PSYCHOPHYSICAL BENEFITS OF ROCK-CLIMBING ACTIVITY¹, ²

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Summary.—The aim of the study was to compare the psychophysical effects of rock climbing with a supervised fitness training in adults. Thirty-three healthy participants (M age = 32 yr., SD = 7) participated in rock climbing or in fitness training. The participants’ functional fitness, anxiety, and mood states were tested before and after 3 mo. of training. There was significant improvement of physical fitness in both groups after the intervention period. Anxiety significantly decreased after each single training session at the end of both courses. Differential effects in the rock-climbing group, as compared to the fitness group, emerged only on Vigor. Specifically, the rock-climbing group showed a decreasing trend in Vigor while the fitness group showed an increasing trend of Vigor after the intervention.

It is known that regular participation in adequate physical activity can have beneficial effects on physical and mental health (Penedo & Dahn, 2005; Eime, Young, Harvey, Charity, & Payne, 2013; Song, Joung, Ikei, Igarashi, Aga, Park, et al., 2013; Berchicci, Lucci, Perri, Spinelli, & Di Russo, 2014), mood, and on frequently diagnosed psychological syndromes such as depression and anxiety (Byrne & Byrne, 1993; Paluska & Schwenk, 2000; Martinsen, 2008; Wegner, Helmich, Machado, Nardi, Arias-Carrion, & Budde, 2014; Yoshihara, Hiramoto, Oka, Kubo, & Sudo, 2014). Health-related quality of life and social and physical functioning improve also in clinical patients (Mishra, Scherer, Snyder, Geigle, Berlanstein, & Topaloglu, 2012; Rosenbaum, Tiedemann, Sherrington, Curtis, & Ward, 2014).

Fitness training is one of the most common types of physical activities practiced by people attending fitness courses and health clubs. This type of program usually includes aerobic, functional strength, and stretching activities. It may also include conventional and unconventional activities performed with rhythmic music, supervised by an expert instructor (Kemmner, Von Stengel, Engelke, Häberle, Mayhew, & Kalender, 2010; ¹Address correspondence to Laura Guidetti, University of Rome “Foro Italico,” Piazza Lauro De Bosis, 6, 00135 Rome, Italy or e-mail (laura.guidetti@uniroma4.it).
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Kemmler, Von Stengel, Bebenek, & Kalender, 2013; Emerenziani, Meucci, Gallotta, Buzzachera, Guidetti, & Baldari, 2014).

Rock climbing is a fast growing sport at both recreational and competitive levels (Aras & Akalan, 2014). In rock climbing, athletes are evaluated on their ability to complete a specific route in the shortest time or to reach the farthest point on a route that represents a certain level of difficulty. The nature of this activity requires athletes to have good physical abilities such as strength, agility, and balance, as well as mental control (Giles, Rhodes, & Taunton, 2006; Morrison & Schöffl, 2007; Hodgson, Draper, McMorriss, Jones, Fryer, & Coleman, 2009). Moreover, research revealed that different types of climbing (e.g., lead or top-rope climbing) had different effects on physiological and psychological factors of climbers, especially on anxiety (Draper, Jones, Fryer, Hodgson, & Blackwell, 2008).

Anxiety and movement behavior are related in rock climbing (Aras & Akalan, 2014), since athletes with high anxiety show longer climbing duration ($d = 1.28$) and number of movements ($d = 0.84$) when compared to those with low anxiety (Nieuwenhuys, Pijpers, Oudejans, & Bakker, 2008).

Emotions prior to competition affect athletic performance (Filaire, Maso, Sagnol, Ferrand, & Lac, 2001). Referring to studies that assume an inverted U-shaped function between anxiety and performance, an individual performs better under optimal anxiety (Yerkes & Dodson, 1908). Therefore, moderate anxiety facilitates and is connected with a good performance (Sanchez, Boschker, & Llewellyn, 2010). The Profile of Mood States is commonly used to evaluate six mood states in athletes. Athletes with low scores on Anxiety, Anger, Depression, Confusion, and Fatigue but high scores on Vigor (the Iceberg Profile) are the most successful (Morgan, 1980).

There are few studies comparing physical and psychological characteristics in rock climbers and other exercise participants (Sherk, Bemben, & Bemben, 2010), particularly with respect to mood states.

