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Original Article

Physiology Section

# Effect of Acute Exercise on Pulmonary Function in Young Adults with Anaemia: A Quasi-experimental Study

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## ABSTRACT

**Introduction:** Anaemia is a condition in which the Haemoglobin (Hb) level in the blood is below the reference range for age and gender. In India, mild anaemia is commonly found among medical students. Exercise capacity is limited by the ability to deliver oxygen to the muscles, and anaemia can impair this process by weakening the respiratory muscles, thus reducing pulmonary function. Pulmonary Function Tests (PFTs), combined with bicycle exercise testing, are useful for detecting occult cardiorespiratory limitations.

**Aim:** To estimate the prevalence of anaemia among first-year medical students and to study the effect of exercise on pulmonary function in individuals with anaemia.

**Materials and Methods:** This was a quasi-experimental study conducted in the Research laboratory of the Physiology Department, at Eastpoint College of Medical Sciences and Research Centre (EPCMSRC), Bengaluru, Karnataka, India between December 2023 and April 2024. The sample size was 136 with male and female, aged 18-23 years. Based on the level of Hb concentration, the participants were divided into a Normal group and an Anaemia group. After 10 minutes, PFT parameters, including Forced Vital Capacity (FVC), Forced Expiratory Volume in the first second (FEV1), the FEV1/FVC ratio, and Peak Expiratory Flow Rate (PEFR) were recorded using a spirometer. Following this, exercise testing was performed using a bicycle ergometer (INCO). PFT was recorded again immediately after exercise and compared. An independent sample t-test was used to find differences between the groups, while a paired t-test was used to compare pre- and post-exercise values within each group. A p-value of <0.05 was considered significant.

**Results:** The prevalence of anaemia was found to be 22.1%, with significantly lower PFT parameters observed in the anaemic group compared to the normal group before exercise ($p<0.05$). However, no significant changes in the parameters were noted after exercise in either group ($p>0.05$).

**Conclusion:** Approximately, 22.1% of participants had anaemia. There was no significant change in pulmonary function after exercise in either the normal or anaemic group.


**Keywords:** Haemoglobin, Physical exertion, Spirometry

## INTRODUCTION

Anaemia is defined as a decreased Hb content or Red Blood Cell (RBC) count that falls below the normal range for age and gender. Approximately, 30% of the world's total population has anaemia, and nearly half of these- about 600 million people- are iron deficient [1]. In anaemia, there is diminished oxygen supply to the tissues, which is reflected in symptoms such as tiredness and breathlessness- non specific indicators of the condition [1]. In India, mild anaemia is also common among medical students, both male and female [2-4].

Exercise represents a state of physical exertion for the body. An individual's ability to exercise is limited by their capacity to deliver oxygen to the working muscles [5]. A decline in work capacity may be associated with low levels of Hb. If oxygen delivery to the exercising muscles is reduced, the ability of those muscles to utilise the delivered oxygen will also decrease, thereby diminishing their capacity to exercise [5]. The severity of anaemia may act as an independent risk factor for functional impairment in aerobic capacity [6].

In anaemia, the body adapts to maintain an adequate oxygen supply to the tissues in order to meet their demands [7]. At rest, oxygen delivery and carbon dioxide transport are adequately maintained by expanding the individual's available haemodynamic compensatory mechanisms [8]. However, during exercise, the oxygen supply to the working muscles, as well as carbon dioxide production is limited despite these haemodynamic adjustments [8]. The cardiorespiratory system undergoes several changes during exercise in order to meet the heightened demands of the tissues for oxygen [9]. Anaemia may decrease respiratory muscle strength, thereby reducing pulmonary function [10].

The PFTs provide valuable information about the status of an individual's respiratory system and its work capacity [10]. They are used for diagnosis, quantifying functional impairment, monitoring treatment, and assessing the disease progression of the lung [1]. PFTs may not be as helpful if resting measurements are taken when the disease is in its early stages or in patients who exhibit only exercise-induced symptoms [1]. Measurements taken after exercise could offer valuable insights into the functional reserve capacity of the lungs, both in healthy individuals and in patients with respiratory diseases [1]. Bicycle exercise testing is useful for quantifying exercise limitations and detecting occult cardiovascular or respiratory limitations in breathless patients [1].

The cardiorespiratory adaptation to exercise has been studied extensively [7,8,11]. However, there is limited evidence regarding the impact of exercise on pulmonary function in individuals with anaemia [9,10]. Thus, the present study was aimed to evaluate the effect of exercise on pulmonary function in individuals with anaemia.

