlike their elite counterparts, who tend to balance sport and life, these individuals may see their sport as an essential 'escape' or 'relief' from daily life pressures, emphasising sport over other life aspects (Woodman et al., 2020).

1.6.2. Sport Specific Anxiety Measures

Anxiety assessments in sports have been developed with either a unidimensional approach (e.g., Sport Competition Anxiety Test, SCAT; Martens, 1977), or a multidimensional approach, which considers various components such as cognitive and somatic anxiety (e.g., Sport Anxiety Scale, SAS, Smith et al., 1990 and Competitive State Anxiety Inventory-2, CSAI-2, Cox et al., 2003; Martens et al., 1990). However, the applicability of these measures to high-risk sports is limited due to unique factors such as the athletes' baseline anxiety levels or their skills in managing anxiety.

Climbing Anxiety. Elite climbers exhibit lower anxiety levels compared to the general population, while novices show increased anxiety, especially in challenging climbing scenarios like lead climbing compared to top-roping (Aras, & Akalan, 2014; Liştea et al., 2017; Pijpers et al., 2006). A climbing-specific anxiety measure could enhance understanding of this impact.

Climbing Self-Efficacy. Llewellyn et al. (2008) developed a scale for assessing self-efficacy in climbing, revealing that climbers with high self-efficacy tend to participate more often in rock-climbing activities of both high and medium risk, tackling climbs of greater difficulty.

1.7. The Power of Nature: Psychological Consequences of Exercising in Natural Environments

1.7.1. Bringing the Outdoors Indoors: Psychological Benefits of Exposure to Simulated Nature

Most of the research comparing real to simulated nature effects on psychological functioning found a significant impact of both, with real environments having a stronger impact on various cognitive and emotional outcomes (Bowler et al., 2010; McMahan, & Estes, 2015). A study by Rogerson et al. (2016) found that outdoor cycling enhances working memory and social interactions, potentially boosting future exercise intentions, unlike indoor cycling in a controlled lab setting. However, Niedermeier et al. (2017) observed no significant difference in stress-related physiological responses (salivary cortisol) between long-duration exercises in natural environments and intense indoor treadmill workouts, attributing the benefits solely to physical activity rather than the environment. The current understanding of the cognitive and affective advantages of exercising in natural settings versus laboratory simulations is ambiguous.

Cognitive Benefits of Exercising in Natural Environments

Attention Restoration Theory (ART; Kaplan, 1995) distinguishes between involuntary and voluntary directed attention, where natural environments facilitate a unique form of concentration that is involuntary, characterized by feelings of “fascination,” “being away,” “extent,” and “compatibility” that allows the brain’s directed attention mechanisms to rest and recover, offering a mental break from the constant focus required by everyday tasks.

Affective Benefits of Exercising in Natural Environments

Stress Reduction Theory (SRT; Ulrich, 1981) highlights the restorative benefits of natural environments, emphasizing their evolutionary significance to humans. Simple exposure to nature scenes can stimulate the parasympathetic nervous system, leading to decreased stress and autonomic arousal (Ulrich et al., 1991). Positive and negative affect, anxiety and depression have been associated with improvements after exposure to nature (Bowler et al., 2010; Berman et al., 2012; Bratman et al., 2012; Bratman et al., 2021; White et al., 2021).

1.8. Theoretical Frameworks: Sport Performance and Mental Health Consequences

1.8.1. Mental Health Model (MHM; Morgan, 1985)

The ***Mental Health Model***, introduced by Morgan (1985) four decades ago states that "that success in sport is inversely correlated with psychopathology" (Morgan, 1985, p. 71) and posits that athletes with higher levels of neuroticism, trait anxiety, depression, confusion, and fatigue are likely to be less successful than those with lower scores in these psychological domains. Conversely, it suggests that positive mental health traits, such as emotional stability, low anxiety, and high psychic energy, correlate with greater sporting success (Beedie et al., 2000; Lochbaum et al., 2021; Rowley et al., 1995). The MHM also explores how changes in an athlete's mental health over time, particularly due to intensive training, can affect performance, noting that positive mental health profiles can deteriorate under such conditions, leading to mood disturbances and performance decline (Morgan, 1985; Morgan, 1988).

MHM is based on findings from eight studies involving athletes across various sports. These studies varied widely in participant numbers, ranging from 16 to 735, and included athletes of varying competencies, from pre-elite to elite or international category (Morgan, 1985). Participants were classified into distinct categories (such as "successful" or "unsuccessful") according to predefined benchmarks, including achievements like the number of varsity letters earned or being part of the starting team. The psychological variables included in the MHM (1985) are the following:

State Trait Anxiety: State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, 1970).

Somatic Anxiety: Somatic Perception Questionnaire (SPQ; Landy & Stern, 1971).

Depression: Depression Adjective Checklist (DACL; Lubin, 1967).

Affect: Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1971).

Personality: Eysenck Personality Inventory (EPI; Eysenck & Eysenck, 1968).

The ***Mental Health Model Revisited*** (MHM-R; Raglin, 2001) strengthened the findings of MHM regarding the significant influence of psychological factors linked to the MHM on athletic performance. Attributes like effective coping skills and strong social networks can lower the risk of emotional disorders like depression and aid injury recovery. MHM research could be enhanced by incorporating coping skills (Haney, & Long, 1995; Kenttä et al., 2001) and social support, and by applying modern personality theories such as the FFM (McCrae & John, 1992). Additionally, evidence indicates a positive relationship between extroversion, seeking social support, and employing coping strategies, highlighting how personality traits such as introversion-extroversion affect sports performance (Raglin, 2001).

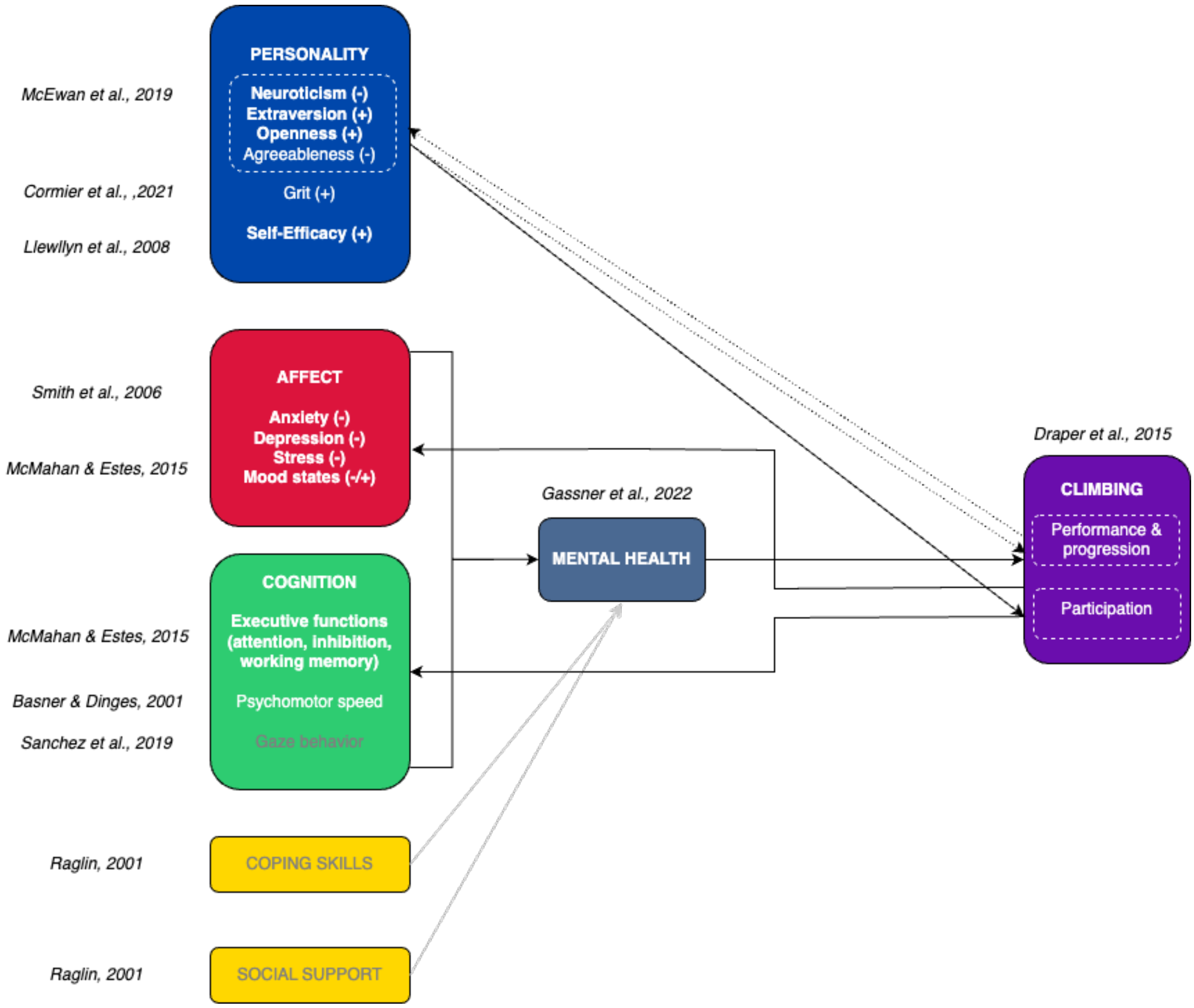
1.8.2. Rock-Climbing Performance and Mental Health (RCPMH): A New Model

