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Effect of High-Intensity Interval Training and Low-To-Moderate Continuous Training on Vital Capacity among College-Level Basketball Play

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ABSTRACT

This study examined the effects of two exercise interventions on vital capacity (VC) in adult participants. Thirty healthy volunteers were randomly assigned to one of three groups: high-intensity interval training (HIIT, n = 10), low-to-moderate continuous training (LMC, n = 10), or a non-training control group (n = 10). Baseline lung function (pre-test VC) was measured for all participants before an 8-week intervention period, and post-test VC was measured afterward. A one-way analysis of covariance (ANCOVA) was conducted on post-test VC, using pre-test VC as a covariate. Results showed that, after adjusting for baseline differences, the type of exercise training significantly affected post-test VC ($F(2,26) = 88.63$, $p < .001$). Post hoc comparisons (Bonferroni-adjusted) revealed that the HIIT group had significantly higher mean VC than both the LMC and Control groups ($p < .001$ for each comparison), and the LMC group's VC was also significantly higher than Control ($p < .001$). In practical terms, HIIT produced the greatest improvements in lung capacity, LMC produced moderate improvements, and no-training control showed the least change. These findings suggest that regular aerobic training—especially high-intensity intervals—can significantly enhance vital capacity in adults.

Keywords: Vital Capacity; High-Intensity Interval Training; Continuous Training; Lung Function; ANCOVA

INTRODUCTION

Lung capacity, often measured as vital capacity (VC), is a key indicator of respiratory health. Vital capacity is the maximum volume of air a person can exhale after a full inhalation, and it tends to decline with sedentary lifestyle and aging. Regular exercise is known to strengthen respiratory muscles and improve lung function [1]. In particular, aerobic training has been shown to increase lung volumes. For example, Rawashdeh and Alnawaiseh reported that participants engaging in high-intensity aerobic exercise showed significant increases in forced vital capacity (FVC), implying greater overall lung capacity [2]. Similarly, Shadmehri, Kazemi, and Heydari found that high-intensity interval training (HIIT) led to larger improvements in respiratory volumes than moderate continuous training in their sample of students [3,4]. Thus, the literature suggests that both HIIT and continuous aerobic exercise can improve pulmonary function, with HIIT often yielding superior gains [5].

Given these findings, the present study compared the effects of two exercise regimens on vital capacity: (1) a high-intensity interval training (HIIT) program, and (2) a low-to-moderate intensity continuous training (LMC) program. A no-exercise control group was also included. We hypothesized that the HIIT group would show the greatest increase in VC, the LMC group would show a moderate increase, and the control group would show little or no change. To test these hypotheses, we conducted an ANCOVA on post-intervention vital capacity scores, using pre-intervention (baseline) VC as a covariate to control for initial differences [6].

METHOD

Participants. Thirty healthy adults (aged 18–25 years) were recruited and randomly assigned to three groups (n = 10 each): HIIT, LMC, and Control. All participants were non-smokers without known respiratory illnesses. The sample included both males and females. (Detailed demographics were similar across groups and are omitted for brevity)

Design

This study employed a randomized controlled design with a between-subjects factor of Group (HIIT, LMC, Control) and a covariate of baseline vital capacity (VC_pre). All participants completed a baseline lung function test, measured with standard spirometry to assess vital capacity (in liters). The HIIT group then participated in an 8-week interval training program (e.g., alternating intense bouts of exercise with rest, three times per week). The LMC group performed 8 weeks of continuous moderate-intensity aerobic exercise (e.g., jogging or cycling at

60–70% of maximal heart rate, three times per week). The Control group did not receive any structured exercise intervention and was instructed to maintain their usual activities. After 8 weeks, all participants returned for a follow-up spirometry test to measure post-intervention vital capacity (VC Post).

Measures and Statistical Analysis. Vital capacity (VC) was measured using a calibrated spirometer following standard procedures (American Thoracic Society, 1995). For statistical analysis, we used analysis of covariance (ANCOVA) to compare the three groups on post-test VC while controlling for pre-test VC. The pre-test score served as a covariate to adjust for baseline differences. This approach increases statistical power by removing variance attributable to initial levels [7]. Prior to the ANCOVA, assumptions were checked. Normality of the VC scores in each group (pre- and post-test) was assessed using the Shapiro–Wilk test, appropriate for small samples ($n < 50$). Homogeneity of regression slopes and other ANCOVA assumptions were also examined [6]. All tests used a significance level of $\alpha = .05$. Post hoc pairwise comparisons were conducted with Bonferroni correction to control for multiple comparisons.

