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Personality Traits as Covariates of Rock-Climbing Performance in Novice Rock Climbers

Courtney N. Gearhart

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ABSTRACT

Background

Existing literature has connected heightened levels of conscientiousness and grit and lowered levels of neuroticism to greater general athletic performance (Courneya & Hellsten, 1998; McEwan, Boudreau, Curran, & Rhodes, 2019; Steca et al., 2018). Rock-climbing is a growing field of interest and the question of whether conscientiousness, neuroticism, and grit are correlated with rock-climbing performance and improvement remains unknown.

Methods

To assess relationships among conscientiousness, neuroticism, grit, and rock-climbing performance, twenty-three undergraduate students with no significant climbing experience participated in a two-part study at a small religious university in the Midwest. Participants were recruited through professors known by the researcher, who passed sign-up sheets to their classes. Upon participation, students were given informed consent forms and scales measuring grit and Big-Five traits, including conscientiousness and neuroticism, then were measured climbing three routes at varying difficulty levels on two occasions, six weeks apart.

Results

Data were analyzed using repeated-measures ANOVA tests, and no statistically significant interactions were found between conscientiousness, neuroticism, or grit and rock-climbing performance.

Conclusion

The lack of statistical significance suggests that the anticipated relationships did not exist in the sample surveyed. However, the sample size was small, and a floor effect existed for one of the operationalizations of rock-climbing performance. Therefore, our conclusions regarding the relationships between conscientiousness, neuroticism, grit, and rock-climbing performance are regarded as tentative.

Keywords: grit, conscientiousness, neuroticism, Big-Five, personality, rock-climbing, athletic performance

LITERATURE REVIEW

Empirical correlates of rock-climbing performance

Rock-climbing is a growing area of interest, and in August 2016 it was approved to be added to the program of the Tokyo 2020 games (International Olympic Committee, 2017). The growth of the sport for competitive purposes has been accompanied by a dramatic growth in indoor recreational climbing gyms in America (IBIS World, 2018).

Physiological correlates of rock-climbing

As interest in climbing has grown, there has been increased interest in possible contributing factors to and correlates of rock-climbing performance. Pijpers, Oudejans, Holscheimer, and Bakker (2003) found that muscles were more rigid and participants more anxious at a higher-altitude and that increased anxiety lead to higher entropy and displacement along with longer climb-times.

Zarattini et al. (2018) conducted a study with nine participants measuring heart rate and climb time of intermediate climbers climbing a lead route versus a top route. The results showed that there are higher physiological demands involved in lead climbing, as demonstrated by higher average and maximum heart rates, as well as longer climb-times.

Psychological profile of rock climbers

The first major psychological profile of rock climbers was based on a group of climbers who were able to lead climb routes five-eight grade and above on the U.S. grading system. (Robinson, 1985) The study found that participants were not drawn specifically to climbing as a means of affiliation, but that affiliation played a role in climbers sticking to the sport. There was no difference between elite climbers and the population of undergraduate males in Need for Achievement, but elite climbers were significantly lower on the Trait Anxiety Inventory and higher in sensation seeking.

Sarrazin, Roberty, Cury, Biddle, and Famose (2002) continued this line of research by conducting a course-based research design to show that participants who were high in task-orientation (motivation based on intrinsic completion) versus ego-orientation (motivation based on extrinsic evaluation) exerted the most effort on the most difficult courses. This study used only boys age twelve to sixteen who had at least one year of climbing experience. Egan and Stelmack (2003) conducted a personality profile of Mount Everest climbers, looking for correlations between climbing performance and personality traits as assessed by the Eysenck Personality Questionnaire-Revised (Roger & Morris, 1991). The study found no significant predictors of climbing performance in personality traits. There were trends in the mean scores indicating that in a male sample, climbers were higher in extraversion, psychoticism, and lie, which tests for social desirability in responses. There was also a nonsignificant trend towards male climbers having lower levels of neuroticism. This study is relevant to the body of research, but it is important to note that this sample of mountaineering rock climbers is not representative of all rock climbers. This study is one of the few studies that looks at personality specifically with respect to rock climbers and does so only at the elite level with mountaineers using a less inclusive personality inventory.

