



Original Article

Longitudinal Analytical Study Estimating the Effect of Defined and Supervised Physical Activity of Five Months Duration on Physical Fitness Parameters and Pulmonary Function Tests in Healthy Adults (Age Group 18–22 Years)

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ABSTRACT

Background: Physical inactivity is a growing global health concern that significantly impacts physiological development and longevity. This study compared the effects of a five-month defined and supervised physical exercise program on pulmonary function tests and physical fitness parameters between two distinct academic cohorts [1, 2]. **Materials and Methods:** A longitudinal cohort study was conducted on 156 healthy first-year undergraduate students aged 18–22 years [3, 4]. The interventional study group (n=78, physical education students) engaged in daily structured aerobic activities for two hours, five days a week, while the control group (n=78, physiotherapy students) continued routine academic activities without structured training [5, 6]. Assessments included aerobic capacity (VO₂ max via Harvard Step Test), flexibility (Sit-and-Reach test), muscle strength (Handgrip Dynamometer), and pulmonary function (Spirometry for FVC and PEFr) [7, 8]. Data were analyzed using the Welch two-sample t-test [9]. **Results:** After five months, the study group demonstrated statistically significant improvements: VO₂ max increased from 3.13 ± 0.48 to 3.30 ± 0.37 ml/kg/min (p < 0.011), flexibility improved from 2.95 ± 2.15 to 11.76 ± 3.27 inches (p < 0.001), grip strength increased from 25.49 ± 5.29 to 44.27 ± 7.83 kg (p < 0.001), and FVC expanded from 4.14 ± 0.24 to 4.40 ± 0.50 Liters (p < 0.001) [10, 11]. The control group exhibited no significant variations across all identical parameters [12, 13]. **Conclusion:** Supervised aerobic exercise over five months markedly improves cardiorespiratory endurance, muscular strength, flexibility, and forced vital capacity in young adults [14, 15]. Academic curricula should formally integrate systematic physical activity to prevent physiological decline [16].

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Keywords: Physical Activity, Pulmonary Function Tests, VO₂ max, Aerobic Exercise, Young Adults.

INTRODUCTION

Physical activity is an indispensable requirement for the optimization and maintenance of human physiological function. The World Health Organization (WHO) consistently recommends a minimum of 150 minutes of moderate-intensity aerobic activity per week for adults to maintain baseline systemic health and mitigate the risks of chronic diseases [1, 2]. However,

the integration of technologically advanced environments, shifting dietary and occupational lifestyles, and rapidly increasing academic pressures have drastically reduced routine physical exercise [3]. This societal shift has catalyzed a 'silent pandemic' of physical inactivity, a condition now held responsible for millions of premature deaths globally [4]. In direct response to this escalating crisis, the Global Action Plan on Physical Activity (GAPPA) emphasized the absolute necessity of active living as a primary intervention to reduce the incidence and severity of non-communicable diseases [5, 6].

A notable and deeply concerning paradox exists among young adults, particularly those enrolled in health-related academic disciplines [7]. Despite possessing an acute theoretical awareness regarding the profound physiological benefits of exercise, these students frequently fail to translate this knowledge into practice, struggling to maintain regular physical activity [8]. Establishing and maintaining regular structured physical activity is critical; it fundamentally enhances cardiorespiratory endurance, optimizes total body re-composition, and significantly improves pulmonary function metrics [9, 10]. These functional improvements are not merely athletic enhancements; they are essential biological assets for long-term health resilience and are central to clinical rehabilitation protocols from chronic airway diseases such as asthma and chronic obstructive pulmonary disease (COPD) [11, 12].

The transition into higher education typically coincides with a sharp decline in physical activity levels [13]. Crucially, this decline occurs during a unique biological window—the late teenage to early adult years—which is physiologically essential for achieving peak musculoskeletal and cardiopulmonary maturation [14]. Therefore, evaluating and implementing structured exercise interventions during this precise age demographic is of paramount importance [15]. The literature highlights that pulmonary function and aerobic capacity are highly responsive to mechanical loading in this age group, suggesting that even moderate systemic interventions can yield outsized clinical benefits [16].