We have developed the '***Rock-Climbing Performance and Mental Health (RCPMH)***', which integrates various psychological factors (personality, affect, and cognition) and their impact on both athletic performance and mental health outcomes (see Figure 1.8.1) in the specific case of rock-climbing. This model draws from MHM (Morgan, 1985), MHM-R (Raglin, 2001), and various empirical results in clinical sport psychology.

The RCPMH model (Figure 1.8.1) describes the pathways linking various psychological variables with athletic outcomes in extreme sports like rock-climbing. More specifically, it links three broad categories of individual differences, *personality* (the FFM – neuroticism, extraversion, openness, agreeableness, conscientiousness, grit, and self-efficacy), *affect* (anxiety, depression, stress, and mood/dispositions), and *cognitive functioning* (attention, inhibition, working memory); and two sets of variables, *coping skills* and *social support*. Extant literature indicates that *three of the five* ***personality*** *traits included in the FFM were linked to sport participation: neuroticism – negatively related, extraversion – positively related*, *and openness – positively related* (Allen et al., 2013; McCrae & John, 1992; McEwan et al., 2019; Tok, 2011), however, no prior research investigated the influence of FFM in relation to climbing performance. Existing reviews indicated that *grit was related with various aspects of both sport-related practice and performance* (Cormier et al., 2021; Cormier et al., 2024), no prior investigation was conducted in rock-climbing. Finally, extant research suggests that *sport-specific self-efficacy plays an important role in various sport and athletic outcomes,* including rock-climbing (e.g., Llewlyn et al., 2008). Surprisingly, we could not identify any significant research indicating that sport performance itself exerts an influence on personality traits over time, therefore this avenue might be pursued in future research endeavours.

Various empirical findings and reviews indicate that ***affective*** *variables such as anxiety and depression can hamper sport-relevant outcomes* (Gouttebarge et al., 2019; Morgan, 1985; Raglin, 2001; Reardon et al., 2019), while *practicing sports and physical activity in general is expected to alleviate some depression or anxiety levels* (McMahan, & Estes 2015; Rebar et al., 2015; Rebar, & Taylor, 2017; Smith et al., 2006). In respect to *cognitive functioning*, the theoretical model described in Figure 1.8.1 specifies *bidirectional influences from cognitive functioning to sport performance*, factors such as *executive functioning, psychomotor speed and gaze behaviour* having been associated with performance in various athletic endeavours (Basner & Dinges, 2001; McMahan, & Estes, 2015; Sanchez et al., 2019); while the *involvement in physical activities, especially in the form of structured sport practice contributes to further enhance cognitive functioning* (Carson et al., 2016; Gassner et al., 2022; Prakash et al., 2015; Rogerson et al. 2016). Especially when considered from longitudinal perspective, *coping skills* play an important role in maintaining sport involvement and overcoming episodes of low performance (Raglin, 2001). Another category of sport performance and sport engagement antecedents is the *social support*, ranging from colleagues, teammates to coaches and familial supporters (Raglin, 2001). Taken together, these five categories of constructs describe most of the psychological factors that have been reported as playing an important role in practicing and performing in various sports.

Figure 1.8.1 *The Rock-Climbing Performance and Mental Health (RCPMH) Model (adapted from Morgan, 1985 and Raglin, 2001).*



II. THEORETICAL AND METHODOLOGICAL AIMS

2.1. Theoretical Aims

Aim 1. Our first aim of the current thesis is to expand scientific knowledge by understanding *the relationship between FFM personality traits and performance in high-risk sports, particularly rock-climbing* (e.g., sport climbing and bouldering). In ***Study 1***, we provide the first empirical evidence in the literature regarding these relationships in rock-climbing, distinguishing our work by focusing on performance rather than merely on associations with participation. In ***Study 2***, we extend the previous findings using a longitudinal design with a follow-up after 12 months.

Aim 2. The second aim of this thesis is to *test whether grit*, a personality trait not included in the FFM, *predicts rock-climbing performance*, over FFM traits, especially conscientiousness. In ***Study 1***, we introduce the first empirical evidence on the relationship between grit and rock-climbing performance. In ***Study 2***, we build on these initial insights through a longitudinal study, including a follow-up period of 12 months.

Aim 3. The third aim of this thesis is to identify the available *evidence regarding the connection between climbing and mental health, wellbeing, quality of life, and stress*. Additionally, we aim to pinpoint research gaps and provide recommendations for future research. To this end, we develop a comprehensive scoping review in ***Study 3***.

Aim 4. The fourth aim of the current thesis is to expand scientific knowledge by *examining anxiety in the realm of rock-climbing*, a high-risk sport. To this end, in ***Study 4***, we explore the *relationship between rock-climbing performance and various psychological factors, including sport anxiety, climbing anxiety, and climbing self-efficacy*.

Aim 5. The fifth aim is to expand scientific knowledge in the *field of outdoor sports by testing potential cognitive and affective benefits of exercising indoors (cycling) when exposed to simulated* *nature*. To this end, in ***Study 5***, we use a randomised crossover trial, distinguishing our work by addressing the limitations from previous studies that did not control for the exercise intensity.

Aim 6. Building on previous literature and current findings, our final aim is to introduce a *novel Rock-Climbing Performance and Mental Health (RCPMH) model* that extends previous theoretical models, such as the *Mental Health Model* (MHM; Morgan, 1985) and the *Mental Health Model Revisited* (MHM-R; Raglin, 2001), by providing a fine-grained examination of the various psychological factors involved in climbing performance and improved mental health and wellbeing following exposure to high-risk sports. Alongside examining the *relationships between personality traits and climbing performance* in ***Study 1*** and ***Study 2***, we delve into the *mental health and wellbeing benefits of rock-climbing* in ***Study 3***, we also explore the i*nterplay between sport anxiety, climbing anxiety, climbing self-efficacy, and climbing performance* in ***Study 4***, proposing the Climbing Anxiety Scale as a new measure. ***Study 5*** marks our attempt to provide evidence for the *cognitive and affective benefits of another outdoor sport, road cycling*, using an experimental design.

2.2. Methodological Aims

Aim 1. Our first methodological aim is to address the limitations of previous studies that grouped different high-risk sports (e.g., BASE jumping, rock-climbing, windsurfing) together, had insufficient statistical power, and lacked adequate female representation. To this end, in ***Study 1*** and ***Study 2***, we *use a large, gender-balanced sample* and *distinguish between two athletic disciplines of rock-climbing*, sport climbing and bouldering.

Aim 2. Following the same overarching aim of addressing previous limitations in the literature, in ***Study 1*** and ***Study 2***, we investigate for the first time the *relationship between personality and various climbing performance indicators (redpoint, flash, onsight)*.

Aim 3. Our third methodological aim is to investigate whether the *FFM and grit findings replicate after a 12-month follow-up* (***Study 2***), and to examine progression in rock-climbing performance (from time 1 to time 2).

Aim 4. Our fourth methodological aim is to explore the potential *advantages of climbing for overall wellbeing in a more diverse population and study designs*, extending beyond individuals with physical or mental health issues, as addressed in previous reviews. To this end, we conduct a comprehensive scoping review (***Study 3***) that includes, for the first time, a range of study designs, not only interventions and experimental studies but also qualitative and mixed-methods research, as well as descriptive studies.