Four years later in 2007, Asçi, Demirhan, and Dinc demonstrated that intrinsic motivation, which is correlated with grit, is significantly positively related to rock-climbing expertise. In 2010, Sanchez, Boschker, and Llewellyn took mental state and performance information from nineteen male climbers competing in the Belgian Climbing Championship to look at psychological states as they relate to climbing performance. The states of interest were cognitive anxiety, somatic anxiety, and self-efficacy or self-confidence. Performance was measured by tracking a magnesium bag attached to the climber. Performance was measured by entropy and flow while climbing, as well as how many and how quickly holds were reached. The results showed that cognitive anxiety was negatively correlated with performance both in success and in speed climbed, and that somatic anxiety and self-efficacy were positively correlated. Looking at the previous research, it is clear that the need remains for more recent personality profiles of those who engage in and excel in rock-climbing.

In addition, researchers have called for an increased attention to detail with respect to rock-climbing research. For example, Draper et al. (2011) reviewed the research literature and studies on rock-climbing and proposed climbing measurement and research report methods to facilitate

consistency in data reporting. They outlined important information to be included in sample size and characteristics, defined key terms in climbing such as *lead*, *sport*, *top*, *bouldering*, *trad*, *redpoint*, *flash*, and *ascent*. They also developed two different ability classification tables for male vs. female climbers, explaining the necessity of clear denotation between skill levels beyond abstract qualitative terms such as “elite, expert, intermediate,” and “recreational.” Similarly, Zarattini et al. (2018) showed that time taken to climb a route could be validated as a measurement of climbing performance.

The Big-Five model of personality

The Five-Factor Model (FFM) of personality was the result of years of factor-analytic work from the trait perspective (Allport & Odbert, 1936); Cattell, Eber, & Tatsuoka, 1970). The FFM was given the label “Big-Five” to describe the broad nature of the dimensions (Goldberg, 1981) and has been supported from both lexical (Goldberg, 1990) and questionnaire-based approaches (Costa and McCrae, 1992). The traits that make up the Big-Five model are conscientiousness, neuroticism, extraversion, agreeableness, and openness or intellect. Those high in conscientiousness are generally “cautious, dependable, persevering, organized, and responsible” (Friedman & Schustack, 2016, p. 187). Neuroticism, also called emotional instability, refers to those who tend to be “nervous, high-strung, tense, volatile, moody, and worrying” (p. 187). Extraversion describes those who are “energetic, enthusiastic, dominant, sociable, and talkative” (p. 187). Agreeable people are “friendly, cooperative, trusting, and warm” (p. 187), whereas those high in openness or intellect generally appear “imaginative, witty, original, and artistic” (p. 187). The fifth factor of openness to experience or intellect has been defined differently across cultures and questionnaires and is the most controversial of the five factors (John & Srivastava, 1999).

The Big-Five grew to become the dominant model of trait psychology (Donnellan, Oswald, Baird, & Lucas, 2006) and several questionnaires were developed to measure Big-Five traits. To increase efficiency, the 50-item International Personality Item Pool-Five Factor Model (IPIP-FFM) was condensed to a shorter twenty-item scale (Mini-IPIP) (Donnellan, Oswald, Baird, & Lucas, 2006). Since then, psychometric properties of the mini-IPIP have been validated with different samples (Baldasaro, Shanahan, Bauer, 2013) and continue to be used in current scholarly research (McEwan, Boudreau, Curran, & Rhodes, 2019). Comprehensive meta-analyses looking at Big-Five correlates have found relationships that include, but are not limited to: burnout, relationship satisfaction, job satisfaction, job performance, academic performance, and team performance (Allen, Greenlees, & Jones, 2013).

Big-Five traits and athletic behavior

A study of 264 undergraduate students found that extraversion and conscientiousness were positively correlated with exercise behavior whereas neuroticism was negatively correlated, with neuroticism negatively, and conscientiousness positively, most consistently related to exercise barriers (Courneya & Hellsten, 1998). A meta-analysis of personality in sport performance found higher levels of extraversion and lower levels of neuroticism in high-risk sport participants (McEwan, Boudreau, Curran, & Rhodes, 2019). Another study of 881 male athletes and non-athletes found that beyond athletic participation, athletes who had experienced the most success in their sport were higher in conscientiousness and agreeableness, but lower in neuroticism (Steca et al., 2018). The less-successful athletes were only higher than non-athletes in agreeableness and extraversion. The only study correlating Big-Five traits and a type of rock-climbing looked at

Mount Everest climbers and was measured by Eysenck Personality Questionnaire-Revised (Roger & Morris, 1991). Results were not statistically significant but found a trend towards lower neuroticism. These findings lead us to Hypothesis One through Hypothesis Four, which expect more successful climbers to be higher in conscientiousness and lower in neuroticism.