Consequently, the present study was designed to explicitly quantify and meticulously compare the physiological adaptations induced by a rigorous five-month supervised exercise program against a highly sedentary academic cohort [16]. Specifically, this investigation evaluates changes in physical fitness parameters— aerobic capacity (VO₂ max), musculoskeletal flexibility, and muscle strength—alongside critical pulmonary function tests, including Forced Vital Capacity (FVC) and Peak Expiratory Flow Rate (PEFR) [15].

MATERIALS AND METHOD

Study Design and Setting

This investigation was designed and executed as a longitudinal cohort study between September 2024 and January 2025 at a medical college attached to a tertiary care hospital. Comprehensive approval for the study protocol was formally obtained from the Institutional Ethical Committee prior to the initiation of any clinical or physiological assessments. Written informed consent was obtained from all participating individuals after the study's aims, methodologies, and potential risks were thoroughly explained.

Study Population

The study included a total sample of 156 healthy young adults strictly aged between 18 and 22 years. The sample was divided into two distinct academic cohorts to form the interventional and control groups. The interventional study group comprised 78 first-year physical education students, a cohort whose primary academic curriculum inherently necessitated rigorous daily physical exertion. Conversely, the control group comprised 78 first-year physiotherapy students, a cohort subjected to a heavily didactic, sedentary academic curriculum.

Inclusion and Exclusion Criteria

Healthy undergraduate students aged 18 to 22 years were included in the study. To ensure that respiratory and cardiovascular data were not confounded by external pathologies or lifestyle toxins, rigorous exclusion criteria were applied [17]. Participants with any documented history of smoking, chronic alcohol consumption, or tobacco use were systematically excluded, as these factors severely confound baseline respiratory variables and alveolar efficiency [18]. Furthermore, individuals suffering from acute or chronic systemic illnesses, or possessing physical disabilities that would preclude their safe participation in maximal exertion testing, were excluded.

Intervention Framework

For a continuous duration of five months, the interventional study group engaged in defined, supervised aerobic and physical conditioning activities. These structured sessions lasted for two hours daily and operated five days per week. The training primarily encompassed continuous aerobic exertion and functional conditioning. In stark contrast, the control group was formally instructed not to participate in any structured or newly introduced physical training regimens, continuing exclusively with their routine, predominantly sedentary academic activities for the full five-month duration.

Preoperative Airway Assessment and Physiological Parameters

Baseline and post-intervention anthropometric measurements, specifically height (in centimeters) and scale body weight (in kilograms), were systematically recorded for all 156 participants.

Aerobic Capacity, defined by the maximal oxygen uptake (VO₂ max), was quantified using the standardized Harvard Step Test, with results plotted on the Astrand-Ryhming nomogram [19]. Participants were instructed to step on a standardized bench at a strict cadence of 22 steps per minute for exactly 4 minutes. Following this exertion, timed recovery pulse rates were recorded to calculate aerobic efficiency [20].

Musculoskeletal flexibility was evaluated via the Well's Sit-and-Reach Test. This standardized metric was utilized to accurately quantify posterior chain extensibility and lumbar flexibility [21].

Muscle Strength, representing upper body neuromuscular integrity, was measured using a manual Handgrip Dynamometer [22]. Following a brief warm-up, subjects executed a 3-second maximum voluntary contraction in a standardized anatomical posture to record peak isometric force.

Pulmonary Function Tests (PFT) were conducted utilizing a computerized automated flow spirometer [23]. The methodology strictly complied with updated metrological standards for spirometry [24, 25]. To rigorously control for diurnal and circadian variations in airway resistance, all spirometry readings were executed at noon in a standardized standing position. The primary parameters extracted for comparative analysis included Forced Vital Capacity (FVC) and Peak Expiratory Flow Rate (PEFR).

Statistical Analysis

All raw physiological and demographic data were compiled and statistically analyzed using Microsoft Excel. To determine the mathematical validity and statistical significance of the physiological shifts recorded over the five-month timeline, the Welch two-sample t-test was deployed to analyze both within-group and between-group variances. Statistical significance was strictly defined a priori as a p-value of less than 0.05.

OBSERVATION AND RESULTS

Baseline physiological characteristics, including age distribution, initial body weight, and baseline pulmonary and strength metrics, were statistically comparable between the physical education (study) cohort and the physiotherapy (control) cohort at the commencement of the trial.

