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## „Effect of climbing on everyday stress management in young men“


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# Abstract

In an evolutionary context, physiological and psychological stress reactions increase chances of survival. In modern society however, chronic stress has become a normality and has been accepted as an aggravating factor for many illnesses. Protective factors such as physical activity and exposure to mild stress can help reduce its negative impact. In this study, the levels of perceived chronic stress have been assessed for three groups of young men using the Trier Inventory for the Assessment of Chronic Stress (Schulz, Schlotz, & Becker, 2004). Individuals who took part in climbing (n= 31), were expected to present lower chronic stress levels than individuals engaging in a similar activity, bouldering, without stress-associated climbing (n= 52). Both groups were compared with physically inactive individuals (n= 31), who were expected to show higher levels of stress.

Physically inactive individuals seemed to experience more stress due to diminished social contact than either climbers or boulderers ($p<0.05$). There were no other significant differences, but median values of the *Screening Scale of Chronic Stress* suggest a trend in line with the hypothesis. Generally, stress scores were above the average population, suggesting medium to high chronic stress levels amongst most participants.

Changes in climbing motivations could partly explain discrepancies between present results and literature. Stress responses are highly individual: administrating the TICS with an objective sampling method should provide clearer results. As the first study investigating the effect of high-risk activity

on chronic stress levels, results nonetheless behold potential for implementation in therapies against stress-associated diseases such as depression.

# Zusammenfassung

Im evolutionären Kontext erhöhen physiologische und psychologische Stressreaktionen die Überlebenschancen. In der heutigen Gesellschaft stellt chronischer Stress jedoch häufig die neue Norm dar und ist nachweislich ein beträchtlicher Risikofaktor für viele Krankheiten. Schützende Faktoren wie körperliche Aktivität und milder Kontakt mit Stress können dazu beitragen, die negativen Auswirkungen von Stress zu verringern. In dieser Studie wurde das Niveau des wahrgenommenen chronischen Stresses von drei Gruppen junger Männer mit Hilfe des Trier Inventory for the Assessment of Chronic Stress bewertet (Schulz et al., 2004). Es wurde untersucht, ob kletternde Personen (n= 31) einen geringeren chronischen Stress aufweisen als Personen, welche bouldern (n= 52). Klettern ist eine eher risikoreiche Aktivität, wohingegen Bouldern keine stressverursachende Klettertouren aufweist. Beide Gruppen wurden mit körperlich inaktiven Personen verglichen (n= 31). Dabei wurde erwartet, dass die Kontrollgruppe einen höheren Grad an chronischem Stress aufzeigt. Körperlich inaktive Personen scheinen aufgrund mangelnder sozialer Kontakte gestresster zu sein als sowohl Kletterer und Boulderer ($p<0.05$). Es gab keine weitere signifikanten Gruppenunterschiede. Die Medianwerte der *Screening-Skala für chronischen Stress* lassen jedoch einen Trend vermuten, welcher mit der Hypothese der vorliegenden Studie übereinstimmt. Insgesamt liegen die Stresswerte über denen der Normpopulation, was auf mittlere bis hohe Stressniveaus bei den meisten Teilnehmern hindeutet. Entwicklungen in den Beziehungen zum Kletter-

risiko könnten die Diskrepanz zwischen den Ergebnissen und früheren Befunden teilweise erklären. Stressreaktionen sind zudem stark individuell: die Verbindung des TICS mit einer objektiven Messmethode sollte klarere Ergebnisse liefern. Die Ergebnisse dieser Studie sind dennoch ermutigend und könnten in Therapien gegen mit Stress-assoziierten Krankheiten wie Depression eingesetzt werden.

# Chapter 1

# Introduction

In 1939, Cannon defined how all living organisms seek an "ideal state", i.e. a state in which all physiological variables in the body such as temperature, blood pressure or water levels, are in an optimal range (Cannon, 1939). This concept called homeostasis has then been updated in consideration of normal periodical (e.g. circadian) changes and termed allostasis, meaning "constancy through change" (McEwen & Wingfield, 2003). Anything disrupting the allostatic balance is defined as a stressor. The psycho-biological stress response is the reaction of body and mind to this challenge, and the effort made to re-establish allostasis (Selye, 1956). The interest in stress research and ways of coping has been growing in the last decades. A period-specific search on the internet platform GoogleScholar shows the number of studies related to the keywords "stress human coping" has been multiplied by 6 every 20 years (18.06.2020). Despite the surge of studies in the last few decades, stress is not a recent concept that appeared suddenly in our modern society. It is rather a defence mechanism on which survival of all living organisms rely (Sapolsky, 2017). Stressors are versatile and range from sudden temperature drop to attacks by a predator by way of sexual tension (Sapolsky, 2017). It is therefore not surprising that stressors and reactions to stress have been studied across species, as has been reviewed

by Koolhaas and colleagues (1999). For humans, however, stress has shifted from being a survival mechanism to a major social and health issue.

In this study, the relationship between chronic stress and high-risk physical activity will be put under scrutiny. The introduction will first review the physiological mechanisms necessary for a functional stress response and the risks associated with repeated stress. Then, physical activtiy as a coping mechanism will be further assessed. Finally, components making climbing a high-risk physical activity will be examined.

## 1.1 Physiology of stress

Stress responses (see Figure 1.1) constitute an effective defence mechanism and help to survive by maintaining a dynamic equilibrium of all parameters of the body. Their physiological background relies on communication between the different systems, i.e. cardiovascular, immune or digestive system, and the brain with its sensory system (McEwen, 2007). Sensory cues such as taste, sound, smell or images are picked up by the sensory system and analysed in the amygdala. This structure is part of the limbic system and linked to feelings of anxiety, fear, pain and aggression (Carlson, Greenberg, & Mujica-Parodi, 2010; LeDoux, Iwata, Cicchetti, & Reis, 1988). If the situation is indeed deemed stressful and dangerous by the amygdala, two main response-axes are activated. First, the hypothalamus inhibits the parasympathicus nervous system (PNS, “rest and digest”) and mobilises the sympathicus nervous system (SNS, “fight or flight”). Both are antagonistic parts of the autonomic nervous system (ANS), which unconscioulsy regulates bodily functions such as digestion, cardiovascular functions, miction or sexual arousal (Jänig, 1985). Mobilisation of the SNS constitutes the first step in the fast stress reaction, and leads to the secretion of the

response hormones adrenaline and noradrenaline by the medulla of the adrenal gland (sympathetic-adrenal-medullary axis, or SAM axis) (Horn, 2012). Adrenaline has been the centre of attention of many studies involving hormonal reaction to stress (e.g. Berger, Werdermann, Bornstein, & Steenblock, 2019; Ganong & Forsham, 1959; Jung et al., 2019; Phillips, 2011; Schneiderman, Ironson, & Siegel, 2008; A. K. Walker et al., 2019). The SNS response also increases pulse rate and blood flow to the muscles and organs, and decreases the blood flow in peripheral areas to avoid heavy bleeding in case of injury (Cannon, 1916). In the lungs, bronchioles dilate to increase $O_2$-levels. Beta-endorphin, a natural painkiller, is released. In parallel, the slower responding hypothalamus-pituitary-adrenal axis (HPA axis) is activated by the binding of noradrenalin, serotonin and acetylcholin to receptors in the hypothalamus. The paraventricular nucleus in the hypothalamus secretes the corticotropin-releasing hormone (CRH), which stimulates the secretion of adrenocorticotropic hormone (ACTH) in the pituitary glands. ACTH is transported through blood vessels to the cortex of the adrenal glands and leads to the production of cortisol (Squire et al., 2012). This hormone mobilises energy by increasing sugar secretion, increases the heart rate and blood pressure, shuts down digestion, and promotes the immune system (Horn, 2012). Its release is an unspecific stress reaction occurring as much against physiological stressors as against psychological ones. Hence, it is one of the best known stress hormones and is often used in stress research as an effective biomarker (Hellhammer, Wüst, & Kudielka, 2009). Finally, cognitive and sensory skills are affected: when confronted to acute stressful situations, subjects showed e.g. better hearing (Sapolsky, 2004), a better working-memory (McEwen, 2007; Roozendaal, McEwen, & Chattarji, 2009), and stress-induced analgesia (Geva, Pruessner, & Defrin, 2014).

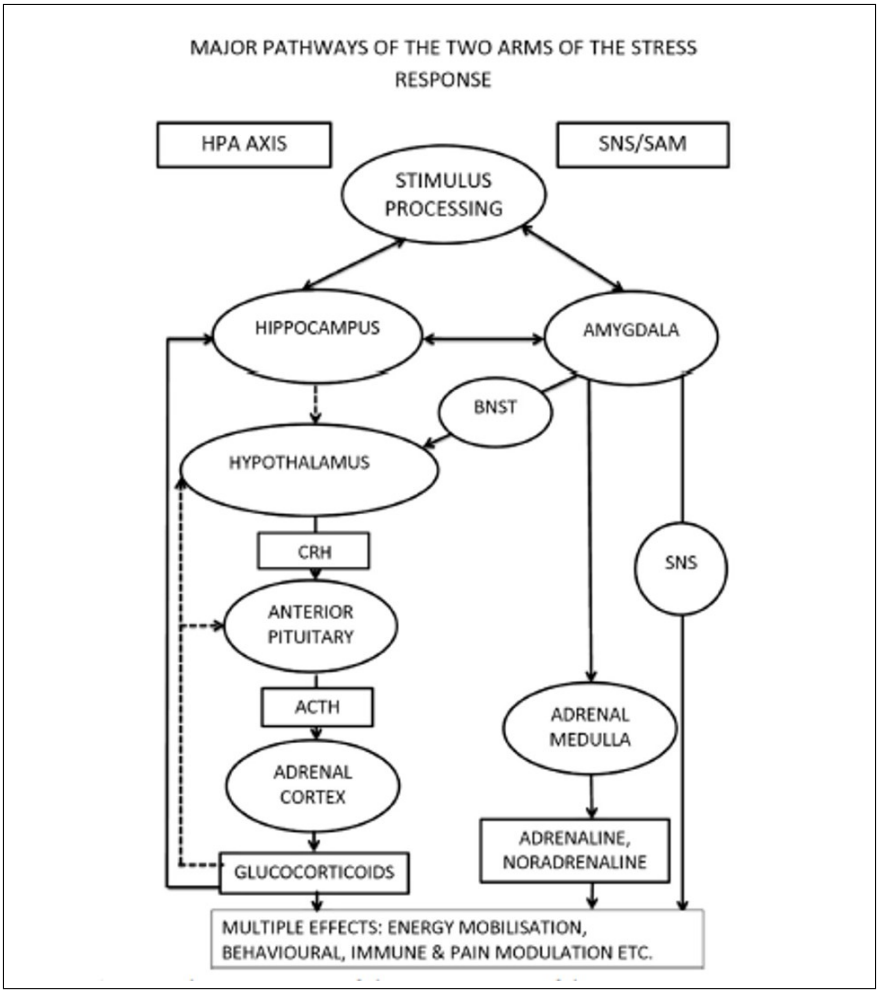


Figure 1.1: Illustration of the stress response system, from Murison, 2016. **HPA-Axis**: *Hypothalamo-pituitary-adrenal axis.* **SAM-Axis**: *Sympathetic-adrenal-medullary axis.* **ACTH**: *adrenocorticotropic hormone.* **CRH**: *corticotropin-realeasing hormone.* **SNS**: *sympathetic nervous system.* Dotted lines represent inhibitory pathways.

The potentially detrimental aspects of repeated stress seem intuitive, and they are the subject of many studies (see section 1.2). However, pioneer Selye already differentiated between positive stress (eustress) and negative stress (distress, or simply stress if not mentioned otherwise) (1956). Both involve physiological stress responses, but in more benevolent settings, such as in sport competitions, roller-coasters or gambling, the lack of predictability

and control, which are key aspects of effective stressors, trigger only a mild secretion of glucocorticoids (Oitzl, Champagne, van der Veen, & de Kloet, 2010; Sapolsky, 2000). The physiological duality of stress can be explained by the presence of two classes of receptors in the hippocampus. Cortisol is a steroid hormone able to bind to the glucocorticoid receptors and to the mineralocorticoid receptors. Glucocorticoid receptors are widely found in the brain but have a lower binding affinity to cortisol than mineralocorticoid receptors (Squire et al., 2012). In major stress situations, cortisol binds mostly to glucocorticoid receptors (Sapolsky, 2000). When stress elicits only a mild or moderate cortisol secretion, the hormone binds to mineralocorticoid receptors, due to the higher binding affinity, and triggers the pleasure pathways, leading to dopamine secretion and positive emotions (Sapolsky, 2004). Of course, inter-individual variability in the levels needed to elicit major stress reactions is high and depends mostly on context and experience (Sapolsky, 2017). For Le Fevre and colleagues (2003), individual perception and interpretation of the context are the main factors to distinguish eustress from distress.

## 1.2 Stress in everyday-life

Acute stress reactions allow an individual to react fast to any danger threatening their life. But in modern, industrialised societies, *Homo sapiens* rarely encounter such situations. Exceptions might be found in action-filled jobs such as firefighters, the military, or the police. Nevertheless, according to surveys conducted every year in the USA by the American Psychological Association, stress is an important part of daily life. According to the Stress in America report for the year 2017 (American Psychological Association, 2017), 75% of 3440 adults experience at least one symptom related to stress per month. These symptoms include feelings of anxiety (36%), irritability

(35%) or sleeplessness (45%). When considering the Gen Z population, i.e. individuals aged 15-21, they are less likely to report good mental health than older generations (Gen Z: 45%, Millenials: 56% and Boomers: 71%) (American Psychological Association, 2018). As a result, 60% of all adults taking the survey in 2012 tried to reduce their stress levels since 2007, by way of different coping methods (American Psychological Association, 2012). Of course, except in some specific situations such as the aformentioned job positions, or in situations of war or homelessness, in which danger is real, this stress feeling is not linked to physical stressors, but is a reaction to frequent psychological stress, i.e. the anticipation of a potential disturbance of allostasis (Sapolsky, 2004). Common stressors include work-related stress and financial concerns (both 64% of American adults), health-related issues (63% of all American adults) and the economy (48% of the interviewees) (American Psychological Association, 2018). Younger individuals also mention bullying, personal debt, housing instability and whether they can get enough to eat as an important source of stress (Horowitz & Graf, 2019; American Psychological Association, 2018). Adding to the daily-life stressors, punctual stress factors concerning political or worlwide health issues also play a role (American Psychological Association, 2012, 2017, 2018). In 2020 alone, several billions of individuals have had to face several political crises, following e.g. tensions between the USA and Iran in February 2020 followed by the political crisis in Malaysia the same month, and massive protests against police brutality in France and the USA in June 2020. Global crises indirectly affect many more people, e.g. through media, adding to stress levels (American Psychological Association, 2019). Naturally, the outbreak of the Covid-19 sanitary crisis has also taken its toll, with Americans reporting higher stress levels during the pandemic (American Psychological Institution, 2020). In general, psychologic stress is related to threats to one's social status, such as shame, exclusion from a group, or difficul-

ties to find a partner. Psychological stressors are characterised by a lack of predictability and a lack of control (Sapolsky, 2017). However, the reaction to a stressor, psychological or otherwise, and its consequences are highly individual. Therefore, precise characteristics of an effective stressor vary, .i.e. they are individual- and context-dependent, and they depend on individual risk factors and on the capacity of the individual to muster coping ressources. Both depend on genetics, life history factors, and social life (Heinrichs, Stächele, & Domes, 2015; Klaperski, 2018).