RESULTS

Descriptive Statistics and Assumptions

Table 1 presents the descriptive statistics (means and standard deviations) of post-test vital capacity by group. The HIIT group achieved the highest mean VC, followed by the LMC group, with the Control group having the lowest mean (see Table 1).

Group	M	SD	n
HIIT	3.551	0.452	10
LMC	3.356	0.518	10
Control	2.93	0.403	10

Table 1: Descriptive Statistics for Vital Capacity (Liters, Post-test) by Group

Note: HIIT = High-intensity interval training, LMC = Low-to-moderate continuous training

Normality of VC scores was confirmed for all groups (see Table 2). Shapiro–Wilk tests were non-significant (all $p > .05$), indicating that the assumption of normal distribution was not violated in any group for either pre-test or post-test VC ($N = 10$ per group).

Measure	Group	Shapiro–Wilk W	df	p
VC_Pre	HIIT	0.906	10	0.253
	LMC	0.913	10	0.306
	Control	0.897	10	0.201
VC_Post	HIIT	0.922	10	0.376
	LMC	0.937	10	0.523
	Control	0.913	10	0.3

Table 2: Tests of Normality for Vital Capacity by Group

Note: VC_pre = baseline vital capacity; VC_post = post-intervention vital capacity

Since all Shapiro–Wilk p-values exceeded .05, we assume the VC distributions did not deviate significantly from normality. (Kolmogorov–Smirnov tests were also non-significant but are not shown, as Shapiro–Wilk is more appropriate for small samples.) Levene's test confirmed homogeneity of variances for the ANCOVA (all $p > .10$; not shown). The homogeneity of regression slopes assumption was met (the group × covariate interaction was non-significant, $p > .10$). Thus, it was appropriate to proceed with the ANCOVA.

A one-way ANCOVA was conducted with Group as the independent variable (3 levels) and baseline VC as covariate. The corrected model was significant ($F(3,26) = 679.79$, $p < .001$), explaining about 98.7% of the variance in post-test VC (Adjusted $R^2 = .986$). The covariate (VC_pre) was a highly significant predictor ($F(1,26) = 1471.26$, $p < .001$), indicating that baseline VC was strongly related to post-test VC. After adjusting for baseline, the main effect of Group on post-test VC was also significant ($F(2,26) = 88.63$, $p < .001$). This means that, even when accounting for initial lung capacity, the three groups differed significantly in their post-test vital capacity (Table 3)

Source	Type III SS	df	Mean Square	F	p
VC_pre (cov)	3.815	1	3.815	1471.26	< .001
Group	0.46	2	0.23	88.63	< .001
Error	0.067	26	0.003		
Total	457.454	30			
Corrected Total	5.356	29			

Table 3: ANCOVA Results (Between-Subjects Effects on Post-test Vital Capacity)

Note: VC_pre = baseline vital capacity; Group effect compares HIIT, LMC, Control (Type III sum of squares)

These results confirm a very strong effect of the intervention on lung capacity. The adjusted means (marginal means) were: HIIT = 3.551 L; LMC = 3.356 L; Control = 2.930 L. In other words, controlling for baseline, the HIIT group's post-test VC was about 0.204 L higher than the LMC group and 0.306 L higher than the Control group (Table 4). All group differences were statistically significant.

Pairwise Bonferroni-adjusted comparisons showed that all between-group differences were significant (Table 4). Specifically, the HIIT group's vital capacity was significantly greater than the LMC group (mean difference = 0.204 L, 95% CI [0.157, 0.250], $p < .001$) and significantly greater than Control (mean diff = 0.306 L, 95% CI [0.257, 0.354], $p < .001$). The LMC group also had significantly higher VC than Control (mean diff = 0.102 L, 95% CI [0.054, 0.151], $p < .001$). These comparisons indicate a graded effect: HIIT > LMC > Control.

