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Original Article

Physiotherapy Section

# Correlation of Core Muscle Strength and Lung Capacity among College-going Students: A Cross-sectional Observational Study

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## ABSTRACT

**Introduction:** The abdominal muscles play a crucial role in posture, trunk stability, and respiration. They regulate Intra-abdominal Pressure (IAP), support spinal stability, and function as accessory respiratory muscles during increased respiratory demand. Pulmonary Function Tests (PFTs), particularly spirometry, assess lung function by measuring airflow and lung capacity. Given the involvement of abdominal muscles in respiration, their strength may influence pulmonary function.

**Aim:** To explore the correlation between abdominal muscle strength and respiratory function, focussing on the Forced Expiratory Volume in one second (FEV1)/Forced Vital Capacity (FVC), ratio and Maximum Voluntary Ventilation (MVV) in healthy adults.

**Materials and Methods:** A cross-sectional observational study was conducted at JSS College of Physiotherapy, Mysore, Karnataka, India. The study was carried out over a six-month period, from July 2021 to December 2021.Participants were recruited through convenience sampling from the college population. A total of 22 healthy college-going students, aged 18-25 years, were included.Participants were informed about the nature and purpose of the study and provided written informed consent. The procedure included, assessment of abdominal muscle strength using a hand-held dynamometer. The test was performed in a standardised supine position on a treatment table inclined at 30°, with lower limbs strapped for stability. Three trials were conducted with 5 second rest intervals, and the average was recorded. PFT was done using a computerised spirometer (EasyOne PC). Parameters recorded included FEV1/FVC ratio, MVV and Tidal Volume (TV). The Pearson correlation coefficient ("r") was utilised to determine the relationship between abdominal strength, FEV1/FVC, MVV, TV, age, height, weight, and Body Mass Index (BMI). A p-value of less than 0.05 was deemed significant.

**Results:** A significant positive correlation was found between abdominal strength and MVV in the 6$^{th}$ second (r=0.420, p=0.049) and TV (r=0.506, p=0.016), indicating that individuals with greater abdominal strength exhibited better ventilatory capacity. However, FEV1/FVC (r=0.196, p=0.381) and overall MVV (r=0.354, p=0.106) did not show statistically significant correlations.

**Conclusion:** This study explored the correlation between core muscle strength and lung capacity among college-going students. The findings indicate a significant correlation between core strength and pulmonary function, suggesting that stronger core muscles may contribute to better lung capacity.


**Keywords:** Abdominal muscles, Medical students, Pulmonary functions, Students, Young adults

## INTRODUCTION

Core muscle strength plays a pivotal role in maintaining postural stability, enhancing movement efficiency, and supporting respiratory function. The core muscles, comprising the abdominal, lumbar, pelvic, and diaphragm muscles, form a dynamic stabilising system that influences both spinal mechanics and lung function [1]. Emerging evidence suggests that the strength of these muscles significantly impacts pulmonary function by modulating IAP, optimising diaphragm mechanics, and facilitating effective respiratory mechanics [2]. Lung capacity, an essential determinant of respiratory health, is often assessed through PFTs such as Forced Expiratory Volume in one second ($FEV_1$), Forced Vital Capacity (FVC), and Peak Expiratory Flow Rate (PEFR) [3]. Studies have highlighted that individuals with stronger core muscles demonstrate improved lung function due to enhanced diaphragmatic efficiency and increased intrathoracic volume [4]. Moreover, core stabilisation exercises that integrate breathing techniques have been shown to improve both respiratory and postural control [5].

Despite growing interest in the relationship between core muscle strength and pulmonary function, limited research has examined this association among young, healthy individuals such as college students. Given that this population engages in diverse levels of physical activity and lifestyle habits that influence core strength and lung capacity, an in-depth investigation is warranted [6]. Understanding this relationship could provide insights into optimising exercise regimens for improving respiratory efficiency and postural stability in young adults [7].

