ORIGINAL ARTICLE

Strength training versus high-intensity aerobic exercise: which is more effective in increasing il-10 production as an anti-inflammatory?

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim Physical exercise is widely recognized as an effective strategy for improving health and quality of life. The purpose of this study was to analyze the effects of high-intensity and low-intensity strength training, as well as high-intensity aerobic exercise, on serum Interleukin-10 (IL-10) production.

Material and Methods Thirty college students were recruited to undergo different training programs in each group. The study employed an experimental design with three exercise groups: high-intensity strength training (STH), low-intensity strength training (STR), and high-intensity aerobic exercise (AH). Each group included 10 participants, and serum IL-10 levels were measured before exercise and 24 hours post-exercise. To assess long-term effects, participants trained three times per week for four weeks under carefully monitored conditions.

Results The results showed that all types of exercise significantly increased serum IL-10 levels. The AH group exhibited the highest increase, followed by the STR and STH groups. These findings align with previous studies demonstrating an increase in IL-10 following high-intensity aerobic exercise. The elevated IL-10 levels in the AH group can be attributed to improved cardiovascular capacity and the body's inflammatory response. Strength training, despite not increasing VO2max, also led to an IL-10 increase, though the effect was smaller compared to aerobic exercise.

Conclusions High-intensity aerobic exercise is more effective at increasing IL-10 production compared to strength training. This study suggests combining both types of exercise to maximize immunological benefits. Such an approach can also enhance post-exercise recovery. It is important to consider the duration and recovery intervals, as these factors influence the immune response.

Keywords: aerobic exercise, anti-inflammatory, high-intensity, strength training

Introduction

Physical exercise has long been recognized as one of the most effective strategies for improving health and quality of life [1]. Various training methods are currently available, including weight training and aerobic training. Previous studies have identified that both weight training and aerobic training offer significant benefits for enhancing physical abilities and metabolic functions [2, 3, 4, 5, 6]. However, despite these positive effects, repeated high-intensity exercise can lead to muscle inflammation [7, 8, 9]. A key indicator often used to measure and assess the resolution of inflammatory responses caused by muscle contractions is Interleukin-10 (IL-10), also known as human cytokine synthesis inhibitory factor (CSIF) [10, 11, 12].

IL-10 is produced to suppress the production of pro-inflammatory cytokines resulting from muscle contractions, which, if continuously produced, can cause tissue damage and delay the recovery process [13, 14]. The production of IL-10 aids in recovery during and after physical exercise [10]. However, to date, no research has specifically analyzed the effects of high- and low-intensity strength training and high-intensity aerobic training on IL-10 production. Each of these methods involves different mechanisms that stimulate the body to adapt to the training process. Strength training relies on muscle strength indicators through the

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use of maximum loads, focusing on maximizing the body's physical capacity for specific movements [15]. In contrast, aerobic exercise emphasizes improving cardiovascular and respiratory function, aiming to increase endurance for sustained physical activity [16, 17]. These differences in mechanisms suggest variations in IL-10 production, which require further analysis through research.

Some previous studies have primarily focused on the differences between exercise types, such as aerobic exercise and strength training, without considering the role of intensity in each type of exercise [18, 19]. However, incorporating intensity has significant potential to influence the physiological and immunological outcomes of exercise.

The urgency of this research is underscored by the critical role of IL-10 in regulating inflammation linked to various health conditions, including heart disease, diabetes, and autoimmune disorders [20, 21, 22, 23]. As more individuals engage in exercise programs to improve health, understanding how exercise intensity and type affect IL-10 production will contribute to designing more effective programs. Such programs could enhance immunity, accelerate recovery, and reduce the risk of chronic inflammatory diseases [24, 25, 26].

This study aims to examine the effects of different exercise types combined with varying intensities on IL-10 biomarker production. It is expected to contribute to a better understanding of how exercise variations influence the body's immune response, particularly in managing post-exercise inflammation.

Materials and Methods

Participants

College students were recruited to participate in different training programs assigned to each group. The students were first matched based on age, resting heart rate (RHr), SpO2, blood pressure, glucose level, hemoglobin, weight, height, BMI, fat percentage, muscle mass, visceral fat, and bone mass. Thirty students, who had a history of engaging in physical exercise three times a week, were randomly assigned to the high-intensity strength training group (STH; age = 18.1 ± 0.31 years, n = 10), low-intensity strength training group (STR; age = 19.6 ± 2.36 years, n = 10), and high-intensity aerobic training group (AH; age = 18.7 ± 1.25 years, n = 10).

The body composition measurement procedure, blood sampling process, and physical exercise protocols were explained to all participants. Each participant read and signed a consent form before joining the study. The experimental procedure was approved by the Ethics Committee (107/EC/KEPK-FKUC/III/2024).

