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The Effect of the Pyramid Training Method System on Upper Body Climbing Endurance in Boulder Athletes

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Abstract

This study aims to determine the effect of the pyramid system training method on upper body climbing endurance in bouldering athletes. The need for upper body strength endurance is a crucial component of bouldering performance because climbing activities require intense and repeated isometric and dynamic contractions. This study used a one-group pretest–posttest experimental design involving ten members of the PAMOR FPOK UPI rock climbing division as research subjects. The instrument used to measure strength endurance was the bent arm hang test, which has high validity and reliability in measuring isometric abilities relevant to climbing performance. The treatment in the form of pyramid system training was given for sixteen sessions with progressive load variations focused on the upper body muscles. Data were analyzed using descriptive tests, normality tests, homogeneity tests, and paired sample t-tests. The results showed a significant increase between pretest and posttest scores, as evidenced by a mean improvement of 2.44 seconds in the bent arm hang test (pretest: 23.32 ± 14.00 s; posttest: 25.76 ± 13.45 s), with the paired sample t-test indicating a statistically significant difference ($t = -10.584$, $p < 0.001$), thus it can be concluded that the pyramid system training method is effective in improving upper body climbing endurance in bouldering athletes. These findings indicate that training with gradual loads can be used as an alternative training program relevant to the physiological demands of rock climbing, especially bouldering.

How to Cite

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INTRODUCTION

Rock climbing is a physical activity that demands comprehensive physical and mental abilities. As the sport evolves, various technical standards, regulations, and coaching patterns are continually refined to meet the needs of modern athletes (Nasugian & Suripto, 2021). The bouldering category is one of the events that demands explosive strength, stability, and the ability to quickly read the path, as each movement requires intense and repeated use of upper body strength.

In the past two decades, scientific attention to the physiology of rock climbing has increased rapidly. Numerous studies have highlighted the role of muscle strength, endurance, movement biomechanics, and physiological characteristics in determining climbing performance (Baláš et al., 2014). In bouldering, the route challenges are often short but intense, requiring strength and endurance in the arm, shoulder, and back muscles to maintain repeated short-duration but high-intensity contractions (White & Peter, 2010).

Boulder athletes need the ability to maintain movement efficiency despite high physiological stress. Hanging, pulling, and explosive weight transfers place significant stress on the upper body, particularly the finger flexors, arm muscles, and shoulders (Stankovic & Andrijasevic, 2011). Therefore, the strength or muscular endurance component is a basic requirement for athletes to be able to complete the route optimally (Sidik, 2019).

Several previous studies have confirmed that upper body muscle strength and endurance are closely related to climbing performance, both in recreational and competitive climbers (Giles et al., 2006; Phillips & colleagues, 2012). Physiological adaptations that support increased endurance are essential, given that bouldering often requires athletes to attempt multiple routes, which demands muscular endurance to maintain performance without significant decline.

On the other hand, training methods are a crucial factor in developing these physical qualities. The pyramid system is a weight training approach that involves progressing from light to heavy weights, with gradually decreasing repetitions (Harsono, 1988; Sidik, 2019). This training model is theoretically capable of increasing strength, muscle mass, and endurance because it provides a gradual stimulus that stimulates neuromuscular and metabolic adaptations (Bakhtiar & Abdullah, 2013).

Research shows that exercises that improve the muscle›s ability to sustain both isometric and dynamic contractions are highly relevant to the demands of rock climbing, particularly in hanging and holding activities in bouldering (Draper et al., 2021). The Bent Arm Hang has been recommended as a valid instrument in measuring the isometric strength capacity of the upper arm and has a relationship with climbing performance (Balas et al., 2012), so it is appropriate to be used as a measuring tool in research related to climbing endurance.

While numerous studies have addressed general rock climbing performance, studies on specific training methods aimed at improving upper-body climbing endurance in bouldering are limited. This underscores the importance of research examining the effect of pyramid system training on bouldering athletes› endurance abilities, given the specific performance enhancement needs in this event (Stien & Bjornsen, 2019).