Therefore, this observational study aims to explore the correlation between core muscle strength and lung capacity among college-going students. By assessing core strength and pulmonary function, this study seeks to provide evidence on whether core stability training can contribute to enhanced respiratory performance, potentially influencing future recommendations for exercise and rehabilitation programs [8,9].

## MATERIALS AND METHODS

The present cross-sectional, observational study was conducted at JSS College of Physiotherapy, Mysore, Karnataka, India. The study was carried out over a six-month period, starting in July 2021 and ending in December 2021. Ethical clearance for the study was obtained from the Institutional Ethics Committee of JSS College of Physiotherapy (Ref. no JSSCPT/IRC/167/2020-2021, dated 24/07/2021). Written informed consent was obtained from all participants after explaining the purpose and procedure of the study. An instruction sheet was also provided for better understanding.

**Sample size calculation:** The technique of testing for the correlation coefficient was used to compute the sample size:

$$n=\frac{(1-r^2)*(Z_{1-\alpha/2}+Z_{1-\beta})^2}{r^2}$$

Where,

$\alpha$=Significance level (5%)

r=Correlation coefficient (0.51)

1-$\beta$=Power (80%)

$$n=\frac{(1-0.51^2)*(1.96+0.84)^2}{(0.51)^2}=22$$

Thus, the sample size for this study is determined as 22.

Based on a 5% level of significance and a power of 80%, the expected correlation coefficient of 0.51 was considered for the sample size calculation. Referring to the standard method described by Machin D, Campbell MJ, Fayers MP, and Pinal APY in Sample Size Tables for Clinical Studies (Second Edition, Blackwell Science Ltd., 1997), the calculated sample size required to detect this correlation was found to be 22 [10].

**Inclusion criteria:**

- All young, healthy adults studying in the JSS College of Physiotherapy;
- All young adults (18-25 years).

**Exclusion criteria:**

- Individuals with lung pathologies and respiratory and cardiac conditions;
- Individuals who are not comfortable undergoing strength testing and PFT.

## Study Procedure

**Materials used for the study:** The materials used for the study included an adjustable couch, straps for participant stabilisation, a hand-held dynamometer [Table/Fig-1] for measuring abdominal muscle strength, and a computerised spirometer (EasyOne PC) [Table/Fig-2a,b] for PFT.

**[Table/Fig-1]:** Illustration showing hand-held dynamometer.

**[Table/Fig-2]:** a) Illustration showing computerised spirometry; b) Illustration showing mouthpiece and nasal clip. (Images from left to right)

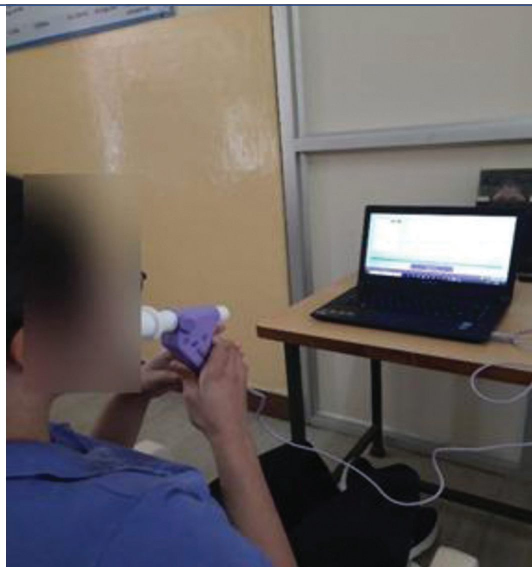
Information about the purpose and procedure of the study was provided to the participants. Informed consent was taken from them before participation, and an instruction sheet was also given to them for better understanding. Outcome measures were abdominal strength testing by a handheld dynamometer (Brand: Baseline®, Manufacturer: Fabrication Enterprises Inc., Country: United States, Website: www.fab-ent.com) and FEV1/FVC, MVV for pulmonary function using a spirometer.

