Current Psychology (2023) 42:2680–2692
https://doi.org/10.1007/s12144-021-01593-y

# Exploring the relationship between mindfulness and rock-climbing: a controlled study

Katherine A. Wheatley [1]

Accepted: 5 March 2021 / Published online: 19 March 2021


## Abstract

Mindfulness is a meditative practice that has received increasing attention within positive psychology as an effective tool to increase wellbeing and decrease anxiety. Previous research has demonstrated that rock-climbers have a higher endorsement of mindfulness and life satisfaction than the general population; yet to date, no research has empirically explored the relationship between mindfulness and rock-climbing. In the current study fifty-nine participants ($\overline{x}$ = 20.63, SD = 1.60) were asked to complete measures of mindfulness, wellbeing and anxiety before and after participating in an 'intervention'. The intervention consisted of a mindfulness activity followed by either indoor bouldering (a form of rock-climbing) versus a physical activity control. A mixed ANOVA revealed that participation in bouldering increased the measure of mindfulness significantly more than the control activity; however, no significant group differences were found for the measures of wellbeing and anxiety. A regression analysis then revealed that group condition accounted for 33% of the variance in post-intervention mindfulness levels when controlling for baseline levels of mindfulness. This is the first study to experimentally demonstrate that engagement with rock-climbing increases mindfulness in young adults. Theoretically, the results have implications for our understanding of "flow" and optimal human experience. Practically, the study highlights the potential to implement rock-climbing as a resilience-building activity and integrate the sport within therapeutic frameworks.

**Keywords** Mindfulness · Rock-climbing · Bouldering · Wellbeing · Anxiety · Flow

## Background

### Mindfulness: A Review in the Context of Wellbeing & Anxiety

Over the past decade, there has been increasing attention directed towards positive psychology and understanding methods of nurturing positive mental health (Rybak, 2013). Since the 1970s, a prominent research topic within positive psychology has been the meditative practice mindfulness (Williams & Kabat-Zinn, 2013). The majority of psychological and neuroscientific studies define mindfulness as "paying attention in a particular way: on purpose, in the present moment and non-judgementally" (Kabat-Zinn, 1994). This definition was put forward by John Kabat-Zinn, who has been a pivotal figure in translating Buddhist mental training techniques into the context of psychological interventions (Malinowski, 2013). Kabat-Zinn's definition eloquently encompasses the three principal components of mindfulness: intention, attention and attitude (Shapiro et al., 2006). Intention, defined as the aims and motivations which underlie a practice, is argued to significantly impact on the benefits drawn from mindfulness (Shapiro & Schwartz, 2000); while attention and attitude embody the actual practice. Attention refers to being fully aware of one's internal experience, whereas attitude is concerned with the quality of the attention, being accepting, kind and curious (Ivtzan, 2016). Evidence indicates that higher levels of mindfulness are associated with life satisfaction (Schutte & Malouff, 2011), and higher degrees of the non-judgemental aspect of mindfulness are predictive of lower levels of stress and anxiety symptomology (Cash & Whittingham, 2010). Furthermore, improvements in mindfulness have been found to mediate between formal mindfulness practice and increases in psychological wellbeing (Carmody & Baer, 2008), indicating that symptom reduction and improved wellbeing are consequential of increased mindfulness, which is the result of mindfulness practice.

✉ Katherine A. Wheatley
kat.a.wheatley@gmail.com

[1] Nottingham Climbing Centre, University of Nottingham, Nottingham, UK

Psychological wellbeing is a multifaceted concept which, at its most basic level, refers to positive mental states such as happiness and life satisfaction (Robertson, 2018). Anxiety, on the other hand is a feeling of unease, worry or fear that ranges from mild to severe (National Health Service, 2020). Most people feel anxiety at certain times, which is normal, however when symptoms are ongoing and severe it can have a significant negative impact on quality of life (Olatunji et al., 2007). Unsurprisingly, levels of anxiety have been found to be inversely correlated with measures of wellbeing (Malone & Wachholtz, 2018), as people living with it are often unable to live the life they would like to (Swift et al., 2014). There is an increasing body of literature supporting mindfulness training, such as mindfulness-based stress reduction (MBSR) and mindfulness-based cognitive therapy (MBCT), as a means to improve wellbeing and anxiety symptomology. Numerous systematic reviews and meta-analyses demonstrate that these interventions lead to clinically significant increases in wellbeing and reduction in anxiety in the general population (Gu et al., 2016; Heckenberg et al., 2018). Reviewers stress the robustness of these results, in that the positive effects are maintained at follow-ups, do not change in relation to publication date, or number of sessions (Hofmann et al., 2010). Individual studies in sport-specific contexts have similar findings. Foster (2017) found a significant direct effect of mindfulness on both sport-specific wellbeing and global wellbeing. Similarly, retired Iranian football players have been found to report reduced stress, anxiety and depression and improved psychological wellbeing following an MBSR program (Norouzi et al., 2020). This evidence, along with the multifariousness of experimental cohorts that have been tested, suggests that mindfulness training is an efficacious, effective and flexible tool to improve wellbeing and anxiety within therapeutic frameworks.

Research assessing mindfulness outside of therapeutic frameworks, such as MBSR and MBCT, although less vast, is also positive. In 2018 Blanck et al. identified and reviewed 18 controlled trials assessing the efficacy of stand-alone mindfulness exercises in non-clinical populations. They found positive reductions on anxiety when compared to controls, with small to medium effect sizes, which remained significant when corrected for potential publication bias. According to the reviewers, "this demonstrates that the mere, regular performance of mindfulness exercises is beneficial, even without being integrated in larger therapeutic frameworks" (Blanck et al., 2018, pp. 25).

However, in real-life settings non-clinical populations are unlikely to engage with mindfulness via in-person training programmes. Caution should therefore be taken to avoid generalizing these results to cohorts that engage with mindfulness through different mediums. Indeed, a rapidly rising medium by which the general population are engaging with mindfulness is via smartphone applications (Economides et al., 2018). Due to the recent advancement of these applications, less is known about the efficacy of these mediums; however, some randomised controlled trials (RCT) have demonstrated positive effects. For instance, Economides et al. (2018) compared an introductory mindfulness meditation program, delivered via the Headspace app, to a psychoeducational audiobook control. Both interventions effectively reduced stress; yet only the mindfulness app improved irritability, affect and stress resulting from external pressure. Similar results were found by Walsh et al. (2019) who compared mindfulness training to cognitive training, both delivered via smartphone apps. They found that participants who engaged with the mindfulness app reported significantly more positive changes in subjective wellbeing, namely mood improvement, reduced stress and greater attentional control. These trials suggest that smartphone apps such as Headspace are an effective medium to deliver mindfulness training and that engaging with them positively influences wellbeing and anxiety symptomology. However, given the finite number of studies in this area, caution should be taken when interpreting this information. More trials, along with stringent reviews, are needed before full confidence can be had as to whether the findings are robust.