However, unlike previous studies that primarily focused on general strength or climbing performance, the present study specifically investigates the application of the pyramid training system to upper-body isometric endurance using a sport-relevant assessment (bent arm hang), thereby providing empirical evidence for a structured, progressive resistance-based approach tailored to the physiological demands of bouldering.

Based on this background, this study seeks to make a scientific contribution by examining the effectiveness of the pyramid system training method in improving upper-body climbing endurance in bouldering athletes. The results are expected to serve as a reference for coaches and athletes in designing more targeted, effective training programs that meet the physiological demands of modern rock climbing.

METHOD

This study used an experimental method with a one group pretest–posttest design, where one group of subjects was given an initial test, then received treatment, and then given a final test to see changes after the intervention (Sugiyono, 2015). This design was chosen to identify changes in climbing endurance ability after being given pyramid system training.

The research subjects were all ten members of the PAMOR FPOK UPI rock climbing division. The sampling technique used was total sampling because the entire population met the research characteristics and was in accordance

with the sampling requirements for experimental research using a single group (Sugiyono, 2019).

The instrument used to measure climbing endurance is the bent arm hang test, which has high reliability and has been proven relevant in assessing climbing ability (Baláš & Kodejška, 2012; Draper et al., 2021). This instrument was used in the pretest and posttest to ensure consistency of upper body isometric strength endurance measurements.

The research procedure began with a pretest, after which subjects received sixteen sessions of weight training using the pyramid system. The training program included a combination of exercises focused on upper-body muscles with gradual variations in load according to the principle of a pyramid without an apex. After the treatment, subjects underwent a posttest to assess changes in performance.

Data analysis was carried out using SPSS with steps including descriptive tests, Kolmogorov–Smirnov and Shapiro–Wilk normality tests, homogeneity tests using Levene's Test, and hypothesis testing using paired sample t-test to see significant differences between the pretest and posttest (Fadluloh et al., 2024).

RESULTS AND DISCUSSION

Table 1. Descriptive Test

	N	Min	Max	Mean	Standard Deviation
Pretest	10	8.29	52.86	23.3190	14.00033
Post Test	10	11.18	54.33	25.7560	13.44987
Valid N (listwise)	10				

Based on the descriptive analysis results in the Descriptive Statistics table, it was found that the number of research subjects was 10 people. In the pretest results, the minimum score achieved by participants was 8.29 seconds, while the maximum score reached 52.86 seconds. The average pretest score was 23.319 seconds with a standard deviation of 14.00033, which indicates that the initial climbing endurance abilities of the research participants had quite large variations.

In the posttest results, the minimum score increased to 11.18 seconds, while the maximum score reached 54.33 seconds. The average posttest score was 25.756 seconds with a standard deviation of 13.44987. There was an increase in the average score compared to the pretest, indicating an improvement in upper body climbing endurance ability after being given pyramid system training.

Normality tests were conducted using two methods, namely Kolmogorov–Smirnov and Shapiro–Wilk. The test results on the pretest data showed a significance value of 0.131 for Kolmogorov–Smirnov and 0.072 for Shapiro–Wilk. Meanwhile, the posttest data obtained a significance value of 0.099 for Kolmogorov–Smirnov and 0.057 for Shapiro–Wilk.

All significance values are greater than 0.05, thus concluding that both the pretest and posttest data are normally distributed. Therefore, the assumption of normality is met, and the analysis can proceed using a parametric test, namely the Paired Sample t-Test.

A homogeneity test was conducted using Levene's Test to determine whether the variances between the pretest and posttest data were similar. Based on the SPSS output for the Based on Mean category, a significance value of 0.897 was obtained. This value is greater than the established significance level of 0.05, thus concluding that the variances of both data groups are homogeneous.