Repeated chronically, distress can have lasting effects on key aspects of one's life. Individuals exposed to chronic stress can experience lasting behavioural changes, such as feelings of anxiety or aggression (McEwen, 2009). Effective against acute stress, certain reactions can become maladaptive and lead to allostatic overload (McEwen, 1998). Chronic stress affects concentration and memory (Roozendaal et al., 2009), the immune system becomes less effective, with e.g. development of ulcers and autoimmune diseases such as diabetes mellitus, Cushing's disease, and proliferation of AIDS (McEwen, 1998). It can lead to central fat deposition and obesity as well as cardiovascular diseases, e.g. chronic hypertension (Dallman et al., 2003). In some extreme cases of psychosocial stress in children, growth can be retarded and lead to psychosocial dwarfism (Hopwood & Becker, 1979). Chronic stress can also affect male and female fertility (Durairajanayagam, 2018; Nargund, 2015; Whirledge & Cidlowski, 2010). Psychosocial factors such as low social support and financial concerns have also been linked to parental burnout (Lindström, Åman, & Norberg, 2011). Finally, allostatic overload is associated with increased susceptibility to post-traumatic stress disorders (PTSD) and major depression disorders (MDD) (Gross & Hen, 2004; Lupien, McEwen, Gunnar, & Heim, 2009). Because of these morbid consequences, stress is viewed as a major health issue. Some research, however, seem to indicate that not all stress is bad for you (Sapolsky, 2017). Unlike distress, few

research has been conducted on eustress. According to the Yerkes-Dodson Law of 1908 (Teigen, 1994), performance and motivation can benefit from stress until an optimum is reached. Eustress, hope, and self-efficacy are positively correlated and can effectively predict life satisfaction (O'Sullivan, 2011; Betoret, 2006; Dwyer & Cummings, 2001). Self-efficacy refers to "an individual's belief in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1994). Individuals with higher self-efficacy usually have higher self-esteem and prosociality (Caprara, Alessandri, & Eisenberg, 2012), low neuroticism, and are known to engage in high-risk activities, such as BASE jumping, kayaking or rock-climbing (Llewellyn, Sanchez, Asghar, & Jones, 2008; Slanger & Rudestam, 1997). Neuroticism is one of the "Big Five" traits of personality, and indicates a proneness to irrational ideas, fear, guilt, or embarrassment. Neurotic people are at higher risks of developing mental disorders or of suffering from stress-related illnesses (Rothmann & Coetzer, 2003).

## 1.3 Physical activity as a coping strategy

The negative consequences of stress on health have led to a new area of research on coping strategies. Historically, Lazarus and colleagues ((1966; 1984)) defined coping as the efforts, both cognitive and behavioural, which allow an individual to endure or avoid the effects of stress. Consensually, two separate kinds of coping strategies have been described (Dumont & Provost, 1999). Both are linked to an individual's approach to the situation and are connected to their personality. The first strategy is active and focuses on problem-solving. The stressed individual tries to analyse the source of stress and to change the situation by seeking advice, comfort, social support, and by taking action. If the individual prefers to avoid the situation, withdraws themself and shows fatalistic attitude, their coping strategy is defined as

emotion-centred (Dumont & Provost, 1999). Both coping strategies are well-researched in adolescents, who are exposed to great stress due partly to daily hassles and partly to biological changes. Seiffge-Krenke (1995) reports problem-solving strategies as functional, and emotion-centred strategies as dysfunctional. Furthermore, Dumont & Provost (1999) mentioned that a high self-esteem in adolescents correlated positively with an active, problem-solving coping strategy, and a higher resilience to distress.

In the APA survey conducted in 2017, 57% of interviewees declared they manage their stress by engaging in activities and spending time with their family and friends (American Psychological Association, 2017). According to the APA report consecrated to teens and adults, data shows that 43% of Americans engage in a physical activity to unwind. However, amongst the 63% of adults who exercise at least once a week, more than half agree that they feel good about themselves afterwards, and 30% feel less stressed. Compared to other stress coping techniques, interviewees find exercising more effective against stress (62%) than watching TV (33%) or going online (29%) (American Psychological Association, 2014). Social activities, which include sports, have been found to highly and positively correlate with high self-esteem (Holland & Andre, 1987). Social support is widely recognised as a coping ressource, and so is physical activity (Heinrichs et al., 2015). Physiologically however, sustained physical activity induces reactions akin to stress reactions; the heart rate rises, adrenalin, noradrenalin and cortisol are released, and sugar is consumed. Furthermore, physical activity can also be associated to psychological stress such as performance or competitivity anxiety (Crocker & Graham, 1995; Scanlan & Lewthwaite, 1984). Yet, the effect of sports on mental well-being is undoubted. Physical activity can improve mood and self-esteem, reduce symptoms of anxiety, depression and perceived stress, and may delay the age-related decline of cognitive

performance (Penedo & Dahn, 2005). A model of the effect of physical activity on stress reactions has been proposed by Fuchs and Klaperski. They postulate that physical activity can act at different points of the relationship between stress and health (see Fig. 1.2). According to their model, physical activity can act either by reducing stress beforehand, e.g. by reducing pre-existing conditions such as diabetes or insomnia, by consolidating coping resources, such as self-efficacy, by reducing the stress-reaction itself and finally, by consolidating physical health, such as cardio-vascular or muscular health (Fuchs & Klaperski, 2018).

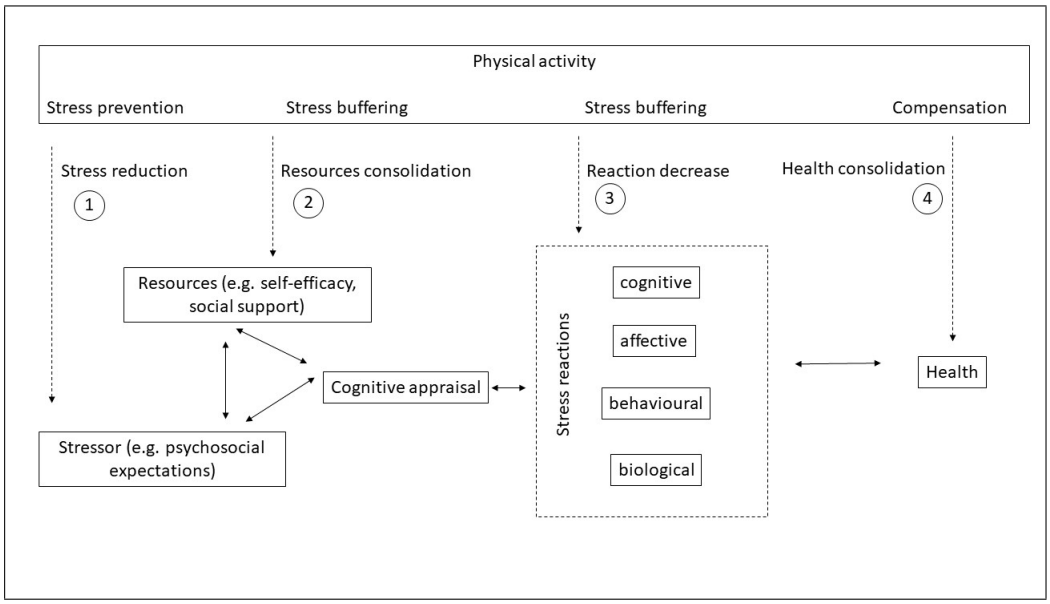


Figure 1.2: Model of the stress-buffering effect of physical activity. Adapted from Fuchs & Klaperski, 2018.

Several studies have been conducted to assess the role of physical exercise on stress tolerance. Findings show not only lower physiological reactivity to stress in sportive men and women, but also lower psychological responses, i.e. better mood and higher calmness (Klaperski, von Dawans, Heinrichs, & Fuchs, 2013; Rimmele et al., 2007). Aerobic activity in particular is known

to elicit better mood and to lessen anxiety post-workout. The most famous example might be the runner's high, or flow, during which the runner experiences a euphoric state. The flow state is characterised by a fit of skills and demands, which are perceived in balance (Nakamura & Csikszentmihalyi, 2014). An individual being "in flow" experiences an intense concentration on the task at hand, distortion of time, loss of "reflective self-consciousness", and a blend of action and sentience (Nakamura & Csikszentmihalyi, 2014). As such, flow state can be perceived as very rewarding and highly motivational (Schuler & Nakamura, 2013). However, the experience of flow and self-efficacy is correlated to higher risk-taking and pursue of extreme sports (Llewellyn et al., 2008).

Parallel to Fuchs' and Klaperski's stress-buffer hypothesis, Sothmann and colleagues (1996) proposed the cross-stressor adaptation hypothesis. The hypothesis stipulates that regular exposure to psychological and physiological stimuli leads to specific and unspecific adaptive reactions. Specific adaptive reactions are usually health-related, while unspecific reactions are thought to be a response to cognitive stressors such as working under pressure or respecting a deadline. Then follow two processes called habituation and sensitization (Sothmann et al., 1996). Habituation means the stressed individual will, after a regular exposure to a stressor, only produce a weakened reaction to that kind of stressor. On the other hand, and because it is still vital to be able to produce a stress reaction, sensitization will lower the threshold of reaction to unknown or intense stimuli (Sothmann et al., 1996).

In conclusion, research strongly supports the effect of physical activity on different aspects of stress management, although the neurological and physiological processes as well as the points of impact differ depending on the chosen angle of research.

## 1.4 Rock climbing: a high-risk activity?

### 1.4.1 History and popularity

Rock climbing has come into focus in the last two decades, as much in the research department as for the public. According to the German Alpine Club (Deutscher Alpenverein, DAV), the percentage of their climbing members rose from 18% in 2004 to 27% in 2017. In the same time, the absolute number of members rose from 686.000 to 1.184.000. All in all, the DAV estimated the number of active climbers in Germany around 500.000 in 2018 (Deutscher Alpenverein, 2018). Sign of its popularity, climbing is the newest addition to the Olympic Games of 2020, with athletes competing in lead-climbing, bouldering and speed-climbing. Climbing as a recreational activity began in the 1970's (Li, Margetts, & Fowler, 2001) in hotspots such as the Yosemite Valley in the U.S.A.. Since then, progress has been made in climbing techniques and climbing gear. In her thesis, Bright (2014) provides a comprehensive history of the evolution of climbing gear. Safety standards have evolved and help palliate to human error, making the sport more accessible to a less well trained public. The evolution of belay devices, for example, illustrates quite well this trend. A belay device mostly uses friction to slow down a fall. The first patented device, called the Sticht plate, was a simple aluminium plate with two apertures. It replaced the carabiner brake method and proved effective in increasing the braking force (H. Huber & Sticht, 1970-11-26). Then, tubular devices increased the friction even more by adding sharper angles, and reduced temperature rise, which can be an issue. Nowadays however, belay devices make it easier to belay with little force by blocking the rope during falls. Even though proper technique is still recommanded, using an auto-blocking device makes climbing safer. As a result, people with less training can still climb while taking limited

risks.

Much has been written on the philosophy of rock climbing (e.g. A. Huber, 2013; Schmid & Reichenbach, 2017). Climbing fascinates climbers and non-climbers alike. The distribution of movies such as "The Wall", or the acclaimed "Free Solo" featuring Alex Honnold in his rope-free ascent of "the Nose" in Yosemite Valley is testament to the fascination climbing can elicit. Online media has helped reaching far more potential climbers through platforms like Instagram and Youtube. For example, French bouldering champion Fanny Gibert totals more than 93K followers on Instagram (07.04.2020). Alex Honnold's account has as many as 2 million followers (07.04.2020). The idea of climbing has been often romanticised, and for many, rock climbing evokes the notion of adventure, individuality, control, and freedom (Schmid & Reichenbach, 2017; A. Huber, 2013).

### 1.4.2 Climbing as a high-risk activity

The term "climbing" represents a group of different disciplines, in which the athlete tries to get on top of a structure, mostly by using hands and feet. In the modern understanding of the sport, only one's own technique and strength are used to climb routes, and gear is only used for safety purposes (Güllich, Hepp, & Heidorn, 1992). Several disciplines exist within the climbing community. The two most popular disciplines, which will be represented in the Olympics in 2020, are sport (lead) climbing, and bouldering, and are the focus of this study. Critically, bouldering is defined as climbing *within jumping height*. Naturally, both present common aspects. The techniques used to correctly step on footholds or to efficiently grip handholds are similar, and so are movement techniques. However, the difficulty and length of climbing and bouldering routes usually differ. Climbing routes are generally longer, and the focus is on endurance rather than on strength.