## How Does Mindfulness Practice Relate to Rock-Climbing?

It appears evident that mindfulness is a well-established concept in the context of mental health. However, what is perhaps more surprising is that mindful practice is also rooted within the rock-climbing community. Many authors such as Arno Ilgner (2003) have written about mindfulness training as a way to improve climbing ability by increasing focus, motivation, and overcoming fears. Clinical specialists that work with competitive rock-climbers have also noted the observational benefits of integrating mindfulness training for sport-performance. Anna Enright, for example, is a psychiatric clinical nurse specialist who incorporates training to focus on breath, body awareness, and visualising peak performance in her work with youth climbing teams. Enright (2016, para.4) describes climbing as an "inherently mindful activity… If it is challenging, we lose focus and forget to scan ahead, breathe and allow our body to direct us… If mindful, one can observe this is happening and using the breath, the eyes, and the feel of the holds can help shift the focus back to the present climb". Such observations have also been recorded by healthcare organisations such as the National Health Service (NHS). According to the NHS (2020) rock-climbing alleviates the symptoms of mental health problems by keeping you focused, clearing your mind of outside worries, and helping you to build your confidence and self-esteem. Upon analysis, this recount reflects characteristics of Shapiro et al.'s (2006) aforementioned components of mindfulness. Specifically, remaining focused and clearing the mind of worries appears to map

onto the components of attention and attitude, respectively. This indicates that rock-climbing offers a unique combination of physical and mental health benefits; as of yet, these have not been empirically validated. Evidence that rock-climbing promotes the development of psychological skills is not merely anecdotal, however. Young and Knigth (2014), for example, demonstrated that elite rock-climbers display a high rate of robust mental skill that allows them to remain present in the moment and perform under high stress conditions. Furthermore, experienced athletes scored significantly higher on measures of coping skill than leisure and novice athletes, suggesting a correlation between engagement in high-risk sports and psychological skills (Young & Knigth, 2014). It has been suggested that this is due to the nature of extreme sports such as rock-climbing, in that they require robust psychological skills to navigate unpredictable and adverse sport environments (Smith et al., 1995). The ability to remain present and in control in spite of fear can mean the difference between success and failure (Rooney, 2017).

In relation to mindfulness skills specifically, there is a distinct lack of research. Following a rigorous literature search one relevant study was identified, which explored the relationship between mindfulness and life satisfaction in rock-climbers and the general population (Steinberg, 2011). Analyses revealed that the rock-climbers had higher endorsements of mindfulness, positive affect and life satisfaction; and revealed a correlation between mindfulness, psychological wellbeing and rock-climbing. According to Steinberg (2011, pp.62), "The significant endorsement of mindfulness by the rock-climbers in this study provides statistical evidence for the potential benefit of using rock climbing as an activity to help facilitate mindfulness". Indeed, one possible explanation of Steinberg's finding is that the high endorsement of mindfulness is consequential of rock-climbing. Thus, based on the reviewed research demonstrating that mindfulness practice promotes wellbeing, if rock-climbing embodies mindfulness practice then rock-climbing should promote psychological wellbeing (see Fig. 1a). This theory is consistent with the evidence demonstrating that engagement with high-risk sports promotes a robust psychological skillset (Rooney, 2017; Smith et al., 1995; Young & Knigth, 2014); however, it is not the only explanation for Steinberg's findings. The other possibility is that mindfulness and engagement with rock-climbing have a common causal factor, such as a facet of

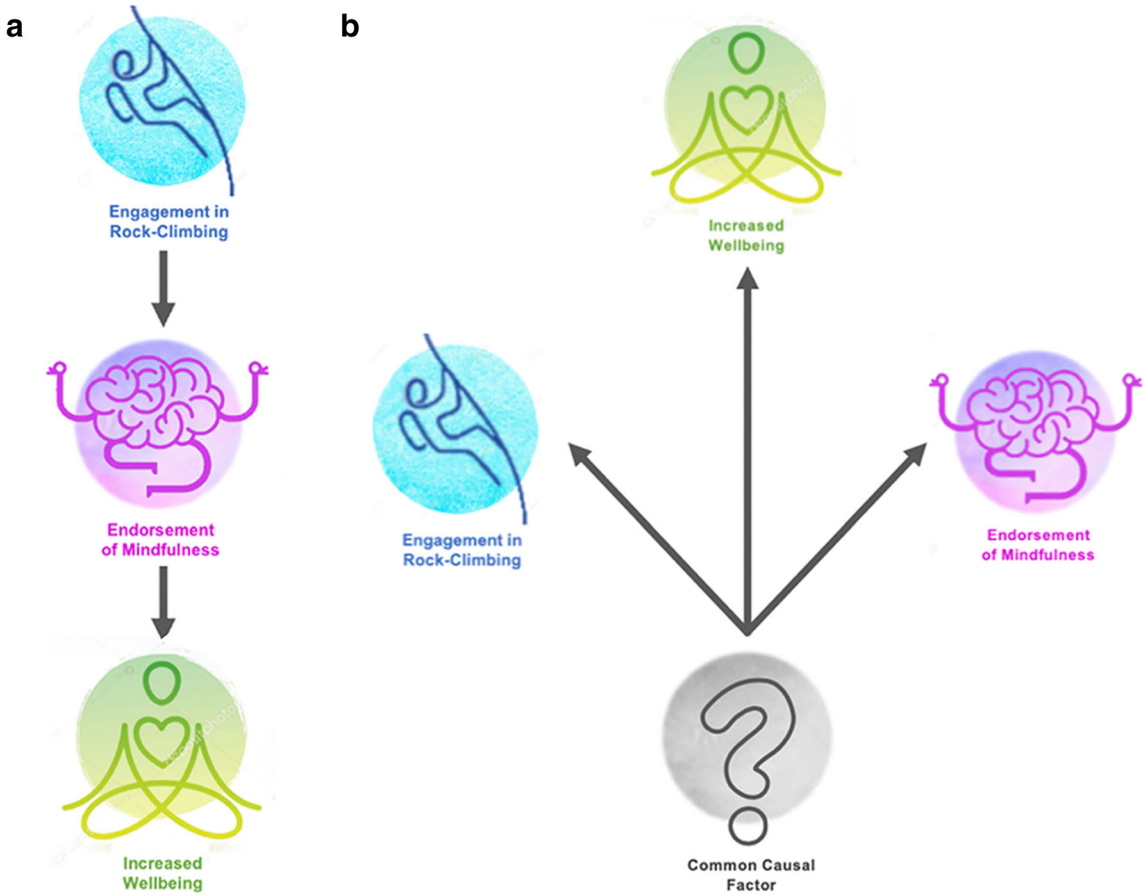


**Fig. 1** Conceptual illustrations of the possible relationships between rock-climbing, mindfulness and wellbeing. *Note.* (**a**) and (**b**) illustrate the possible explanation of Steinberg's (2011) findings discussed in this background of this paper

personality. Meta-analyses have indicated that low neuroticism is associated with both mindfulness (Hanley & Garland, 2017) and engagement with high-risk sports (McEwan et al., 2019) such as rock-climbing. Therefore, rock-climbing and mindfulness may be independent consequences of low neuroticism, with this predicting wellbeing (see Fig. 1b). As of the time of writing, no empirical research had been conducted attempting to determine the nature of the relationship between rock-climbing and mindfulness, thus highlighting a striking gap in the psychological literature.

### Purpose of the Current Study

This purpose of this study was to explore the relationship between rock-climbing, mindfulness and wellbeing in a non-clinical sample. The majority of research has focused on the benefits of mindfulness training for wellbeing, anxiety and rock-climbing performance, revealing a distinct lack of research as to the potential mental benefits of rock-climbing. And, while Steinberg (2011) has asserted that rock-climbing may facilitate mindfulness, at the time of writing this had not been empirically investigated. Hence, an aim of this experiment was to fill this gap in the literature by assessing whether participation in rock-climbing would increase measures of mindfulness when compared to a control group. Based on the evidence demonstrating that mindfulness practice improves wellbeing and anxiety symptomology, this study also aimed to investigate how participation in rock-climbing would affect these variables. This was achieved by exploring changes in measures of mindfulness, anxiety and wellbeing following an 'intervention', which for the purposes of this study is defined as participation in a mindfulness exercise followed by either rock-climbing or a control activity. To the best of my knowledge, this was the first controlled study to investigate the relationship between mindfulness and rock-climbing.

## Methods

### Participants

Due to the lack of previous research an a priori power analysis could not be performed. Instead, recruitment estimations were informed by Luttenberger et al.'s (2015) study of bouldering and depressive symptomology which found a significant medium effect size according to Cohen's *d* with 47 participants. In the current study 68 participants were recruited using two opportunity samples, advertised via posters and social media posts. Climbing abilities ranged from complete-beginners ("never having climbed") to advanced-beginners ("having climbed once or less a year"); and experience using mindfulness apps ranged from "never" to "once a month". Eligible participants were over the age of 18 and physically able to participate in the activities described in the procedure. Additional eligibility criteria were included for participants in the bouldering cohort to minimise the risk of harm. As such, participants were pre-screened and not invited to participate in the bouldering activity if they reported a history of epilepsy, panic attacks, or scored above clinical 'caseness' for anxiety or depression in the Hospital Anxiety and Depression Scale (see materials). Written informed consent was obtained from all participants at T0 and T1. All participants were debriefed following participation.