Research Design

This study investigated the effects of four weeks of physical training using different methods on IL-10 production. All participants completed a personal and medical history questionnaire and a lifestyle assessment, which served as a screening tool. Participants were familiarized with the testing procedures before starting the study.

To assess the long-term effects, participants underwent training three times per week for four weeks under carefully monitored conditions. Blood samples were collected at the beginning and end of the training period to measure serum IL-10 concentrations.

The VO2peak test, maximal strength assessment (for the STH and STR groups), body composition measurements, and IL-10 level evaluations were performed at the start and end of the training period. All measurements were conducted by the researcher at the same time each day. The study took place from August to September 2024.

Body Composition Measurement and Health

Body composition measurements were conducted using Tanita BC-545N series scales to collect data on body weight, BMI, body fat, muscle mass, visceral fat, and bone mass. Glucose levels were measured using the Accutrend Plus, hemoglobin (HB) levels using Easytouch, SpO2 levels using the Beurer PO40, and blood pressure using the Omron Blood Pressure Monitor Hem-8712. Each participant's pulse was measured using the Polar H-10 device [27].

The physical exercise program was designed to optimize participants' training outcomes and ensure adherence to the study protocol. Details of the program are illustrated in Figure 1, which outlines the exercise methods and regimens used during the four-week intervention.

Before testing, athletes were given 2 × 24 hours of rest to ensure optimal condition for the 1 RM bench press and leg extension tests. The implementation and procedures for the bench press and leg extension followed the guidelines of the NSCA [28]. Repetitions were performed in a controlled rhythm, with concentric contractions lasting approximately 1 second and eccentric actions lasting about 2 seconds. A 90-second rest period was provided between sets.

Statistical Analysis

Data analysis was performed using SPSS version 29 software. The Shapiro-Wilk test was used to assess the normality of the data, while the Levene test evaluated the homogeneity of variance. Data with a normal distribution and homogeneous variance were analyzed using paired t-tests and one-way ANOVA. Results are presented as mean ± SD. GraphPad Prism 10 software was used to create visual graphs.

Results

Based on the descriptive analysis, no significant differences were observed in the sample profiles across the three groups, as indicated by the results of the one-way ANOVA analysis shown in Table 1. The analysis results of the IL-10 biomarker for each group are presented in Table 2. Additionally, differences in serum IL-10 levels within each group and the corresponding delta values are displayed in Figure 2.

Table 2 shows the serum IL-10 levels for each group. The Pre serum IL-10 value was measured 24 hours before the exercise, while the Post value was measured 24 hours after the physical exercise.

Figure 2 illustrates that serum IL-10 levels before and after exercise differed significantly in each group ($p < 0.05$). Serum IL-10 levels increased after exercise in all groups.

Figure 3 presents the results of the one-way ANOVA test, followed by Tukey HSD post-hoc analysis across the three groups. IL-10 values were not significant (ns) in the pre-exercise data. However, significant differences (*) were observed between STH vs. AH and STR vs. AH in the post-exercise IL-10 values ($p < 0.05$). Similar significant differences were found in the delta calculations for STH vs. AH and STR vs. AH.

Discussion

The results of this study demonstrate that physical exercise interventions, regardless of the model and intensity applied, can increase serum IL-10 levels as an anti-inflammatory marker. These findings align with several previous studies, which also concluded that physical exercise elevates serum IL-10 levels 24 hours after activity [29, 30, 31]. The increase in anti-inflammatory serum serves as a counterbalance to the pro-inflammatory effects induced by exercise.