Rock-climbing indoor walls are usually 12-18 meters high, but outdoor walls can be climbed in several rope lengths. As a reference, the *Nose* on El Capitan in Yosemite is composed of 31 rope lengths or pitches, and towers at nearly 915 meters above the ground (Snyder, Barnes, & McNamara, 2001). Lynn Hill, the first to climb the *Nose* without aid gear, in 1994, climbed for 4 days to reach the top (Hill, 1994). The climber wears a harness and is attached to its belayer, who makes sure the climber will not fall to the ground. Two different safety protocols can be used which influence both the physical and psychological difficulties of the route. A climber "leading" a route will trail its rope, place quickdraws on pre-placed bolts if climbing outdoors, and attach the rope through the quickdraw. The fall that might result depends on the position of the last bolt; bolts are usually placed every 2-5 meters, which means a climber can fall up to 12 meters (Schöffl, Morrison, Schwarz, Schöffl, & Küpper, 2010). The second safety protocol involves a rope attached to the top of the route ("top-rope" protocol). The belayer can immediately stop a fall, which can be between 30 cm and a meter (Bisharat, 2009). This protocol is mostly used by beginners, or for training on a particularly difficult route section. On the other hand, bouldering is a discipline involving smaller walls (approx. 3 to 4 meters) and no ropes, but large mattresses, or crashpads. Boulder problems, i.e. the equivalent to climbing routes, are usually made of 10-15 movements. Historically, bouldering was not considered a discipline per se, but a way to warm up or train particularly difficult sections of a climbing route (Güllich et al., 1992). Bouldering presents practical advantages over rock climbing: as there is no security protocol, there is no need for gear besides a crashpad, climbing shoes, magnesium, and eventually a brush. Magnesium, usually called "chalk", dries up the hands and makes gripping the holds easier. The brush is used to clean holds afterwards. Climbers additionnally need a harness, a rope, a belay device, quickdraws and carabiners. Furthermore,

most climbers need a partner, while bouldering can be done solo. However, both sport climbing and bouldering are defined as mostly individual activities. Apart from competition settings, the adversary is not an opponent but rather the environment, or route. Therefore, the challenge is associated with the perspective of becoming a better climber for yourself, rather than being focused on comparing yourself with fellow climbers. This psychological aspect is crucial: climbing has a long history of ethical disputes amongst the different sub-communities. Climbing is not only about being to physically conquer a route: the way of doing so matters. The documentary *Valley Uprising* for example illustrates well the divergence of opinions of Royal Robbins and Warren Hardings on the use of bolts on the Dawn Wall in Yosemite in 1971 (*Valley Uprising*, 2014). These ethical positions reflect different motivations, which can in turn affect psychological strains and risk taking. Free solo climbing is an extreme example of the way motivation can impact risk taking. Free solo climbing is the ascent of climbing routes without security gear, like bouldering.

For researchers, climbing is of interest because of the multidimensionality of physical and psychological strains. Physical demands include muscle strength, aerobic capacities, endurance, agility, and flexibility. The psychological aspects are related to height, falling possibility, performance anxiety if climbing with an audience, and to the style of ascent, which can be defined as free solo, lead, top-rope or bouldering (Giles et al., 2014). In research, rock climbing is often mentioned as an adventure or high-risk activity. In the most extreme high-risk activities (e.g. BASE jumping or free-solo climbing), an error is more likely to result in severe injuries or death than in other sports. Austin Howell is the latest free soloing victim, falling at the end of June 2019 in North Carolina (Levy, 2019), but accidents also happen on a regular basis amongst well-trained climbers using safety protocols. At the end of November 2019, record-breaker and speed climber Brad Gobright fell

to his death in Mexico after using a rappel technique and neglecting to tie knots at the end of his rope (Poulet, 2019). Mostly, both adventure and high-risk activities have been associated with negative behavioural patterns and with negative health outcomes (Frühauf & Kopp, 2020). However, recent research shows taking part in adventure activities is associated with better mood and higher self-efficacy and resilience (Frühauf & Kopp, 2020). Indeed, because of the high stakes, athletes need to effectively regulate their emotions and to think clearly. Therefore, they need to use a problem-solving coping strategy in an effort to efficiently control the situation (Woodman, MacGregor, & Hardy, 2019).

Considering psychological strains, climbing and bouldering differ. Many studies have been conducted on stress and flow during a climb. The level of cortisol secretion is linked to the style of ascent; an intermediate climber "leading" a route (i.e. with a higher fall distance) will produce more cortisol than a climber of the same grade in a top-rope protocol (i.e. with a fall distance reduced to a minimum) (Draper, Jones, Fryer, Hodgson, & Blackwell, 2008). Furthermore, the falling distance positively correlates with cortisol levels post-climb, even within the same safety protocol. As a result, because bouldering is practiced at jumping height, there is less anxiety involved (Giles et al., 2014). Furthermore, the involvment of a belayer in climbing implies a particular trust relationship between climbing partners. The belayer has to have proper technique and training. They also need to know the climber well, especially in lead climbs. As falls are more likely to happen and to be longer, it is essential the belayer anticipates where the climber might have difficulties, and how to soften a fall. Typically, trust is a factor in stress coping (Piippo, 2016). Guinot et al. (2014) also link interpersonal trust to higher job satisfaction and lower workplace-related stress. Therefore, it is not surprising that climbing activities have been proposed as a way to elicit team-workers to trust each other more (e.g. as part of a Corporate

Adventure Training, see e.g. Gass, Goldman, & Priest, 1992). Despite the physical and psychological difficulties and the risk of falling, one of the main motivation for all climbers is reaching flow state and eustress, in par with feelings of self-confidence and better mood post-achievement (Giles et al., 2014; Motl, Berger, & Wilson, 1996). As such, rock-climbing and bouldering have already successfuly been implemented as a therapy against depression (Luttenberger et al., 2015).

## 1.5 Research question and hypothesis

Rock-climbers are subjected to stressful situations during practice, which could potentially lead to allostatic overload. However, they also experience eustress and flow feelings, a fast recovery after a cortisol peak, and high feelings of self-efficacy. Furthermore, regular physical activity may act as a stress-buffer. All these positive aspects would suggest that a climber could be more stress-resilient in their everyday-life, especially if climbing occurs on a regular basis. The purpose of this study is therefore to investigate the relationship between rock-climbing as an example of potentially dangerous activity and chronic stress resilience. Comparing a group of rock-climbers with a group of boulderers and physically inactive individuals, I hypothesise that rock-climbers perceive less stress in their everyday-life than boulderers, who in turn feel less stressed out than physically non-active individuals.

# Chapter 2

# Material and Methods

## 2.1 Sample groups

To study the effect of climbing activity on stress, three groups of men between 18 and 35 years old were asked to complete a questionnaire on their everyday-life stress level. Repartition in groups was resolved after taking the stress questionnaire by asking all participants whether they predominantly practice rock climbing, bouldering, or none of these two activities. The first group comprises rock-climbers using a rope and a belaying device, who mostly practice rock climbing but may also boulder. The second group encompasses boulderers who have little to no experience in rock climbing but practice bouldering on a regular basis. The third group is composed of men who exercise 2 hours and a half or less per week. Their activity cannot be either climbing or bouldering. Women were not included in the sample. The exclusion of women from the sample pool was motivated by several studies underlining the difference in cortisol reaction of men and women. Kirschbaum and colleagues (1992) found sex differences in the cognitive and emotional responses following distressing situations. Furthermore, the cortisol awakening response was found higher in women than men in high

stress situations (Schulz, Kirschbaum, Prüßner, & Hellhammer, 1998). According to these studies and others (e.g. Wolf, Kirschbaum, Hellhammer, McEwen, & Schommer, 2002), research seems to show higher cortisol levels in women than in men. Moreover, other studies show the link between the use of female oral contraceptive and negative responsivity of femen subjects to psychological stress (Kirschbaum et al., 1995; Merz et al., 2012). To simplify recruitement and analysis in the context of a master thesis, it was decided to include only male participants for this study. Likewise, the age limit was decided based on Otte's study, who found a positive relationship between age and cortisol levels (Otte et al., 2005).

### 2.1.1 Climbers

In the first group (rock-climbers), participants who took on climbing after 2017 were excluded. To be included, participants must climb at least 2.5 hours per week in the climbing gym or outdoors, independently of whether they practice other activities beside climbing. Furthermore, only climbers reaching at least an "intermediate level" such as described by Draper et al. (2015) were included. Considering those criteria, the number of participants used for the analysis amounts to 31. Their mean age is 27.7 years (± 4.03), they have a mean BMI of 22.4 (± 1.81). 63% declared being in a relationship, and 10% have children.

### 2.1.2 Boulderers

In the second group (boulderers), participants have a mean age of 27.3 (± 3.89), and have a mean BMI of 22.7 (± 2.04). Like climbers, the majority (67%) of boulderers is in a relationship, and only 4% have children. They practice bouldering on a regular basis, at least for the last two years, and also

reach an intermiediate grade. Some boulderers indicated a rock-climbing activity, the regularity of which is unknown, but which is subsidiary to their bouldering habits. After a negative testing for major demographic differences between those boulderers who also climb sporadically and exclusive boulderers, it has been decided not to separate them. For more information, a summary is provided in the Appendix, section 5.3. In total, 52 individuals were included in the analysis.

### 2.1.3 Control group

Finally, the control group consists of physically non-active men, who, as per definition of the World Health Organisation, do less than 2.5 hours of sportive activity per week. They have a mean age of 24.7 ($\pm$ 3.47) and a mean BMI of 23.6 ($\pm$ 3.29). Only 41% are in a relationship, and 93% do not have children. A total of 31 individuals were kept for the analysis.

## 2.2 Recruitement

Participants were recruited between July and October 2019 at local bouldering- and climbing gyms, as well as at several universities in Austria and Germany. Recruitment was also achieved through advertisement using flyers and websites. Websites included *www.surveycircle.com* and *www.thesius.de*. Participants were not aware of the goal of the study beforehand, and were only told that the questionnaire lasts for about 15 min. They knew it was for a master thesis, but did not know the field of application. I typically approached them by asking whether they would have 15 minutes to answer a questionnaire for a master thesis. To those who asked more details before or during the questionnaire, I answered I could give detailed information during the

debriefing at the end. Online participants did not have the possibility to ask anything beforehand, but an e-mail address was provided for feedback and questions. Participants had the opportunity to take part in a lottery, for which they had to provide an e-mail address. The game was organised by Thesius.

The online questionnaire was generated using SoSci Survey (Leiner, D. J., 2020-08-05) and was made available to users via www.soscisurvey.de. Participants recruited in local climbing gyms could answer on one of the two laptops I provided. Participants answering from home were told to use their own laptop or PC.

Out of the 114 individuals kept for analysis, the majority answered from Austria (51%). There were 36 individuals participating from Germany (32%). Answers came also from Switzerland (9%), and 9% of participants did not specifiy where they were answering from, i.e. they answered "at home".

The majority of climbers (71%) and physically inactive individuals (81%) was recruited online. Repartition was more balanced concerning boulderers: 56% were recruited at local gyms. There was no interviewer effect in the data of either climbers or physically inactive participants (Wilcoxon-test, $p>0.05$). However, concerning boulderers, they typically obtained lower scores when data was collected by myself (see Appendix, Table **??**.

There was no significant difference in data when comparing by recruitment period, except in one category, and for the control group only. However, as all other $p$-values were extremely high, the difference was not taken into account (see Appendix, Table 5.4).

Obviously botched or non-serious answers were not taken into account (28.6% of all answers). Complementary information on participants can be found in the Appendix.

## 2.3 Questionnaire

All participants were asked to complete the latest version (version 3) of the Trier Inventory for the Assessment of Chronic Stress (TICS) (Schulz et al., 2004). The original questionnaire is written in German, so there was no need to translate into English. This questionnaire includes 57-item questions and allows the screening of nine chronic stress categories: *work overload*, *social overload*, *pressure to succeed*, *dissatisfaction at work*, *excessive demands at work*, *lack of social approval*, *social tension*, *social isolation*, and *chronic apprehension*. A tenth category, *SSCS*, summarizes the stress scores. Definitions infered from the questions asked for each category can be found in Table 2.1. Higher scores indicate a higher feeling of stress. For each question, participants had to indicate how often they experienced each situation in the last three months, ranking from 0 (never) to 4 (very often) (five-points Likert scale). The score for each stress type is obtained from the plain sum of the scores. For example, scores for the category *social overload* are obtained from the 6 questions nr. 07, 19, 28, 39, 49 and 57. If an individual X, a male aged 20, answers "sometimes" (level 2) to each question, the raw score for the category will be 2x6, so 12. To obtain a stress profile, each score is transformed into a T-value according to scales provided by the authors. T-values are provided for each category. In our example, with a raw score of 12 in the category *social overload*, the corresponding T-value will be 56. The transformation scales are provided for different population samples, differentiated mainly by demographics. A T-value of 50 is representative of the norm population used for the development of the stress test. The TICS manual (Schulz et al., 2004) recommends an analysis based on four blocks. The first block comprises *work overload*, *social overload* and *pressure to succeed*. This block emphasizes stress related to the perceived frequency of duties, related to work or to others (i.e. social), and is more

related to demographic variables and outer conditions than personality characteristics. The second block consists of stress related to *dissatisfaction at work*, *excessive demands at work*, *lack of social approval*, *social tension*, and *social isolation*. This section expresses feelings of lack of need satisfaction and depends more on personality traits and the ability to cope. The third block is made of the *chronic apprehension* score, and focuses more on stress feelings related to chronic overload. The last unit is the *SSCS*, or Screening Scale for Chronic Stress, and sums up overall stress levels. The test scored high on internal reliability with coefficients between 0.84 and 0.91 (Cronbach's alpha) (Schulz et al., 2004). The authors describe the test as suitable for group comparisons for individuals aged 16 or more. Strong correlations were found between test scores and cortisol levels.

The TICS questionnaire was administred first, then followed by personal questions. Participants were asked to give some personal information, such as their body weight, height, age, professional occupation, academical level, familial situation, and eventual money problems. They were asked to indicate whether they experienced a particularly stressful life event in the last three months. They also indicated whether they smoke, drink, or consume other drugs on a regular basis. Finally, they reported on their current mood. Climbers and boulderers had an additional set of questions the International Rock Climbing Research Association (IRCRA) deems necessary when conducting research on climbers (Draper et al., 2015). Those questions were in-between the TICS questionnaire and the demographics questions. They gave information about the disciplines they take part in, the time they spend climbing indoors vs. outdoors, the mean amount of time per week they spend climbing, the year they started climbing, whether they take part in competitions, and, for rope climbers, their preference for style of ascent and terrain. All additionnal informations can be found in the Appendix.

## 2.4 Statistical Analysis

### 2.4.1 Analysis of the Questionnaire

In order to decide which statistical test is best suited to test the hypothesis, a test on the normal distribution of the answers to each question within each group was performed. For this analysis, the distribution of the raw answers (i.e. not yet transformed according to the manual) was observed and tested for normality using the Shapiro-Wilk test. Small $p$-values indicate a non-normal distribution. All $p$-values were smaller than 0.05 for all groups, indicating that no question obtained normaly distributed answers across all groups. Once the sum of raw scores had been established for each stress category, the value was transformed according to the table provided by Schulz et al.. This transformation takes into account the different number of items corresponding to each category and uses coefficients depending on demographics. The transformed values followed a normal distribution in all ten stress categories for the climbers' group. In the boulderers' group, only the categories *excessive demands at work* ($p$= 0.0374) and *chronic apprehension* ($p$= 0.0132) were not normally distributed. In the control group, values for the categories *social overload* ($p$= 0.0174), *excessive demands at work* ($p$= 0.0295, and *lack of social approval* ($p$= 0.0455) were not normally distributed either. Respective $p$-values can be found in the Appendix, Table 5.1.