### Procedure

This study used a quasi-experimental design in which the independent variable was group allocation: bouldering versus control. The control sample were required to participate in regular strength & conditioning (S&C) training and thus were recruited through the University of Nottingham (UoN) sports teams. As such, random allocation was not possible. The three dependent variables (mindfulness, wellbeing and anxiety) were collected at two timepoints: baseline, a week prior to the intervention (T0); and follow-up, immediately after the intervention (T1). Participants that met the exclusion criteria were screened out following collection of T0 data. The intervention consisted of a mindfulness activity, completed by all participants, followed by engagement in either a climbing or control activity. This study was approved by the UoN School of Psychology ethics committee and a full risk assessment was completed.

**Mindfulness Activity** The purpose of the mindfulness activity was to set the intention of mindful participation, which has been identified as a principal component of mindfulness (Shapiro et al., 2006). Participants were seated in a quiet room with no distractions in group sizes ranging from 7 to 30 individuals. They were instructed to listen to three 3-min auditory guided meditations selected from the Headspace app, as at the time of writing Headspace was the only evidence-based mindfulness app available, had been downloaded more than 64 million times and was the highest scoring mindfulness-based app according to the Mobile Application Rating System (Mani et al., 2015). The meditations were called "Breathe", "Body Scan" and "Refresh" and were chosen to encapsulate Kabat-Zinn's (1994) core elements of mindfulness. The meditations were played from the researcher's laptop with a 1-min break between each; the order of presentation did not vary between groups so as not to introduce confounding variables. This activity took 11-min in total.

**Climbing Activity: Bouldering** Indoor bouldering is a form of rock-climbing whereby people climb on artificial climbing structures (up to 4.5 m in height) without a rope. Bouldering walls offer a variety of routes that vary in difficulty, which

allows people of different fitness levels to easily boulder together without being underchallenged or overstrained. The bouldering activity took place at the Nottingham Climbing Centre (NCC) in four groups of 7–13 participants. Prior to attending participants signed a waiver and completed a bouldering induction, allowing them to boulder as unsupervised adults. The bouldering activity consisted of warming-up exercises led by the researcher, who is a qualified Climbing Wall Instructor; followed by 1-h of unsupervised bouldering. The researcher was present at all times however only offered instruction relating to safety guidelines.

**Control Activity: Strength & Conditioning (S&C)** To be eligible to partake in this activity participants had to attend S&C training as part of a sports team, as the researcher was not qualified to conduct this activity. The S&C training involved using gym-equipment as part of a regular programme to improve sport performance over time. Exercise has been shown to increase wellbeing therefore this activity, which requires similar levels of exertion as bouldering, was identified as a suitable control. The S&C activity took place at the David Ross Sports Village (DRSV) in one group of 30 and lasted 1-h. The researcher was not present for this activity.

## Measures

Questionnaires were administered on Qualtrics (http://www.qualtrics.com) and complied with general data protection regulations. The initial questionnaire completed at T0 (see supplementary material) collected demographical information, to gather relevant sample characteristics such as climbing experience; and screening information, to assess suitability for the bouldering activity. The following measures, along with a unique identification code to match the questionnaires, were collected at T0 and T1:

**Hospital Anxiety and Depression Scale (HADS)** The HADS is a 14-item instrument designed to measure the levels of anxiety (HADS-A) and depression (HADS-D) that a person is experiencing (Snaith & Zigmond, 1986). Items are scored from 0 to 3, with items 1, 3, 5, 6, 7, 9, 10 and 11 being reversed scored. Scores below 7 indicate normal levels of anxiety and depression, scores of 8–10 indicate borderline symptoms, and scores above 11 indicate clinically significant symptoms. A literature review indicated that the HADS is highly correlated with other commonly used questionnaires and verified both the HADS-A (Cronbach's $\alpha = .83$) and HADS-D (Cronbach's $\alpha = .82$) were reliable measures of symptom severity (Bjelland et al., 2002). Therefore, this current study used the HADS-A as a measure of anxiety; and enlisted both subscales to pre-screen participants in the bouldering cohort. The score of each subscale ranges from 0 to 21, with scores of 11 or above indicating clinical 'caseness'; a term meaning symptomology is severe enough to be regarded as needing a clinical intervention. Thus, a score of 11 or above in the HADS-A or HADS-D was used as a cut-off to minimise risk to participants in the bouldering activity.

**State Mindfulness Scale for Physical Activity (SMS-PA)** The SMS-PA is a 12-item measure that is used to assess the specific experience of mindfulness in physical activity (Cox et al., 2016). 6-items assess state mindfulness of the mind, which refers to an awareness of thoughts and emotions; and 6-items assess state mindfulness of the body, which represents being present in one's physical experience. Items are scored from 0 to 4, with higher scores indicated higher endorsement of mindfulness. Initial validity tests have indicated that the SMS-PA provides reliable estimates of mental (Cronbach's $\alpha = .89$), physical (Cronbach's $\alpha = .90$), and overall mindfulness (Cronbach's $\alpha = .90$) at test and retest (Cox et al., 2016). As of the time of writing, the SMS-PA was the only available measure that facilitated the examination of state mindfulness in a physical activity context (Cox et al., 2016) and was therefore selected as a suitably sensitive measure of mindfulness in the current study.

**The Flourishing Scale (FS)** The FS is an 8-item instrument used to assess core aspects of psychological wellbeing; see supplementary materials for items and scoring. It provides a single measure of self-perceived wellbeing in important areas such as relationships, self-esteem, purpose and optimism (Silva & Caetano, 2013). Items are scored from 0 to 7, with higher scores indicating stronger psychological resources and strengths. Validity tests have indicated the FS has good psychometric integrity, scores highly on estimates of reliability (Cronbach's $\alpha = .87$) at test and retest and is strongly associated with other psychological wellbeing scales (Diener et al., 2009). It has been established as a viable measure for assessing wellbeing in student samples (Howell & Buro, 2015); and therefore, was selected as an appropriate measure of wellbeing for the current study.

## Analyses

Data analyses were conducted using IBM SPSS Statistics software, version 26. Intervention methods were used to investigate within- and between- group differences for measures of anxiety, mindfulness and wellbeing; effect sizes were calculated according to Cohen's *d*. Following this, a multiple linear regression (MLR) analyses was then conducted for dependent variables whereby change scores varied significantly between groups. This was done to assess how much of the variance was accounted for by group condition. Finally, analyses were repeated in a sensitivity analysis whereby the same exclusion criteria were applied to the control and boulder groups. All fixed effects were similar so these are reported only briefly below.

## Results

### Sample

Of the 68 participants that completed the baseline questionnaire 59 were included in the main analysis and 56 were included in the sensitivity analysis. Participants in the bouldering and control groups did not differ significantly in mindfulness experience or climbing experience; however, the groups did differ significantly in age and gender (see Table 1). Flow of participants, including reasons for exclusion and dropout, are presented in Fig. 2.