Hypothesis 1. Rock climbing participants will have an improved mood profile compared to those practicing fitness training.

Hypothesis 2. Rock climbing participants will have improved physical performance compared to those practicing fitness training.

Method

Participants

Thirty-three healthy volunteers (age range = 22–52 years) participated in the study. All participants were recreationally active at baseline, and the fact that they did not participate in any other organized physical activity prior to the intervention classified them as beginners for this study. After the
recruitment, they self-selected to participate in one of two types of a physical education class: rock climbing (N=20; 8 women, 12 men; M age=32 yr., SD=7 yr.; M height=1.72 m, SD=0.08; M weight=64.3 kg, SD=10.5; M body mass index=21.6 kg/m², SD=2.3) or fitness (N=13; 5 women, 8 men; M age=32 yr., SD=8; M height=1.72 m, SD=0.08; M weight=68.6 kg, SD=12.0 kg; M body mass index=23.1 kg/m², SD=2.9 kg/m²). Differences in the baseline anthropometric, physical performance, and psychological measures of the rock-climbing group and fitness group were not statistically significant.

The participants had no history of medical, psychiatric, or neurologic disease, no chronic pain conditions, and were taking no analgesic medications. Furthermore they had no family history of epilepsy, no current pregnancy, no implants in the head, and did not take acute or chronic medication. According to Italian regulations, all participants underwent the annual sport/physical activity eligibility screenings at the beginning of their course, certifying that they were physically and neurologically healthy. All participants were naive to the purpose of the experiment.

The Institutional Review Board of the University of Rome “Foro Italico” approved this investigation. Written informed consent forms were obtained from the participants prior to study participation.

*Measures*

For the evaluation of the physical fitness, four different tests were performed. These tests were selected from the EuroFIT test battery for adults (Oja & Tuxworth, 1995) since they showed good psychometric properties (objectivity, standardization, reliability, validity, and availability of reference data; Committee of Experts on Sports Research EuroFIT, 1993; Oja & Tuxworth, 1995; Tsigilis, Douda, & Tokmakidis, 2002).

Some authors have already demonstrated that rock climbers need specific physiological qualities to successfully perform a climb (Giles, et al., 2006; Morrison & Schöffl, 2007; Magiera, Roczniok, Maszczyk, Czuba, Kantyka, & Kurek, 2013). Flexibility, muscular strength, and muscular endurance are advantageous, because of a great demand upon the upper body during climbing (Giles, et al., 2006). According to this theoretical background, assessment of strength, flexibility, and balance, rather than aerobic capacity, were of interest as physical factors particularly required in climbing training.

*Balance ability.*—A static balance test, standing in an upright position on one leg with arms extended laterally at shoulder level, was performed. During the test, the participants stood on a beam 50 cm long, 5 cm high, and 3 cm wide with a bare foot. The value used for test analysis was the number of times balance was lost (when the other foot touched the floor),
and was recorded in 60 total sec. of balancing. This test has a reported test-retest reliability of ICC = .73 (Tsigilis, et al., 2002).

Lower back/upper thigh flexibility.—The sit-and-reach test was conducted. The participants sat on the floor with legs straight ahead, bare feet placed against the sit-and-reach box, and hands on top of each other with palms facing down. After taking a deep breath, participants exhaled and reached forward along the measuring line as far as possible. After three practice reaches, the average values were calculated and recorded. This test has a reported test-retest reliability of ICC = .94 (Tsigilis, et al., 2002).

Abdominal strength and endurance.—A sit-up test was conducted. The participants laid on their backs with knees bent at a 90° angle and feet and hands on the floor, started the sit-ups by raising the upper body, and then lowered their body until the shoulders touched the ground. The numbers of sit-ups performed in 30 sec. were recorded. This test has a reported test-retest reliability of ICC = .83 (Tsigilis, et al., 2002).

Upper body strength and endurance.—The flexed arm hang test was done. The participants were instructed to hold a horizontal bar with supinated hands and reach a flexed arm position while hanging with their chin held above the bar as long as possible. The time in seconds spent in this position was recorded. This test has a reported test-retest reliability of ICC = .89 (Tsigilis, et al., 2002).