### 2.4.2 Statistical Tests

Taking into consideration the distribution of the T-values, a parametric test was not possible for every stress category. However, certain categories being

normally distributed across all groups, it was possible to use a parametric test (i.e. one-way ANOVA with post-hoc Tukey-Kramer HSD) for those categories, and a non-parametric test (i.e. Kruskal-Wallis' test with post-hoc Dunnett's test) for categories which did not follow a normal distribution.

All statistical analysis were conducted with JMP version 13 (*www.jmp.com*).

Table 2.1: Definition of stress categories. In this table, stress categories are defined. Definitions are expressed by summarizing items asked in each category. Details in Schulz et al., 2004.

| **Stress category** | **Definition** |
|---|---|
| Work overload | There is too much to do in too little time. |
| Social overload | I am responsible of others. |
| Pressure to succeed | I am feeling put under pressure by the judgement of others. |
| Dissatisfaction at work | My job is boring and there is no challenge. |
| Excessive demands at work | I cannot meet the demands of my job and it leads to accumulated errors. |
| Lack of social approval | Although I feel like I do my job well, I am not recognized by my peers or superior. |
| Social tension | Differences in opinion often lead to conflicts. |
| Social isolation | I have too little contact to others and noone to confide in. |
| Chronic apprehension | I have many sorrowful thoughts which I cannot repress. |
| SSCS | Summary score |

# Chapter 3

# Results

In this section, data distribution is first described for each group and category using median T-values, interquartile range (IQR) and overall range. Then, results of both ANOVA and Kruskal-Wallis tests are reported. Figures and tables are provided for a better understanding.

Results are presented in Figures 3.1 and 3.2, and Table 3.1 summarises the data. In the stress category *work overload*, climbers and boulderers have similar medians (51.000), while individuals in the control group have a median of 52.00. However, the ranges differ across all three groups. Climbers tend to obtain lower scores, ranging from 25 to 66, with an IQR of 15.00. Boulderers have scores situated between 33 and 69, with an IQR of 13.00. Finally, the total score range for the control group is the highest of the groups, and is recorded between 30 and 75, with an IQR of 18.00. In the category *social overload*, all groups present at least one outlier (minimum: 26). Climbers and individuals of the control group have the same median (50.00), but the IQR is smaller in the control group (8.00 vs. 12.00). On the other hand, boulderers present the highest Q1, median, Q3 and maximum T-value. In the category *pressure to succeed*, the scores of climbers are contained in the smallest overall range (36-61), but the highest IQR (climbers: 14.00, boulderers: 13.25, control group: 10). The control group

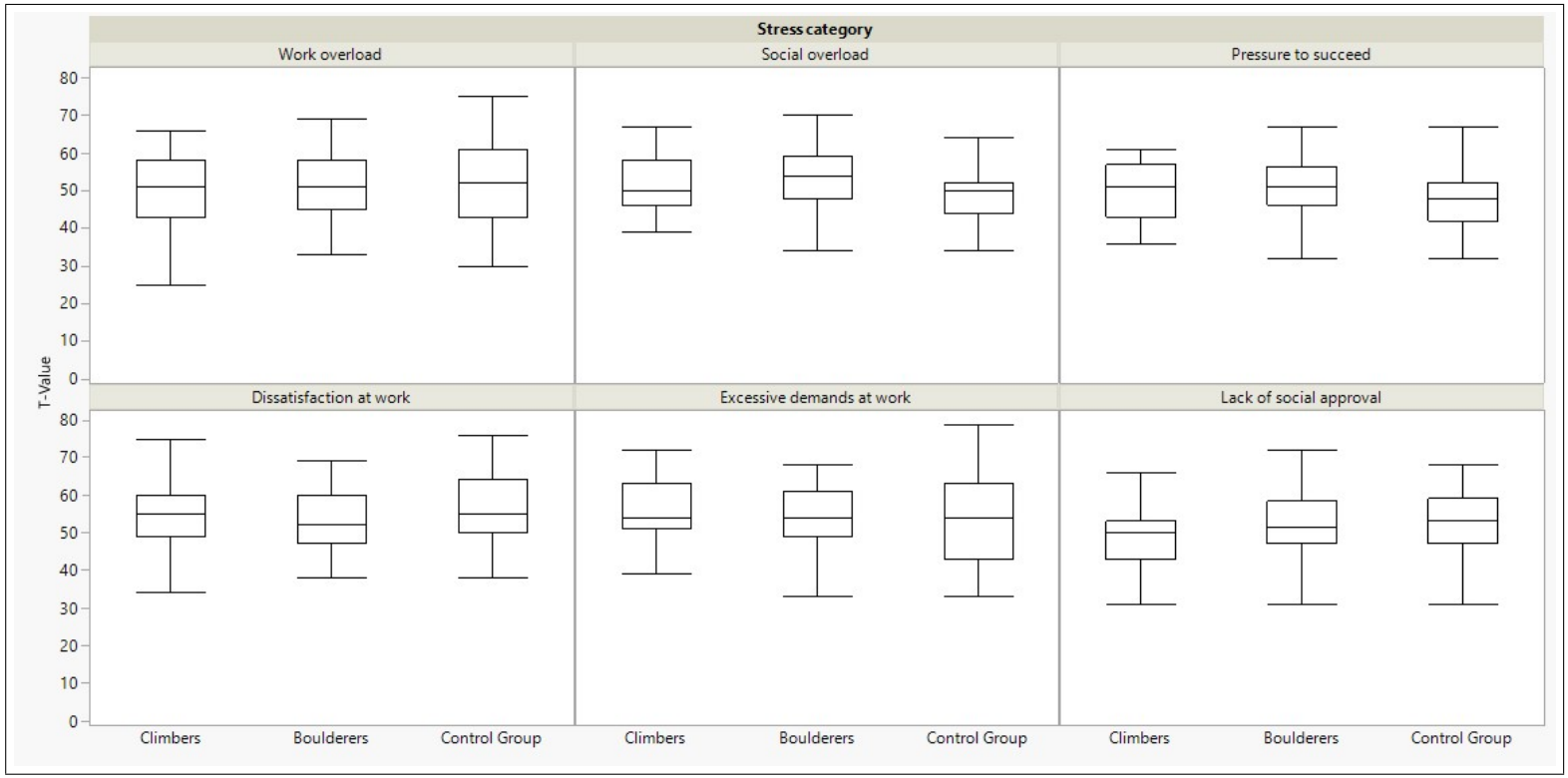


Figure 3.1: Statistical distribution of T-values for the stress categories *work overload*, *social overload*, *pressure to succeed dissatisfaction at work*, *exccessive demands at work* and *lack of social approval*. In each panel, the boxplot on the left-hand side represents the distribution amongst climbers. Boulderers are represented in each panel by the boxplot in the middle, and the boxplot on the right of each panel illustrates T-values amongst the control group. T-values are indicated by the y-axis and span between 0 and 80. A score of 50 is representative of the stress levels of the norm population used to calibrate the test.

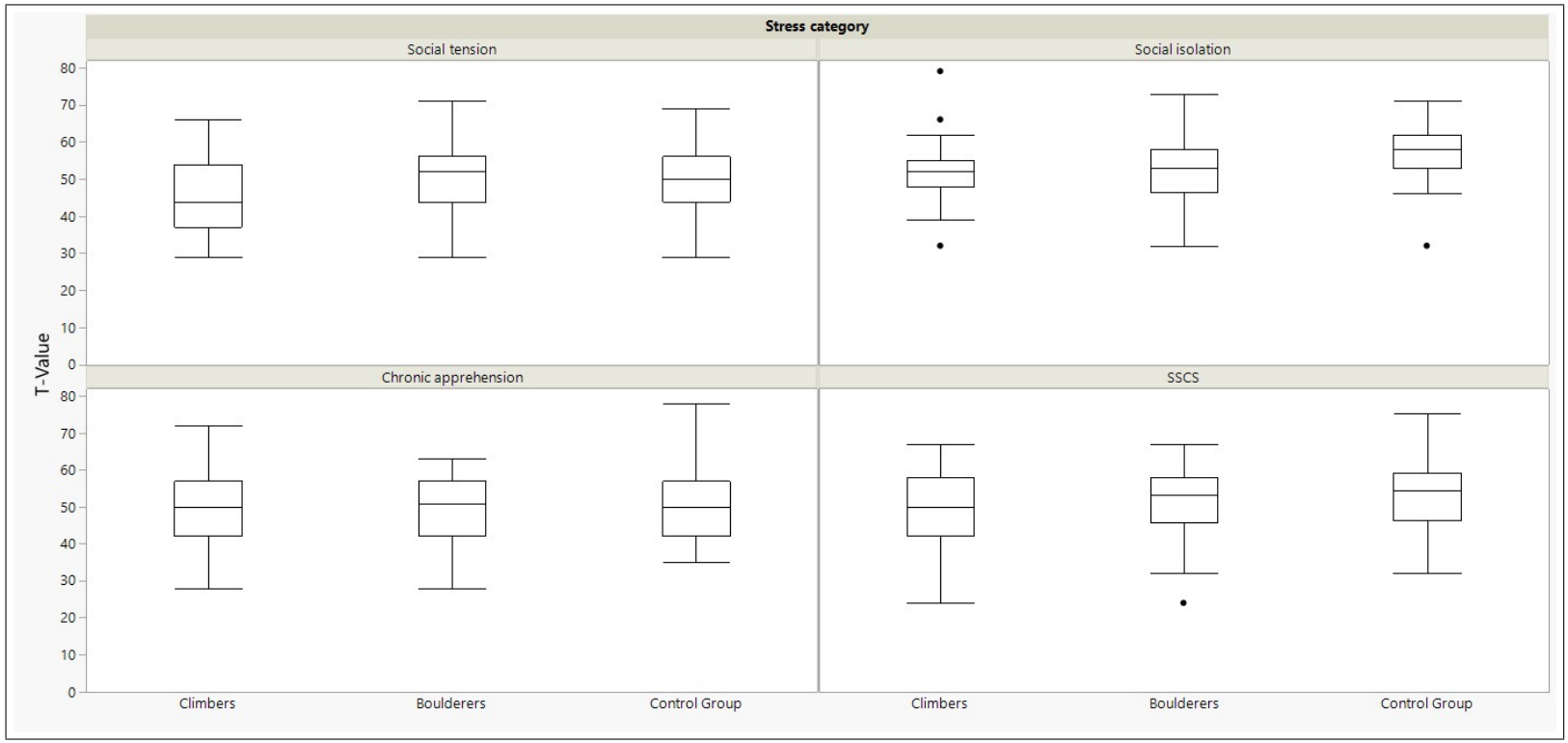


Figure 3.2: Statistical distribution of T-values for the stress categories *social tension*, *social isolation*, *chronic apprehension* and *SSCS*. In each panel, the boxplots on the left-hand side represents the distribution amongst climbers. Boulderers are represented in each panel by the boxplot in the middle, and the boxplot on the right of each panel illustrates T-values amongst the control group. T-values are indicated by the y-axis and span between 0 and 80. A score of 50 is representative of the stress levels of the norm population used to calibrate the test.

has the lowest median (48.00), followed by both climbers and boulderers (51.00). Two outliers in the boulderers' group mean they have the highest maximum T-values, with a score of 75. Overall, in the first block, no real pattern can be observed. The highest variability in IQR is observed for the control group. Concerning their *dissatisfaction at work*, the overall range is highest among climbers (20-75 vs. 38-69 for boulderers and 38 to 76 for the control group). However, the IQR is lowest for climbers (11.00), followed by boulderers (12.75) and the control group (14.00). Concerning the medians, boulderers obtained the lowest (52.00), while climbers and the control group both reached a median T-value of 55.00. The medians of all three groups in the category *excessive demands at work* amount to 54.00. However, the IQR for the control group (20.25) is by far higher than for climbers and boulderers (both IQR at 12.00). The data in the climbers' group is visibly skewed, with an interval of 3.00 between Q1 and the median. In the stress category *lack of social approval*, all three groups have a minimum T-value of 31. Climbers have a median of 50.00, boulderers obtained a median of 51.50, and the control group scored a median of 53.00. Again, the data in the climbers' group is skewed, with an IQR of 10.00, and an interval of 3.00 between median and Q3. In comparison, the data for boulderers and the control group is more equally distributed with IQRs of respectively 11.25 (Q1= 47.00) and 12.00 (Q1= 47.00). Regarding the *social tension*, the minimum T-value is of 29 for all three groups. Climbers show the lowest median (44.00 vs. 52.00 for boulderers, and 50.00 for the control group), but present the highest IQR (17.00). The two other groups have the same IQR of 12.00. About *social isolation*, the climbers' group present a few outliers, one in the lower range, and two in the upper span. An outlier amongst the control group also makes up for a minimum value of 32, meaning all three groups have the same minimum T-value. Excluding the outliers however, the total range is highest for boulderers (32-73). The range of T-values of the control

group is comparatively skewed to the higher values (46-71). Excluding the outliers, climbers obtain values between 46 and 71. Furthermore, the groups differ greatly concerning the median, with an all-time high value of 58.00 for the control group. Climbers and boulderers had a respective median of 52.00 and 53.00. The lowest IQR is found amongst climbers (7.00), followed by the control group (9.00) and finally the boulderers (11.50). Again, the second block does not present a recognizable pattern. It is noteworthy that stress categories relative to social issues seem to cleave groups more than other stress factors, with the two most extreme medians in *social tension* and *social isolation*. The latter category is also the one with the lowest IQR for climbers and boulderers, and second lowest for the control group. Concerning the category *chronic apprehension*, the groups present similar medians (climbers and control group: 50.00, boulderers: 51.00) and the same IQR (15.00) and Q1 of 42.00. The total range differs however, with data starting at 28 for climbers and boulderers, and 35 for the control group. The scores span up to 72 in the climbers' group, 63 for the boulderers, and to 78 for the control group, meaning the data for the latter is again skewed compared to the others. Finally, climbers' and boulderers' T-value in the *SSCS* category range from 24 to 67, with an outlier corresponding to the minimum value amongst the boulderers. The median follows a growing trend, starting at 50.00 in the climbers' group to 54.50 in the control group, with boulderers registering a median of 53.00. The IQR (12.50) is lowest for boulderers, followed by the control group (13.00) and finally the climbers, with an IQR of 16.00.

One-way ANOVA was performed on the following categories: *work overload*, *pressure to succeed*, *dissatisfaction at work*, *social tension*, *social isolation*, and *SSCS*. The corresponding $p$-values can be found in the Appendix, Table 5.2. The only significant difference between groups occurs in the category *social isolation*. After a post-hoc test (all pairs' Tukey-Kramer HSD),

it was confirmed that the control group differs significantly from both boulderers and climbers (respective $p$-value= **0.0319*** and **0.0327***). Physically inactive participants obtained scores which were higher in both cases (respective mean ±SD values 57.48 ± 8.52, 52.59 ± 8.05, and 52.03 ± 8.96).