### Preliminary Analyses

Prior to analyses the dependent variables were tested for internal consistency, measured by Cronbach's $\alpha$. All the variables demonstrated high reliability at T0 (mindfulness: $\alpha = .73$; anxiety: $\alpha = .78$; wellbeing: $\alpha = .93$); however, at T1 only anxiety and wellbeing demonstrated high reliability (mindfulness: $\alpha = .67$; anxiety: $\alpha = .86$; wellbeing: $\alpha = .93$). Following this, single scores of mindfulness, anxiety and wellbeing were calculated at T0 and T1 for each participant. Each variable was then verified to see if parametric tests were suitable to use on the data. These preliminary analyses revealed that none of the variables violated the assumption of homogeneity of variances or the assumption of sphericity. One participant in the control group was identified as an extreme outlier and was therefore excluded from the analyses. Tests of normality indicated that mindfulness was not in violation of the assumption of normality, however wellbeing and anxiety were. A logarithmic transformation of wellbeing, reported as log(wellbeing), corrected for this violation. Transformations were unable to correct for normality in anxiety; however, values of kurtosis and skewness indicated this would not impact on the validity of the results when analysed using a robust parametric test (Schmider et al., 2010). As such, all the measures were analysed using a mixed ANOVA as this is a powerful test requiring smaller sample sizes and minimises family-wise error. It is important to note that the logarithmic transformation of wellbeing reversed the direction of the relationship; therefore, a negative relationship from log(wellbeing) at T0 and T1 represents an increase in wellbeing.

### Mixed ANOVA

Within-group comparisons were conducted to investigate whether the bouldering and control activities had caused a change in mindfulness, wellbeing and anxiety. Between-group comparisons were conducted to investigate whether the bouldering had affected any of the variables more than the control activity.

**Mindfulness** There was a significant main effect of time, $F(1, 57) = 22.74$, $p = .000$, $r = .53$, with contrasts revealing that mindfulness was significantly greater at T1 than T0, $F(1, 57) = 22.74$, $p = .000$, $r = .53$. There was no significant main effect of group condition, $F(1, 57) = .005$, $p = .942$, $r = .01$, indicating that mindfulness scores were similar for participants in the bouldering and control groups. There was a significant interaction effect between time and group condition $F(1, 57) = 10.77$, $p = .002$, $r = .34$. This effect indicates that the increase in mindfulness differed in the boulder and control groups. To break down this interaction, contrasts compared mindfulness at each time point to average mindfulness, across the boulder and control participants.

These contrasts revealed significant interactions when comparing participants' scores in the boulder and control groups to T0 compared to T1, $F(1, 57) = 10.74$, $p = .000$, $r = .34$. The interaction graph (see Fig. 3a) shows that although mindfulness increased in both groups, this increase was more pronounced in the boulder condition.

**Anxiety** There was no significant main effect of time, $F(1, 57) = 2.59$, $p = .113$, $r = .21$, nor was there a significant effect of group, $F(1, 57) = 1.32$, $p = .255$, $r = .15$. This indicates that anxiety scores were similar for both participants in the bouldering and control groups. There was no significant interaction between time and group condition, $F(1, 57) = 1.19$, $p = .279$, $r = .14$, indicating that change in anxiety did not differ between the groups. See Fig. 3b for the interaction graph.

**Wellbeing** There was a significant main effect of time on log(wellbeing), $F(1, 57) = 15.60$, $p = .000$, $r = .46$, with contrasts revealing that log(wellbeing) was significantly greater at T1 than T0, $F(1, 57) = 15.60$, $p = .000$, $r = .46$. There was no significant main effect of group condition, $F(1,57) = .158$, $p = .693$, $r = .05$, indicating that log(wellbeing) scores were similar for participants in the bouldering and control groups. There was no significant interaction between time and group condition, $F(1, 57) = 1.85$, $p = .179$, $r = .18$, however. This indicates that increases in log(wellbeing) did not differ between the groups. See Fig. 3c for the interaction graph.

### Regression Analysis

The between-group comparisons revealed that mindfulness was the only measure in which change scores varied significantly between groups. Therefore, a MLR analysis was conducted on mindfulness at T1 to assess whether the condition effect remained when baseline levels of mindfulness were controlled for. Prior to this, preliminary analyses were conducted on mindfulness at T1, mindfulness at T0 and group condition to verify whether an MLR was suitable to use on the data. These revealed that none of the variables violated the

**Table 1** Characteristics, descriptive statistics & correlations, and linear model predictors of mindfulness of the full analysis sample

| Sample Characteristics | Total Sample (n = 59) | | Boulder (n = 30) | | Control (n = 29) | | t(59) | *p* |
|---|---|---|---|---|---|---|---|---|
| | T0 | T1 | T0 | T1 | T0 | T1 | | |
| *Age (years):* | | | | | | | | |
| Mean | 20.63 | | 21.40 | | 19.79 | | 4.49 | ***.00*** |
| (SD) | (1.60) | | (1.48) | | (1.26) | | | |
| *Sex (n):* | | | | | | | | |
| Male | 37 | | 11 | | 26 | | .53 | ***.00*** |
| Female | 22 | | 19 | | 3 | | | |
| *Mindfulness Experience (n):* | | | | | | | | |
| Yes | 18 | | 10 | | 8 | | 0.61 | .55 |
| No | 42 | | 20 | | 22 | | | |
| *Climbing Experience (n):* | | | | | | | | |
| Yes | 22 | | 9 | | 13 | | 0.90 | .37 |
| No | 37 | | 21 | | 16 | | | |

| Mixed ANOVA Descriptive Statistics | Total Sample | | Boulder | | Control | |
|---|---|---|---|---|---|---|
| | T0 | T1 | T0 | T1 | T0 | T1 |
| *Mindfulness* | | | | | | |
| Mean | 26.53 | 30.78 | 25.03 | 32.13 | 28.07 | 29.38 |
| (SD) | (8.00) | (8.41) | (8.61) | (8.74) | (7.12) | (7.96) |
| *Anxiety* | | | | | | |
| Mean | 5.85 | 5.29 | 5.60 | 4.70 | 6.07 | 5.90 |
| (SD) | (3.07) | (3.07) | (2.70) | (2.49) | (3.44) | (3.51) |
| *Wellbeing* | | | | | | |
| Mean | 1.16 | 1.12 | 1.18 | 1.12 | 1.15 | 1.12 |
| (SD) | (.15) | (.16) | (.15) | (.17) | (.16) | (.15) |

| Descriptive Statistics and Correlations for MLR Variables | M | (SD) | 1. | 2. | 3. |
|---|---|---|---|---|---|
| 1. Mindfulness (T1) | 30.43 | (8.63) | - | ***.53*** | .13 |
| 2. Mindfulness (T0) | 26.42 | (8.00) | | - | -.18 |
| 3. Group Condition | .50 | (.50) | | | - |

| Linear Model Predictors of Mindfulness | *B* | SE *b* | β | 95% Confidence Intervals | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| *Step 1* | | | | | |
| Constant | 15.33 | 3.33 | | 8.67 | 22.00 |
| Mindfulness (T0) | .57 | .12 | ***.53*** | .33 | .81 |
| *Step 2* | | | | | |
| Constant | 12.18 | 3.56 | | 5.05 | 19.31 |
| Mindfulness (T0) | .62 | .12 | ***.57*** | .38 | .86 |
| Group Condition | 3.97 | 1.89 | *.23** | .20 | 7.74 |

*Note.* Group condition is included as a binary variable coded 0 (boulder) and 1 (control).