## Abdominal Strength

The abdominal strength was measured through a hand-held dynamometer. Participants were tested on a treatment table, which had the same height for all. The head of the table was 30° inclined and was measured with a goniometer. The participant lay supine with their back fully on the head of the table. The lower limb was fixed with straps for stabilisation (above the knee and the Anterior Superior Iliac Spine (ASIS)). The arms of the participants were resting on their abdomen while the test was performed. The hand-held dynamometer was placed in the lower 3rd of the sternum between the nipples, and the test was repeated for three trials with five seconds of rest in between each trial [Table/Fig-3]. The average of all three trials was considered. A standardised command and encouragement were given. The positioning of the hand-held dynamometer was standardised for each participant [11,12].

**[Table/Fig-3]:** Measurement of abdominal strength with a hand-held dynamometer.

**FEV1/FVC ratio and MVV:** A PFT was performed with spirometry software- Easy one connect (3.4.0.23) (developed and maintained by ndd Medical Technologies) [Table/Fig-4]. The participants were made to sit comfortably and relax in a chair with an armrest. They were instructed to take a deep breath, put the mouthpiece into their mouth, and make a good seal around the mouthpiece. Then they were asked to exhale rapidly and forcefully until six seconds and inhale deeply through the mouth to obtain an FVL-flow-volume loop [13].



**[Table/Fig-4]:** Pulmonary Function Test (PFT) procedure.

MVV was measured by asking them to inhale and exhale rapidly and deeply through the mouth for 12 seconds. Every participant was provided with different and new mouthpieces for the spirometry test.

The study process has been explained in [Table/Fig-5].

Participants were selected according to the inclusion and exclusion criteria and sample size.

↓

An explanation about the study and the aim was given.

↓

Every participant was subjected to abdominal muscle strength testing through a handheld dynamometer.

↓

The participants whose abdominal muscle strength was measured were also measured for respiratory function tests using a spirometer.

↓

RESULT: Both handheld dynamometer and spirometry values were correlated by a statistical test.

**[Table/Fig-5]:** Flowchart illustrating the procedure of the study.

## STATISTICAL ANALYSIS

The collected data were summarised by using the descriptive statistics: frequency, percentage, mean, and SD. The Independent sample t-test was used to compare age, height, weight, BMI, abdominal strength, FEV1/ FVC, MVV, and TV between males and females. To find the relation between abdominal strength, FEV1/ FVC, MVV, TV, age, height, weight, and BMI, the Pearson correlation coefficient ("r") was used. The p-value <0.05 was considered significant. Data were analysed by using the Statistical Package for Social Sciences (SPSS) software (SPSS Inc.; Chicago, IL), version 29.0.10.

## RESULTS

Participants' ages ranged from 19 to 23-year-old (mean: 21.41±1.18 years); their heights between 151 and 181 cm (mean: 165.43±8.77 cm); their weights between 45 and 101 kg (mean: 66.45±16.25 kg); and their BMIs between 17.8 and 31 kg/m$^2$ (mean: 24.04±3.93 kg/m$^2$) [Table/Fig-6].

| Variables | Range | Mean | SD |
|---|---|---|---|
| Age (years) | 19 to 23 | 21.41 | 1.18 |
| Height (cm) | 151 to 181 | 165.43 | 8.77 |
| Weight (kg) | 45 to 101 | 66.45 | 16.25 |
| BMI (kg/m$^2$) | 17.8 to 31 | 24.04 | 3.93 |

**[Table/Fig-6]:** Descriptive statistics for age, height, weight, and BMI (n=22).

Among the 22 participants, the majority were males (59.1%), and 40.9% were females [Table/Fig-7].

| Gender | Frequency | % |
|---|---|---|
| Male | 13 | 59.1 |
| Female | 9 | 40.9 |

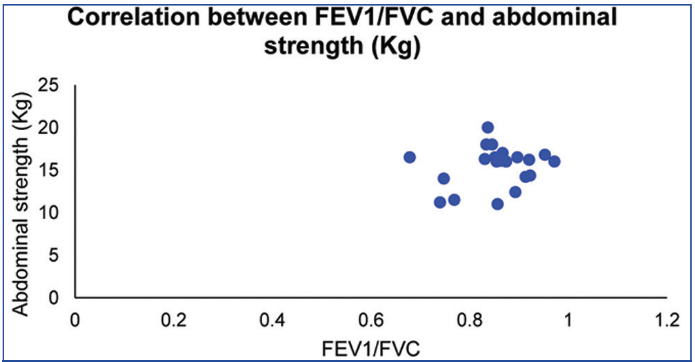
**[Table/Fig-7]:** Gender distribution.