The Kruskal-Wallis test was performed on the following categories: *social overload*, *excessive demands at work*, *lack of social approval*, and *chronic apprehension*. The corresponding $p$-values can be found in the Appendix, Table 5.3. No significant difference was found between groups.

Table 3.1: Summary statistics for all stress categories and groups. Minimum T-Value, 1st quartile, median, 3rd quartile and maximum T-value are provided.

| | Climbers | | | | | Boulderers | | | | | Control group | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stress category | Min | Q1 | Med | Q3 | Max | Min | Q1 | Med | Q3 | Max | Min | Q1 | Med | Q3 | Max |
| Work overload | 25 | 43.00 | 51.00 | 58.00 | 66 | 33 | 45.00 | 51.00 | 58.00 | 69 | 30 | 43.00 | 52.00 | 61.00 | 75 |
| Social overload | 26 | 46.00 | 50.00 | 58.00 | 67 | 26 | 48.00 | 54.00 | 59.00 | 70 | 26 | 44.00 | 50.00 | 52.00 | 67 |
| Pressure to succeed | 36 | 43.00 | 51.00 | 57.00 | 61 | 32 | 46.00 | 51.00 | 56.25 | 75 | 32 | 42.00 | 48.00 | 52.00 | 67 |
| Dissatisfaction at work | 20 | 49.00 | 55.00 | 60.00 | 75 | 38 | 47.00 | 52.00 | 59.75 | 69 | 38 | 50.00 | 55.00 | 64.00 | 76 |
| Excessive demands at work | 39 | 51.00 | 54.00 | 63.00 | 72 | 33 | 49.00 | 54.00 | 61.00 | 68 | 33 | 43.00 | 54.00 | 63.25 | 79 |
| Lack of social approval | 31 | 43.00 | 50.00 | 53.00 | 66 | 31 | 47.00 | 51.50 | 58.25 | 72 | 31 | 47.00 | 53.00 | 59.00 | 68 |
| Social tension | 29 | 37.00 | 44.00 | 54.00 | 66 | 29 | 44.00 | 52.00 | 56.00 | 71 | 29 | 44.00 | 50.00 | 56.00 | 69 |
| Social isolation | 32 | 48.00 | 52.00 | 55.00 | 79 | 32 | 46.50 | 53.00 | 58.00 | 73 | 32 | 53.00 | 58.00 | 62.00 | 71 |
| Chronic apprehension | 28 | 42.00 | 50.00 | 57.00 | 72 | 28 | 42.00 | 51.00 | 57.00 | 63 | 35 | 42.00 | 50.00 | 57.00 | 78 |
| SSCS | 24 | 42.00 | 50.00 | 58.00 | 67 | 24 | 45.50 | 53.00 | 58.00 | 67 | 32 | 46.25 | 54.50 | 59.25 | 75 |

# Chapter 4

# Discussion

In this chapter, the median profiles for each group will first be qualitatively interpreted according to Schulz et al. (2004). Then, the differences between the groups will be considered in light of the hypotheses. Finally, methodical limitations and applicability will be presented.

## 4.1 Qualitative interpretation of stress profiles

As laid out in Section 2.3, an analysis based on four blocks is recommended in the TICS-manual. For a better understanding of each stress category, please refer to Schulz (2004).
The first block does not depend on personality, but rather on demography and life conditions, such as work-, family-, or money-related stress issues. The second block takes personality traits into account, and distinguishes between worklife and social life. The third block is about chronic apprehension, and depends partly on personality characteristics. Finally, the fourth block, or *SSCS*, summarizes all nine stress category in a single score.

In the following sections, all four blocks will be qualitatively interpretated for all three subjects' groups.

### 4.1.1 Climbers

In the first block, the median T-values indicate climbers perceived stress levels similar to the norm population's used to calibrate the test. Apart from the category *work overload*, and an outlier in the category *stress overload*, both of which are increasing the total data range, the IQR indicated a tendency of climbers to feel unburdened by feelings or stressful situations related to their life conditions. With values of respectively 51.00, 50.00, and 51.00, it seems that climbers are exposed to some stressful situations, but not in excess, as suggested by the comparatively low maximum T-values. Concerning the second block, all median values were greater than 50.00, except in the categories *lack of social approval* and *social tension*. These results could indicate that climbers were mostly subjected to stress concerning their workplace. Interestingly, although the Q3 in the category *social tension* (54.00) was not much lower than in other categories, the median for this category (med = 44.00) was the only value under 50.00 amongst climbers' results. However, the IQR was amongst the highest, suggesting a disparity in climbers' perception of stress related to social tension. Climbers did not seem particularly prone to chronic apprehension, as shown in the third block by a median T-value of 50.00 and an IQR (15.00) similar to others. Finally, according to the median SSCS score (med= 50.00), climbers' stress levels were overall normal and did not differ much from that of an average population.

### 4.1.2 Boulderers

In the first block, median values were not as similar as they were for climbers. Boulderers scored a median of 51.00 for both *work overload* and *pressure to succeed*, suggesting they did not feel like they have too many obligations,

nor too many things to do, as suggested by scores only slightly greater than the norm population. However, with a median T-value of 54.00 in the category *social overload*, it seems they perceived some stress related to the number and extent of their social interactions. The overall range and IQR (respectively 26-70 and 11.00) however suggest this feeling was not close to being unanimous. With regard to the second block, all medians and IQRs were similar, indicating no perceived difference between workplace related stress and stress provoked by social situations. All median T-values were between 51.50 (*lack of social approval*) and 54.00 (*excessive demands at work*), denoting stress levels slightly above the norm. The median T-value for the category *chronic apprehension* (med= 51.00) seems to reflect a group not likely to worry too much. Although the median for boulderers was greater than the median value for climbers (med= 50.00) or control group (med= 50.00), the differences in the maximum values is notable. Compared to both other groups, boulderers' maximum T-values were decidedly lower, supporting the idea of lower feelings of apprehension or anxiety across the group. All in all, their SSCS score (med= 53.50) suggests boulderers might be a bit more stressed out than climbers or the average population, but not significantly so.

### 4.1.3 Control group

Finally, subjects of the control group might have felt like they had too much on their plate, as indicated by a median of 52.00 in the *work overload* category, but they did not feel especially burdened by social obligations or performance stress ($\text{med}_{\text{social overload}}$= 50.00, $\text{med}_{\text{pressure to succeed}}$= 48.00). They reported a certain dissatisfaction with their worklife, as indicated by a high median T-value (med= 55.00). Although they did not report high stress related to social tension (med= 50.00), their level of stress concerning social

isolation was higher than any other median (med= 58.00). Furthermore, the overall range and IQR in the category *social isolation* were relatively small, indicating the burden of social isolation was perceived by the whole control group. Non-active individuals did not seem particularly burdened by chronic apprehension, as underlined by the median (med= 50.00). However, the data distribution seems skewed, and the minimum and maximum T-values are both second-highest within the control group, and highest amongst all groups within the *chronic apprehension* category. Their overall stress level, represented by the median SSCS score (med= 54.50), was higher than that of the norm population, showing the control group feels qualitatively more stressed out than the average person.

## 4.2 Effect of physical activity on stress

### 4.2.1 Boulderers and non-active individuals

Part of the research question focused on the potential effect of physical activity on daily, chronic stress. For that purpose, boulderers were compared to self-reported, physically inactive participants.

Concerning workplace-related stress, participants of that control group felt like they have too much to do, and were less satisfied at work than boulderers. However, their stress was less related to immoderate requests at work than in the case of boulderers. Concerning social stress, boulderers expressed to be more bothered by too many social obligations, a higher performance anxiety, and other social strains compared to non-active subjects. Contrary to that, the latter group may have felt more isolated and less supported by their environment. This significant difference has been confirmed between boulderers and the control group in the category *social isolation*. Boulderers

worried slightly less than non-active participants, which is supported by the overall lower range of T-values amongst boulderers. The screening scala reveals boulderers were in seemingly less subjected to stress than participants of the control group, even though the difference is marginal.

In summary, the only significant difference between both groups applied to *social isolation* ($p$= 0.0319). Additionnaly, the control group scored only marginally higher than boulderers in four categories (*work overload*, *dissatisfaction at work*, *lack of social approval*, and *SSCS*). On the other hand, boulderers scored somewhat higher than the control group in the four categories *social overload*, *pressure to succeed*, *social tension* and *chronic apprehension*. In the category *excessive demands at work*, boulderers and non-active individuals obtained the same median, but the IQR and overall range were both higher in the control group.

This result is not compliant with the first part of the hypothesis stated in the introductory chapter. According to literature, physical active individuals usually cope better with stress than sedentary and non-active people:

The stress-buffer-hypothesis (Klaperski et al., 2013) implies an effect of physical activity on coping resources and strategies. Most cross-sectional and longitudinal studies partly or fully support the stress-buffer-hypothesis, but very few experimental studies have been conducted. The results often show a negative correlation between stress levels and physical activity. However, several key points relative to previous studies need to be addressed: first, the correlation effect is often quite small (Klaperski, 2018). Secondly, even if a correlation is established and evidence supports the stress-buffer-hypothesis, there is yet to be found support for a particular causality; whether stress levels are indeed influenced by physical activity, or whether physical activity is influenced by stress is of the utmost importance. According to Klaperski (2018), both causalities might be possible depending on personality traits and sporingt habits (i.e. a person used to physical ac-

tivity might turn to sport as a way to cope, thus reducing stress levels, while a person reluctant to physical activity might begin to avoid goint to the gym when their stress levels are rising). The *Stress in America* survey of the APA states that 43% of adults who exercise purely to relieve stress regularly skip exercising due to stress (American Psychological Association, 2014). In our sample, without experimentally inducing a controlled, stressful situation, it is difficult to assess whether physical activity habits reflect a response to stress. Finally, it seems essential to have a minimum of physical activity for the buffer-effect to work (Dunn, Trivedi, Kampert, Clark, & Chambliss, 2005). This point is critical, as the cohorts were asked to report their weekly physical activity themselves. Literature suggests possible bias in reporting the exact duration of exercise, possibly due to social pressure or to inexperience, especially in the case of infrequent individual practicing or in settings without clear beginning and end time, i.e. training alone and/or at home (Rzewnicki, Auweele, & De Bourdeaudhuij, 2003). Rzewnicki found that 74% of the population tend to over-report the time spent exercising. Since individual variability is quite high, this could majorly influence results in experiments with small samples. In our study, there could be differences in accuracy in the different groups. Climbers and boulderers practice in groups, in an exterior location exterior rather than in their own home. Therefore, planning exercise times and places is essential, and makes tracking accurate exercise duration easier. Issues with self-reporting lead to a further dispute with potential implications in this study. Since errors in self-reporting might not be conscious, it does imply a distorted perception of one's fitness. Nonetheless, perceived fitness might be more important than actual fitness with regard to coping. Evidence suggests the existence of a placebo effect (Crum & Langer, 2007), and underlines the importance of perceived fitness on mood, self-efficacy, stress, and even variables such as weight, hip-to-waist ratio, and blood pressure (Plante et al., 2007; Crum & Langer, 2007). The

lack of consensus in literature makes it difficult to weigh the implications of real and perceived activity time on chronic stress levels.

In conclusion, according to literature, there should be at least a small, significant difference in overall stress levels between boulderers and the control group, but it could not be confirmed in this sample. Bias in self-reporting and the placebo effect of perceived fitness could explain why such a correlation was not established in the present study. Implications for future research will be developed in section 4.6.

### 4.2.2 Climbing and *social isolation*

There was no significant difference between climbers and non-active individuals, except in one category (*social isolation*, $p= 0.0327$). Similarly to boulderers, climbers did not score particularly low ($\text{med}_{\text{climbers}}= 52.00$, IQR= 7.00; $\text{med}_{\text{boulderers}}= 53.00$, IQR= 11.50) but the control group scored rather high (med= 58.00, IQR= 9.00). Qualitatively, it does not mean that climbers and boulderers did not perceive stress related to social isolation, but that non-active individuals felt especially burdened. This result is compliant with Klaperski's studies on the stress-buffering effect of physical activity, in which she noted that under stress, both (chronically) active and non-active individuals experience varabilities in their psychological well-being, but that non-active individuals react much stronger (Klaperski et al., 2013). However, it is interesting to note that the only category for which groups present a significant difference concerns social connections, and more precisely social isolation. While the categories *social overload* and *social tension* also have a social dimension, their essence is different. The former considers more closely the weight of responsibility taken towards others, while the latter emphasises conflicts which are due to differences of opinions between the participant and their environment. On the other hand, the questions in the

category *social isolation* address the lack of contact with friends and the impossibility to talk about one's own problems. Here, the social aspect of climbing and bouldering might be more important in the coping mechanism than the physical activity itself. One might have expected more staggered values between climbers and boulderers, due to the almost obligatory presence of a belayer during a climb. However, social contact differs in quality and quantity in both disciplines and might explain the lack of difference: on one hand, rock-climbing is a physical activity which cannot be practised alone, contrary to bouldering. Due to the high risk, trust is necessary between a climber and their belayer. On the other hand however, the social aspect of climbing can be found in bouldering too, which can explain why the scores are so similar. Boulderers do not need a partner per se, but they often practice in group, especially in climbing gyms. Outdoors, they might need a partner to "spot" them, i.e. make sure they fall correctly on the crash-pad. Bouldering injuries may not seem as spectacular as climbings', but spotting nevertheless requires some level of trust and experience between partners. There is to this day no study on the different group compositions of climbers and boulderers, but it could be of interest, as network size can also affect social resources of stress coping (Cohen & Wills, 1985). Finally, all participants could have been socializing outside sport-related frames, or on online social networking platforms, for which there was no control in the present study. This social aspect could have skewed the results (Heinrichs et al., 2015), thus showcasing an example of the stress-buffering effect of social contacts rather than of physical activity.

## 4.3 Climbing and bouldering

The second part of the work hypothesis stipulates that climbers should be less subjected to chronic stress than boulderers. The results, however, did

not show any significant difference between either groups. The main argument for a difference in stress levels between regular rock-climbers and boulderers was based on previous studies on Sothmann's hypothesis, which asserts that due to the unspecificity of stress reactions to psychological stressors, exposure to a mild stressor would create habituation and ease the reaction to unrelated stressors, psychological and physiological alike (Sothmann et al., 1996). In this section, factors highlighting the difference between climbers and boulderers which might have influenced the results are discussed.