Anthropometrics.—Body weight was measured using a scale to the nearest 0.5 kg. Height was measured using a stadiometer to the nearest 0.1 cm. The participants’ body mass index (BMI) was calculated as the weight in kilograms divided by the square of the height in meters (kg/m²).

Profile of Mood States (POMS).—Developed by McNair, Lorr, and Droppleman (1992), this scale assesses six self-reported psychological states, namely Tension, Depression, Anger, Vigor, Fatigue, and Confusion. The questionnaire comprises 58 separate adjectives, each of which refer to one of the six mood states. The participants rated the extent to which the adjective characterized their mood state at that moment (right now) on a 5-point scale, with anchors of 0: Not at all and 4: Extremely. For each dimension, use of software permitted the computation of a T score subjected to analysis, with higher T scores indicating a stronger mood state. The Italian version of the POMS was used (McNair, et al., 1992) for its optimal psychometric properties (Cronbach’s α coefficient values of .74–.91) and stability (test-retest reliability coefficients values of .65–.74; McNair, et al., 1992).

State-Trait Anxiety Inventory (STAI).—Developed by Spielberger (1996), this scale is used to assess anxiety. It includes two dimensions, i.e., state anxiety (State), which evaluates the emotional state of an individual in a particular situation, and trait anxiety (Trait), which refers to a relatively stable characteristic of personality. STAI State was used to assess state anxi-
STAI Trait was used to assess trait anxiety before and after the intervention. The inventory comprises 20 items describing positive (10 items, e.g., “I feel relaxed”) or negative (10 items, e.g., “I feel tense”) statements. The participants rated each item on a 4-point scale with anchors of 1: Not at all and 4: Extremely. The scale scores were the sum of negative item scores and the positive item scores (after reversal), so higher scores indicate greater anxiety. The Italian version of the STAI was used (Spielberger, 1996). This version has good internal consistency reliability (Cronbach’s α coefficient values of .91–.95 for STAI State and .85–.90 for STAI Trait) and stability (test-retest reliability coefficient values of .49 for STAI State and .82 for STAI Trait; Spielberger, 1996).

Exercise Training Programs

The intervention period lasted 3 mo. Both interventions were equivalent in overall duration and total physical activity amount, but different in structure because of the different training schedules. The rock climbing intervention had a frequency of 1.5 hr., twice per week, while the fitness intervention had a frequency of 1 hr., three times per week.

The rock climbing intervention was structured to improve cardiovascular endurance, upper- and lower-body strength and endurance, flexibility, and sport-specific skill with cross-training for muscle balance to improve physical fitness and allow climbers to successfully perform the route (Anderson, 2014). Moreover, the training program included several sport-specific skill-development training sessions to familiarize the participants with gear and rope management, to acquire footwork and route finding, and to locate good belay spots and resting positions while climbing. Indoor climbing was performed at rock-climbing gyms. Each rock climbing lesson included 15 min. of warm-up, 60 min. of activities to acquire and practice fundamental climbing skills (e.g., body position, spotting and belaying, equipment use, knots, and communication), footwork, and handwork to hold the participants in place while moving from one location or position to another on the climbing wall, and finally 15 min. of cool-down and stretching.

The fitness group performed 60 min. of a supervised program comprising 15 min. of aerobic activities at low to moderate intensity, followed by 35 min. of functional strength training (divided in 10 min. of upper limbs, 10 min. of lower limbs, and 15 min. of trunk exercises performed on the floor) and 10 min. of stretching. Walking and jogging were used as aerobic exercises corresponding with the participants’ personal fitness levels. Curl-ups, push-ups, squats, and other common calisthenic exercises were performed, using also light weights or elastic bands as functional strength
training. The exercises performed during each training session changed every time to increase the variability and to avoid monotony in the program.

The participants carried out their training protocol for 3 mo., for 3 hr. per week. Before and after the 3 mo. training period, anthropometric characteristics, physical efficiency, and psychological variables were evaluated. Anthropometric measurements were made first, then the participants’ psychological variables were assessed. Afterward, fitness tests were performed in the following order: balance test, sit-and-reach test, and abdominal and upper-body strength and endurance tests. To avoid the effects of fatigue and muscle soreness on performance, there was a minimum of a 3 min. rest period between these tests.