Hypothesis One: Conscientiousness levels will be positively correlated with climbing improvement (as measured by time to completion) with a sample of novice climbers.

Hypothesis Two: Conscientiousness levels will be positively correlated with amount of increase in holds reached over a six-week period with a sample of novice climbers.

Hypothesis Three: Neuroticism levels will be negatively correlated with climbing improvement (as measured by time to completion) with a sample of novice climbers.

Hypothesis Four: Neuroticism levels will be negatively correlated with amount of increase in holds reached over a six-week period with a sample of novice climbers.

Grit as a measure of personality

Grit is defined as the passion and perseverance for longterm goals (Duckworth, Peterson, Matthews, & Kelly, 2007). Where the FFM comes from an inductive, data-driven origin, grit is a deductive and theory-driven measure of personality. In a study seeking to find a predictor of success and retention with United States Military Academy (USMA), West Point cadets, grit was first defined and found to be a significant predictor over academic scores, physical ability, intelligence quotient (IQ), and Big Five personality traits. Beyond USMA cadet retention, grit was found to be a significant predictor of success in the following areas: educational attainment, grade point average among Ivy League undergraduate students, and ranking in a national spelling bee. Grit itself was not found to be significantly correlated with IQ, but was found to be significantly correlated with the Big-Five trait conscientiousness. The original, Twelve-Item Grit Scale (GRIT-O) was revised to a newer Short Grit Scale (GRIT-S) (Duckworth & Quinn, 2009), and since then the original studies have been replicated with respect to Big-Five personality traits, USMA retention (Kelly, Matthews, & Bartone, 2014), and academic performance (Rimfeld, Kovas, Dale, & Plomin, 2016).

Grit and athletic behavior

Further research has expounded upon grit literature in finding grit as a predictor in the athletic arena. One such study outlines the correlations between grit, conscientiousness, industriousness, and exercise score, finding grit as the strongest predictor of exercise score (Reed, 2014). Two years later, Larkin, O'Connor, and Williams (2016) used GRIT-S in addition to soccer-specific perceptual-cognitive expertise assessments to collect data. They surveyed 385 soccer players, finding significant positive correlations between grit, engagement, and perceptual-cognitive expertise. A study conducted using National Collegiate Athletic Association division II basketball players found through quantitative and qualitative measures that grit scores and basketball performance were positively correlated (Morgan, 2017).

However, grit has not been studied specifically with respect to climbing performance or retention in the sport. Personality traits somewhat related to grit including sociability, toughmindedness, and

anxiety have been studied in climbers, but the correlations between these and climbing ability have not been significant (Egan & Stelmack 2003). A study of rock-climbing performance and improvement that looks at grit as a personality trait may yield more significant results. Studying grit in the area of climbing performance and improvement would have interesting implications for climbing gyms and individual climbers, as well as add to the growing body of research on both topics. These findings lead to Hypotheses Five and Six, which expect climbers to have higher grit levels.

Hypothesis Five: Grit levels will be positively correlated with climbing improvement (as measured by time to completion) with a sample of novice climbers.

Hypothesis Six: Grit levels will be positively correlated with amount of increase in holds reached over a six-week period with a sample

METHODS

Participants

Participants included 31 undergraduate students recruited through introduction to psychology courses at a small religious university in the Midwestern United States. All participants were novice climbers, defined as having climbed three times or fewer. Eight participants did not return for the second round of data collection and were not included in the data. The average age of participants was 19.5 years ($SD = 1.5$ years), and females accounted for 19 of the 23 completed responses. Of the participants, the majority of participants (17) identified as white, with 4 identifying as Hispanic, Latino, or Spanish origin, and 2 as Black or African American. Twenty-six percent of participants (6) were fourth-year students, 17.4% (4) were third-years, 17.4% (4) were second-years, and 39.1% (9) were first-years.

Six and a half percent of students (2) reported that they had climbed once at an off-campus gym. Four participants reported climbing at least once in the past and had an average time spent in one climbing visit of 11.3 minutes. Average enrolled credit hours at the time of the study was 15.6 ($SD = 1.63$).

Materials

Big-Five traits were assessed using the Mini-IPIP (Donnellan, Oswald, Baird, & Lucas, 2006). The scale included twenty total statements (four statements for each of the Big-Five traits) assessed on Likert scales with five points ranging from very accurate to very inaccurate. After reverse-scoring, higher scores mean higher levels of the trait being measured. Internal consistency for each of the Big-Five traits was high (See Table 1).