** $p < .05$* ***** $p < .001$.***

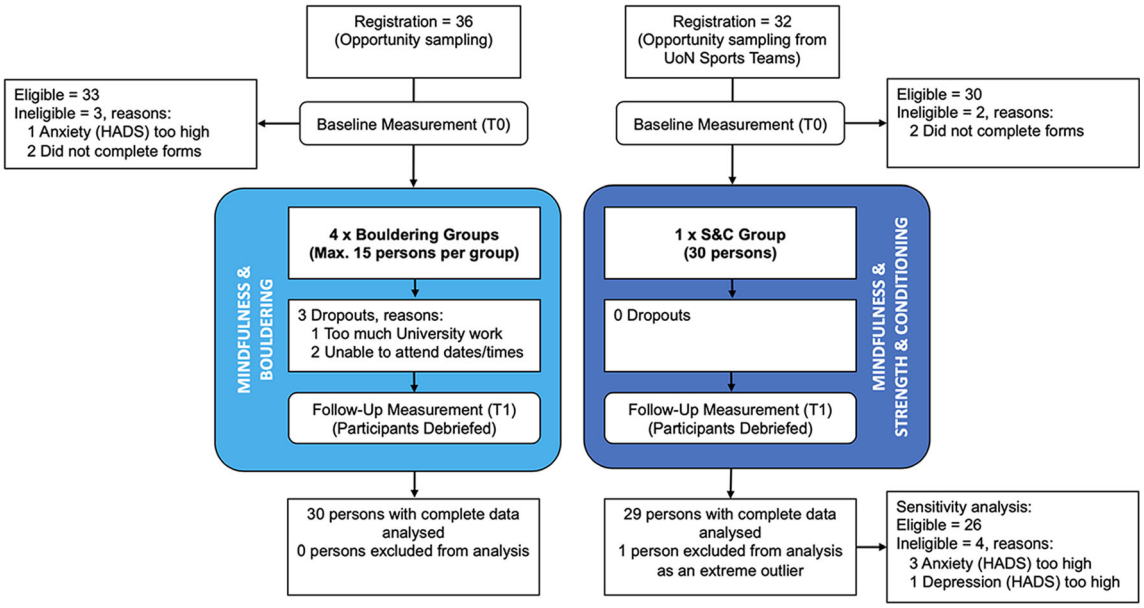


**Fig. 2** Flow chart of participants

assumptions of normality, linearity and multicollinearity; and indicated there were no extreme outliers. Table 1 presents the means, standard deviations and bivariate correlations between the core variables included in the analysis. As expected, the correlation between mindfulness at T0 and mindfulness at T1 was positive and significant.

To examine whether mindfulness at T1 was related to group condition when participants' baseline mindfulness was controlled for, a block entry (set-wise) regression analysis was performed. Mindfulness at T0 was entered into block 1 and group condition was entered into block 2. The analysis revealed that mindfulness at T0 accounted for a significant amount of the variance in mindfulness at T1, $R^2 = 28\%$, $F(1, 58) = 22.43$, $p < .001$. As expected, mindfulness at T0 was positively associated with mindfulness at T1, indicating that higher levels of mindfulness at T0 were associated with higher levels of mindfulness at T1. The addition of group condition in block 2 while controlling for baseline mindfulness explained an additional significant amount of the variance in mindfulness at T1, $R^2 = 33\%$, $F(1, 57) = 4.45$, $p = .04$. This variable was an independent predictor of mindfulness at T1, as can be seen in the summary of the model depicted in Table 1.

### Sensitivity Analysis

Sensitivity analyses were conducted whereby the same exclusion criteria were applied to the control and boulder groups. All fixed effects for both the mixed ANOVA and MLR were similar to those reported for the main analyses in direction, magnitude and statistical significance (see Table 2).

## Discussion

The aim of this experiment was to explore the relationship between rock-climbing and mindfulness in a controlled design. This was achieved by assessing how participation in bouldering affected measures of mindfulness, wellbeing and anxiety when compared to a control group undertaking a similar physical activity. As predicted, mindfulness increased significantly in the bouldering group only. The results regarding wellbeing and anxiety symptomology, however, were not consistent with the hypotheses in so far as no significant differences were found between the bouldering and control activity. This study provides the first evidence that rock-climbing increases mindfulness and has demonstrated that a single 1-h session does not affect measures of wellbeing and anxiety when compared to a similar physical activity.

Previous research has demonstrated a high rate of robust mental skills in rock-climbers (Young & Knigth, 2014); conjected to be a consequence of the need to remain present and in control in unpredictable environments (Smith et al., 1995). The findings of this study provide support for this conjecture in so far as the bouldering activity was found to be predictive of mindfulness, a psychological skill of awareness and attention (Shapiro et al., 2006); even when controlling for participants' baseline levels of mindfulness. This provides strong support for Steinberg's (2011) assertion that rock-climbing could be used as an activity to help facilitate mindfulness, as well as claims that rock-climbing clears and focuses the mind (NHS, 2020). Furthermore, it demonstrates that rock-climbing embodies mindful practice, as has previously been observed by clinical specialists and authors of sport-performance programmes (Enright, 2016; Ilgner, 2003).

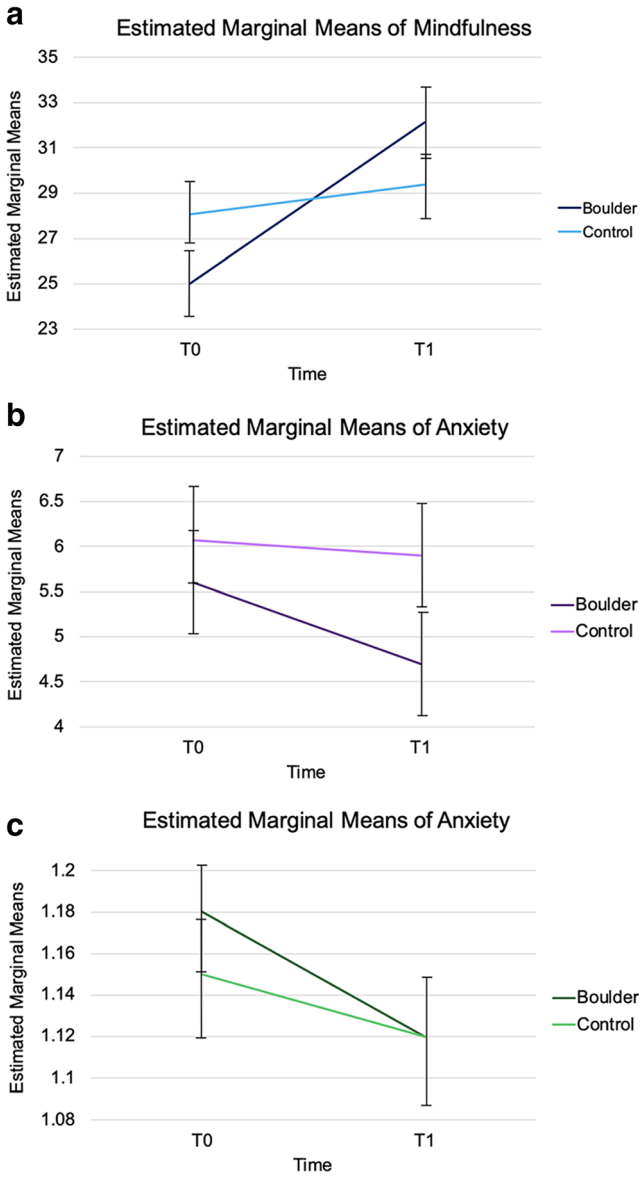


**Fig. 3** Within- and between- group comparisons of the main analysis for (**a**) mindfulness, (**b**) anxiety, and (**c**) log(Wellbeing). *Note.* Bars represent one standard error of the mean

In contrast, the current findings are inconsistent with the extant of research demonstrating that mindfulness practice promotes wellbeing and reduces anxiety (Blanck et al., 2018; Gu et al., 2016; Heckenberg et al., 2018), in so far as the increase in mindfulness in the bouldering cohort was not accompanied by greater changes in wellbeing and anxiety. This may be a reflection of the sample characteristics, in that both groups reported high levels of wellbeing and participants with a clinically relevant level of anxiety were excluded from the study. As such, there is not sufficient reason to expect significant changes in these measures. Furthermore, it is worth considering that a single 1-h session of bouldering is not a sufficient duration for mindfulness practice to affect these measures. Interventions for generalized anxiety disorders (NICE, 2019); trials investigating rock-climbing as a treatment for depression (Luttenberger et al., 2015; Stelzer et al., 2018); and research assessing the efficacy of mindfulness interventions are conducted for a minimum of 8 weeks. Therefore, the short duration and exclusion criteria of may have limited the findings of this study.