Analysis

Descriptive statistics were calculated. Physical performance, Trait anxiety, and POMS data were analyzed using separate $2 \times 2$ mixed-model analyses of variance (ANOVA), with Group (rock-climbing group vs fitness group) and Intervention (pre- vs post- 3 mo. intervention) as factors. To investigate the possible effect of exercise on State anxiety, a separate $2 \times 2 \times 2$ mixed-model ANOVA with Group (rock-climbing group vs fitness group), Intervention (pre- vs post- 3 mo. intervention), and Session (pre- vs post-session) as factors was used. For the analysis, the first and the last training sessions of both groups were considered. A post hoc analysis was further performed to analyze significant interactions between factors. Within the Group factor, differences in the baseline anthropometric, physical performance, and psychological measures of the rock climbing and fitness groups were assessed with unpaired t tests. Effect sizes were calculated using Cohen’s estimates of small, medium, and large effect sizes as $d = 0.20$, $0.50$, $0.80$. Statistical significance was set at $p \leq .05$.

RESULTS

Physical Performance Results

Table 1 shows pre-intervention and post-intervention individual EuroFIT scores. Intervention (pre- vs post-intervention) had significant main effects on balance ability ($F_{1,22} = 12.14$, $p = .002$, $d = 1.0$) and abdominal strength and endurance (sit-ups) ($F_{1,22} = 18.76$, $p = .001$, $d = 1.0$), and no significant main effect on flexibility ($F_{1,22} = 0.19$, $p = .47$, $d = 0.20$) and upper body strength and endurance ($F_{1,22} = 4.16$, $p = .06$, $d = 0.94$). Group had no significant main effect on balance ability ($F_{1,22} = 1.50$, $p = .23$, $d = 0.55$), abdominal strength and endurance ($F_{1,22} = 0.57$, $p = .47$, $d = 0.35$), flexibility ($F_{1,22} = 0.54$, $p = .66$, $d = 0.35$), and upper body strength and endurance ($F_{1,22} = .23$, $p = .63$, $d = 0.59$). Intervention $\times$ Group interaction had no significant effect on bal-
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Performance ability \( (F_{1,22} = 1.89, \ p = .18, \ d = 0.63) \), abdominal strength and endurance \( (F_{1,22} = 1.68, \ p = .23, \ d = 0.59) \), flexibility \( (F_{1,22} = .83, \ p = .37, \ d = 0.41) \), and upper body strength and endurance \( (F_{1,22} = 1.60, \ p = .22, \ d = 0.59) \).

Psychological Results

State anxiety scores were affected only by Session \( (F_{1,22} = 4.58, \ p < .05, \ d = 0.91) \). Specifically, State anxiety significantly decreased at the end of the last training session in both groups (rock-climbing group: \( M=34, \ SD=8 \) vs \( M=30, \ SD=6 \), pre- vs post-session, respectively; \( p < .005 \) (fitness group: \( M=39, \ SD=9 \) vs \( M=35, \ SD=9 \), pre- vs post-session, respectively; \( p < .05 \)). There was no significant main effect of Intervention \( (F_{1,22} = 1.11, \ p = .30, \ d = 0.45) \) or Group \( (F_{1,22} = 1.24, \ p = .28, \ d = 0.47) \) for the State anxiety scores.

No significant main effect of Intervention and of Group and no significant interaction effect (Intervention × Group) were found for the Trait anxiety scores.

Table 2 reports the ANOVA results on POMS scores: main effects of Intervention and of Group and Intervention × Group interaction. Intervention × Group interaction had a significant effect on the vigor variable \( (p = .05) \).

The likely presence of differential effects of the rock-climbing group as compared to the fitness group emerged only in the vigor variable. The variable showed an opposite trend in the rock climbing and fitness groups (Figs. 1-2). Specifically, the rock-climbing group showed a decreasing trend while the fitness group showed an increasing trend of the vigor variable after intervention \( (T \) scores, rock-climbing group: \( M=54.7, \ SD=5.3 \) vs \( M=51.9, \ SD=8.2 \), respectively; fitness group: \( M=49.0, \ SD=11.2 \) vs \( M=53.9, \ SD=9.9 \), respectively). However, these changes across the 3 mo. intervention were not statistically significant. No significant differences were found for the other POMS variables between pre- and post-intervention and between groups.