## MATERIALS AND METHODS

This was a quasi-experimental study. The study participants were recruited through a convenient sampling method. The study was conducted in the Research Laboratory of the Physiology Department at Eastpoint College of Medical Sciences and Research Centre (EPCMSRC), Bengaluru, Karnataka, India, between December 2023 and April 2024, after obtaining ethical clearance from the Institutional Ethical Committee of EPCMSRC (No. EPCMSRC/ADM/

IEC/2022-23/20, dated 12.08.2022). First-year medical {Bacheolar of Medicine and Bacheolar of Surgery (MBBS)} students were approached with the study protocol seeking volunteers. Written informed consent was obtained from each participant.

**Inclusion criteria:** Students who were apparently healthy and had normal or decreased Hb concentration were considered. Both male and female students aged 18-23 years who were willing to participate in the study were included.

**Exclusion criteria:** Students who smoked, were on medication for any condition, had respiratory allergies or infections, or any other diseases were excluded from the study. Students involved in any physical conditioning programmes, such as regular dance practice, aerobics, or any sport, were also not considered.

**Sample size calculation:** sample size was estimated [4] using the formula:

$n= Z^2 pq/d^2$

Z= 1.96, p= 41, q=59 (1-p)=

$=Z2 pq/d^2$= (3.84) (41) (59)/(8.3)2= 136. In which,

$Z2 pq/d^2$= Is the conventional multiplier for alpha= 0.05= 1.96

P= Proportion/ Prevalence = 0.41

d = is the allowable error= 8.3%

Sample size= 136

### Study Procedure

A total of 150 students volunteered to participate in the study. After exclusions, a total of 136 students were recruited.

When the participants arrived at the laboratory, a blood sample was collected by pinprick, and Hb estimation was conducted using Sahli's acid hematin method. Based on the level of Hb concentration, participants were classified into a normal group (Hb% above 12 g/dL for females and above 14 g/dL for males) [12]. The anaemic group was further classified as mild anaemia (Hb% between 10 and 11.9 g/dL), moderate anaemia (Hb% between 8 and 9.9 g/dL), and severe anaemia (Hb% below 8 g/dL) [12].

After a relaxation period of 10 minutes, a resting PFT was recorded for each participant. The PFT parameters recorded included FVC, timed vital capacity, FEV1, the ratio of FEV1/FVC, and PEFR, all measured using a Windows-based digital spirometer (Spirowin).

Following this, exercise testing was performed using a bicycle ergometer (INCO) with an electronic gear shift and intensity ranging from 25 to 800 watts. Participants were instructed regarding the exercise protocol, which comprised a warm-up period of pedalling without resistance for five minutes, followed by pedalling with a progressive increase in resistance every two minutes up to 800 watts for the next 15 minutes. Participants were advised to stop and discontinue the exercise if they felt breathless or uncomfortable. Immediately after the exercise, the PFT was recorded again for comparison.

## STATISTICAL ANALYSIS

The data were entered into an Excel spreadsheet, and statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 20.0 for Windows. Descriptive analysis was conducted using the mean and standard deviation for quantitative variables, and frequency and proportion for categorical variables. The Chi-square test was performed to determine whether there was any association within the categorical data. An independent sample t-test was used to find any significant differences in the means between the groups when the data followed a normal distribution. A paired t-test was employed to compare pre- and post-exercise values within the groups. A p-value of <0.05 was considered statistically significant.

## RESULTS

The present study is a quasi-experimental study that was conducted on 136 participants aged between 18 and 23 years. Of these participants, 57 (41.9%) were male and 79 (58.1%) were female. The characteristics of the participants has been depicted in [Table/Fig-1].

| Parameters | Overall (N=136) | Haemoglobin (Hb) | | p-value¥ |
|---|---|---|---|---|
| | | Normal (n=106) | Anaemic (n=30) | |
| **Age** | 20.6±1.7 | 20.7±1.7 | 20.0±1.8 | 0.044 |
| **Age range** | | | | |
| 18-19 years | 40 (29.4%) | 26 (24.5%) | 14 (46.7%) | 0.061 |
| 20-21 years | 51 (37.5%) | 43 (40.6%) | 8 (26.7%) | |
| >=22 years | 45 (33.1%) | 37 (34.9%) | 8 (26.7%) | |
| **Gender** | | | | |
| Male | 57 (41.9%) | 51 (48.1%) | 6 (20.0%) | 0.006 |
| Female | 79 (58.1%) | 55 (51.9%) | 24 (80.0%) | |
| **Height (cm)** | 164.1±9.3 | 164.8±9.3 | 161.7±9.0 | 0.114 |
| **Weight (kg)** | 59.8±12.6 | 60.3±13.0 | 58.1±10.8 | 0.399 |
| **Basal Metabolic Index (kg/m²)** | 22.1±3.8 | 22.1±4.0 | 22.1±3.2 | 0.987 |

