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Assessing the Impact of Stair Climbing Exercise on Endurance Performance in Athletes

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ABSTRACT

Background: This study explores the impact of stair climbing exercise on endurance performance in athletes. It provides evidence for stair climbing as a potential endurance training modality.

Objectives: To investigate the impact of stair climbing program on endurance performance in endurance athletes.

Methods: A quasi-experimental study involving 30 endurance athletes was conducted, with participants assigned to an intervention group that completed an 8-week stair climbing program. Baseline data, including demographics and initial fitness levels, were collected using the 3-minute step test and Cooper run test. After the intervention, fitness levels were reassessed, and paired t-tests were performed for statistical analysis.

Results: The intervention group showed significant improvements. The 3-minute step test mean performance improved from 120.73 (SD = 9.548) to 116.77 (SD = 9.383) ($t(29) = 16.076$, $p < .000$). Cooper run test mean distance increased from 2290.00 meters (SD = 138.240) to 2369.83 meters (SD = 137.028) ($t(29) = -15.256$, $p < .000$).

Conclusion: Stair climbing exercise effectively enhances endurance performance in athletes, as evidenced by significant improvements in the 3-minute step test and Cooper run test. This highlights its potential as a valuable addition to endurance training programs.

Keywords: Aerobic capacity, Endurance training, Exercise Therapy, Exercise Test, Fitness assessment, Oxygen Consumption, Physical Endurance, Stair climbing

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Introduction

Stair climbing is a commonplace activity that transcends its utilitarian purpose to serve as a potent cardiovascular exercise with profound physiological and psychological benefits. Unlike other forms of aerobic exercise, stair climbing engages a comprehensive range of muscle groups, including the quadriceps, hamstrings, glutes, calves, and core, through repetitive concentric and eccentric muscle contractions. These biomechanical demands foster muscular endurance, strength, and joint stability, distinguishing stair climbing from more traditional endurance exercises such as running and cycling (1). Additionally, its inherent reliance on body weight as resistance elevates it as a practical and accessible form of high-intensity physical activity suitable for diverse populations (2).

From a cardiovascular perspective, stair climbing provides sustained aerobic activity that significantly elevates heart and respiratory rates, enhancing the body's oxygen transport capacity and overall cardiovascular efficiency. This dual aerobic and resistance training modality confers unique advantages in improving stamina and reducing cardiovascular risk factors, such as high resting heart rate and poor circulation (3). Psychological benefits, including elevated endorphin levels, further contribute to its appeal by improving mental well-being and reducing stress (4).

Historically, stair climbing has been an integral part of human activity, whether as part of daily routines in ancient civilizations or as a cross-training method to complement structured exercise programs (5). The activity's potential to enhance endurance performance has been underutilized despite its alignment with the key principles of endurance training, such as the development of aerobic capacity, muscular strength, and stamina. Emerging research highlights its effectiveness in promoting adaptations that support athletic performance, making it a promising alternative to conventional endurance training regimens (6). However, a notable gap exists in evidence-based exploration of stair climbing's role in structured endurance training for athletes.

Endurance athletes require a fine-tuned balance of physiological and biomechanical efficiency to excel in their disciplines. Traditional training methods often emphasize activities such as running, swimming, and cycling, while novel exercises like stair climbing remain underexplored despite their potential advantages (7). Recent investigations into diverse aerobic exercises—including swimming (8), cycling (9), jogging (10), and trekking (11)—underline the importance of variety in endurance training. Stair climbing's capacity to integrate strength and cardiovascular endurance positions it as an efficient and versatile exercise for athletes seeking innovative ways to enhance their performance. This research addresses the question of whether stair climbing can significantly influence endurance performance among athletes. By bridging the current gap in the literature, the study aims to provide valuable insights into the physiological adaptations associated with stair climbing and its role as a potential cornerstone of endurance training. Such findings could guide athletes and coaches in optimizing training protocols, broadening the spectrum of effective endurance-building strategies.

Materials and Methods

A quasi-experimental study was conducted at The University of Lahore, Lahore, Pakistan, following ethical approval obtained from the institution's review board. A total of 30 endurance athletes, aged 18 to 25 years, were recruited using inclusion criteria. Participants were screened for any medical conditions or injuries that could contraindicate physical exercise, ensuring safety and homogeneity within the study population. Written informed consent was obtained from all participants prior to their inclusion in the study.

Baseline assessments comprised demographic data collection, anthropometric measurements, and fitness evaluations. Fitness levels were determined using the 3-minute step test and the Cooper run test, both of which are validated tools for measuring cardiovascular endurance and aerobic capacity. Participants were underwent 8-week stair climbing training program.

The intervention consisted of three weekly sessions of stair climbing exercises, with intensities progressively adjusted based on individual fitness levels. Each session included a structured warm-up, a main training phase incorporating moderate to high-intensity climbing, and a cool-down period. The experimental group's training program was carefully designed to avoid overtraining and injury, emphasizing proper form, adequate hydration, and recovery between sessions.

Post-intervention assessments were conducted using the same fitness tests to evaluate changes in endurance performance. Data collection was performed by trained personnel blinded to group allocation to minimize bias. Outcome measures included changes in the 3-minute step test scores and distances covered in the Cooper run test, analyzed using paired sample t-tests.