TABLE 1: DESCRIPTIVE STATISTICS AND INTERCORRELATIONS

Items 7-8 are discrepancy scores created from subtracting scores time two from time one. $**p < .01$, $*p < .05$.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Conscientiousness	—														
2. Neuroticism	0.13	—													
3. Grit	0.11	-0.28	—												
4. Intellect	-0.10	0.19	-0.33	—											
5. Extraversion	-0.27	-0.25	0.09	-0.05	—										
6. Agreeableness	-0.25	0.16	0.13	0.03	0.22	—									
7. Time Route A	0.03	0.26	-0.02	0.13	-0.47 *	-0.22	—								
8. Holds Route A	-0.04	0.18	0.07	0.15	-0.47 *	-0.24	.71 **	—							
9. Falls Route A	0.14	-0.03	-0.09	-0.10	0.20	-0.13	-0.54 **	-0.74 **	—						
10. Time Route B	-0.32	-0.13	-0.19	0.06	<0.01	-0.10	0.18	0.28	-0.49 *	—					
11. Holds Route B	-0.12	-0.19	-0.18	0.21	0.15	-0.32	0.02	0.37	-0.45 *	0.51 *	—				
12. Falls Route B	0.02	0.12	-0.36	-0.05	-0.04	-0.18	0.32	0.06	-0.11	0.56 **	0.26	—			
13. Time Route C	0.05	-0.14	0.18	0.15	0.07	-0.04	0.44 *	0.26	-0.23	0.04	-0.07	0.24	—		
14. Holds Route C	0.13	0.06	-0.51 *	0.09	-0.12	0.09	-0.04	0.17	-0.13	0.01	0.27	0.19	-0.25	—	
15. Falls Route C	0.25	-0.10	0.06	0.13	0.03	-0.08	0.40	0.07	-0.11	-0.06	-0.20	0.28	0.88 **	-0.16	—
Mean	14.6	11.3	3.54	16.1	13.2	16.9	16.2	1.52	0.00	31.1	-0.13	1.00	56.3	0.09	2.17
Standard Deviation	3.92	3.67	0.49	2.09	2.70	2.39	28.7	6.93	0.41	57.7	2.83	2.02	104	7.35	4.74
Reliability	.81	.89	.83	.78	.91	.80									

Grit was assessed using Grit-O (Duckworth, Peterson, Matthews, & Kelly, 2007). Participants responded to twelve statements on four-point scales with endpoints ranging from very much like me to not like me at all. All items were reverse scored so that higher scores reflected higher levels of grit. This scale had high internal consistency (See Table 1).

Climbing performance was measured by time taken to climb each route and highest hold reached. A record was kept of number of falls taken. The three routes were climbed top-rope in growing difficulty: Route A (35 holds, 25 ft), Route B (25 holds, 37 ft), and Route C (52 holds, 56 ft). Finally, participants were asked to indicate their gender, year in school, age, ethnicity, credit hours, climbing experience, and whether or not they had a job outside of schooling (Hughes, Camden, & Yangchen, 2016).

Procedures

Participants received a sign-up sheet from their introductory psychology professor briefly describing the study and requesting their participation. Participants wrote their name and email then followed a link sent to them where they selected a 30-minute time slot to participate. Some participants entered their names to receive extra credit in a course, and all participants were awarded a five-dollar gift card upon completion of participation.

Once students arrived for the study for the first time, they were met by a researcher (or a research assistant). Each participant was given an informed consent document that gave students a brief overview of the procedures and objectives of the research and explained the completely voluntary nature of their participation. Participants were reminded that they may withdraw from the study at any time without penalty, privacy expectations were discussed, and contact information was given.

Participants were then given both personality inventories. Upon completion, they were asked to climb all three routes interspersed with 90-second breaks. Each climb was timed, and a record was kept of the number of holds reached and number of falls taken. After climbing, students filled out the demographic questionnaire.

Upon second participation, six weeks after the first set of climbs, participants were again met by a researcher or research assistant. There, they climbed Routes A-C again with 90-second breaks between each route. After climbing, students were debriefed on the intent of the study. Once collected, data was entered into and analyzed using the Jamovi computer program. Hypotheses were tested using repeated-measure ANOVAs with personality traits as covariates.

RESULTS

Table 1 contains the means, standard deviations, and intercorrelations between each of the main continuous variables in this study. In addition, internal consistency for each of the scales used to assess personality can be found in Table 1.