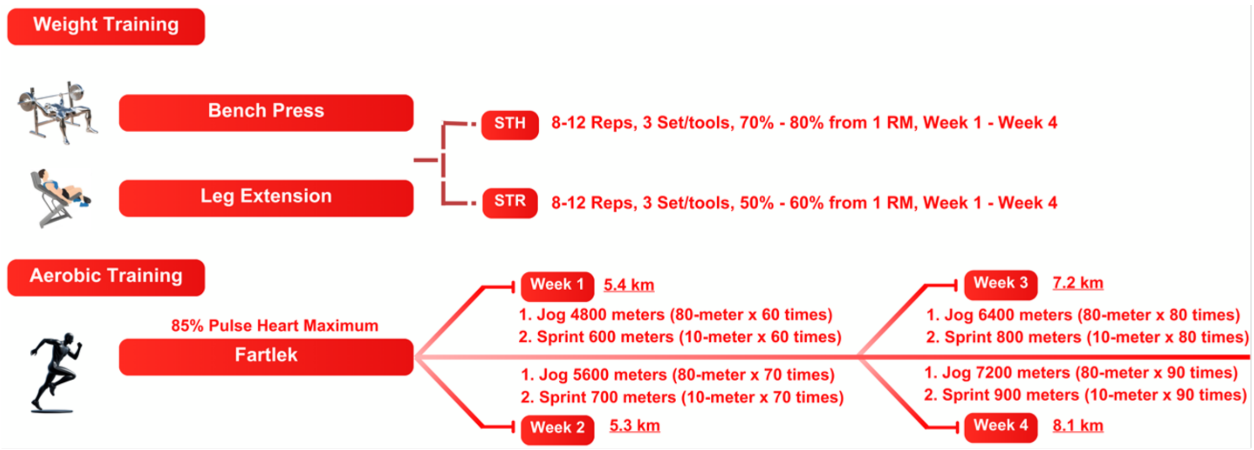

Figure 1. Physical exercise program

Table 1. Sample Profile Characteristics

Variable	STH	STR	AH	p-value
Age (years)	18.1 ± 0.31	19.6 ± 2.36	18.7 ± 1.25	0.114
RHR (bpm)	67 ± 6.84	70.6 ± 5.98	69.3 ± 4.39	0.389
SpO2 (%)	97.6 ± 1.26	97.6 ± 1.07	97.1 ± 1.10	0.540
Systole (mmHg)	114.9 ± 3.47	119.1 ± 2.96	118.3 ± 3.49	0.200
Diastole (mmHg)	74.7 ± 5.73	74.4 ± 4.92	73.9 ± 6.90	0.954
Glucose (mg/dL)	96.7 ± 8.08	101.8 ± 10.61	102.2 ± 9.23	0.357
HB (g/dL)	14.54 ± 1.13	14.23 ± 1.57	13.86 ± 1.30	0.538
Body Weight (kg)	62 ± 7.94	61.5 ± 6.20	64 ± 10.36	0.780
Height (m)	1.68 ± 0.05	1.69 ± 0.07	1.68 ± 0.06	0.910
BMI (kg/m^2)	21.73 ± 2.23	21.44 ± 1.39	22.59 ± 2.70	0.476
Body Fat (%)	15.14 ± 3.89	18.15 ± 3.26	18.01 ± 4.13	0.152
Muscle Mass (kg)	48.86 ± 5.40	48.61 ± 4.43	50.29 ± 6.15	0.755
Visceral Fat (level)	5 ± 1.33	4.55 ± 1.93	4.1 ± 1.39	0.453
Bone Mass (kg)	5.8 ± 0.49	5.86 ± 0.49	5.92 ± 0.64	0.887

Description: STH (strength training with high intensity), STR (strength training with low intensity), AH (aerobic training with high intensity).

Table 2. IL-10 Level in each group

Test	Group	N	Mean ± St.dev	Minimum	Maximum
Pre	STH	10	84.36 ± 19.46	63.52	124.79
	STR	10	82.10 ± 37.77	23.07	129.93
	AH	10	107.73 ± 20.73	81.10	157.00
Post	STH	10	136.33 ± 34.91	68.59	193.30
	STR	10	139.16 ± 29.26	82.59	173.82
	AH	10	199.76 ± 29.86	158.10	270.70
Delta	STH	10	51.96 ± 36.60	3.80	110.45
	STR	10	57.05 ± 32.49	10.29	127.47
	AH	10	92.02 ± 22.14	54.10	122.10