| Test                | Rock-climbing Group | Fitness Group |
|---------------------|---------------------|---------------|
|                     | Pre                 | Post          | Pre     | Post |
|                     | M  SD               | M  SD         | M  SD   | M  SD |
| Flamingo balance test | 7 4               | 3 2           | 4 4     | 3 3   |
| Sit-and-reach test   | 23 7               | 22 7          | 25 7    | 25 8  |
| Sit-ups test         | 15 3               | 16 2          | 13 4    | 15 4  |
| Flexed arm hang test | 18 10              | 19 11         | 13 15   | 18 22 |

TABLE 1
PHYSICAL FITNESS VARIABLES IN ROCK-CLIMBING GROUP AND IN FITNESS GROUP BEFORE (PRE) AND AFTER (POST) INTERVENTION
Previous studies reported that sport practice could increase physical and psychological well-being (Penedo & Dahn, 2005; Eime, et al., 2013; Song, et al., 2013; Berchicci, et al., 2014). Results revealed that both rock climbing and fitness training positively affected physical fitness and Anxiety. Moreover, interesting results were reported for the Vigor variable in both groups.

**Physical Performance**

After the intervention, both groups performed better on abdominal strength and balance tests with a large effect size. Participants of the fitness-training group performed a total of 35 min. of functional strength training per session as reported by the guidelines for exercise prescription in healthy adults to develop and maintain musculoskeletal fitness (Garber, Blissmer, Deschennes, Franklin, Lamonte, Lee, et al., 2011). This specific strength training also included 10 min. of conventional exercises such as half squat, squat, and squat jump for leg power training and 15 min. of trunk exercises performed on the floor for abdominal strength and endurance. As confirmed by previous studies, optimal gains in muscle strength

| Variable | Factor         | \( F \) | \( df \) | \( p \) | \( d \) |
|----------|----------------|--------|--------|--------|--------|
| Tension  | Intervention   | 2.73   | 1      | .11    | 0.70   |
|          | Group          | 0.11   | 1      | .74    | 0.20   |
|          | Intervention × Group | 0.30 | 1   | .59    | 0.20   |
| Depression| Intervention | 0.35   | 1      | .56    | 0.29   |
|          | Group          | 0.32   | 1      | .58    | 0.29   |
|          | Intervention × Group | 0.35 | 1   | .56    | 0.29   |
| Anger    | Intervention   | 1.13   | 1      | .72    | 0.20   |
|          | Group          | 0.54   | 1      | .47    | 0.35   |
|          | Intervention × Group | 0.22 | 1   | .64    | 0.20   |
| Vigor    | Intervention   | 0.33   | 1      | .57    | 0.29   |
|          | Group          | 0.29   | 1      | .60    | 0.20   |
|          | Intervention × Group | 4.32 | 1   | .05    | 0.91   |
| Fatigue  | Intervention   | 2.29   | 1      | .15    | 0.67   |
|          | Group          | 1.94   | 1      | .18    | 0.63   |
|          | Intervention × Group | 0.99 | 1   | .33    | 0.46   |
| Confusion| Intervention  | 3.52   | 1      | .07    | 0.81   |
|          | Group          | 0.01   | 1      | .92    | 0.06   |
|          | Intervention × Group | 0.55 | 1   | .47    | 0.35   |
occur with training two to three times per week (Rhea, Alvar, Burkett, & Ball, 2003; Peterson, Rhea, & Alvar, 2005; Wernbom, Augustsson, & Thomee, 2007; Emerenziani, et al., 2014). This can be effectively achieved with whole body training sessions completed two to three times per week (Garber, et al., 2011).

Balance ability is significantly related to performance measures in various sports (Hrysomallis, 2011). The static unipedal balance improvement of the fitness group was due to an increase in the strength and endurance of the whole body and by an increase in body awareness, as the callisthenic exercises performed involved many coordinative skills, and thus improved balance and proprioceptive ability.

Fig. 1. Profile of mood state in rock-climbing group and in fitness group before intervention (±SEM)

Fig. 2. Profile of mood state in rock-climbing group and in fitness group after intervention (±SEM)
The rock-climbing group also significantly improved in abdominal strength and balance. Rock climbing beginners had to develop poise and confidence in climbing hand-over-hand up vertical routes, to explore more difficult terrains (Luebben, 2011). Climbers performed general and sport-specific strength training exercises to strengthen muscles. They also performed specific training to maintain stable joints and proper posture in order to be efficient and effective in the vertical movements of climbing. Rock climbing requires high strength and power (Magiera, et al., 2013); it also stimulates the development of complex technical skills that require movement economy and safety (Horst, 2003). Therefore, improvement in climbers' strength and balance ability and technical training are critical elements of the rock-climbing program.