**[Table/Fig-1]:** Anthropometric measurements of the study participants.
¥n (%): Chi-square test; Mean±SD: Independent sample t-test

In a total of 136 participants, the prevalence of anaemia was 22.1%, meaning that 30 participants had anaemia, while 106 (77.8%) participants had a normal level of Hb. Out of these 30 participants with anaemia, 24 (17.64%) had mild anaemia (Hb ranging from 10 to 12 g/dL), whereas six participants had moderate to severe anaemia (Hb level <10 g/dL). Anaemia was also found to be more common in 24 females than in six males, which was statistically significant, p<0.006 [Table/Fig-2].

| Parameters | n (%) |
|---|---|
| **Haemoglobin (Hb)** | 13.0±2.3 |
| **Hb status** | |
| Normal | 106 (77.9%) |
| Anaemic | 30 (22.1%) |
| **Anaemia levels** | |
| Normal | 106 (76.8%) |
| Mild | 24 (17.64%) |
| Moderate | 2 (1.4%) |
| Severe | 4 (2.9%) |
| **Gender** | |
| Male | 6 (20%) |
| Female | 24 (80%) |

**[Table/Fig-2]:** Haemoglobin (Hb) levels, anaemia status, and gender distribution among participants (N=136).

The height (p=0.114), weight (p=0.399), and Body Mass Index (BMI) (p=0.987) of all participants, including both the normal and anaemia groups, were measured and calculated. There was no statistically significant difference in these parameters among the participants (p-value>0.05) [Table/Fig-1].

All participants completed the exercise testing without incident. The dynamic ventilatory tests were performed, and FVC, FEV1, FEV1/FVC, and PEFR were recorded in both groups. The exercise responses of all participants, along with various percentage predictions of FVC, FEV1, FEV1/FVC, and PEFR, are depicted in [Table/Fig-3].

The PFTs were recorded before and after exercise and compared between the normal and anaemic groups. Intergroup comparisons of PFT parameters, including FVC, FEV1, FEV1/FVC, and PEFR, showed that the values were significantly lower (p<0.05) in the anaemia group before exercise compared to the normal group [Table/Fig-3].

| Parameters | Pre-exercise | | | Post-exercise | | |
|---|---|---|---|---|---|---|
| | Normal (n=106) | Anaemia (n=30) | p-value | Normal (n=106) | Anaemia (n=30) | p-value |
| FVC (Lts) | 3.1±0.8 | 2.8±1.1 | 0.075 | 3.2±0.9 | 2.9±1.0 | 0.207 |
| FEV1 (Lts) | 2.6±0.7 | 2.1±0.7 | 0.003 | 2.7±0.6 | 2.2±0.7 | 0.012 |
| FEV1/FVC (%) | 83.2±9.7 | 76.4±12.9 | 0.002 | 82.2±11.6 | 77.9±17.2 | 0.118 |
| PEFR (L/sec) | 5.6±1.4 | 4.2±1.6 | <0.001 | 5.6±1.4 | 4.4±1.4 | <0.001 |

**[Table/Fig-3]:** Intergroup comparison of Pulmonary Function Test (PFT) parameters before and after.
Lts= in Litres

Intragroup comparisons of pre- and post-exercise PFT, including FVC, FEV1, FEV1/FVC, and PEFR in both the normal and anaemia groups, revealed a slight improvement following exercise. However, these changes were not statistically significant (p>0.05) in either group [Table/Fig-4].

| Parameters | Normal (n=106) | | | Anaemic (n=30) | | |
|---|---|---|---|---|---|---|
| | Pre-exercise | Post-exercise | p-value | Pre-exercise | Post-exercise | p-value |
| FVC (in Lts) | 3.11±0.81 | 3.13±0.81 | 0.555 | 2.78±1.11 | 2.91±1.01 | 0.335 |
| FEV1 (in Lts) | 2.55±0.67 | 2.56±0.67 | 0.856 | 2.13±0.67 | 2.19±0.69 | 0.448 |
| FEV1/FVC (%) | 83.15±9.74 | 83.15±11.60 | 0.321 | 76.42±12.88 | 77.92±17.23 | 0.459 |
| PEFR (in Lts/sec) | 6.30±7.79 | 6.56±1.43 | 0.315 | 4.19±1.55 | 4.38±1.43 | 0.325 |

**[Table/Fig-4]:** Comparison of Pulmonary Function Test (PFT) parameters before and after exercise in normal and anaemic participants.