Aim 5. Our fifth methodological aim is to contribute to the broader field of sport and athletic research by *developing and validating a theoretically-anchored climbing-specific anxiety measure*. To this end, we provide *preliminary evidence of the Climbing Anxiety Scale* in ***Study 4*** by testing factorial and criterion-related validity.

Aim 6. Our sixth methodological aim addresses the limitations of previous studies in the domain of outdoor sports which explore the *cognitive and affective benefits of exercising in simulated nature, distinguishing our work by controlling for exercise intensity (set at 75% of the athletes' submaximal effort)*, using a randomised crossover trial, and employing an experimental within-subject design that contrasts two different conditions (***Study 5***): indoor exercising (*cycling*) with a video simulation of nature (*simulated nature*) compared to indoor exercising (*control condition*).

III. ORIGINAL RESEARCH CONTRIBUTIONS

3.1. Study 1: Personality, Grit, and Performance in Rock-climbing: Down to the Nitty-Gritty[1]

Personality traits play a significant role in extreme sports. Our study pursues two main objectives: first, to investigate whether the associations observed in previous research extend to relatively new and high-risk sports, such as rock-climbing (sport climbing and bouldering); second, to identify whether additional personality-related variance in rock-climbing performance can be uncovered by considering the role of grit, a personality trait placed outside the FFM. Among the FFM traits openness (e.g., Rumbold et al, 2021), extraversion (e.g., Wilson & Dishman, 2015) and neuroticism (e.g., McEwan, et al, 2019) consistently predict high-risk sport participation, we expect these traits to account for most of the personality-related variance in rock-climbing performance. One trait sitting outside the FFM, associated with success in long-term endeavours, is grit (Duckworth et al., 2007). The passion and perseverance in attaining long-term objectives might be particularly relevant to rock-climbing performance. However, any empirical grit-oriented investigation should adequately control for the potential overlaps with conscientiousness (Credé et al., 2017).

Consequently, we hypothesise that:

H1: FFM personality traits will account for a significant proportion of variance in rock-climbing performance, when controlling for age, gender, and years of experience in rock-climbing.

H1a: Most of the personality-related variance in rock-climbing performance will be explained by neuroticism, extraversion, and openness.

H2: Grit will account for a significant proportion of variance in rock-climbing performance, over age, gender, experience and FFM traits, in particular over and beyond conscientiousness.

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[1] The content of this sub-chapter represents in its entirely the manuscript published in the International Journal of Sport and Exercise Psychology: **Ionel, M. S.**, Ion, A., & Visu-Petra, L. (2023). Personality, grit, and performance in rock-climbing: down to the nitty-gritty. *International Journal of Sport and Exercise Psychology*, *21*(2), 306-328. https://doi.org/10.1080/1612197X.2022.2044368

3.1.1. Method

We collected data from 272 participants (155 boulderers) who volunteered to respond to our invitation. The sample included 114 females (41,91 %) and 158 males, with ages between 16 and 69 (*M* = 32.13, *SD* = 10.01) – with parental consent for participants under 18 years old. To be included in the current study the participants had to have at least 12 months of experience in practicing rock-climbing. Their experience in rock-climbing ranged between 1 and 40 years (*M* = 9.02, *SD* = 9.14).

Measures

Climbing Performance. In estimating performance within sport climbing and bouldering, two components are taken into account: route difficulty level (as per the International Rock-Climbing Research Association – IRCRA scale; Draper et al., 2015) and climbing style (redpoint, flash and onsight). Participants reported the most difficult routes they had successfully completed in the three different styles.

Personality. In order to ensure a brief, but accurate estimation of the FFM traits, personality was measured via Big Five Inventory–2 Short Form (BFI-2-S; Soto & John, 2017). The five domains were measured with 30 items rated on a 5-point scale from 1 (*strongly disagree*) to 5 (*strongly agree*).

Grit. Grit was measured by employing the 12-item inventory (Duckworth et al., 2007). Some example items are 'Setbacks don't discourage me' or 'I often set a goal but later choose to pursue a different one', measured on a scale from 1 (*not like me at all*) to 5 (*very much like me*).

3.1.2. Results and Conclusions

We conducted confirmatory factor analyses (CFA) for all variables and exploratory structural equation modelling (ESEM) for the personality measure. Next, we examined the criterion-related validity of the CFA-derived latent factors for FFM traits and grit over age and gender in predicting various facets of sport climbing performance and bouldering performance, respectively.

To this end, we employed a hierarchical regression. For *Sport Climbing Performance*, the FFM dimensions that significantly predicted overall sport climbing performance were openness (β = 2.89, $p < .001$) and agreeableness (β = -2.08, $p < .001$), as well as grit (β = 3.59, $p < .001$). This accounted for a mere 2.7% of the overall variance in sport climbing performance over age, gender, experience, and FFM dimensions ($\Delta R^2 = .027$, $p < .001$). For *Bouldering Performance,* the FFM dimensions that significantly predicted overall bouldering performance were openness (β = 1.37, $p < .01$) and agreeableness (β = -1.46, $p < .001$), as well as grit (β = 2.60, $p < .001$). This accounted for a mere 2% of the overall variance in overall bouldering performance over age, gender, experience, and FFM dimensions ($\Delta R^2 = .020$, $p < .01$).

Several key findings emerged: (1) the FFM dimensions predicted different performance criteria in both sport climbing and bouldering, over and beyond age, gender, and experience; (2) Grit consistently predicted different performance criteria in both sport climbing and bouldering, over and beyond individual FFM dimensions; (3) a post-hoc methodological contribution: although performance in sport climbing and bouldering as measured via the IRCRA is assumed to be multidimensional in nature (including both difficulty rating and style – redpoint, onsight and flash), our analyses suggested that a unidimensional model of climbing performance exhibited a the best fit to the data. Taken together, our findings suggest that grit, openness, and agreeableness had a relevant impact over rock-climbing performance.

3.2. Study 2: Personality and Rock-climbing Performance Progression: A 12-months Follow-up[2]

Despite the call for additional research on the longitudinal associations between personality and sport-related outcomes (Allen et al., 2013), research tapping into the longitudinal interplay between personality and sport-related outcomes is generally scarce. The first key aim of the 12-months follow-up investigation is to examine whether findings from Study 1 replicate, further contributing to understanding how personality facilitates performance in rock-climbing. The second aim of the study is to explore progression in rock-climbing performance (time 2 – time 1) over a 12-months timespan. Consequently, we hypothesise that:

Hypothesis: Five-Factor Model personality traits and grit will significantly predict rock-climbing performance after 12-months follow-up, over age, gender, and experience, with openness to experience and grit exhibiting the strongest associations.

3.2.1. Method

Out of the 272 participants (time 1), a total of 113 answered the second survey (time 2 after 12 months): 43 females (38,10 %) and 70 males, with ages between 17 and 67 (M = 34.19, SD = 10.53) – and parental consent for participants under 18 years old. Their experience in rock-climbing ranged between 2 and 41 years (M = 11.76, SD = 9.42). The response rate amongst bouldering practitioners fell well below the thresholds indicated by the power analysis.

Measures

Climbing performance. Performance in outdoor sport climbing was assessed by employing the measure recommended by IRCRA (Draper et al., 2015). A detailed presentation of the procedure for measuring rock-climbing performance was included in Ionel et al. (2023). Each participant was asked to report the highest grades attained during the past 12 months.

[2] The content of this sub-chapter represents in its entirely the manuscript published in the International Journal of Sport and Exercise Psychology: **Ionel, M. S.**, Ion, A., & Visu-Petra, L. (2023). Personality and rock-climbing performance progression: a 12-months follow-up. *International Journal of Sport and Exercise Psychology*, 1-24. https://doi.org/10.1080/1612197X.2023.2293935

Personality. Big Five Inventory–2 Short Form was used to measure the FFM personality traits (BFI-2-S; Soto & John, 2017) at time 1.

Grit. Grit was measured with the 12-item inventory (Duckworth et al., 2007) comprising two facets: perseverance of effort and consistency of interests.

Both measures of FFM personality traits and grit were administered in the first wave (time 1). Only data pertaining to climbing performance was collected during time 1 and follow-up (time 2).