An initial repeated-measures ANOVA found significant differences between all three climbing measures on each route, so three separate calculations corresponding to each of the three routes were conducted for all six hypotheses. No significant differences or strong effect sizes were found for either improvement in number of holds reached on Routes A-C or improvement in number of falls on Route A. Of the five remaining areas of significant improvement, no significant interactions were present. Tables 2-4 contain the means and standard deviations for time, holds, and falls for each of the routes climbed, both at time one and at time two.

TABLE 2: REPEATED-MEASURES ANOVA RESULTS FOR ROUTE A

Personality traits under measurements of climbing performance refer to covariates in repeated-measures ANOVA analyses. $*p < .05$.

	Time 1		Time 2		<i>F</i>	<i>p</i>	η^2_p
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Route A							
Time	78.7	31.8	62.5	31.9	7.33	0.01 *	0.25
Conscientiousness					0.02	0.90	<0.01
Neuroticism					1.47	0.24	0.07
Grit					0.01	0.92	<0.01
Extraversion					5.88	0.02 *	0.22
Holds	31.1	5.84	29.6	7.57	1.11	0.30	0.05
Conscientiousness					0.03	0.86	<0.01
Neuroticism					0.70	0.41	0.03
Grit					0.09	0.77	<0.01
Falls	0.44	0.51	0.44	0.51	0.00	1.00	0.00

TABLE 3: REPEATED-MEASURES ANOVA RESULTS FOR ROUTE B

Personality traits under measurements of climbing performance refer to covariates in repeated-measures ANOVA analyses. $*p < .05$.

	Time 1		Time 2		<i>F</i>	<i>p</i>	η^2_p
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Route B							
Time	135	80.2	104	66.8	6.67	0.02 *	0.23
Conscientiousness					2.43	0.13	0.10
Neuroticism					0.35	0.56	0.02
Grit					0.78	0.39	0.04
Holds	11.7	8.16	11.8	7.70	0.05	0.83	<0.01
Conscientiousness					0.33	0.57	0.02
Neuroticism					0.78	0.39	0.04
Grit					0.68	0.42	0.03
Falls	2.52	2.15	1.52	1.27	5.62	0.03 *	0.20
Conscientiousness					0.01	0.92	<0.01
Neuroticism					0.29	0.60	0.01
Grit					3.21	0.09	0.13

TABLE 4: REPEATED-MEASURES ANOVA RESULTS FOR ROUTE C

Personality traits under measurements of climbing performance refer to covariates in repeated-measures ANOVA analyses. $*p < .05$.

	Time 1		Time 2		<i>F</i>	<i>p</i>	η^2_p
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Route C							
Time	149	108	92.9	59.3	6.68	0.02 *	0.23
Conscientiousness					0.06	0.82	0.00
Neuroticism					0.41	0.53	0.02
Grit					0.73	0.40	0.03
Holds	16.7	15.4	16.6	17.0	<0.01	0.96	<0.01
Conscientiousness					0.37	0.55	0.02
Neuroticism					0.08	0.79	<0.01
Grit					7.23	0.01 *	0.26
Falls	4.87	5.09	2.70	2.14	4.83	0.04 *	0.18
Conscientiousness					2.60	0.12	0.11
Neuroticism					0.22	0.64	0.01
Grit					0.07	0.80	<0.01

Hypothesis One predicted a positive correlation between conscientiousness and climbing performance as measured by time to completion. Inconsistent with our predictions, no relationship was found between conscientiousness and improvement in time to completion on routes A, B, or C (See Tables 1-4).

Hypothesis Two predicted a positive correlation between conscientiousness and climbing performance as measured by number of holds reached. Inconsistent with our predictions, no

relationship was found between conscientiousness and improvement in number of holds reached on routes A, B, or C (See Tables 1-4).

Hypothesis Three predicted a negative correlation between neuroticism and climbing performance as measured by time to completion. Inconsistent with our predictions, no relationship was found between neuroticism and improvement in time to completion on routes A, B, or C at time one or at time two (See Tables 1-4).

Hypothesis Four predicted a negative correlation between neuroticism and climbing performance as measured by number of holds reached. Inconsistent with our predictions, no relationship was found between neuroticism and improvement in number of holds reached on routes A, B, or C (See Tables 1-4). This is because no actual differences were found between time one and time two for number of holds reached.

Hypothesis Five predicted a positive correlation between grit and climbing performance as measured by time to completion. Inconsistent with our predictions, no relationship was found between grit and improvement in time to completion on routes A, B, or C (See Tables 1-4).