Psychological Performance

Variance in rock climbing performance is explained by trainable variables (Mermier, Janot, Parker, & Swan, 2000) such as strength, climbing technique, complex reaction time, and mental endurance (Magiera, et al., 2013). Moreover, successful performance could be affected by activation, attention, and stress perception (Horst, 2003), related to safety perception and anxiety control (Aras & Akalan, 2014).

Studies revealed that when practicing under elevated pressure, anxiety control allows better sport performance (Oudejans & Pijpers, 2009; Lawrence, Cassell, Beattie, Woodman, Khan, Hardy, et al., 2014). A stress- and anxiety-inducing activity such as rock climbing could be affected positively by anxiety control and related mood states. Results indicated that state anxiety significantly decreased over single training sessions for both groups, in agreement with previous studies revealing that acute bouts of aerobic exercise were effective in reducing post-exercise state anxiety (Cox, Thomas, Hinton, & Donahue, 2004; Smith, 2013). Previous studies revealed that thermogenic, neurophysiological, motivational, and psychological mechanisms simultaneously operate to reduce state anxiety following acute exercise (Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991). Another possible explanation of the reduction in state anxiety associated with acute exercise is the distraction hypothesis, that physical exercise can be a distractor from stressful stimuli (Petruzzello, et al., 1991). However, in the present study the decrease in state anxiety occurred only after single training sessions at the end of the interventions. Positive effects of acute exercise may be observed only after a sufficient training period to induce feelings of mastery and a sense of accomplishment and thereby positively change mood states (Tuson & Sinyor, 1993).

The absence of a significant difference on trait anxiety between the two groups pre- and post-intervention could be due to the fact that the climbers trained at an indoor climbing gym, a more benign environment
than a natural outdoor climbing area. This may have eliminated the stressors caused by perceived danger and greatly reduced the expected difference in feelings of conquering fear, compared to the fitness group. It would be of interest to compare a fitness group to a group learning to climb in a more challenging outdoor setting.

Vigor is an important variable for both athletes and non-athletes (Prapavessis, 2000; Filho, Ribeiro, & García, 2005), as it is related to performance and because high Vigor characterizes the Iceberg Profile of successful athletes and positive mental health (Morgan, 1980, 1985; Beedie, Terry, & Lane, 2000). The POMS profile before intervention did not match the Iceberg Profile in either group (when Tension, Depression, Anger, Fatigue, and Confusion are scored below the 50th T score while Vigor is scored above; Terry & Lane, 2000). However, after the 3-mo. intervention the results of the rock-climbing group did match the Iceberg Profile, while the fitness group positively improved their profile toward the Iceberg Profile. These results may be explained by the mood-enhancing properties of sport training and physical activity (Terry & Lane, 2000), indicating that participants of both groups may more successfully perform (Morgan, 1980; Pulkinnen, 2001).

A limitation of the study is the non-random group but the self-selection assignment. The lack of assessment of physical ability variables in addition to the four selected subtests of the EuroFIT test battery was problematic, especially the lack of an aerobic fitness measure. However, these tests were chosen due to their relevance to exercises for body training and conditioning proposed in both interventions. All participants were primarily trained to improve their physical fitness globally, since they were inexperienced in physical activity. For these reasons, some tests (e.g., hand-grip test) were excluded from physical performance measures, although specific training to enhance hand strength should be considered for rock climbers (Grant, Hynes, Whittaker, & Aitchison, 1996; Bertuzzi, Franchini, Tricoli, Lima-Silva, Pires, Okuno, et al., 2012).

In conclusion, findings suggest a medium to large effect size for both rock climbing and fitness training on physical fitness, mood states, and state anxiety. Interesting results were reported for Vigor in both groups. Further research is needed to investigate how to potentiate the positive effects of rock climbing training over longer interventions and to better specify some exercise parameters (e.g., intensity) in order to obtain optimal effects on anxiety and mood states.

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