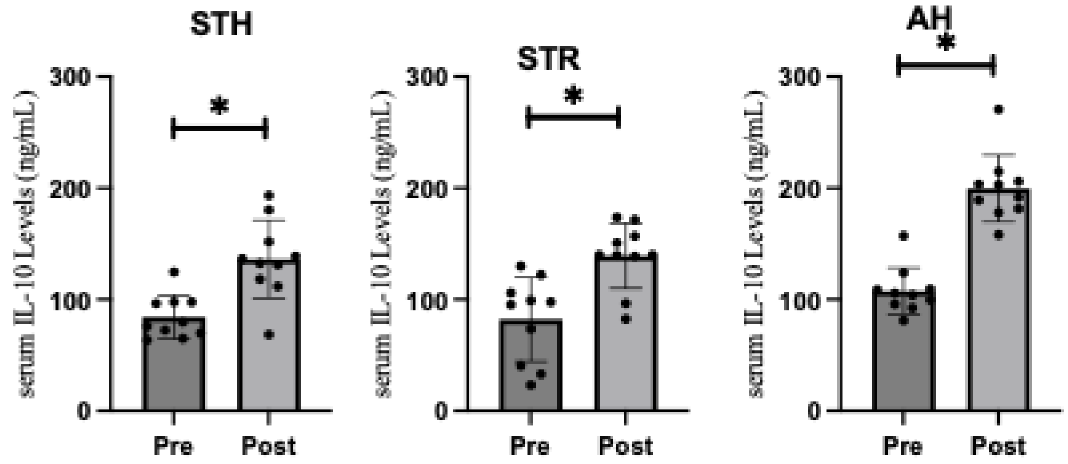

Figure 2. Differences in serum IL-10 Pre and Post for each group

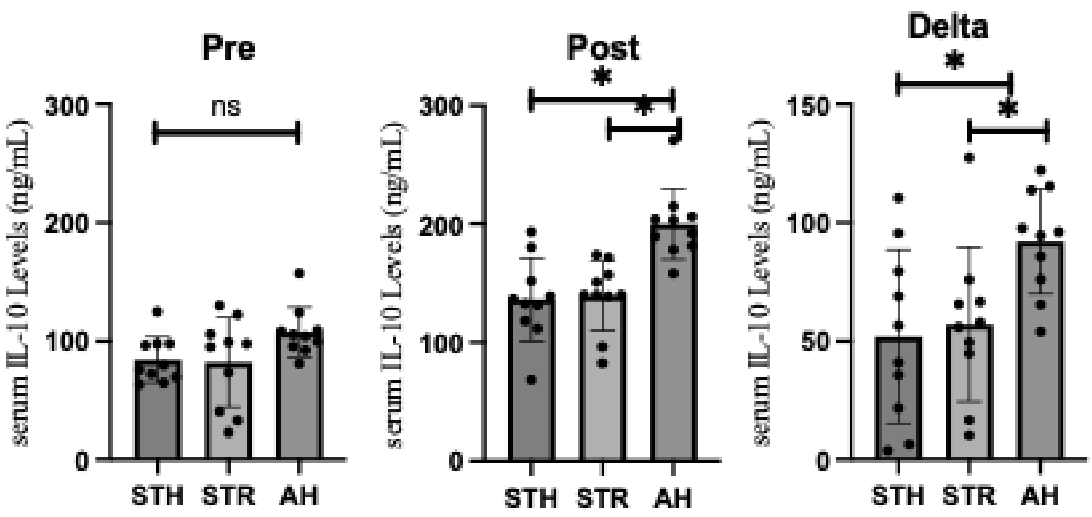

Figure 3. Differences in serum IL-10 in the three groups

Interestingly, this study found that the three training methods resulted in different changes in serum IL-10 levels. The high-intensity aerobic training group showed the greatest increase among the three groups. This finding is supported by previous research [32, 33, 34], which also reported an increase in serum IL-10 following high-intensity aerobic exercise. The increase in IL-10 occurs because high-intensity aerobic exercise induces inflammation, such as lipopolysaccharide-mediated activation of the Akt-STAT3 axis [35]. This activation triggers an anti-inflammatory response by increasing IL-10 production as a mechanism to reduce inflammation.

The increase in serum IL-10 observed in the weight training group contrasts with previous studies [36, 37], which reported no change in serum IL-10 levels following weight training. However, this finding aligns with other research [38, 39], which also concluded that strength training with weights leads to an increase in IL-10 levels.

The mechanism by which aerobic exercise over four weeks increases IL-10 production is not only linked to the high levels of inflammation experienced by athletes during training but also to improvements in VO2max. This aligns with findings from previous research [34], which demonstrated a relationship between increased VO2max and IL-10 production. In contrast, weight training in this study did not increase VO2max, as it primarily focused on changes in muscle size [40, 41, 42]. Differences in IL-10 production are also influenced by factors such as the type of exercise, intensity, duration, recovery between sessions, and variations in exercise regimens [43, 44, 45].

This study yielded interesting results, showing an increase in IL-10 production across all groups, with aerobic exercise producing a greater increase compared to strength training. These findings suggest that combining aerobic and strength training in the exercise process may provide greater benefits by improving both cardiovascular function and muscle strength. For older adults, enhanced cardiovascular and muscular capabilities can contribute to better health and fitness.

Study Limitations

This study is limited by its small sample size and short training duration, which may affect the generalizability of the findings. Additionally, the research focused solely on IL-10 production without exploring other related biomarkers or long-term health outcomes. Future studies should involve larger and more diverse populations, extend the training period, and investigate additional indicators such as oxidative stress markers, inflammatory cytokines, and mental health parameters to provide a more comprehensive understanding of the effects of combined exercise regimens.

Conclusions

This study concluded that all three exercise models (STH, STR, AH) were effective in increasing the production of the anti-inflammatory biomarker IL-10. High-intensity aerobic exercise had a greater impact on IL-10 production after four weeks of training. The primary advantage of high-intensity aerobic exercise lies in its significant effect on cardiovascular capacity and the inflammatory response. In contrast, strength training did not directly enhance cardiovascular capacity. Therefore, combining strength training with aerobic exercise is likely to provide greater benefits for the body's immune response and the acceleration of recovery processes.

Conflict of interests

The authors declare that there is no conflict of interests.

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