## DISCUSSION

The present study aimed to investigate the effect of exercise on pulmonary function in individuals with anaemia among first-year medical students. A total of 136 students were recruited for the study, and all participants underwent bicycle exercise testing to quantify the pulmonary effects of anaemia. The prevalence of anaemia in this study was 22.1%, which is lower than that reported in previous studies [2-4]. Among the student participants with low Hb levels, 18% had mild anaemia, 2.1% had moderate anaemia, and 2.9% had severe anaemia. A higher proportion of females (80%) were affected by low Hb levels compared to males (20%) within the group. This finding contrasts with a study by Kanchana R and Pushpa K in which anaemia was found to be more prevalent in males than in females [4].

The PFT parameters, including FVC, FEV1, FEV1/FVC, and PEFR, were lower in the anaemic group compared to the normal group before exercise. The PFT parameters, including FVC, FEV1, FEV1/FVC, and PEFR, were lower in the anaemic group compared to the normal group, which was statistically significant (p<0.05). This demonstrates a strong association between anaemia and functional deficits, which is in accordance with a study conducted by Scholz BD et al., [13]. Edgerton VR et al., also reported improved work performance in participants with normal Hb levels compared to those with lower Hb levels [14]. Low Hb impairs tissue oxygenation, which causes dyspnoea on mild exertion and easy fatigability. The reduced strength of the respiratory muscles, including the diaphragm, decreases pulmonary function as well as work capacity in individuals with anaemia. All PFT parameters were found to be decreased in participants with anaemia in a study conducted by Kumari AK et al., which is similar to the findings of present study [15].

Studies have shown a significant correlation between BMI and lung function, with lower FEV1/FVC%, which is attributed to mechanical restrictions in chest movement among overweight individuals. In the current study, the FEV1/FVC% was lower in the anaemic group compared to the normal group; however, no significant difference in BMI was observed among the participants [16].

The present study found no significant changes in respiratory parameters following exercise in both the anaemia and normal groups, as evidenced by intragroup comparisons. Similarly, Jeong Y et al., observed no clear relationship between pulmonary function and anaemia or Hb levels in healthy non smokers [17]. However, a study conducted by Thaker H et al., reported a decrease in these parameters post-exercise in obese individuals compared to those with a normal BMI, which contrasts with the findings of this study [18]. The reason for this may be the increased body fat percentage, which causes mechanical restrictions on the movement of the abdomen and thorax, as well as increased airway resistance in overweight and obese individuals [18].

Although the PEFR showed improvement after exercise in the anaemic group, its mean value remained significantly lower compared to that of the normal participants. This may be due to the fact that PEFR is more sensitive to the muscular elements of respiration, which could explain the lower values observed in anaemia, both before and after exercise [15]. When the oxygen-carrying capacity of the blood declines, it leads to the accumulation of lactate and other metabolites, as well as tissue hypoxia, which can result in muscle fatigue, including in the diaphragm [14].

The study by Singh HD and Peri S reported that PEFR is higher in males than in females. They also observed elevated values of PEFR in athletes, police, and army personnel, highlighting the significance of nutrition and physical fitness in maintaining respiratory strength [19]. Furthermore, regular engagement in integrated exercises that target respiratory muscles has been shown to improve lung function [20]. However, the current study did not assess the difference in PEFR between genders; nonetheless, there was an improvement in the post-exercise values among the anaemic group, which was statistically significant (p=0.001).

### Limitation(s)

The Hb estimation by Sahli's method is a visual technique that relies on manual interpretation, which makes it prone to errors. A larger sample size might improve the applicability and relevance of the findings. Additionally, factors such as environmental influences and nutritional status should be taken into consideration in future studies.

## CONCLUSION(S)

The prevalence of anaemia among first-year medical students was 22.1%, with a higher proportion of females affected compared to males. In the present study, no significant change in pulmonary function was observed after exercise in either the normal or anaemic group. Maintaining normal levels of Hb is crucial for optimal health; therefore, the correction of anaemia is essential. Regular exercise is beneficial for enhancing pulmonary function and overall fitness.

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