Group (I)	Group (J)	Mean Diff (I–J)	SE	p	95% CI [Lower, Upper]
HIIT	LMC	0.204	0.023	< .001	[0.157, 0.250]
	Control	0.306	0.024	< .001	[0.257, 0.354]
LMC	HIIT	-0.204	0.023	< .001	[-0.250, -0.157]
	Control	0.102	0.023	< .001	[0.054, 0.151]
Control	HIIT	-0.306	0.024	< .001	[-0.354, -0.257]
	LMC	-0.102	0.023	< .001	[-0.151, -0.054]

Table 4: Pairwise Comparisons of Group Differences (Adjusted VC_post Means)

Note: Comparisons are Bonferroni-adjusted; $p < .001$ for all

In summary, the adjusted (post-intervention) VC means showed that the HIIT group had the highest lung capacity, followed by LMC, with the Control group lowest. The magnitude of the differences (e.g., +0.306 L for HIIT vs. Control) is both statistically and practically meaningful. The large F-statistic for Group (88.63) and the effect size (partial $\eta^2 \approx .87$) indicate that training type had a very strong influence on VC outcomes.

DISCUSSION

This study found that an 8-week exercise intervention significantly improved vital capacity compared to no training, with high-intensity interval training (HIIT) yielding the greatest benefit. After controlling for baseline VC, both exercise groups showed higher post-test lung capacity than the control, confirming our hypotheses. The HIIT group outperformed the low-to-moderate continuous (LMC) group, consistent with prior research. For example, Shadmehri observed that female students performing HIIT experienced larger gains in lung volumes than those doing steady-state aerobic training [4]. Likewise, Rawashdeh reported significant improvements in FVC and FEV_1 in participants after high-intensity training, indicating enhanced pulmonary function [5].

The improvements in VC for the HIIT and LMC groups are likely due to the physiological adaptations from regular aerobic exercise. As exercise-trained muscles (including respiratory muscles) become stronger and more efficient, lung ventilation improves [1]. HIIT, with its repeated bouts of near-maximal effort, may stimulate lung tissue and respiratory muscles more intensely than moderate exercise, leading to greater increases in lung volumes. Enhanced alveolar recruitment and increased chest wall expansion could also contribute to the observed gains in vital capacity.

Practically, these results suggest that implementing HIIT protocols can be especially effective for boosting lung function in healthy adults. The HIIT group in this study gained about 0.306 liters more VC than the control group, a substantial margin. Even the moderate continuous training produced significant gains (0.102 L above control), but to a lesser degree. Such enhancements in lung capacity can have wide-reaching health benefits, potentially improve endurance and reduce respiratory strain during daily activities [1].

Several limitations should be noted. The sample size was modest (N=30), and participants were relatively young and healthy; thus, the findings may not generalize to older or clinical populations. We also did not directly measure physiological mediators (e.g., respiratory muscle strength), so mechanistic explanations remain speculative. Future research could include direct measures of lung compliance or muscle strength, and examine longer follow-up to see if gains in VC are maintained.

In conclusion, the ANCOVA results demonstrate that both HIIT and moderate continuous training significantly improve vital capacity relative to no exercise, with HIIT producing the largest improvements. These findings align with current evidence that high-intensity exercise enhances pulmonary function [2-4]. For practitioners, incorporating high-intensity interval workouts may be the most efficient strategy to optimize lung health in healthy adults.

Practical Implications. Exercise programs aiming to improve respiratory health should consider including high-intensity interval components. Fitness trainers and rehabilitation specialists can leverage HIIT protocols to boost clients' lung function more effectively. Because even low-to-moderate continuous training yielded improvements (LMC group), any regular aerobic activity is better than none; however, the time-efficient nature of HIIT may make it more appealing for those with limited training time.

CONCLUSION

This study Concluded that an 8-week exercise intervention significantly improved vital capacity compared to no training, with high-intensity interval training (HIIT) yielding the greatest benefit. After controlling for baseline VC, both exercise groups showed higher post-test lung capacity than the control, confirming our hypotheses. The HIIT group outperformed the low-to-moderate continuous (LMC) group, consistent with prior research. Exercise programs aiming to improve respiratory health should consider including high-intensity interval components. Fitness trainers and rehabilitation specialists can leverage HIIT protocols to boost clients' lung function more effectively. Because even low-to-moderate continuous training yielded improvements (LMC group), any regular aerobic activity is better than none; however, the time-efficient nature of HIIT may make it more appealing for those with limited training time.

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