### 4.3.1 Indoor vs. outdoor climbing

Previous studies support the existence of stressors associated with rock-climbing: during climbs, high catecholamines secretions have been observed (Baláš et al., 2017), and the link with anxiety, eustress and flow is undoubted (Csikszentmihalyi, 1975). However, participants (climbers and boulderers alike) reportedly trained mostly in climbing gyms (see Appendix, Fig. 5.7). Climbers and boulderers differed greatly in the percentage of days spent climbing outside compared to total days of climbing. 90% of interviewed boulderers did not allocate more than 16% of their time at outside crags, while this percentage was already reached for half of all climbers. This could be linked to climbing motivation and underline the differences between both disciplines. Naturally, outdoor and indoor climbing and bouldering present similarities, and techniques used in climbing gyms can be replicated outdoors. However, several factors are less linked to physical challenges than to psychological considerations. In climbing gyms, bolts and quickdraws are placed regularly, and falls are less spectacular. Outdoors, not only are bolts positions variables, the climber also has to place quickdraws before clipping. Being able to find the right holds is an outdoor challenge, while in

the gym, colourful holds offer few doubt about the right route. Finally, the presence of gym employees and other climbers means assistance on the spot is possible. Meanwhile, crags are sometime in remote areas, and being rescued fast might not be an option. There is an obvious discrepancy between the control one has on the environment in a gym setting or outdoors. The increased control on the climbing environment could reduce perceived risks and therefore associated stress (Sapolsky, 2017; Martha, Sanchez, & Gomà-i Freixanet, 2009). As a result, the cross-stressor adaptation would not apply. Furthermore, the lack of difference between climbers and boulderers could be due to the stress-buffering effect of physical activity being more important than the cross-stressor effect. Indeed, bouldering too offers protective factors such as active coping, social support, cardio-vascular health, or a heightened sense of accomplishment after solving a problem. For those reasons, climbing and bouldering alike have been proposed as therapies against depression (Luttenberger et al., 2015).

### 4.3.2 Acquired resilience

Secondly, resilience to stress is a trait which is in part inherited, but also partly built during personal life history (Haglund, Nestadt, Cooper, Southwick, & Charney, 2007; Waaktaar & Torgersen, 2013). Due to the potential implications in treatment of post-traumativ stress disorders (PTSD) or major depression disorders (MDD), the underlying neurobiology has been the focus of recent studies, although it isn't fully understood yet (Osório, Probert, Jones, Young, & Robbins, 2017). Acquired resilience has been observed not only in humans (e.g. overcoming parental divorce), but also in primates and rodents (Haglund et al., 2007). Individuals overcoming mildly stressful challenges in their (early) childhood will cope better in stressful situations later on in life. The concept of stress inoculation is thought to be

unspecific to the kind of stressor (Haglund et al., 2007). Biological embedding (i.e. alteration of physiology by experiences (Berens, Jensen, & Nelson, 2017)) occurs to four different periods of personal development, ranging from *in utero* development to adolescence (Karatsoreos & McEwen, 2013). For this study, it would mean taking on activities such as climbing as a child or adolescent could have more impact on stress resilience vs. beginning as an adult. In this sample, only three individuals started climbing before the age of 10, and the mean starting age was 19 years (± 6.19) (see Appendix, Fig. 5.6). At this age, it could take longer for climbing to have a long lasting impact on resilience.

### 4.3.3 Motivational differences in climbing

Finally, motivational differences amongst climbers and boulderers could be a factor too. Climbing, as a high-risk physical activity, is associated with a sense of adventure and communion with natural environment. But with the development of ever-safer climbing gear (Bright, 2014) and the increase in popularity, rock climbers can no longer be considered a homogenous group. They present differences for instance in their motivation (e.g. sense of adventure, competition, socializing, self-efficacy (Gomez, Hill, & Ackerman, 2008)) and their values (e.g. indoor vs. outdoor climbing (Ferrero Camoletto & Marcelli, 2020), traditional vs. sport climbing (Schuster, Thompson, & Hammitt, 2001)). Therefore, individuals that might not fit to the traditional psychological profile of climbers (see Llewellyn et al., 2008; Dishman et al., 2005) may still be part of the sample. As an example, whether one climbs predominantly indoors or outdoors does not reflect the same motivaion. Data shows that climbers did spend more climbing time outdoors than boulderers, yet the total range is far larger for climbers. The distribution indicates that within the climbers' group, motivation differs greatly

(see Appendix, Fig. 5.7). If both boulderers and climbers had been homogenous groups, a lower range in T-values and IQR could have been expected. However, the data shows no substantial trend in this aspect (see Fig. 3.1, 3.2 and Table 3.1).

## 4.4 Comparison to Schulz' sample and biological relevance

### 4.4.1 Norm population and study participants

All in all, the levels of stress amongst participants, independently of their level of physical activity, was in the middle- or high-range, compared to the norm population used to calibrate the test. Except for climbers in the category *social isolation* (med= 44.00) and physically inactive individuals in the category *pressure to succeed* (med= 48.00), all median values are equal to (23%) or above (70%) 50. This suggests levels of stress that are collectively higher for this sample than for the population described by Schulz (2004). The APA mentions that stress levels are highest amongst Millenials, mostly due to work or financial issues (American Psychological Association, 2012). But Schulz et al. used data from individuals aged 16 to 30 to establish conversion tables from raw scores to T-values (Schulz et al., 2004). These individuals are therefore arguably likewise preoccupied by the same issues. Nevertheless, the demographics do not completely fit with the samples I used. In Schulz (2004), the proportion of individuals aged 16-19 corresponds to 10% of the population, and women make up more than half their sample. Literature suggests heightened HPA axis activity and increased vulnerability to stress following puberty and throughout adolescence (E. F. Walker, Sabuwalla, & Huot, 2004; Stroud et al., 2009). Concerning women being

included in the sample, there is overwhelming evidence of gender disparities in chronic stress reports: while women do not have a higher vulnerability to stress than men (McDonough & Walters, 2001), they do report more overall chronic stress (Hamilton & Fagot, 1988; McDonough & Walters, 2001). Altogether, the inclusion of both women and adolescents in the calibration sample suggests disparities in average stress levels between them and participants of the present study. The conversion of raw scores to T-values is fitted so that a T-value of *50* represents the average level of stress in the sample. Conclusively, actual stress levels of climbers, boulderers and physically inactive individuals might be even higher if compared to a matching sample.

Concerning a potential interviewer or location effect, there were only disparities amongst boulderers (see Appendix, Table 5.5). Consequently, it cannot be argued that the presence of an interviewer could have influenced data in all three groups.

A ceiling or floor effect can also be ruled out, as data repartition shows no accumulation of T-values in the lower or higher range. Furthermore, as answers are subjective (from "never" to "very often"), participants can interpret for themselves the definition of each answer.

Lastly, potential negative seasonal effects can also be ruled out. Literature suggests seasonal differences in salivary cortisol concentrations (Persson et al., 2008). Like seasonal depression, cortisol concentrations are highest during winter months (Persson et al., 2008; Rosenthal et al., 1984). Data collection for Schulz' sample occured between spring and summer 2003 (Schulz et al., 2004). Similarly, recruitement for this study occured between July and October, when cortisol concentrations and stress levels are reportedly lowest.

### 4.4.2 Biological relevance

Schulz and colleagues (2004) provide correlation coefficients between the different stress categories and several other stress tests. Furthermore, they asked some participants to their study to indicate whether they experience physiological (e.g. circulatory, digestive or muscular) or psychological (e.g. depression) pains and issues. Unsurprisingly, *social isolation* correlates strongly with psychological complaints ($r$= 0.42) and feelings of depression ($r$= 0.35). This category also correlates strongly with physiological complaints concerning the digestive system ($r$= 0.26). However, other categories correlate much stronger with complaints expressed by patients. As a result, it is difficult to say with certainty that the scores obtained in the category *social isolation* have a notable effect on the physiological level.

## 4.5 Methodical limitations and implications

### 4.5.1 Methodical limitations

The results did not fully support the hypotheses. As has been discussed in the sections above, there is as of yet no complete consensus on neither the cross-stressor adaptation hypothesis nor the stress-buffer effect of physical activity, although literature research suggests a higher effect of the latter. Furthermore, underlying neurobiological processes are not fully understood either. However, methodical shortcomings could have played a role and will be examined in the following section:

- *Sample size* As mentioned by Haglund (2007), stress resilience is linked to a high and variable individuality, and coping mechanisms are influenced by personal experience, personality traits, coping mech-

anisms, and depends on age, life situation and stress situation. As a result, a small sample of participants is a clear disadvantage. Due to the timeline of data collection however, it was not possible to increase sample size. Ideally, there would have been at least between 80 and 100 participants in each group.

- *Confounding of objective and subjective stressors* Moreover, while the TICS has been proven reliable by many studies, there are very few who use it as a stand-alone method. The TICS is easy and cheap to use, but there are several drawbacks. First, in *Measuring Stress: A Guide for Health and Social Scientists*, Lepore (1997) defines the best method to measure chronic stress as one "that is free of subjective biases, or error", but states that often, researchers have to rely on social-sciences techniques, which are, by definition, not free of subjectivity. The issue with self-report questionnaire like the TICS, he says, is that objective and subjective stressors are confounded. As such, subjects give at the same time the description of their stressor and their own value assessment of it: it is not possible to objectively assess the link between the stressor and its effect on the stress level of the subject (Lepore, 1997; Kasten & Fuchs, 2018). For example, situation nr. 16 of the questionnaire is "times, at which I cannot repress sorrowful thoughts". Participants either have sorrowful thoughts, which they can repress or not, or they don't. Consequently, two participants, X1 and X2, can give the same answer ("never") even though one may not be experiencing the stressful situation (i.e. sorrowful thoughts) at all, the implied answer being *"I never have to repress sorrowful thoughts because I am not experiencing any"*. X1 might not be confronted to the situation at all, and X2 could be simply good at coping. Answers to this question do not indicate how X1 would react were they confronted to the situation.

- *Qualitative interpretation* Finally, the lack of indication concerning the qualitative interpretation is an issue. There is an example provided in the manual, but valid only for values further apart from the scores of the average population. As most studies have qualitatively interpreted their data with a further quantitative method, like salivary cortisol sampling, there are no real references or comparisons possible.

### 4.5.2 Implications for future research

A relevant issue of the present study is the self-reporting and risk of high subjectivity. Questionnaires are often used in stress research, because stress perception is sometimes more important than objective stress measurements, but they consequently lack in objectivity. Further studies should consider following measures:

- *Repeated and objective measures* The TICS could be administered several times to each subject, e.g. at a month' interval. Repeated measurement could help assess chronic stress more accurately. Coupled to qualitative interviews, the questionnaire would be more precise, and the answers less subjected to personal interpretation. An ideal objective method would be the use of saliva cortisol sampling, with active stress tests, which would allow a better analysis of perceived stress, and resolve the confounding issue.

- *Social buffer-effect* Finally, a long-term study with climbers training with automatic belaying devices, akin to those used in speed-climbing, could be implemented to test for the social buffer-effect; such a study design could e.g. prevent the influence of the social aspect of climbing, i.e. the intervention of a belayer. However, both

methods would be more costly and require more cooperation from participants and/or financial compensation. It is hardly applicable within the framework of a master thesis.

## 4.6 Applicability

Although the present study could not confirm either the stress-buffer nor the cross-stressor adaptation hypothesis, there is strong indication in literature that physical activity in general and climbing (both rock-climbing and bouldering) in particular could help reduce the negative effect of everyday stress on health. Furthermore, as a social activity for which active, problem-solving behaviour is necessary and is developed, climbing could help increase natural resilience and provide feelings of self-efficacy. Practiced outside, the effect might be heightened.

The decision not to include women in the sample was motivated in part by previous research indicating female subjects react differently to stress than men (see Kirschbaum et al., 1992; Schulz et al., 1998; Wolf et al., 2002; Merz et al., 2012). However, as there is strong indication that women suffer more than men from chronic stress, independently of age or economic status (Hapke et al., 2013), it seems crucial to underline the importance of stress research on women. New research on the therapeutic effect of physical activity or rock climbing should therefore include female participants in the sample, in an effort to fill the existing gender data gap.

## 4.7 Conclusion

Stress reactions are not merely an evolutionary mismatch. While physiological challenges might not be the main cause for stress nowadays, psycholog-

ical stress is still associated with social and reproductive status (Goymann & Wingfield, 2004). The high amount of social relationships in our modern environment means we can more easily be overloaded by psychological stress (Goymann et al., 2003). Therefore, the study of stress shows true multidisciplinarity: it can provide information on past challenges and behaviours, and has to be understood to palliate to the social and health questions it raises in our modern environment.

In this study, no satisfactory conclusion to the working hypothesis could be made, but directly investigating chronic stress levels of climbers and boulderers is a new approach. Contrary to previous findings in similar studies, there was no difference between physically active individuals and sedentary participants. However, the method used was new, in the sense that analysis relied solely on chronic stress perception by use of a questionnaire. Adding an objective stress hormone measurement, such as salivary cortisol, might be the key to obtain conclusive results. The matured method could then be applied to boulderers and climbers. Climbing, all disciplines confounded, is a sport in expansion and on the verge of becoming a mass sport. In a society were stress levels are ever-rising, the benefits of fear management and increased coping resources in everyday life could be of interest for people already presenting signs of depression or stress-related health problems. They could also help prevent their development in the first place. Furthermore, as climbing is a booming activity with economical implications, correctly managing the expansion in benefit of the disciplines with the most therapeutic effect is a factor to be considered. Therefore, further investigations should also concentrate on the differences between climbing and bouldering.

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# Chapter 5

# Appendix

## 5.1 Complementary information on participants

### 5.1.1 Climbers, boulderers and control group

Some complementary information on participants is provided. The information was not used per se in the study, but could be of interest for a deeper understanding of the results, as some may be a factor to stress levels. However, due to the small sample size, a multifactorial analysis could not be undertaken.