## Theoretical & Practical Implications

This is the first controlled study to investigate the relationship between rock-climbing and mindfulness. The results provide novel evidence that rock-climbing increases mindfulness which encourages speculation as to the mechanism by which this may occur. One conjecture is that both mindfulness and rock-climbing promote "flow"; a state of mind believed to occur during optimal human experience (Wright et al., 2006). In positive psychology, a flow state is the mental state in which a person performing an activity is fully involved, energetically focused, and completely absorbed in the enjoyment of the process (Csikszentmihalyi, 1988). Mindfulness and challenge-skills such as rock-climbing are believed to create a flow state by forcing an individual to live in the present moment, not worry, and perform an activity because it is intrinsically rewarding (Csikszentmihalyi et al., 2014). Therefore, the state of mind a person experiences while rock-climbing may be synonymous to that of mindfulness. Flow is considered to reflect optimal experience and, fundamentally, promote overall life satisfaction, which one could consider as an explanation for the high levels of life satisfaction reported by rock-climbers in Steinberg's (2011) study. In 2018, Šimleša et al. proposed the 'Flow Engine Framework', a cognitive model to explain how this psychological phenomenon works. Exploring rock-climbing and mindfulness within the context of models such as these is an intriguing direction for future research to take and will have implications for the development of therapeutic rock-climbing programmes.

Indeed, the results of this current study alongside Steinberg's (2011) findings indicate that rock-climbing is an effective, efficacious, and ecologically valid tool to increase mindfulness. This indicates that engagement with rock-climbing promotes the development of robust psychological skills important for confidence, academic success, and overall wellbeing (Galli & Gonzalez, 2015). In this sense rock-climbing could be considered to be a protective factor; which in this context refers to an activity that helps an individual deal more effectively with stressful events (Sarkar & Fletcher, 2014). Practically this has implications with regard to the future implementation of rock-climbing as a resilience-building activity as well as the potential integration of rock-climbing within therapeutic frameworks. The potential of this within both clinical and non-clinical populations should be considered by future research, however caution should be taken as to which clinical populations this is be applied to. According to

**Table 2** Mixed ANOVA results, descriptive statistics & correlations, and linear model predictors of mindfulness of the sensitivity analysis sample

| Mixed ANOVA Descriptive Statistics | Total Sample (n = 59) | | Boulder (n = 30) | | Control (n = 29) | |
|---|---|---|---|---|---|---|
| | T0 | T1 | T0 | T1 | T0 | *T1* |
| *Mindfulness:* | | | | | | |
| Mean | 26.35 | 30.78 | 25.03 | 32.13 | 28.07 | 29.38 |
| (SD) | (7.99) | (8.41) | (8.61) | (8.61) | (7.12) | (7.96) |
| *Anxiety:* | | | | | | |
| Mean | 5.83 | 5.29 | 5.60 | 4.70 | 6.07 | 5.90 |
| (SD) | (3.07) | (3.07) | (2.70) | (2.49) | (3.44) | (3.51) |
| *log(Wellbeing):* | | | | | | |
| Mean | 1.16 | 1.12 | 1.18 | 1.12 | 1.15 | 1.12 |
| (SD) | (.15) | (.16) | (.15) | (.17) | (.17) | (.15) |

| Mixed ANOVA Results | Time | Group | Interaction |
|---|---|---|---|
| *Mindfulness* | | | |
| F(1,54) | ***20.74*****| .01 | *9.41** |
| Cohen's *d* | ***.53*** | .01 | *.39* |
| *Anxiety* | | | |
| F(1,54) | 1.55 | .05 | 1.84 |
| Cohen's *d* | .17 | .03 | .18 |
| *log(Wellbeing)* | | | |
| F(1,54) | ***13.32***** | .77 | 1.93 |
| Cohen's *d* | ***.44*** | .12 | .19 |

| Descriptive Statistics and Correlations for MLR Variables | M | (SD) | 1. | 2. | 3. |
|---|---|---|---|---|---|
| 1. Mindfulness (T1) | 30.89 | 8.59 | - | ***.60***** | -.16 |
| 2. Mindfulness (T0) | 26.45 | 8.17 | | - | -.19 |
| 3. Group Condition | .46 | .50 | | | - |

| Linear Model Predictors of Mindfulness | *B* | SE *b* | β | 95% Confidence Intervals | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| *Step 1* | | | | | |
| Constant | 14.10 | 3.15 | | 7.78 | 20.43 |
| Mindfulness (T0) | .64 | .11 | ***.60***** | .41 | .86 |
| *Step 2* | | | | | |
| Constant | 14.86 | 3.00 | | 8.84 | 20.88 |
| Mindfulness (T0) | .69 | .11 | ***.66***** | .47 | .91 |
| Group Condition | -4.77 | 1.79 | *-.28** | -8.35 | -1.19 |

*Note*. Group condition is included as a binary variable coded 0 (boulder) and 1 (control).

* $p < .05$ ** $p < .001$.

Farias and Wikholm (2016) mindfulness meditation has potentially damaging effects in around 5% of people, which is likely due to underlying trauma. Many psychiatric illnesses are rooted in trauma, and people often cope with this by drawing on a wide range of distracting mechanisms; mindfulness involves stopping all these mechanisms at once, which can be distressing and induce severe panic and anxiety (Ransford, 2015).

## Strengths of the Research

A major strength of this study is that, unlike previous research in this area, it adopted a quasi-experimental design with a stringent and appropriate control condition. S&C training is used by elite climbing athletes to improve their performance (Phillips et al., 2012) and is therefore appropriate as a tool to engage the same muscles at a similar intensity to rock-climbing. Furthermore, both the bouldering and S&C training were conducted in groups. This removed potentially confounding variables from the study, such as social interaction and an- / aerobic respiration, and therefore the change in mindfulness can be confidently implicated to the rock-climbing activity.

Another strength of this study is that the analysis sample had no or minimal rock-climbing experience. As higher endorsement of psychological skills and mindfulness have been reported in rock-climbers (Steinberg, 2011) and athletes in other high-risk sports (Young & Knigth, 2014), omission of experienced climbers ensured that the sample was more likely to accurately represent mindfulness of young adults within the general population. In addition to this, low neuroticism has been associated with both mindfulness (Hanley & Garland, 2017) and engagement with high-risk sports (McEwan et al., 2019). While measures of personality facets were not measured, it is hoped that omission of individuals that regularly engage with mindfulness or high-risk sports protected against recruiting an unusual sample with lower neuroticism than young adults within the general population.

## Limitations & Future Directions

Several notable limitations constrain the conclusions that can be drawn from this study. First, due to time and resource constraints, the researcher decided to recruit a stringent control group rather than randomly allocating participants. According to Schulz (2000) random allocation is the only method that eliminates selection and confounding biases by ensuring comparison groups are on equal footing at study onset. Nevertheless, the strengths of adopting an appropriate and stringent control sample are considered to outweigh the limitations of random allocation for this study. Another contributor of potential bias was the lack of concealment of group condition; this was not possible as the study was planned and conducted by one researcher. Furthermore, the researcher was present for the bouldering activity but not control activity and could therefore could have potentially influenced the bouldering group to participate in a more mindful way. This had the potential to introduce bias and inflate effect sizes (Schulz et al., 1995), however given the intention of mindful participation was set for both the bouldering and control group prior to the activities this is considered unlikely by the researcher.

It is also important to note the potential limitations arising due to the sample. Firstly, the sample included mostly students; therefore, the results may not generalise to other age groups and educational backgrounds. Secondly, there was a significant gender-ratio disparity between the bouldering and control groups; due to the lack of randomisation. While Tihanyi et al. (2016) have reported no gender difference in body awareness and mindfulness in physical activity, other studies indicate there may be subtle gender differences to facets within mindfulness (Alispahic & Hasenbegovic-Anic, 2017; Cathcart et al., 2014). The potential bias introduced by these subtle gender differences was not controlled for within this study. However, initial validation of the SMS-PA has indicated it is a reliable measure of mindfulness in both males and females (Cox et al., 2016).