Hypothesis Six predicted a positive correlation between grit and climbing performance. Inconsistent with our predictions, no relationship was found between grit and improvement in number of holds reached on routes A, B, or C (See Tables 1-4). This is because no actual differences were found between time one and time two for number of holds reached.

With respect to exploratory analyses, there was a significant interaction between extraversion and time taken to climb Route A with a medium-strong effect size, meaning that participants with higher extraversion took less time to complete the easiest route (see Table 2). No notable relationships or trends were found with respect to agreeableness or openness. There was a significant decrease in falls taken on Routes B and C, but no interactions with personality traits were present (see Tables 3 and 4). Grit as a covariate had a medium effect size on number of falls taken on Route B from time one to time two (see Table 3).

As further exploratory analyses, independent samples t-tests were conducted comparing those who finished Routes A and B with those who did not on conscientiousness, neuroticism, and grit for both time one and time two. Similar analyses were only conducted with Route C for time two because no participants completed Route C at time one. At time two, there were significant differences between finishers and non-finishers for Routes A and B on conscientiousness. At times one and two, a significant difference was found with respect to neuroticism on Route B with a strong effect size. There was also a nonsignificant difference of grit between finishers and non-finishers on Route A (see Table 5).

TABLE 5: INDEPENDENT SAMPLES T-TEST

An independent samples t-test was not conducted for Route C at time one because only one student finished the route at that time. $*p < .05$, $**p < .01$.

	Time 1			Time 2		
	t	p	Cohen's d	t	p	Cohen's d
Route A						
Conscientiousness	1.09	0.28	0.39	0.46	0.65	0.19
Neuroticism	0.40	0.69	0.14	0.72	0.48	0.31
Grit	1.74	0.09	0.62	1.66	0.11	0.70
Route B						
Conscientiousness	1.95	0.06	0.89	2.35	0.03 *	1.30
Neuroticism	2.62	0.01 *	1.19	2.30	0.03 *	1.27
Grit	1.58	0.13	0.72	0.27	0.79	0.15
Route C						
Conscientiousness				3.40	<0.01 **	2.11
Neuroticism				1.72	0.10	1.07
Grit				-0.69	0.50	-0.42

DISCUSSION

This study assessed the interactions between conscientiousness, neuroticism, and grit with rock-climbing improvement among university students over a six-week period. The study found no relationships between conscientiousness, neuroticism, grit, and two different indices of climbing performance. Some of this deviation from the research may be due to the relative expertise of the novice samples in this study as compared the expert samples of the research. Nonetheless, this result contradicts the research hypotheses and appears to contradict the implications of existing literature on the topics, at least suggesting that relationships between the variables are less meaningful than other research would point to. The exceptions to this are in the interaction between extraversion and time taken to climb and the differences between finishers and non-finishers on conscientiousness and neuroticism. However, these were exploratory analyses and replication would be necessary to draw further conclusions.

This study is hindered by several limitations. Small sample sizes, though realistic for the study, contributed to less statistical power. For half of the hypotheses, analyses were not possible because there was no significant change over time with respect to number of holds reached. This outcome may be due to the fact that the study involved such time- and energy-intensive participation and was encouraged with extrinsic reward. This may have led students to participate based on a desire for specific reward rather than a desire or interest in rock-climbing, which may be more representative of the population of beginning rock climbers. For this and other reasons, the sample may not be representative of the beginning-climber or undergraduate population. This could be remedied through random selection of those who have expressed a previous interest in rock-climbing. There may be a sampling bias due to the recruiting methods used to obtain participants, through professors known by the researcher.

Future research in this area would benefit from different methods of assessing personality traits and rock-climbing performance. Many of the participants were not able to complete the routes, leading to time as an inconsistent measure of performance. More precise and accurate measurements of climbing performance such as entropy-tracking could provide more reliable and valid data (Pijpers, Oudejans, Holscheimer, & Bakker, 2003; Sanchez, Boschker, & Llewellyn, 2010).

The hypothesized relationships, therefore, may truly not exist in this population, or they may have been identified using a different, valid scale to measure climbing performance. Presenting participants with more attainable goals would reduce a floor effect and including a restriction on number of falls and time spent hanging may have led to a more valid measure of time taken to climb and number of holds reached.

Given the growing interest in the sport of rock-climbing, research identifying non-physiological causes and correlates climbing improvement could lead to a valuable increase in body of knowledge and predictive opportunity. Although this study did not provide conclusive results, the implications for sport-psychology and rock-climbing should be considered.

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