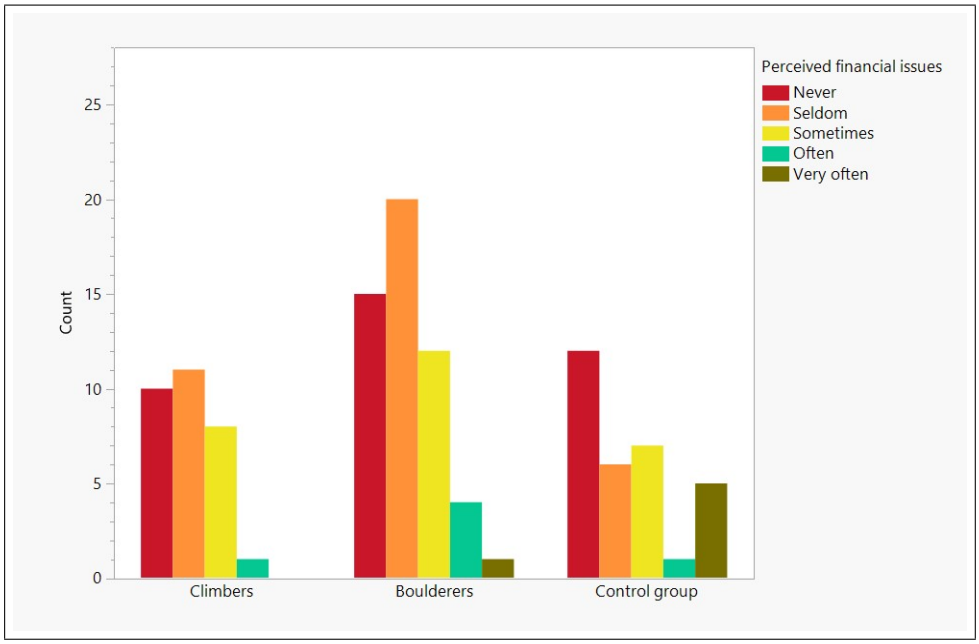


Figure 5.1: Perceived financial issues in all three groups. Participants were asked following question: "Do you regularly have financial problems?", and could answer at various degrees between "never" and "very often". The option "do not wish to answer" was provided, but was not chosen by any participant.

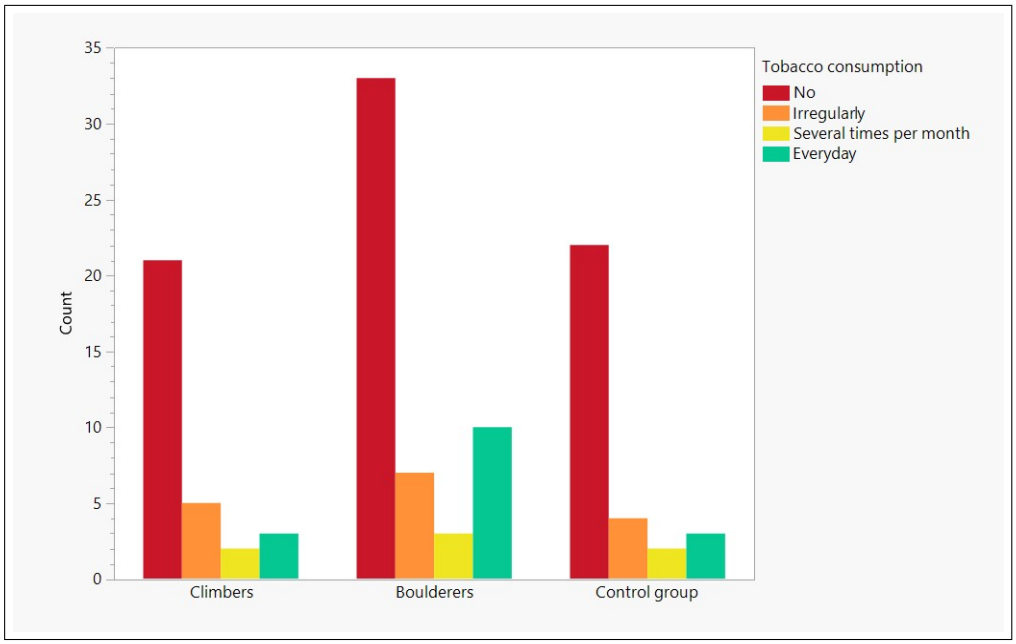


Figure 5.2: Usual tobacco consumption in all three groups. Participants were asked following question: "Do you smoke (tobacco, e-cigarettes...)?" and could answer at various degrees between "no" and "everyday". The option "do not wish to answer" was provided, but was not chosen by any participant.

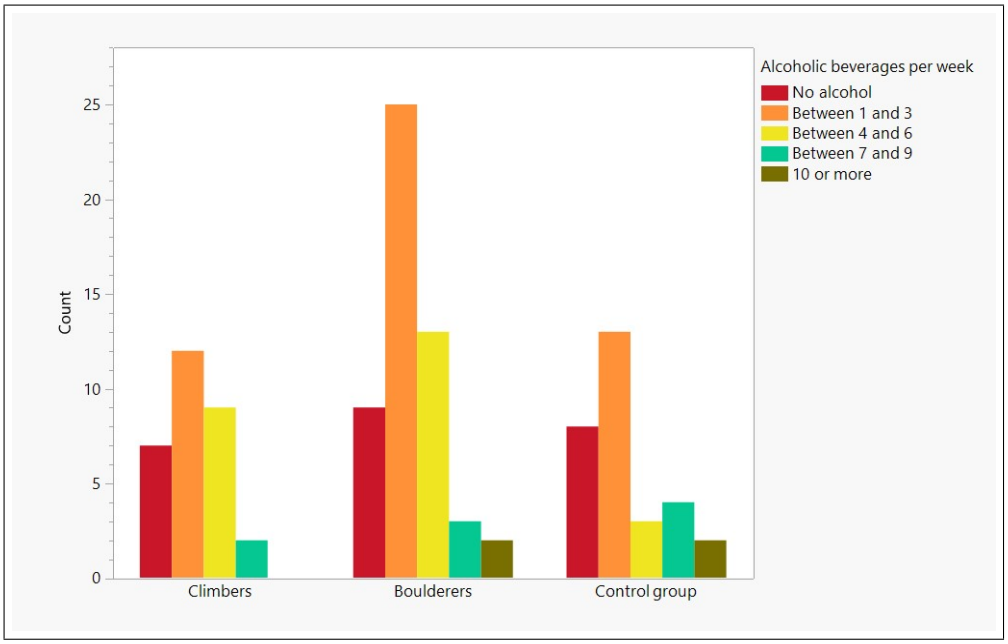


Figure 5.3: Average consumption of alcoholic beverages per week in all three groups. Participants were asked following question: "How many alcoholic beverages do you drink per week?" and could answer at various degrees between "no alcohol" and "10 or more". The option "do not wish to answer" was provided, but was not chosen by any particpant.

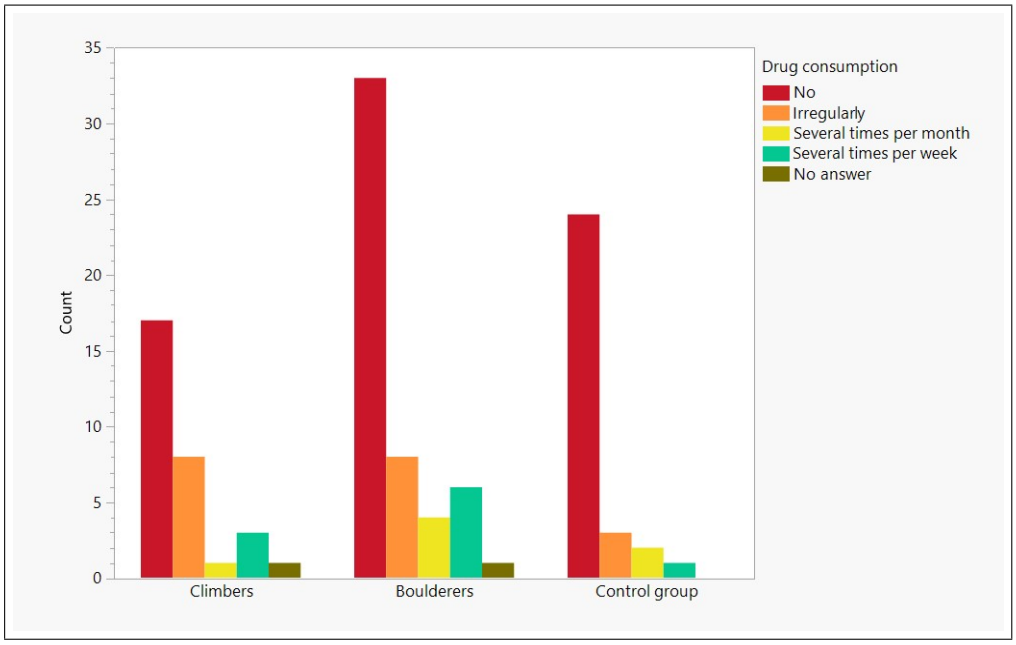


Figure 5.4: Usual drug consumption in all three groups. Participants were asked following question: "Do you take other kinds of drugs?" and could answer at various degrees between "no" and "several times per week". The option "do not wish to answer" was provided and was chosen by respectively one climber and one boulderer.

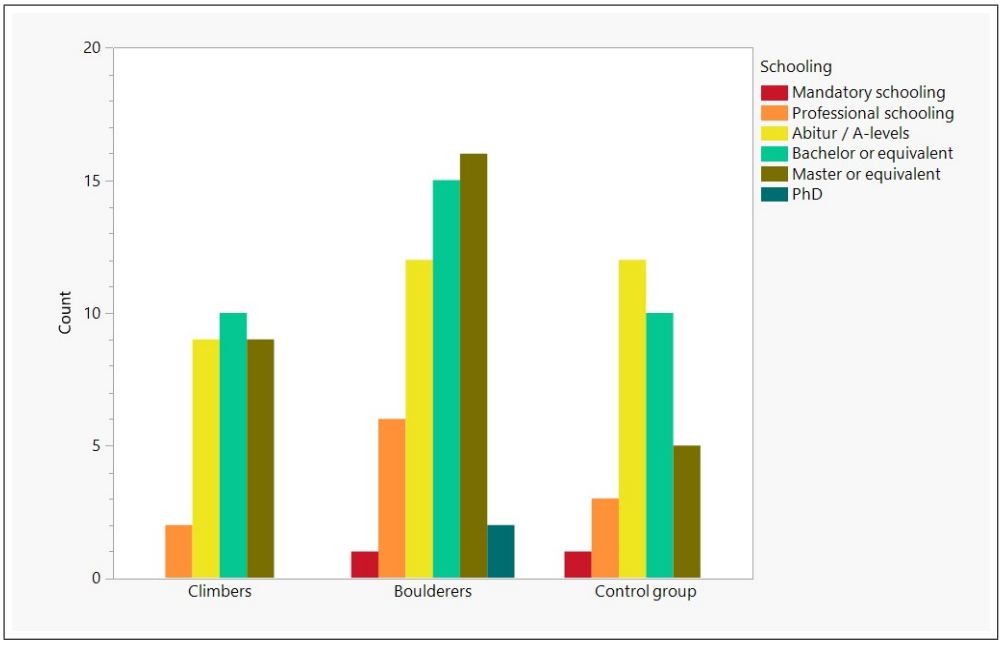


Figure 5.5: Highest educational level reached in all three groups. Participants were asked to indicate their highest degree of education and could answer at various degrees ranging from "mandatory schooling", separated into the German terms "Pflichtschule" and "Volksschule" ("Volksschule", however, was not chosen by any participant), to "PhD". The option "do not wish to answer" was provided, but was not chosen by any particpant.

### 5.1.2 Climbers and boulderers

In this section, complementary information about climbing experience and level of the participants is available. The information is based on self-report. Furthermore, the grading scale, proposed by Draper (2015) and used in this study, and the correspondance with usual scales (e.g. Fontainebleau and UIAA scales) are provided for a better understanding.

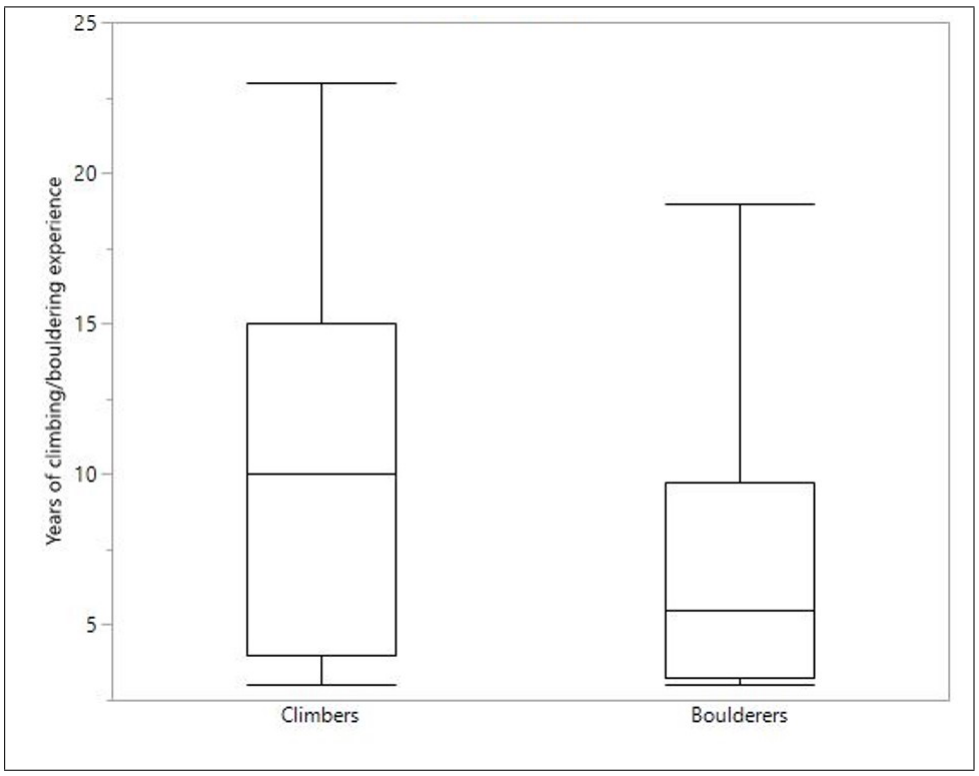


Figure 5.6: Years of climbing or bouldering experience (self-report). The mean number of years of climbing experience for climbers is 9.1 ± 6.23 years, and for boulderers 6.2 ± 4.3 years.

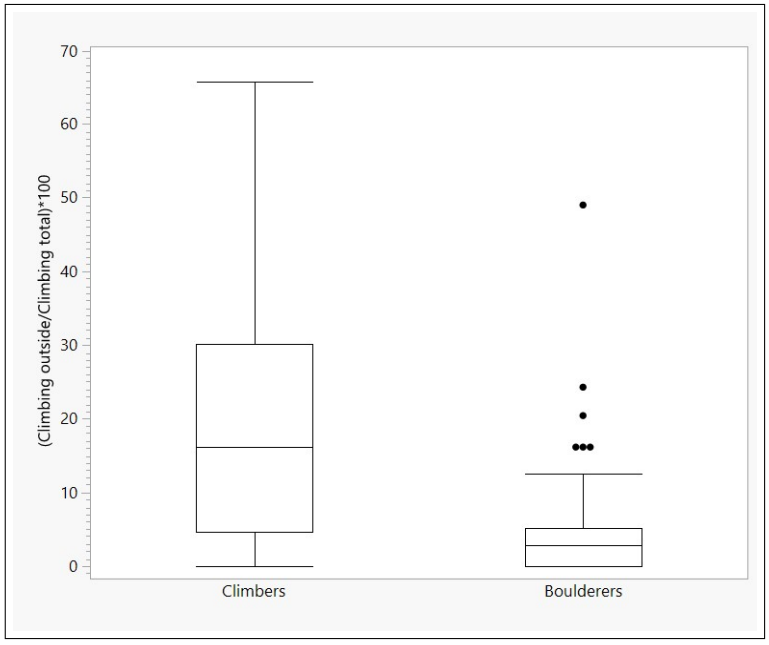


Figure 5.7: Percentage of climbing/bouldering time spent outside compared to total climbing/bouldering time in 2018 (self-report). The median climber spent 16.1% of their climbing time outdoors, while boulderers spent 2.8% of their total climbing time outdoors.