Despite these limitations this experiment provides evidence that rock-climbing has practical implications within positive psychology and mental health. Firstly, it adds to the existing literature in support of physical activity to increase wellbeing in young adults; and secondly, it provides the first evidence that bouldering can effectively increase mindfulness in a healthy sample of young adults. Future research should aim to independently replicate these findings in light of the limitations discussed above. In this way a fully randomized, concealed and longitudinal trail incorporating age, gender and personality facets within the analysis would be an appropriate next step for future research. Furthermore, researchers could take the direction to replicate this study in clinical samples or explore the findings within the context of a cognitive model of flow.

**Supplementary Information** The online version contains supplementary material available at https://doi.org/10.1007/s12144-021-01593-y.

**Code Availability** Qualtrics software was used to create questionnaires. Data was analysed using IBM SPSS Statistics software (version 26).

**Data Availability** The dataset generated during and analysed during the current study are available in the figshare repository, with identifier https://doi.org/10.6084/m9.figshare.13239077.v1.

## Declarations

**Conflicts of Interest / Competing Interests** The author declares that they have no conflict of interest.

**Ethics Approval** This study was approved by the School of Psychology, University of Nottingham ethics committee (No. S1234) and was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

**Consent to Participate** Written informed consent was obtained from all individual participants included in the study.

**Consent for Publication** The author affirms that all individual participants provided informed consent for publication of the data collected.



## References

Alispahic, S., & Hasenbegovic-Anic, E. (2017). Mindfulness: Age and gender differences on a Bosnian sample. *Psychological Thought, 10*(1), 115–166. https://doi.org/10.5964/psyct.v10i1.22.

Bjelland, I., Dahl, A. A., Haug, T. T., & Neckelmann, D. (2002). The validity of the hospital anxiety and depression scale: An updated literature. *Journal of Psychosomatic Research, 52*(2), 69–77. https://doi.org/10.1016/S0022-3999(01)00296-3.

Blanck, O., Perleth, S., Heidenreich, T., Kröger, P., Ditzen, B., Bents, H., & Mander, J. (2018). Effects of mindfulness exercises as stand-alone intervention on symptoms of anxiety and depression: Systematic review and meta-analysis. *Behaviour Research and Therapy, 102*, 25–35. https://doi.org/10.1016/j.brat.2017.12.002.

Carmody, J., & Baer, R. A. (2008). Relationships between mindfulness practice and levels of mindfulness, medical and psychological symptoms and well-being in a mindfulness-based stress reduction program. *Journal of Behavioural Medicine, 31*, 23–33. https://doi.org/10.1007/s10865-007-9130-7.

Cash, M., & Whittingham, K. (2010). What facets of mindfulness contribute to psychological well-being and depressive, anxious, and stress-related symptomatology? *Mindfulness, 1*, 177–182. https://doi.org/10.1007/s12671-010-0023-4.

Cathcart, S., McGregor, M., & Groundwater, E. (2014). Mindfulness and flow in elite athletes. *Journal of Clinical Sport Psychology, 8*(2), 119–141. https://doi.org/10.1123/jcsp.2014-0018.

Cox, A. E., Ullrich-French, S., & French, B. F. (2016). Validity evidence for the state mindfulness scale for physical activity. *Measurement in Physical Education and Exercise Science, 20*, 38–49. https://doi.org/10.1080/1091367X.2015.1089404.

Csikszentmihalyi, M. (1988). The flow experience and its significance for human psychology. In M. Csikszentmihalyi & I. S. Csikszentmihalyi (Eds.), *Optimal experience: Psychological studies of flow in consciousness* (pp. 15–35). Cambridge University Press.

Csikszentmihalyi, M., Abuhamdeh, S., & Nakamura, J. (2014). Flow. In M. Csikszentmihalyi (Ed.), *Flow and the foundations of positive psychology* (pp. 227–238). Springer. https://doi.org/10.1007/978-94-017-9088-8_15.

Diener, E., Wirtz, D., Tov, W., Kim-Prieto, C., Choi, D., Oishi, S., & Biswas-Diener, R. (2009). New well-being measures: Short scales to assess flourishing and positive and negative feelings. *Social Indicators Research, 97*, 143–156. https://doi.org/10.1007/s11205-009-9493-y.

Economides, M., Martman, J., Bell, M. J., & Sanderson, B. (2018). Improvements in stress, affect, and irritability following brief use of a mindfulness-based smartphone app: A randomized controlled trial. *Mindfulness, 9*, 1584–1593. https://doi.org/10.1007/s12671-018-0905-4.

Enright, A. (2016, April 14). Mindfulness in climbing. Crux Crush. http://cruxcrush.com/2016/04/14/mindfulness-in-climbing/

Farias, M., & Wikholm, C. (2016). Has the science of mindfulness lost its mind? *British Journal of Psychology Bulletin, 40*(6), 329–332. https://doi.org/10.1192/pb.bp.116.053686.

Foster, B. J. (2017) *Contributions of Psychological Skills and Mindfulness to NCAA Student-Athlete Well-Being* [unpublished doctoral dissertation]. Florida State University.

Galli, N., & Gonzalez, S. P. (2015). Psychological resilience in sport: A review of the literature and implications for research and practice. *International Journal of Sport and Exercise Psychology, 13*(3), 243–257. https://doi.org/10.1080/1612197X.2014.946947.

Gu, J., Strauss, C., Bond, R., & Cavanagh, K. (2016). How do mindfulness-based cognitive therapy and mindfulness-based stress reduction improve mental health and wellbeing? A systematic review and meta-analysis of meditation studies. *Clinical Psychology Review, 37*, 1–12. https://doi.org/10.1016/j.cpr.2015.01.006.

Hanley, A. W., & Garland, E. L. (2017). The mindful personality: A meta-analysis from a cybernetic perspective. *Mindfulness, 8*(6), 1456–1470. https://doi.org/10.1007/s12671-017-0736-8.

Heckenberg, R. A., Eddy, P., Kent, S., & Wright, B. J. (2018). Do workplace-based mindfulness meditation programs improve physiological indices of stress? A systematic review and meta-analysis. *Journal of Psychosomatic Research, 114*, 62–71. https://doi.org/10.1016/j.jpsychores.2018.09.010.

Hofmann, S. G., Sawyer, A. T., Witt, A. A., & Oh, D. (2010). The effect of mindfulness-based therapy on anxiety and depression: A meta-analytic review. *Journal of Consulting and Clinical Psychology, 78*(2), 169–183. https://doi.org/10.1037/a0018555.

Howell, A. J., & Buro, K. (2015). Measuring and predicting student well-being: Further evidence in support of the flourishing scale and the scale of positive and negative experiences. *Social Indicators Research, 121*, 903–915. https://doi.org/10.1007/s11205-014-0663-1.

Ilgner, A. (2003). *The rock warrior's way* (2nd ed.). Desiderata Institute.

Ivtzan, I. (2016). Mindfulness in positive psychology: An introduction. In I. Ivtzan & T. Lomas (Eds.), *Mindfulness in positive psychology: The science of meditation and wellbeing*. Routledge.

Kabat-Zinn, J. (1994). *Wherever you go, there you are: Mindfulness meditation in everyday life*. Hachette Books.

Luttenberger, K., Stelzer, E.-M., Först, S., Schopper, M., Kornhuber, J., & Book, S. (2015). Indoor rock climbing (bouldering) as a new treatment for depression: Study design of a waitlist-controlled randomized group pilot study and the first results. *BMC Psychiatry, 15*, 201. https://doi.org/10.1186/s12888-015-0585-8.

Malinowski, P. (2013). Neural mechanisms of attentional control in mindfulness meditation. *Frontiers in Neuroscience, 7*(7), 8. https://doi.org/10.3389/fnins.2013.00008.

Malone, C., & Wachholtz, A. (2018). The relationship of anxiety and depression to subjective well-being in a mainland Chinese sample. *Journal of Religion and Health, 57*, 266–278. https://doi.org/10.1007/s10943-017-0447-4.