3.2.2. Results and Conclusions

CFA for all the measures were reported in Study 1 (Ionel et al., 2023) and a separate progression score (time 2 – time 1) was computed (Cohen et al., 2002). Next, we conducted hierarchical regressions for *Sport Climbing Performance*. Grit predicted overall sport climbing performance (latent) adding an additional 2.9% of unique variance beyond age, gender, and experience ($\Delta R^2 = .029$, $p < .001$). Openness ($\beta = .40$, $p < .001$) and grit ($\beta = .63$, $p < .001$) were the strongest predictors. The progression from time 1 to time 2 is plotted in Figure 3.2.1 and the results of the main findings and regressions are depicted graphically in Figure 3.2.2.

Figure 3.2.1 *Progression from time 1 to time 2 of Overall Sport Climbing Performance (IRCRA scale) in rock-climbing: scatter plot.*

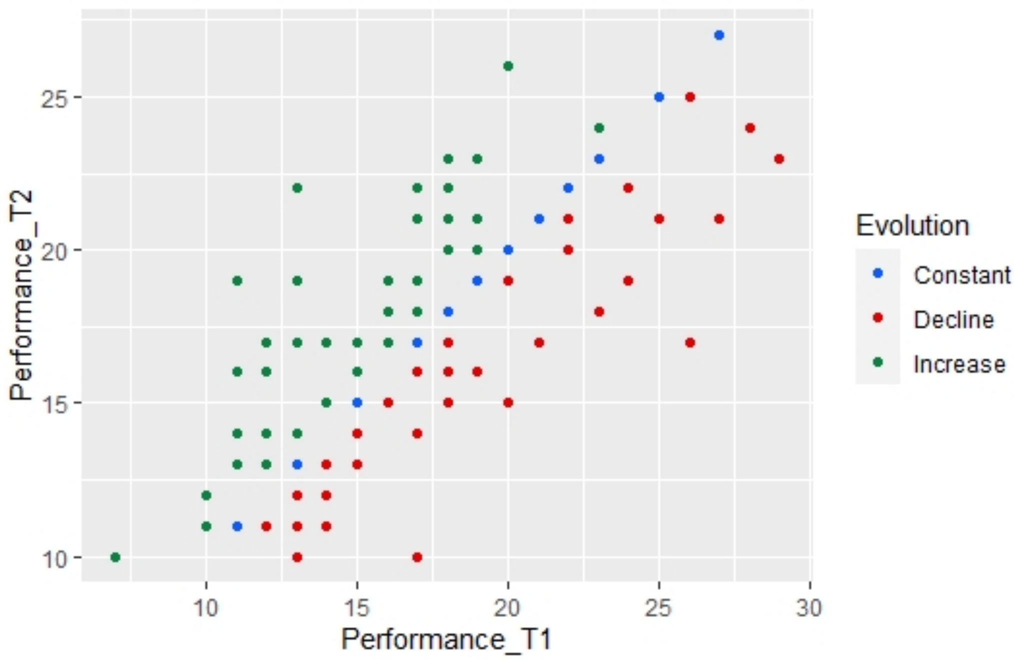
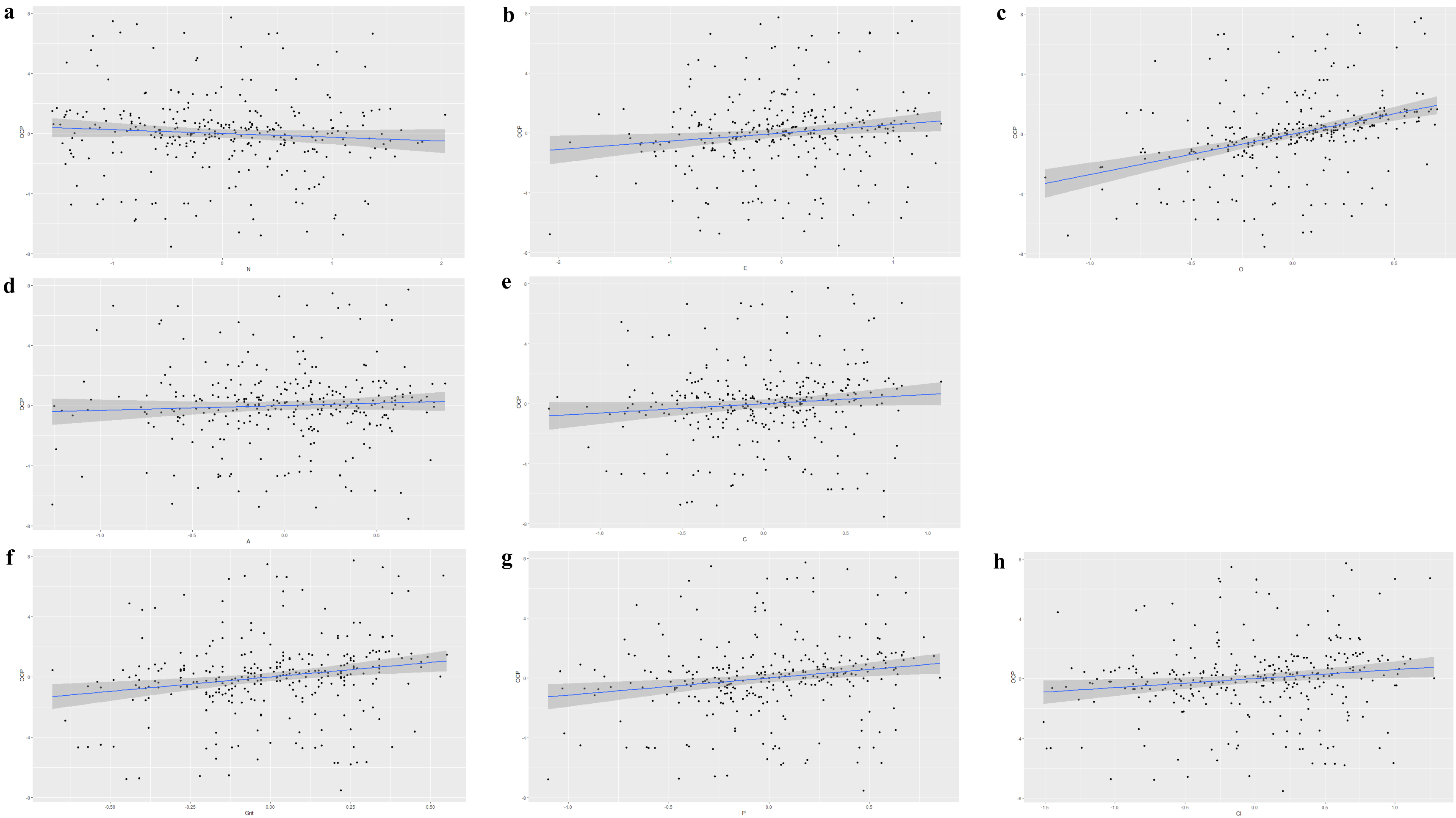


Figure 3.2.2 *Five Factor Personality Traits, Grit and Overall Sport Climbing Performance (time 2) in rock-climbing: scatter plot.*



Note: (a) *N* = Neuroticism. (b) *E* = Extraversion. (c) *O* = Openness. (d) *A* = Agreeableness; (e) *C* = Conscientiousness. (f) Grit. (g) Grit P = Perseverance of effort. (h) Grit CI = Consistency of Interests. OCP = Overall Sport Climbing Performance (IRCRA scale).

The main key findings, after 12-months follow-up were: (1) Similar to the initial findings, only openness accounted for a significant proportion of variance in outdoor rock-climbing performance, over and beyond age, gender and experience, replicating the results of our previous study (Ionel et al., 2023); (2) grit continued to account for significant amount of variance in outdoor sport climbing performance over age, gender, experience, and FFM personality traits, replicating also this finding from the study already mentioned; (3) neither one of the FFM dimensions, nor grit predicted progression in rock-climbing performance over a 12-months timespan. Taken together, our findings suggest that future investigations, as well as interventions aimed at facilitating performance in high-risk sports, should not ignore openness to experience and grit.

3.3. Study 3: The Associations between Climbing and Mental Health and Wellbeing: A Mixed-Methods Scoping Review[3]

The positive relationship between physical activity and mental health is well established (Paluska & Schwenk, 2000). In recent years climbing (including rock-climbing and bouldering) as a form of physical activity has been explored as a potential therapeutic strategy for preventing and treating mental ill-health and improving quality of life (QoL), but attempts to collate the growing evidence have been narrow in focus (Gassner et al., 2022; Liu et al., 2022ş Zieliński et al., 2018). Therefore, the purpose of the current scoping review is to examine the existing evidence concerning the relationship between climbing and mental health and wellbeing, to identify gaps and make recommendations for future research and practice.