[Table/Fig-8] shows Pearson correlation coefficient analysis revealed that MVV in the 6$^{th}$ second (r=0.420, p=0.049) and TV (r=0.506, p=0.016) were significantly positively correlated with abdominal strength, indicating that individuals with greater abdominal strength demonstrated higher TVs and improved ventilatory capacity over time. However, FEV1/FVC (r=0.196, p=0.381) and overall MVV (r=0.354, p=0.106) did not show statistically significant correlations with abdominal strength, suggesting that abdominal muscle strength may not have a direct impact on these parameters in this sample. These findings highlight the potential influence of abdominal strength on specific aspects of lung function, particularly TV and sustained ventilation.

| Variables | Abdominal strength (Kg) | |
|---|---|---|
| | "r" | p-value |
| FEV1/FVC | 0.196 | 0.381 |
| MVV (Litres) | 0.354 | 0.106 |
| MVV in 6$^{th}$ second | 0.420 | 0.049* |
| Tidal Volume (TV) (Litres) | 0.506 | 0.016* |

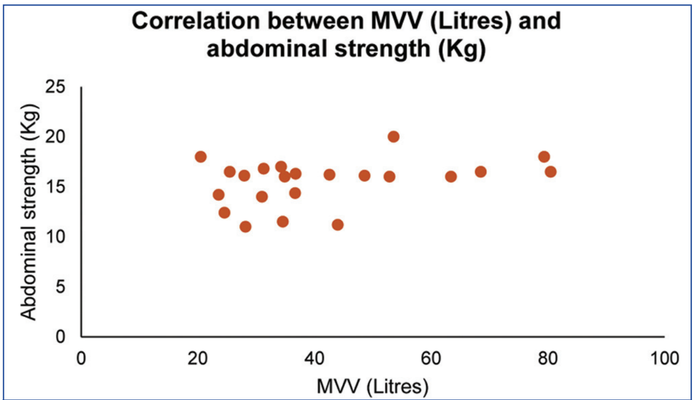
**[Table/Fig-8]:** Relation of FEV1/ FVC, MVV, and Tidal Volume (TV) with abdominal strength.
("r"=Pearson correlation coefficient; * Significant)

[Table/Fig-9]: A scatter plot illustrating the relationship between FEV1/FVC and abdominal strength (kg), The abdominal strength levels range from 10 to 20 kg, and the data points are clustered between FEV1/FVC values of 0.7 to 1.0. There is no clear linear trend visible, suggesting a weak or no significant correlation between FEV1/FVC ratio and abdominal strength among the participants.




**[Table/Fig-9]:** Correlation between FEV1/FVC and abdominal strength.

[Table/Fig-10] illustrates the relationship between abdominal strength (kg) and MVV (Litres). While the numbers for abdominal strength range from around 11 to 20 kg, the MVV values range from around 20 to 80 litres. The data points show a weak or no correlation between the subjects' MVV and abdominal strength, appearing widely dispersed and lacking any discernible trend.