Mani, M., Kavanagh, D. J., Hides, L., & Stoyanov, S. R. (2015). Review and evaluation of mindfulness-based iPhone apps. *JMIR mHealth and uHealth, 3*(3), e82. https://doi.org/10.2196/mhealth.4328.

McEwan, D., Boudeau, P., Curran, T., & Rhodes, R. E. (2019). Personality traits of high-risk sport participants: A meta-analysis. *Journal of Research in Personality, 79*, 83–93. https://doi.org/10.1016/j.jrp.2019.02.006.

NHS. (2020, February 14). *Climbing*. Retrieved March 02, 2020, from https://www.nhsinform.scot/healthy-living/keeping-active/activities/climbing

NICE. (2019). *Generalised anxiety disorder and panic disorder in adult: Management, National Institute for Health and Care Excellence*. Retrieved March 10, 2020, from https://www.nice.org.uk/guidance/cg113/chapter/1-Guidance#principles-of-care-for-people-with-generalised-anxiety-disorder-gad.

Norouzi, E., Gerber, M., Masrour, F. F., Vaezmosavi, M., Pühse, U., & Brand, S. (2020). Implentation of a mindfulness-based stress reduction (MBSR) program to reduce stress, anxiety, and depression and to improve psychological well-being among retired Iranian football player. *Psychology of Sport and Exercise, 47*, 101636. https://doi.org/10.1016/j.psychsport.2019.101636.

Olatunji, B. O., Cisler, J. M., & Tolin, D. F. (2007). Quality of life in the anxiety disorder: A meta-analytic review. *Clinical Psychology Review, 27*(5), 572–581. https://doi.org/10.1016/j.cpr.2007.01.015.

Phillips, K. C., Sassaman, J. M., & Smoliga, J. M. (2012). Optimizing rock climbing performance through sport-specific strength and conditioning. *Strength and Conditioning Journal, 34*(3), 1–18. https://doi.org/10.1519/SSC.0b013e318255f012.

Ransford, H. C. (2015). The far horizons of time: Time and mind in the universe. *De Gruyter Open*. https://doi.org/10.2478/9783110440287.1.

Robertson, I. (2018, December 16). What is psychological wellbeing? Robertson Cooper. Retrieved March 03, 2020, from https://www.robertsoncooper.com/blog/what-is-psychological-wellbeing/

Rooney, C. (2017). Can this practice make you a better climber? Headspace. Retrieved on March 05, 2020, from https://www.headspace.com/blog/2017/03/09/can-practice-make-better-climber/

Rybak, C. (2013). Nurturing positive mental health: Mindfulness for wellbeing in counselling. *International Journal for the Advancement of Counselling, 35*, 110–119. https://doi.org/10.1007/s10447-012-9171-7.

Sarkar, M., & Fletcher, D. (2014). Psychological resilience in sport performers: A review of stressors and protective factors. *Journal of Sports Sciences, 32*(15), 1419–1434. https://doi.org/10.1080/02640414.2014.901551.

Schulz, K. F. (2000). Assessing allocation concealment and blinding in randomised controlled trials: Why bother? *BMJ Evidence-Based Medicine, 5*, 36–38. https://doi.org/10.1136/ebm.5.2.36.

Schulz, K. F., Chalmers, I., Hayes, R. J., & Altman, D. G. (1995). Empirical evidence of bias. Dimensions of methodological quality associated with estimates of treatment effects in controlled trials. *JAMA, 273*(5), 408–412. https://doi.org/10.1001/jama.273.5.408.

Schutte, N. S., & Malouff, J. M. (2011). Emotional intelligence mediates the relationship between mindfulness and subjective well-being. *Personality and Individual Differences, 50*(7), 1116–1119. https://doi.org/10.1016/j.paid.2011.01.037.

Schmider, E., Ziegler, M., Danay, E., Beyer, L., & Bühner, M. (2010). Is it really robust? Reinvestigating the robustness of ANOVA against violations of the normal distribution assumption. *Methodology: European Journal of Research Methods for the Behavioral and Social Sciences, 6*(4), 147–151. https://doi.org/10.1027/1614-2241/a000016.

Shapiro, S. L., Carlson, L. E., Astin, J. A., & Freedman, B. (2006). Mechanisms of mindfulness. *Journal of Clinical Psychology, 62*(3), 373–386. https://doi.org/10.1002/jclp.20237.

Shapiro, S. L., & Schwartz, G. E. (2000). The role of intention in self-regulation: Toward intentional systematic mindfulness. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of Self-Regulation* (pp. 253–273). Academic Press. https://doi.org/10.1016/B978-012109890-2/50037-8.

Silva, A. J., & Caetano, A. (2013). Validation of the flourishing scale and scale of positive and negative experience in Portugal. *Social Indicators Research, 110*(2), 469–478. https://doi.org/10.1007/s11205-011-9938-y.

Šimleša, M., Guegan, J., Blanchard, E., Tarpin-Bernard, F., & Buisine, S. (2018). The flow engine framework: A cognitive model of optimal human experience. *Europe's Journal of Psychology, 14*(1), 232–253. https://doi.org/10.5964/ejop.v14i1.1370.

Smith, R. E., Schutz, R. W., Smoll, F. L., & Ptacek, J. T. (1995). Development and validation of a multidimensional measure of sport-specific psychological skills: The athletic coping skills inventory-28. *Journal of Sport & Exercise Psychology, 17*, 379–198.

Snaith, R. P., & Zigmond, A. S. (1986). The hospital anxiety and depression scale. *British Medical Journal (Clinical Research Ed.), 292*(6516), 344. https://doi.org/10.1136/bmj.292.6516.344.

Steinberg, R. (2011). *Mindfulness, psychological well being and rock climbing: An exploration of mindfulness in rock climbing and the potential for psychological benefit* [unpublished doctoral dissertation]. The Wright Institute.

Stelzer, E.-M., Book, S., Graessel, E., Hofner, B., Kornhuber, J., & Luttenberger, K. (2018). Bouldering psychotherapy reduces depressive symptoms even when general physical activity is controlled for: A randomized controlled trial. *Heliyon, 4*(3), e00580. https://doi.org/10.1016/j.heliyon.2018.e00580.

Swift, P., Cyhlarova, E., Goldie, I., & O'Sullivan, C. (2014). Living with anxiety: Understanding the role and impact of anxiety in our lives. Mental Health Foundation. Retrieved February 28, 2020, from https://www.mentalhealth.org.nz/assets/A-Z/Downloads/Living-with-anxiety-report-MHF-UK-2014.pdf

Tihanyi, B. T., Sági, A., Csala, B., Tolnai, N., & Köteles, F. (2016). Body awareness, mindfulness and affect: Does the kind of physical activity make a difference? *European Journal of Mental Health, 11*(1–2), 97–111. https://doi.org/10.5708/EJMH.11.2016.1-2.6.

Walsh, K. M., Saab, B. J., & Farb, N. A. S. (2019). Effects of a mindfulness meditation app on subjective well-being: Active randomized controlled trail and experience sampling study. *Journal of Medical Internet Research, 6*(1), e10844. https://doi.org/10.2196/10844.

Williams, J. G., & Kabat-Zinn, J. (Eds.). (2013). Mindfulness: Diverse perspectives on its meaning, origins and applications. *Routledge*. https://doi.org/10.4324/9781315874586.

Wright, J. J., Sadlo, G., & Stew, G. (2006). Challenge-skills and mindfulness: An exploration of the conundrum of flow process. *Occupational Therapy Journal of Research, 7*, 320–328. https://doi.org/10.1007/s12671-015-0441-4.

Young, P. R., & Knigth, E. L. (2014). Use of psychological skills by risk sport athletes. *Journal of Human Performance in Extreme Environments, 11*(2), Article 2. https://doi.org/10.7771/2327-2937.1061.