Specifically, it aims to:

1. Identify the types of studies exploring associations between climbing, mental health, wellbeing, stress, and/or quality of life.
2. Examine how research is conducted within this field, including types of study designs, and the content and context of the interventional studies.
3. Identify and analyse knowledge gaps and areas for future research.

3.3.1. Method

The 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses: Extension for Scoping Reviews' (PRISMA-ScR; Tricco et al., 2018) was used as a guideline along with the Joanna Briggs Institute's protocol for scoping reviews (Aromataris & Munn, 2020). A protocol was prepared in advance and published on the Open Science Framework (Hall & Ionel et al., 2021). We searched seven scientific literature databases (MEDLINE, PsychINFO,

[3] The content of this sub-chapter represents in its entirely the manuscript *submitted* in the journal Psychology of sport and exercise: **Ionel, M. S.**, Hall, L. H., Gude, A., Trasca, A., Murray, H., & Gridley, N. (*submitted*). The Associations between Climbing and Mental Health and Wellbeing: A Mixed-Methods Scoping Review (Preprint). https://doi.org/10.31234/osf.io/f735b

SCOPUS, EMBASE, Web of Science, SPORTdiscus, and CINAHL) on 25th of June 2021 with no restriction on date. We used keywords and MESH terms related to: climbing, bouldering, adventure therapy, mental health, wellbeing, quality of life, stress. All articles were quality assessed in duplicate (20% by 5 authors) using the Mixed Methods Appraisal Tool (MMAT), version 2018 (Hong et al., 2018).

3.3.2. Results and Conclusions

A total of 59 articles were eligible for inclusion (see OSF https://osf.io/udfxa/files/osfstorage). The results of this scoping review present data from studies with a wide range of aims and designs, of varying quality, showing mixed results. Our search terms and criteria were intentionally broad in an attempt to capture studies exploring climbing and mental health and wellbeing comprehensively; yet we were surprised at the amount of literature the searches returned, indicating a growing field of investigation. Overall, the trend of evidence suggests that regardless of population (climbers or non-climbers, clinical or non-clinical, adults, children) or study design, climbing in its various forms seems to have some mental health and wellbeing benefits, with evidence from the highest quality RCTs supporting this. However, it remains unclear what mechanisms or 'active ingredients' specifically contribute to these benefits, thus, more high-quality research is needed. This review demonstrates the potential benefit to wellbeing for a wider range of people – not just those with physical or mental health ailments.

These studies suggest that climbing, in various forms, may have mental health and wellbeing benefits to a wide range of people. Further high-quality research is warranted to investigate exactly how, where, when, and for who climbing can improve mental health and wellbeing, and to investigate the underlying mechanisms of action to understand why it can have beneficial effects.

3.4. Study 4: Climbing Anxiety Scale (CAS-20): Preliminary Development and Validation[4]

Anxiety received the lion's share of attention in sport psychology (Janelle et al., 2020). The overarching goal of our investigation was twofold: (1) to develop and validate a theoretically-anchored sport climbing inventory/questionnaire and (2) to provide preliminary evidence on its construct and criterion-related validity. We tackled these objectives via two phases.

3.4.1. PHASE 1: Scale development and content validity

3.4.1.1. Method and Results

Phase 1 of the study involved the participation of four female sport psychologists, one female clinical psychologist, and one male coach, all of whom were specialized in working with climbers, and were aged between 29 and 46 years old.

Climbing Anxiety Scale (CAS). The final item set included a total of 45 items.

Results

The experts provided ratings for the items using a 4-point Content Validity Index (CVI) scale (Waltz & Bausell, 1983). Items with a CVI of .75 or higher were contemplated to have adequate content validity. In total, six items had mean CVIs below .75 and were removed from the item pool.

3.4.2. PHASE 2: Scale validation

The aim of the second phase was to examine the internal structure of the scale generated in Phase 1. We tested the preliminary factor structure of the newly developed measure and refined it through an iterative process.

3.4.2.1. Method and Results

We collected data from 153 participants, regular practitioners of rock-climbing (sport climbing and/or bouldering), 95 males and 58 females (37.9%), with ages between 17 and 67 (*M* = 33.18, *SD* = 10.75). Experience in rock-climbing ranged between 2 and 42 years (*M* = 11.18, *SD* = 9.32).

[4] The content of this sub-chapter is a manuscript *under review (second round)* in the journal *Psychology of sport and exercise*. The authors are **Ionel, M. S.**, Ion, A., Iliescu, D., & Visu-Petra, L.

Measures

Depression Anxiety Stress Scales Short Form (DASS-21; Lovibond et al., 1995). DASS-21 is a brief version of DASS-30 which is a self-report measure of negative emotional states of depression, anxiety, and stress.

Sport Anxiety Scale-2 (SAS-2; Smith et al., 2006). Sport anxiety was assessed by employing the 15-item inventory that measures the competitive trait anxiety which is usually experienced by athletes before or during competitions.

Climbing Self-Efficacy Scale (CSES; Llewellyn et al., 2008). The CSES evaluates self-efficacy in relation to the various sub-skills needed for successful performance in climbing.

Climbing Anxiety Scale (CAS-39). Climbing anxiety was assessed by using the 39-item scale developed in Phase 1.

Sport Climbing Performance. The reported grades have been converted according to the recommendations outlined in IRCRA's position statement (IRCRA; Draper, 2015).

Results

Step 1. Response distribution. We removed 33 items that had a range of less than 4 steps.

Step 2. Internal reliability analysis. Internal consistency reliability was computed (Cronbach's alpha = .87). We removed ten items with item-total correlations less than .30. The omega coefficient for the overall CAS measure (ω = .94), suggest a good reliability (McDonald, 1999).

Step 3. Exploratory Factor Analysis (EFA). We examined three different forms of validity, and proceeded as follows:

(a) Factor Structure and Factorial validity. After analysing the pattern of item loadings, we eliminated eight items having a low communality (< .20) and/or a pattern of cross-loadings amongst the three different factors (Child, 2006). A second exploratory analysis was performed on the remaining 20-item data set (accounting for 48% of variance). Next, we conducted CFA based on a maximum likelihood estimation. The three-factor solution (Factor 1 – Cognitive

Anxiety, Factor 2 – Somatic Anxiety, and Factor 3 – Self-confidence) provided a good fit for the data, *CFI* = .92, *RMSEA* = .06, 90% C.I. [.05 - .08], and *SRMR* = .06.

(b) Convergent and discriminant validity was examined by analysing the scale's associations with latent factors for anxiety levels, depression and stress, sport anxiety, and climbing self-efficacy. For the overall measure, the Average Variance Extracted (AVE) was .51.

(c) Criterion-related validity. We employed hierarchic regression for *Sport Climbing Performance.* The dimensions that significantly predicted overall sport climbing performance (latent) were climbing self-efficacy ($\beta = .21$, $p < .01$), sport anxiety ($\beta = .20$, $p < .05$), and climbing anxiety ($\beta = -.07$, $p < .05$), accounting for a mere 4% of the overall variance in sport climbing performance over age, gender, experience, climbing self-efficacy, and sport anxiety ($\Delta R^2 = .040$, $p < .01$).