Statistical analysis was performed using SPSS version 25. Descriptive statistics summarized demographic and baseline characteristics, while paired sample t-tests evaluated within-group differences pre- and post-intervention. A p-value of <0.05 was considered statistically significant. All data were handled confidentially, and results were reported in aggregate to maintain participant anonymity. The study's design and execution adhered to rigorous scientific and ethical standards to ensure the reliability and validity of findings.

Results

The study was conducted on 30 athletes with diverse demographic characteristics. The participants had a mean age of 21.8 years (SD = 2.355), a mean weight of 67.23 kg (SD = 10.549), and a mean height of 171.93 cm (SD = 12.295). The calculated mean BMI was 23.17 kg/m² (SD = 3.777), reflecting the overall physical characteristics of the study group.

Table 1: Demographic Characteristics of the Participants

Parameter	Mean	Standard Deviation
Age (years)	21.8	2.355
Weight (kg)	67.23	10.549
Height (cm)	171.93	12.295
BMI (kg/m²)	23.17	3.777

The results of the study revealed changes in performance following the interventions across two fitness tests. In the 3-Minute Step Test, the mean from 120.73 pre-intervention to 116.77 post-intervention, indicating an improvement in cardiovascular efficiency. Similarly, performance on the Cooper Run Test improved, with the mean distance covered increasing from 2290 pre-intervention to 2369.83 post-intervention. These findings suggest that the interventions were effective in enhancing both cardiovascular endurance and overall aerobic capacity. In the end, results demonstrate significant improvements in both the 3-minute step test and Cooper Run Test following the stair climbing intervention. These findings suggest that stair climbing exercise positively influences endurance performance in athletes.

Table 2: Pre-Intervention and Post-Intervention Endurance Performance testing

Test Condition	Interventions	Mean	Standard Deviation	Std. Error Mean
3-Minute Step Test	Pre-Intervention	120.73	9.548	1.743
	Post-Intervention	116.77	9.383	1.713
Cooper Run Test	Pre-Intervention	2290	138.240	25.239
	Post-Intervention	2369.83	137.028	25.018

The paired samples test indicates a statistically significant improvement in the 3-minute step test and Cooper Run Test scores post-intervention. The mean performance improved by 3.967 units and 79.833 units respectively. The results were highly significant in both interventions ($p < 0.000$).

Table 3: Paired Samples Test for 3-Minute Step Test and Cooper Run Test

Paired Samples Test	Mean Difference	Std. Deviation	Std. Error Mean	t	df	Sig.
3-Minute Step Test	3.967	1.351	0.247	16.076	29	< 0.000
Cooper Run Test	79.833	28.662	5.233	15.256	29	< 0.000

Discussion

The findings from this study demonstrated that stair climbing exercises significantly enhanced endurance among athletes, as evidenced by improvements in both the 3-minute step test and the Cooper Run Test. These results indicated a statistically significant difference in performance metrics between pre- and post-intervention measurements, reflecting the efficacy of stair climbing exercises in boosting endurance performance. The increase in the mean performance in the 3-minute step test and the notable improvement in the mean distance covered in the Cooper Run Test suggested a consistent and robust enhancement in cardiovascular and muscular endurance. This aligns with previous studies emphasizing the benefits of stair climbing as a functional and accessible form of exercise that challenges both aerobic and anaerobic systems (1,2).

The study also highlighted the practical application of stair climbing exercises as an integral component of endurance training regimens. The intervention's effectiveness in enhancing performance in standardized endurance tests supports its potential for incorporation into various athletic disciplines. Prior research has documented similar benefits, such as the improvements in physical work capacity and reduced leg muscle fatigue observed during exhaustive stair-climbing tasks (4). Furthermore, stair climbing's ability to enhance both strength and endurance has been explored in the context of other physical fitness components, emphasizing its versatility and broad applicability (5,6).

However, several limitations must be acknowledged. The characteristics of the study population, including sample size and demographic homogeneity, may limit the generalizability of the findings. Additionally, the intervention's duration and intensity were fixed, leaving unexplored the potential dose-response relationship between stair climbing and endurance improvements. Similar research, such as investigations into short bouts of stair climbing and their impact on musculoskeletal performance and creativity, highlights the need to assess variations in protocol design (7,8). Strengths of this study included the use of standardized performance tests, which provided objective and comparable measures of endurance improvements.

Future research should explore the optimal frequency, duration, and intensity of stair climbing interventions to maximize benefits across diverse athletic populations. Investigations into long-term adaptations to stair climbing, as well as its effects on other physical and psychological health outcomes, would also be valuable. The findings contribute to the growing body of evidence supporting the role of stair climbing as a time-efficient and effective modality for enhancing endurance, aligning with broader public health initiatives to promote physical activity and overall well-being (13).

Conclusion

This study provided evidence that stair climbing exercises significantly enhanced endurance among athletes, with improvements observed in both the 3-minute step test and the Cooper Run Test. These findings suggest that incorporating stair climbing into training regimens can effectively enhance endurance performance and overall fitness, contributing positively to human health and well-being.

Authors' Contributions

ICMJE authorship criteria	Detailed contributions	Authors
Substantial Contributions	Conception or Design of the work	1,2,3
	Data acquisition	2,3,5
	Data analysis or interpretation	1,3,5
Drafting or Reviewing	Draft the work	1
	Review critically	2,4,6
Final approval	Final approval of the version to be published.	1,2,3,4,5,6
Accountable	Agreement to be accountable for all aspects of the work.	1,2,3,4,5,6

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