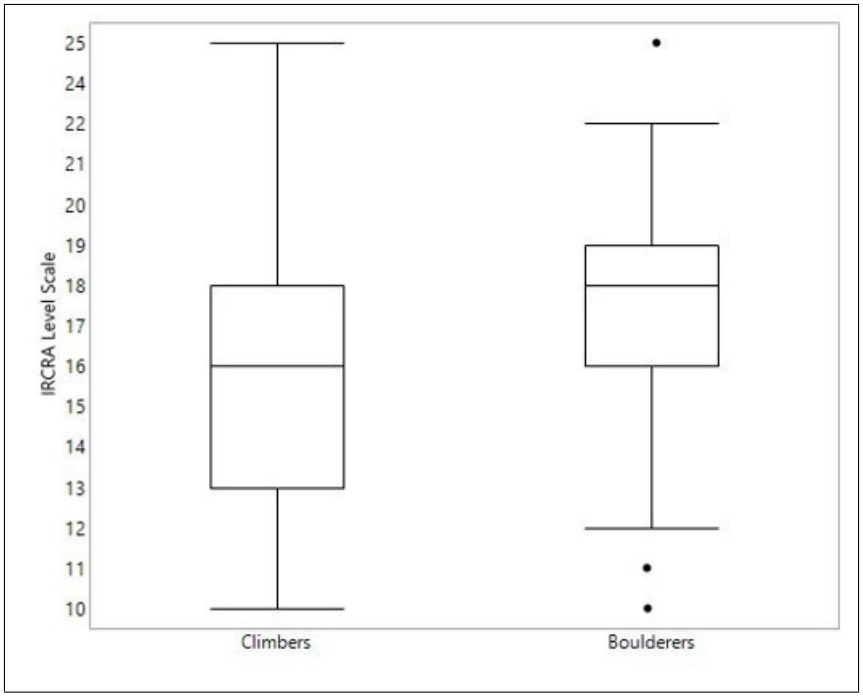


Figure 5.8: Climbing or bouldering level on the IRCRA Scale (see Fig. 5.9). Four individuals (two climbers, two boulderers) did not meet the required intermediate level, but were nonetheless taken into analysis. Indeed, other data from those individuals show a regular climbing/bouldering activity since respectively 8, 10 and 3 years.

| Climbing Group | | Vermin | Font | IRCRA Reporting Scale | YDS | French/sport | British Tech | Ewbank | BRZ | UIAA | Metric UIAA | Watts |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 5.1 | 1 | | 4 | I sup | I | 1.00 | |
| | | | | 2 | 5.2 | 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 | 4.00 | |
| | | | | 6 | 5.6 | 3+ | 4 | 12 | | IV+ | 4.33 | 0.00 |
| | | | | 7 | 5.7 | 4 | | 14 | V | V- | 4.66 | 0.25 |
| | | | | 8 | 5.8 | 4+ | | | | V | 5.00 | 0.50 |
| | | VB | < 2 | 9 | 5.9 | 5 | 5a | 16 | V sup | V+ | 5.33 | 0.75 |
| | | | | 10 | 5.10a | 5+ | | 18 | | VI- | 5.66 | 1.00 |
| | Intermediate (Level 2) Female | V0- | 3 | 11 | 5.10b | 6a | 5b | 19 | VI | VI | 6.00 | 1.25 |
| | | V0 | 4 | 12 | 5.10c | 6a+ | | | | VI+ | 6.33 | 1.50 |
| Intermediate (Level 2) Male | | V0+ | 4+ | 13 | 5.10d | 6b | 5c | 20 | VI sup | VII- | 6.66 | 1.75 |
| | | V1 | 5 | 14 | 5.11a | 6b+ | | | | VII | 7.00 | 2.00 |
| | | V2 | 5+ 6A | 15 | 5.11b | 6c | | 21 | 7a | VII+ | 7.33 | 2.25 |
| | | | | 16 | 5.11c | 6c+ | 6a | 22 | 7b | VIII- | 7.66 | 2.50 |
| | Advanced (Level 3) Female | V3 | 6A+ 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 | X | 10.00 | 4.50 |
| Elite (Level 4) Male | | V10 | 7C+ | 25 | 5.13d | 8b | 7a | 31 | 10b | | | 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 | V14 | 8B+ | 29 | 5.14d | 9a | 7b | 35 | 11c | XI+ | 11.33 | 5.75 |
| Higher Elite (Level 5) Male | | V15 | 8C | 30 | 5.15a | 9a+ | | 36 | 12a | | | 6.00 |
| | | V16 | 8C+ | 31 | 5.15b | 9b | | 37 | 12b | XII- | 11.66 | 6.25 |
| | | | | 32 | 5.15c | 9b+ | | 38 | 12c | XII | 12.00 | 6.50 |

Figure 5.9: Comparison of different grade scales, from Draper et al. (2015).

## 5.2 Statistical results

In this section, Tables 5.1, 5.2 and 5.3 present the results to the different statistical tests used for the analysis. Furthermore, Tables 5.4 and 5.5 show the results of the tests resepctively comparing data collected in summer or fall, and with or without an interviewer.

Table 5.1: $p$-values for the Shapiro-Wilk test on the normality of T-values' distributions. An * indicates a $p$-value under 0.05, and therefore non-normally distributed data.

| Stress category | Climbers | Boulderers | Control group |
|---|---|---|---|
| Work overload | 0.3581 | 0.3863 | 0.6195 |
| Social overload | 0.1538 | 0.3346 | **0.0174*** |
| Pressure to succeed | 0.0623 | 0.1263 | 0.6805 |
| Dissatisfaction at work | 0.1441 | 0.1408 | 0.7956 |
| Excessive demands at work | 0.3262 | **0.0374*** | **0.0295*** |
| Lack of social approval | 0.0710 | 0.1001 | **0.0455*** |
| Social tension | 0.2262 | 0.0707 | 0.5892 |
| Social isolation | 0.2350 | 0.4726 | 0.1282 |
| Chronic apprehension | 0.7328 | **0.0132*** | 0.1554 |
| SSCS | 0.3813 | 0.0634 | 0.3551 |

Table 5.2: Statistical values for one-way ANOVA. An * indicates a $p$-value under 0.05. $F$-ratio and degrees of freedom ($df$) are provided.

| Stress category | $F$-Ratio | $df$ | $p$-value |
|---|---|---|---|
| Work overload | 0.5097 | 2 | 0.6021 |
| Pressure to succeed | 1.624 | 2 | 0.2018 |
| Dissatisfaction at work | 1.1049 | 2 | 0.3349 |
| Social tension | 1.4647 | 2 | 0.2356 |
| Social isolation | 4.1695 | 2 | **0.0179*** |
| SSCS | 03290 | 2 | 0.7204 |

Table 5.3: Statistical values for Kruskal-Wallis' test. An * would indicate a $p$-value under 0.05. *Chi-square* and degrees of freedom ($df$) are provided.

| Stress category | *Chi-square* | $df$ | $p$-value |
|---|---|---|---|
| Social overload | 4.6520 | 2 | 0.0977 |
| Excessive demands at work | 0.2153 | 2 | 0.8980 |
| Lack of social approval | 1.5256 | 2 | 0.4664 |
| Chronic apprehension | 0.0380 | 2 | 0.9812 |

Table 5.4: Results of the Wilcoxon test to analyse the potential effect of the period of the year (summer vs. fall) at which data was collected. Data collection spanned from July 2019 to October 2019. As there were few data points in August and October, July and August were grouped in one period, and September and October as one period too. According to the Wilcoxon test, the period of data collection had no incidence on T-values, except in one case (*dissatisfaction at work*, control group, $p$= 0.037).

| | Climbers | | | Boulderers | | | Control group | | |
|---|---|---|---|---|---|---|---|---|---|
| | n SUMMER= 7, n FALL= 24 | | | n SUMMER= 31, n FALL= 21 | | | n SUMMER= 13, n FALL= 18 | | |
| Stress category | $S$ | $Z$ | $p$-value | $S$ | $Z$ | $p$-value | $S$ | $Z$ | $p$-value |
| Work overload | 151.5 | 1.889 | 0.0645 | 588 | 0.579 | 0.562 | 212 | 0.140 | 0.888 |
| Social overload | 91 | -0.972 | 0.331 | 580 | 0.429 | 0.667 | 200.5 | -0.282 | 0.778 |
| Pressure to succeed | 78.5 | -1.563 | 0.118 | 542 | -0.262 | 0.794 | 212 | 0.141 | 0.888 |
| Dissatisfaction at work | 137.5 | 1-185 | 0.236 | 525 | -0.579 | 0.562 | 260.5 | 2.089 | **0.037*** |
| Excessive demands at work | 135.5 | 1.097 | 0.273 | 594.5 | 0.702 | 0.483 | 187.5 | -0.804 | 0.422 |
| Lack of social approval | 117 | 0.215 | 0.829 | 623 | 1.234 | 0.215 | 203.5 | -0.162 | 0.871 |
| Social tension | 129 | 0.786 | 0.432 | 555.5 | -0.009 | 0.993 | 225 | 0.664 | 0.507 |
| Social isolation | 117 | 0.214 | 0.831 | 457 | -1.853 | 0.064 | 193.5 | -0.562 | 0.574 |
| Chronic apprehension | 136 | 1.115 | 0.2265 | 553.5 | -0.005 | 0.963 | 204.5 | -0.121 | 0.904 |
| SSCS | 136 | 1.112 | 0.266 | 611 | 1.01 | 0.313 | 200.5 | -0.281 | 0.779 |

Table 5.5: To find out if there was a difference in T-values depending on the way data was collected, and to determine if the presence of an interviewer may have had an importance, a Wilcoxon test was performed. Data was split into two categories answering the question: "was the questionnaire administred by an interviewer?". For climbers and physically inactive individuals, the wide majority answered online. Frequency of online and live answers was almost uniform for boulderers. No difference between live and online answers could be observed for either climbers or physically inactive individuals. However, half the stress categories present a significant difference ($p$ <0.05, indicated by an *****).

| | Climbers | | | Boulderers | | | Control group | | |
|---|---|---|---|---|---|---|---|---|---|
| | n $_{\text{YES}}$= 9, n $_{\text{NO}}$= 22 | | | n $_{\text{YES}}$= 29, n $_{\text{NO}}$= 23 | | | n $_{\text{YES}}$= 6, n $_{\text{NO}}$= 25 | | |
| Stress category | $S$ | $Z$ | $p$-value | $S$ | $Z$ | $p$-value | $S$ | $Z$ | $p$-value |
| Work overload | 127.5 | -0.699 | 0.485 | 729.5 | 2.208 | **0.027*** | 82 | -0.676 | 0.499 |
| Social overload | 120.5 | -1.005 | 0.315 | 677.5 | 1.246 | 0.213 | 100.5 | 0.201 | 0.841 |
| Pressure to succeed | 148 | 0.153 | 0.879 | 599.5 | -0.175 | 0.861 | 99.5 | 0.151 | 0.880 |
| Dissatisfaction at work | 149 | 0.197 | 0.844 | 730.5 | 2.225 | **0.026*** | 88.5 | -0.351 | 0.725 |
| Excessive demands at work | 135 | -0.373 | 0.709 | 699.5 | 1.656 | 0.098 | 95.5 | -0.00 | 1.000 |
| Lack of social approval | 256 | 0.507 | 0.612 | 739.5 | 2.404 | **0.016*** | 93.5 | -0.101 | 0.919 |
| Social tension | 154.5 | 0.439 | 0.661 | 740 | 2.408 | **0.016*** | 85.5 | -0.503 | 0.615 |
| Social isolation | 156 | 0.503 | 0.615 | 650.5 | 0.749 | 0.454 | 91.5 | -0.201 | 0.841 |
| Chronic apprehension | 139.5 | -0.175 | 0.861 | 690 | 1.481 | 0.139 | 92.5 | -0.151 | 0.879 |
| SSCS | 139 | -0.196 | 0.845 | 724.5 | 2.116 | **0.034*** | 91.5 | -0.201 | 0.841 |

## 5.3 Exclusive boulderers and sporadic climbers

Some self-reported boulderers mentioned occasional rock-climbing activity. However, there was no indication of climbing frequence or activity. Therefore, the "boulderer" group was scinded into sporadic climbers and exclusive boulderers. In the following tables and figures, both groups are compared. As there was no real difference between both groups, they were kept as one group (i.e. boulderers) in the main analysis.

Table 5.6: Comparison of sporadic climbers and exclusive boulderers. An * indicates normal distribution of the data. Mean is followed by SD.

| Label | Sporadic climbers | Exclusive boulderers |
|---|---|---|
| N | 39 | 13 |
| Age | 27.55 ± 3.77 | 27* ± 4.34 |
| BMI | 22.83 ± 2.11 | 22.3* ± 1.9 |
| Years of experience | 6.43 ± 4.59 | 5.38 ± 3.66 |
| Days outside last year | 8.79 ± 14.02 | 5.15 ± 7.48 |

Table 5.7: $p$-values for the Shapiro-Wilk test on the normality of T-values' distributions for sporadic climbers and exclusive boulderers. An * indicates non-normal distribution.

| Stress category | Sporadic climbers | Exclusive boulderers |
|---|---|---|
| Work overload | 0.4740 | 0.2301 |
| Social overload | 0.3440 | 0.1263 |
| Pressure to succeed | 0.0570 | 0.9561 |
| Dissatisfaction at work | **0.0378*** | **0.0352*** |
| Excessive demands at work | 0.1125 | 0.4378 |
| Lack of social approval | 0.1853 | 0.7249 |
| Social tension | 0.2749 | 0.1678 |
| Social isolation | 0.4187 | 0.9627 |
| Chronic apprehension | **0.0143*** | 0.6575 |
| SSCS | 0.1615 | 0.4885 |