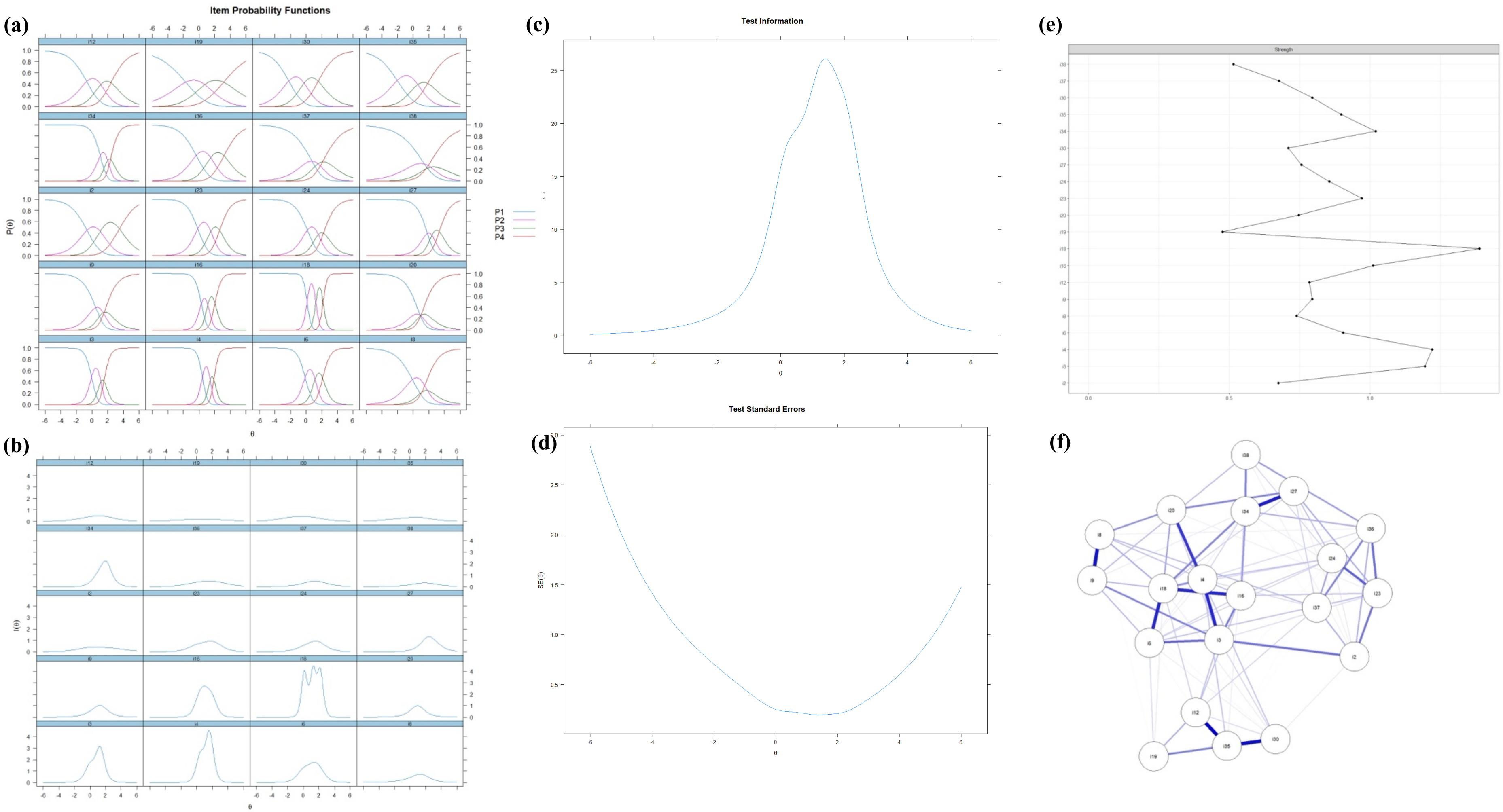
Item Response Theory (IRT) analysis yielded good fit indices for a unidimensional model: *RMSEA* = .075; *TLI* = .938, *CFI* = .946. Figures 3.4.1a and 3.4.1b visualize the item traces and item information, showing both differences in discrimination between the various items, and the fact that most items cover the average and medium-to-high areas with more information (roughly the area between $\theta = [0.00, 2.00]$). Figure 3.4.1c presents the Test Information Function for the entire test, while Figure 3.4.1d visualizes the standard error of measurement for the test score. These figures show that the test discriminates very well at "ability levels" (i.e., symptom levels) of $\theta = [-0.50, 3.00]$, with the lowest possible measurement errors at symptom levels of $\theta = [0.00, 2.00]$.

For network analysis, Figure 3.4.1e visualizes the centrality chart for the nodes (items), and Figure 3.4.1f visualizes the network plot showing the various relationships (in form of proximity of nodes) and strengths of relationships (i.e., the line width of lines spanning the nodes). These results confirm in principle the structure of the test in 3 separate, but closely connected clusters of items.

3.4.3. Conclusions

Our investigation contributes to the general literature on anxiety in sports extending the cognitive-affective model of anxiety to high-risk sports like rock-climbing (e.g., Martens et al., 1990).

Figure 3.4.1 *(a) Item traces for the test's items. (b) Item information function for the test's items. (c) Test Information Function. (d) Standard error of measurement for the test score, conditional on ability level. (e) Centrality chart for the nodes (items). (f) Network plot showing relationships (proximity of nodes) and strengths of relationships (line width between nodes)*



3.5. Study 5: Simulating Nature? The Impact of Indoor Exercising on Cognitive and Affective Functioning: A Randomized Crossover Trial[5]

Extant research suggests that both exposures to nature and to simulations of nature result in significant beneficial cognitive and emotional effects (Bowler et al., 2010). In echoing the call for additional research in the green exercise domain, particularly regarding simulations of nature (Lahart et al., 2019), our main objective was to identify psychological benefits of exercising indoor at submaximal levels in two different conditions: indoor exercising with simulation of nature (*simulated nature condition*) and indoor exercising without simulated nature (*control condition*).

Therefore, we tested two main hypotheses:

H1: Indoor exercising with a video simulation of nature (*simulated nature*) will increase performance in core executive functions (executive attention, working memory, vigilance and sustained attention) compared to the *control condition* (indoor exercising without simulated nature), while controlling for exercise intensity.

H2: Indoor exercising with a video simulation of nature (*simulated nature*) will (a) reduce negative affect (negative affect, anxiety, and depression symptoms) and (b) increase positive affect compared to the *control condition* (indoor exercising without simulated nature), while controlling for exercise intensity.

3.5.1. Method

We collected data from 21 physically active Spanish amateur cyclists (2 females, M_{age} = 27.05, SD = 5.71), via opportunity sampling. To control for individual differences in their performance, participants had to be physically capable of cycling for 55 minutes at 75% of their aerobic power. Participants were tested during three sessions, as follows. During Session

[5] The content of this sub-chapter represents in its entirety the manuscript published in the Advances in the Cognitive Psychology Journal: **Ionel, M. S.**, Rueda, M. R., & Visu-Petra, L. (2024). Simulating Nature?! The Impact of Indoor Exercising on Cognitive and Affective Functioning: A Randomized Crossover Trial. *Advances in Cognitive Psychology, 20*(1), 64-79. DOI: 10.5709/acp-0416-3. https://www.ac-psych.org/en/current#art423

1, participants completed an incremental effort to determine their *submaximal aerobic power* (VO_2 Submax; Sartor et al., 2013). During the next two sessions, the participants were instructed to bring their personal bikes.

Cognitive Measures

Arrows and Words task (AW, Aarts et al., 2010) is designed to measure executive attention by assessing task-switching behavior using incongruent arrow-word combinations as targets. The entire task lasted approximately 15 minutes, starting with a familiarization trial.

Psychomotor Vigilance Test (PVT, Basner & Dinges, 2011). Vigilance and sustained attention were measured using a precise computer-based version lasting 9 minutes, following a familiarization session.

Operation Span Working Memory Task (OSpan, Tokowicz et al., 2004) measured individual differences in working memory capacity. It involved solving mathematical expressions while maintaining sets of words in memory and lasted approximately 10 minutes, including a familiarization trial in the beginning.

Affective Measures

Positive and Negative Affect Scale (PANAS, Watson et al., 1988). A Spanish version of PANAS was used to measure affective state (Sandín et al., 1999), with a 20-item self-report survey that is composed by positive and a negative scales.

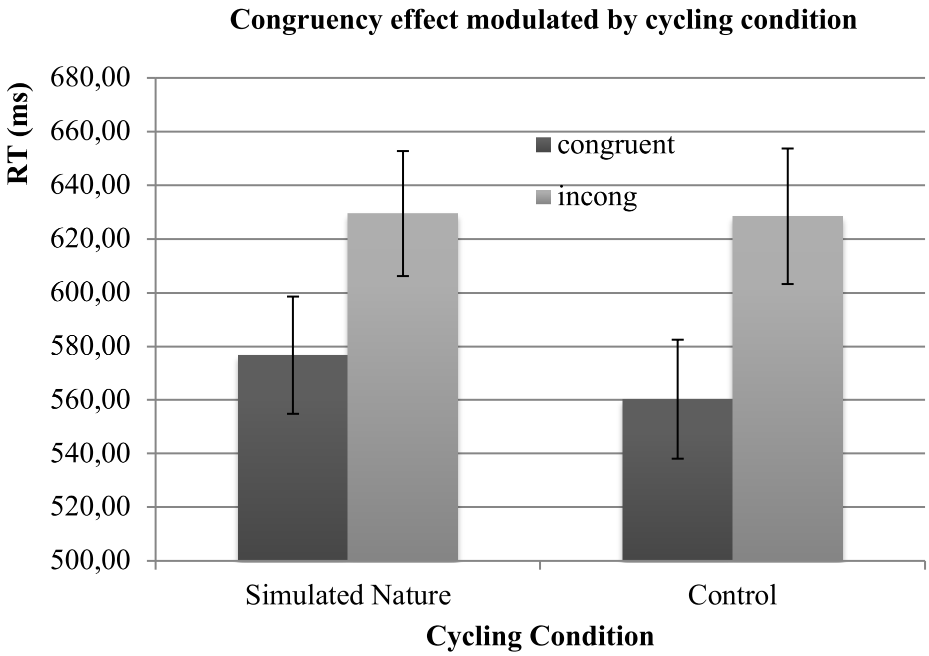
Beck Anxiety Inventory (BAI, Beck et al., 1988). Recent anxiety symptoms were assessed using the Spanish version of the BAI (Magán et al., 2008), a 21-item multiple-choice self-report inventory that measures the severity of anxiety in adults.