Based on the results of the Paired Sample t-Test, the mean difference between the pretest and posttest was –2.437 seconds with a standard deviation of 0.72812. The calculated t value = –10.584 with degrees of freedom (df) = 9 and significance $p = 0.000$ ($p < 0.05$), so it can be concluded that there is a significant difference between the pretest and posttest results. Thus, it can be stated that the pyramid system training has a significant effect on increasing upper body climbing endurance in bouldering athletes.

The results of the study indicate that the pyramid system training program positively contributed to improving upper body climbing endurance in bouldering athletes. This finding aligns with various studies confirming that strength endurance is a crucial component of rock climbing performance, particularly in bouldering events that require repeated and intense activation of the arm, shoulder, and back muscles. Bouldering activities place significant loads on the finger, arm, and shoulder flexor muscles, so improving the ability to maintain both isometric and dynamic contractions will have a direct impact on climbing performance (Stien & et al., 2019; White & Peter, 2010).

The pyramid training system provides physiologically relevant adaptations to the demands of sport climbing. This system uses a high-repetition progression initially with light weights, then gradually decreasing the repetitions while increasing the load. This pattern has been shown to be effective in increasing muscle capacity through a

combination of metabolic and mechanical stimuli, both of which are necessary for improving strength endurance (Azhari & Firmansyah, 2022). Recent studies also report that gradual intensity training can improve muscle fatigue resistance by increasing oxidative capacity and neuromuscular efficiency (Stien & Saeterbakken, 2023).

In the context of rock climbing, increased endurance is primarily related to the ability to maintain isometric muscle contractions in the upper arm and finger flexors during the hanging and hold-transfer phases. Previous research has confirmed that this ability directly correlates with successful route completion in bouldering events (Baláš et al., 2014; Draper & colleagues, 2021). Pyramid system training allows for such adaptations to occur because its repetitive structure triggers a controlled accumulation of local fatigue, thus providing appropriate stimulation to increase the local isometric and anaerobic capabilities of the muscles.

The performance improvements found in this study are also consistent with the findings of Stien et al. (2021) that weight training targeting dominant muscles in rock climbing can significantly improve performance, particularly in boulder climbers who rely on upper body strength and coordination. This is also supported by reports (Sanchez & Lambert, 2019) that upper limb muscle strength and endurance are strong predictors of bouldering ability, particularly on high-intensity, explosive routes.

Additionally, the pyramid training method provides intensity variation that prevents neuromuscular fatigue and helps maximize training adaptation. The variation in load and repetitions in this method has been shown to enhance neuromuscular integration and more effective motor unit recruitment, resulting in increased muscle endurance capacity (Bakhtiar & Abdullah, 2013). Thus, the implementation of this training throughout the research period provided an opportunity for athletes to experience continuous adaptation to progressively increasing training loads.

Practically, the observed increase in climbing endurance suggests that the pyramid system training program can be an effective alternative for developing bouldering abilities, particularly in the context of performance development at the college or beginner club level. The adaptations that occurred reflect the physiological match between the pyramid training structure and the physiological demands of bouldering events, which involve intense effort over relatively short but repetitive durations.

Taking into account the current research trend which shows that a structured, progressive and sport-specific training approach provides the best results in improving performance, the findings of this study provide an empirical basis that the pyramid system method can be used as part of a bouldering athlete development program (Vasile & Popescu, 2022). The significant improvement in upper-body isometric endurance observed in this study supports the principle of training specificity, as the pyramid system's progressive load structure closely reflects the repetitive, high-intensity muscular demands of bouldering movements. This confirms that the appropriate selection of training methods not only enhances general physical capacity but also directly influences key performance components that determine an athlete's ability to efficiently complete bouldering routes under fatigue conditions.

CONCLUSION

This study shows that the pyramid system training method effectively improves upper body climbing endurance in bouldering athletes. Progressive training through varying loads and repetitions can improve the ability of upper body muscles to maintain isometric contractions, which are the primary demands of bouldering. The use of the bent arm hang as a measurement instrument also proved relevant for assessing changes in athletes' strength endurance capacity. Therefore, the pyramid system method can be recommended as an effective alternative training program for developing bouldering athlete performance, particularly in climbing endurance.

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