Table 1: Physical Fitness and Pulmonary Parameters at Baseline and After 5 Months (Study Group, n=78)

Variable	Baseline (Mean ± SD)	After 5 Months (Mean ± SD)	p-value
Weight (kg)	74.63 ± 10.99	71.51 ± 11.74	0.089
VO ₂ max (ml/kg/min)	3.13 ± 0.48	3.30 ± 0.37	<0.011
Sit & Reach (inches)	2.95 ± 2.15	11.76 ± 3.27	<0.001
Strength (kg)	25.49 ± 5.29	44.27 ± 7.83	<0.001
FVC (Liters)	4.14 ± 0.24	4.40 ± 0.50	<0.001
PEFR (L/min)	5.27 ± 0.21	6.11 ± 0.18	0.169

Table 1 presents the profound physiological augmentations experienced by the interventional study group following the 5-month mechanical loading protocol. VO₂ max increased significantly from 3.13 ± 0.48 to 3.30 ± 0.37 ml/kg/min (p = 0.011). The most dramatic adaptation was observed in musculoskeletal flexibility, which expanded exponentially from 2.95 ± 2.15 inches to 11.76 ± 3.27 inches (p < 0.001). Similarly, absolute grip strength increased massively from 25.49 ± 5.29 kg to 44.27 ± 7.83 kg (p < 0.001). Scale body weight within this cohort dropped from a mean of 74.63 kg to 71.51 kg; however, this trend did not achieve strict statistical significance (p = 0.089). Spirometry revealed a statistically significant expansion in FVC, rising from 4.14 ± 0.24 Liters to 4.40 ± 0.50 Liters (p < 0.001). PEFR increased from 5.27 ± 0.21 L/min to 6.11 ± 0.18 L/min, though this did not reach statistical significance (p = 0.169).

Table 2: Physical Fitness and Pulmonary Parameters at Baseline and After 5 Months (Control Group, n=78)

Variable	Baseline (Mean ± SD)	After 5 Months (Mean ± SD)	p-value
Weight (kg)	71.59 ± 10.25	71.60 ± 10.25	0.994
VO ₂ max (ml/kg/min)	3.18 ± 0.50	3.19 ± 0.51	0.895
Sit & Reach (inches)	2.71 ± 2.19	3.23 ± 2.28	0.144
Strength (kg)	25.35 ± 5.74	25.77 ± 5.75	0.646
FVC (Liters)	4.26 ± 0.52	4.36 ± 0.52	0.226
PEFR (L/min)	5.16 ± 0.12	5.20 ± 0.16	0.534

Table 2 illustrates the data for the highly sedentary control group, demonstrating absolute physiological stasis across all measured physical metrics over the identical five-month timeline. VO₂ max shifted insignificantly from 3.18 ± 0.50 to 3.19 ± 0.51 ml/kg/min (p = 0.895). Flexibility rose marginally but insignificantly (p = 0.144), isometric strength stagnated entirely (p = 0.646), and body weight remained entirely constant (71.59 kg to 71.60 kg, p = 0.994). Expectedly, the control cohort registered no significant respiratory improvements, with FVC remaining flat at 4.26 ± 0.52 to 4.36 ± 0.52 Liters (p = 0.226) and PEFR completely stagnant (p = 0.534).

DISCUSSION

The primary objective of this longitudinal investigation was to ascertain and quantify the isolated physiological effects of a rigorous five-month structured aerobic program on healthy young adults. The resultant data empirically validates the massive efficacy of consistent mechanical loading in triggering systemic body adaptations. Concurrently, the data serves as a stark physiological indictment of the heavily sedentary academic lifestyles currently prevalent in modern higher education settings [26].

The significant elevation in aerobic capacity (VO₂ max) observed exclusively in the interventional group highly corroborates established global literature confirming a linear dose-response relationship between aerobic exercise volume and optimal cardiovascular remodeling [27, 28]. According to Scribbans et al. [27] and Gormley et al. [28], the intensity and duration of aerobic training directly dictate the magnitude of improvement in maximal oxygen uptake. Our data, reflecting a shift from 3.13 to 3.30 ml/kg/min ($p=0.011$) over five months, aligns seamlessly with these precedents, proving that a daily two-hour exertion model effectively forces cardiac hypertrophy and enhanced systemic vascular extraction of oxygen.