Beck Depression Inventory II (BDI-II; Beck et al., 1996). Depression symptoms were assessed using the Spanish version of BDI-II (Sanz et al., 2003), a 21-item of self-evaluative statements that measure the severity of depression in adults.

3.5.2. Results and Conclusions

We performed analyses of variance (ANOVAs) to test the core hypotheses. For *executive attention* a four-way repeated measures ANOVA was conducted, with exercising condition (simulated nature vs. control) x switching (switch vs. no switch) x task (word vs. arrow) x task congruency (congruent vs. incongruent). The results revealed a statistically significant interaction between exercising condition x task congruency, $F(1, 19) = 4.36$; $p < .05$; $\eta^2 = 0.19$, as well as between task x task congruency, $F(1, 19) = 6.90$; $p < .05$; $\eta^2 = 0.27$, indicating a larger conflict effect for the word task in the simulated nature condition (see Figures 3.5.1 and 3.5.2).

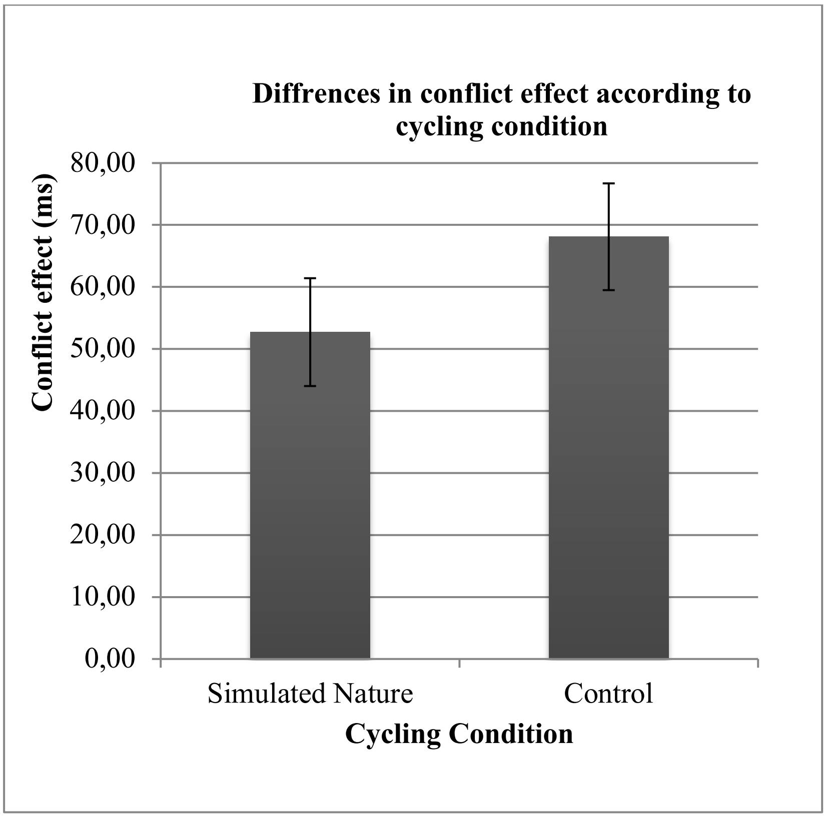
Figure 3.5.1 *Arrow-Word Switching Task results according to congruency in Simulated Nature and Control conditions.*



For *vigilance and sustained attention,* a one-way repeated measures ANOVA showed no statistically significant effects. Similarly, the performance on the *working memory* task showed no statistically significant changes across the conditions.

As for differences in *affective* measures within-group one-way repeated measures ANOVA showed no statistically significant differences between the two conditions.

Figure 3.5.2 *Arrow-Word Switching Task results for conflict effect in Simulated Nature and Control conditions.*



Taken together, our study expands the current scientific understanding regarding the potential cognitive and affective benefits stemming from exposure to simulations of natural environments in several ways. First, we found little evidence that exposure to soundscape videos of natural environment triggers cognitive and affective benefits. Second, by instructing the participants to exert submaximal physical effort, we controlled for potential confounded effects of exposure to simulations of natural environments and physical activities performed under such conditions.

Our findings suggest that soundscape videos of natural environments do not trigger immediate positive cognitive and emotional effects, while controlling for submaximal physical effort levels. Future research should investigate the minimal degrees of immersion that trigger the positive mental and emotional benefits in both regularly active individuals and in the general population.

IV. GENERAL DISCUSSION AND CONCLUSIONS

The overarching aim of the current thesis was to investigate both psychological antecedents involved in rock-climbing performance, including personality traits and anxiety, and consequences of participating in such sports, such as improvements in mental health, quality of life, and gains in affective and cognitive functions following exposure to rock-climbing or outdoor sports. Based on these findings and on the previously outlined theoretical frameworks, we proposed *a* ***new integrative model of 'Rock-Climbing Performance and Mental Health (RCPMH)'*** bridging the antecedents predicting climbing performance and consequences following exposure to rock-climbing or outdoor sports.

To achieve the underlying theoretical goal of the current thesis, we introduced new predictors, such as grit and climbing anxiety, and explore their relationship with climbing performance. Additionally, we reviewed mixed-methods studies investigating the effects of therapeutic climbing. We also developed a new experimental testing paradigm to test the psychological effects of simulated nature on a different outdoor sport, cycling. Lastly, from a practical standpoint, this thesis aimed to advance the understanding of climbing performance and the mental health benefits of outdoor sports, introducing key tools and findings on personality traits, therapeutic climbing, and the impact of exposure to nature.

4. Overview of the studies

The present work has been prepared as self-contained work and is based on five manuscripts that have either already been published, *submitted* or are *under review* for publication.

Study 1

Ionel, M. S., Ion, A., & Visu-Petra, L. (2023). Personality, grit, and performance in rock-climbing: down to the nitty-gritty. *International Journal of Sport and Exercise Psychology, 21*(2), 306-328. https://doi.org/10.1080/1612197X.2022.2044368. **(IF: 4.048, Q2 Psychology, Applied**)

Study 2

Ionel, M. S., Ion, A., & Visu-Petra, L. (2023). Personality and rock-climbing performance progression: a 12-months follow-up. *International Journal of Sport and Exercise Psychology*, 1-24. https://doi.org/10.1080/1612197X.2023.2293935. (**IF: 3.300, Q2 Psychology, Applied**)

Study 3

Ionel, M. S., Hall, L. H., Gude, A., Trașcă, A. G., Murray, H., & Gridley. N. (*submitted*). The Associations between Climbing and Mental Health and Wellbeing: A Mixed-Methods Scoping Review (Preprint). https://doi.org/10.31234/osf.io/f735b.

Study 4

Ionel, M. S., Ion, A., Iliescu, D., & Visu-Petra, L. (*under review, second round*). Climbing Anxiety Scale (CAS-20): Preliminary Development and Validation. *Psychology of sport and exercise*. https://www.sciencedirect.com/journal/psychology-of-sport-and-exercise. (**IF: 3.400, Q1 Sport Sciences; Q2 Psychology, Applied**)

Study 5

Ionel, M. S., Rueda, M. R., & Visu-Petra, L. (2024). Simulating Nature?! The Impact of Indoor Exercising on Cognitive and Affective Functioning: A Randomized Crossover Trial. *Advances in Cognitive Psychology, 20*(1), 64-79. DOI: 10.5709/acp-0416-3. https://www.ac-psych.org/en/current#art423. (**IF: 1.200, Q4 Psychology, Experimental**)

4.1. Theoretical Contributions

The evidence provided by our studies set the stage for *a* ***new integrative model of 'Rock-Climbing Performance and Mental Health (RCPMH)'***. This represents one of the fewest attempts to integrate both the antecedents of climbing performance and the mental health consequences of participating in rock-climbing. Table 4.1.1. summarises the theoretical contributions of the current thesis.

Table 4.1.1. *The Main Theoretical Contributions of the Current Thesis*

Study	Aim	Main theoretical contributions
Study 1	Test if FFM personality traits and grit predict rock-climbing performance.	- Advanced the understanding of *FFM personality traits* as predictors of rock-climbing performance, distinct to mere participation. - Advanced the understanding of *Grit Theory* as predictor of rock-climbing performance.
Study 2	Test if FFM personality traits and grit predict rock-climbing performance after 12-months follow-up.	- Nuanced perspective on *FFM personality traits as longitudinal* predictors of rock-climbing performance. - Advanced the understanding of *Grit Theory as longitudinal* predictor of rock-climbing performance. - Provide support for our *new integrative model* concerning personality predictors of rock-climbing performance (overall theoretical contribution of the current thesis).
Study 3	Review various study designs addressing the connection between (therapeutic) climbing and Mental Health.	- Contribute to the *Mental Health Model*, *Attention Restoration Theory* and *Stress Redaction Theory* by reviewing various study designs assessing the mental health benefits of participating in (therapeutic) climbing.
Study 4	Examine the relationship between anxiety symptoms, climbing self-efficacy, and rock-climbing performance.	- Contribute to the *theoretical underpinnings of cognitive-affective model of anxiety in sport* by demonstrating how a specific-sport anxiety scale can better identify anxiety symptoms and predict rock-climbing performance. - Provided *preliminary evidence for the development and validation* of a theoretically anchored climbing anxiety scale.
Study 5	Test the impact of simulated nature in indoor exercising (cycling) on cognitive and affective functioning.	- Nuanced perspective on the *Attention Restoration Theory* and *Stress Redaction Theory* by providing evidence for the psychological effects of simulated nature when controlling for physical exertion.

Note: FFM = Five Factor Model.

4.2. Empirical Contributions

Table 4.2.1. summarises the empirical contributions of the current thesis.

Table 4.2.1. *The Main Empirical Contributions of the Current Thesis*

Study	Variable	Antecedent/ Consequence	Study Design	Participants	Main conclusions
Study 1	FFM personality, grit, climbing performance	Antecedent	Cross-sectional	*N* = 272 sport climbers, 155 boulderers (114 F, 158 M)	- Openness negatively predicts climbing performance. - Grit predicts climbing performance over and beyond FFM personality traits.
Study 2	FFM personality, grit, climbing performance	Antecedent	Longitudinal	*N* = 113 sport climbers (43 F, 70 M)	- Grit predicts climbing performance over and beyond FFM personality traits performance after a 12-month follow-up. - Grit does not predict progression in rock-climbing over a 12-month timeframe.
Study 3	MH symptoms, wellbeing, QoL, climbing	Consequence	Scoping review	59 studies	- Therapeutic Climbing has benefits for MH and wellbeing across a diverse range of individuals.
Study 4	Sport anxiety, climbing anxiety, climbing performance	Antecedent	Measure validation	*n* = 6 clinical/sport psychology experts; *N* = 153 sport climbers (43 F, 70 M)	- Climbing Anxiety Scale (CAS-20) is more effective at identifying climbing-related anxiety symptoms compared to other sport or general anxiety measures.
Study 5	Anxiety, depression, PANA	Consequence	Experimental	*N* = 21 road cyclists (2 F, 19 M)	- Exercising in simulated natural environment conditions has little significant cognitive and affective benefits after controlling for physical effort.

Note: FFM = Five Factor Model; F = Females; M = Males; MH = Mental Health; QoL = Quality of Life; PANA = Positive and Negative Affect.

4.3. Practical Implications

The current thesis has important practical implications for outdoor sports, particularly rock-climbing.

Our *first practical implication* suggests that openness and grit are important personality characteristics for climbing performance, indicating that climbers and professionals should focus on developing these traits in training (***Study 1*** and ***Study 2***). These insights might generalise in other domains of human performance characterised by similar levels of risk.

Our *second practical implication formulates recommendations regarding the use of climbing therapy*, particularly weekly indoor bouldering combined with psychotherapy elements have shown *improvement in mental health, e.g., reduction of depressive symptoms and stress, as well as an increase in wellbeing and quality of life* (***Study 3***), in the most rigorous studies, such as RCTs.

Our *third practical implication* is the creation and validation of the *novel Climbing Anxiety Scale (CAS-20)*, which can be efficiently used by specialists in the field of climbing psychology (***Study 4***).

Our *final practical implication recommends incorporating exposure to real nature over indoor exercising alongside video simulation of nature to see cognitive or affective benefits* (***Study 5***). When simulation is employed, practitioners need to *ensure high immersion and to control for physical exertion*.

4.4. Limitations and Conclusions

The current thesis presents several limitations that need to be acknowledged. The cross-sectional design (***Study 1***) limits our ability to infer potentially causal relationship, highlighting the need for more robust longitudinal and/or experimental research to explore the relationship between personality traits like openness and grit with climbing performance. We addressed this limitation in ***Study 2***, however, common method bias and the exclusion of certain personality dimensions, such as impulsivity or sensation-seeking, could further nuance our understanding of performance in rock-climbing. The generalisability of our findings is constrained by the reliance on self-reported performance metrics, retrospective data collection, and a sample that might not fully represent the diversity of climbing practitioners or account for socio-economic and cultural differences (***Study 2***). Additionally, a limitation in ***Study 3*** could have been the exclusion of non-English language articles, and we may have omitted valuable insights, despite focusing on scientifically sound studies. Our review potentially missed to include recent studies, though efforts were made to identify ongoing and recently published work. Also, the studies included in the review had small sample sizes and poor study quality, especially for secondary mental health outcomes. In respect with ***Study 4***, future studies should consider employing objective performance assessments, larger and more diverse samples, and longitudinal designs to validate the Climbing Anxiety Scale (CAS-20) across different climbing disciplines and cultures. Additionally, our investigation into the effects of simulated nature on psychological functioning (***Study 5***) faced limitations such as potential distractions in the simulation condition and an under-representation of females in the sample. Future research should aim for a more balanced gender representation and explore the impact of various indoor and outdoor environments on attention and affective states during physical exercise.

Future studies. Future research should further differentiate between amateur and professional climbers, taking into account cross-cultural differences to enhance the representativeness and relevance of findings (***Study 1***, ***Study 2***, ***Study 4***). In light of ***Study 3***, the unique benefits of climbing compared to other physical activities, including the interaction of bio-psycho-social factors, warrant further exploration. Additionally, the effects of indoor versus outdoor climbing on mental health, the potential negative impacts of elite competition, and the risks of eating disorders in climbing need examination. Future studies should detail their interventions for replication and broader application, considering socio-demographic factors to enhance generalisability and address accessibility. Building on ***Study 4***, there is the need for development and validation of sport-specific measures like the CAS-20 for broader application in elite sports, and to investigate whether sport-specific items enhance the precision and relevance of psychological assessments in sports across diverse samples. Following ***Study 5***, it is essential to explore various simulations, including Virtual Reality (VR), to assess their efficacy in mimicking natural environments, which are key areas for future investigation.

In conclusion, the current thesis complements and extends the existing literature by addressing the significance of personality traits, such as openness to experience and grit, in predicting performance in rock-climbing, a high-risk sport, as well as advocating for the inclusion of these traits in future performance-enhancing interventions. The findings also shed light on the potential mental health and wellbeing benefits of climbing, urging further detailed investigations into its therapeutic effects and the mechanisms behind them. By developing the Climbing Anxiety Scale (CAS-20), this thesis contributes to a deeper understanding of anxiety's role in rock-climbing and potentially other high-risk sports, providing a tool for more nuanced assessments and interventions. Additionally, our exploration into the effects of simulated nature environments during indoor exercising suggests that such simulations do not replicate the cognitive and affective benefits of direct nature exposure, when controlled for physical exertion, highlighting the need for future research to identify the essential elements of immersion necessary to achieve these benefits.

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