Interestingly, there was an absence of a statistically significant total scale weight drop in the active group—dropping from 74.63 kg to 71.51 kg ($p=0.089$)—despite these students engaging in ten hours of highly demanding weekly physical training. This phenomenon heavily highlights a deep internal tissue recomposition process. The vast structural gains documented in isometric grip strength (skyrocketing from 25.49 kg to 44.27 kg) and musculoskeletal flexibility (expanding from 2.95 inches to 11.76 inches) suggest that systemic lipolysis and fat mass reduction were physically offset by concurrent skeletal muscle hypertrophy and enhanced neural motor-unit recruitment. This strongly aligns with previous clinical findings regarding BMI and physical fitness decoupling, indicating that weight alone is a poor metric for health in an exercising cohort [29]. Furthermore, the remarkable grip strength improvements mirror the findings of Godsday et al. [22], who validated that isometric handgrip exercises improve systemic muscular strength while concurrently correlating with improved spirometric capacities. The enhancements in flexibility also parallel the criterion-related validity studies by Mayorga-Vega et al. [21], confirming the Sit-and-Reach test as an excellent marker of overall posterior chain health, which vastly improved under our exercise regimen.

From a respiratory standpoint, the expansion in Forced Vital Capacity (FVC) from 4.14 Liters to 4.40 Liters ($p<0.001$) serves as a vital indicator of substantial respiratory muscle conditioning. The daily ventilatory resistance encountered during intense, sustained aerobic loading acts as direct conditioning for the diaphragm and the external intercostal muscles. As suggested by Enright and Unnithan [30], as well as D'souza and Avadhany [31], this resistance allows for a more profound thoracic excursion and the recruitment of previously dormant alveoli, thereby increasing the total exchangeable volume of the lungs. Interestingly, while the Peak Expiratory Flow Rate (PEFR) increased in the study group (5.27 to 6.11 L/min), it failed to reach the threshold of statistical significance. This physiological nuance suggests that while continuous aerobic models expand vital lung capacity, the explosive velocity of expiration relies more heavily on specialized, high-velocity anaerobic, or high-intensity interval training (HIIT) rather than purely steady-state aerobic models [32]. This finding warrants the integration of mixed-modality training to optimize all facets of pulmonary mechanics. The addition of manual therapy or targeted inspiratory muscle training, as observed in studies by Buran Cirak et al. [33] and Lu and Zhang [29], could potentially bridge this gap in expiratory velocity optimization.

The most concerning observation derived from this study remains the absolute stagnation of the control cohort. Despite actively engaging in the intellectual pursuit of physiotherapy and inherently possessing high health literacy regarding human mechanics and rehabilitation, this group demonstrated no cardiopulmonary or musculoskeletal improvements whatsoever [33]. This outcome provides incontrovertible proof that theoretical understanding of health provides zero biological protection against physiological decay in the prolonged absence of active mechanical loading.

Methodological Limitations:

While the findings are robust, certain pragmatic challenges represent limitations. Ensuring strict participant adherence to the intensive daily protocol while they balanced demanding academic burdens was challenging. Additionally, relying on standard scale weight limited our ability to map true physiological changes; future studies would benefit tremendously from incorporating DEXA (Dual-Energy X-ray Absorptiometry) scans to precisely map the lean mass to fat mass recomposition ratios that mask scale weight reductions. Furthermore, as highlighted by Khan et al. [34], standardizing exercise routines to specific individual chronotypes (morning versus evening peaks) could yield optimized physiological returns in aerobic testing. Finally, evaluating post-viral recovery populations—such as those suffering from long COVID-19 as studied by Bai et al. [35]—alongside healthy cohorts would broaden the clinical applicability of these supervised aerobic frameworks.

CONCLUSION

Supervised, structured physical exercise executed over a continuous five-month span definitively and substantially enhances cardiorespiratory endurance, upper body musculoskeletal strength, posterior chain flexibility, and forced vital capacity in healthy young adults. In stark contrast, enforced sedentary academic routines trigger an absolute state of

physiological stasis, even among populations with high theoretical health literacy. Given these profound findings, institutions of higher education must formally mandate the integration of systematic, credit-based physical activity into health science curricula. Implementing active physical loading is non-negotiable to inculcate the next generation of healthcare professionals against chronic systemic decline and non-communicable diseases.

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