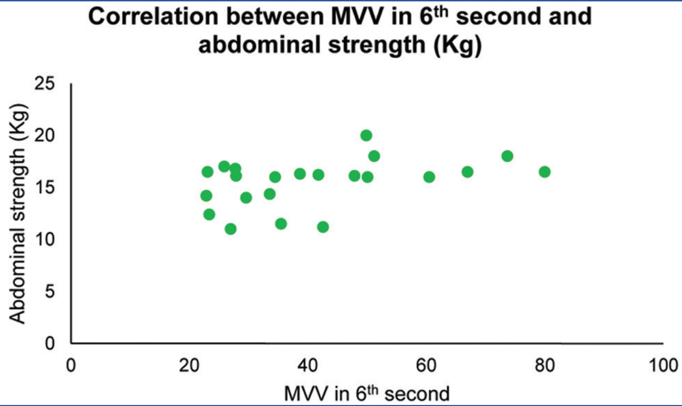

**[Table/Fig-10]:** Correlation between MVV (Litres) and abdominal strength (Kg).

[Table/Fig-11]: Illustrates the relationship between abdominal strength (kg) and MVV (Litres) in 6$^{th}$ second. The data points show a moderate correlation between subjects' MVV (L) and abdominal strength (kg).

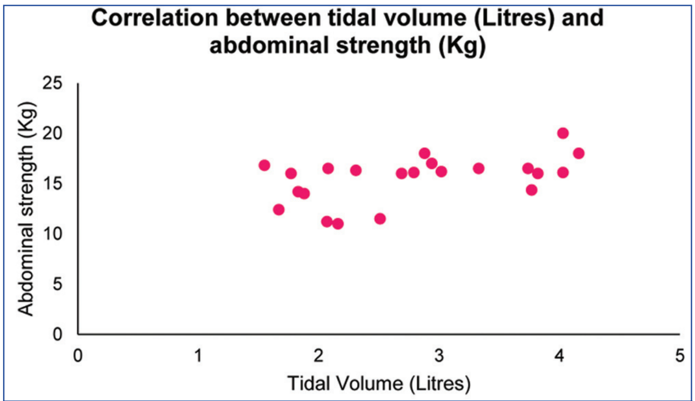
[Table/Fig-12]: Describes the Correlation between TV (L) and abdominal strength in (kg). The data points show moderate correlation between subjects' Tidal Volume (TV) (L) and abdominal strength (kg).

## DISCUSSION

The present study aimed to investigate the correlation between core muscle strength and lung capacity among college-going students. Findings indicate that individuals with greater core strength exhibit enhanced respiratory function, aligning with existing literature. Core muscles, especially the abdominals, play a vital role in maintaining




**[Table/Fig-11]:** Correlation between MVV in the 6th second and abdominal strength.




**[Table/Fig-12]:** Correlation between Tidal Volume (TV) (Litres) and abdominal strength (Kg).

IAP and facilitating diaphragmatic movement during respiration. Research suggests that activation of these muscles enhances lung function by stabilising the thoracic cavity and optimising diaphragmatic excursions, especially important in physically active individuals, where core endurance supports efficient ventilation mechanics.

Several studies have established that core muscle weakness is associated with reduced respiratory efficiency, particularly in sedentary populations. This interplay between postural stability and respiratory performance is evident in both athletic and non-athletic groups, where stronger core musculature correlates with improved PFT parameters such as FVC and FEV1. For instance, Neha G et al., assessed the strength and endurance of the transversus abdominis in 80 healthy adults, finding fair correlations with respiratory measures including Breath-Holding Time (BHT), PEFR, TV, and MVV [6]. Similarly, Patel R et al., reported a weak negative correlation between abdominal muscle strength and FEV1/FVC ($r=-0.27$, $p=0.03$), and a weak positive correlation with PEFR ($r=0.34$, $p=0.007$) in young adults with low back pain, suggesting that abdominal strength may modestly influence expiratory capacity [14].

A major strength of the current study lies in its objective quantification of the relationship between abdominal muscle strength and lung function, particularly focusing on parameters such as FEV1/FVC and MVV. The use of numerical data and standardised testing enhances the precision and reliability of the findings, contributing to the growing evidence on the functional significance of core muscles in respiratory mechanics.

Future studies should aim to include a broader and more diverse sample, including older adults and individuals with respiratory conditions, to enhance generalisability. Longitudinal research would allow for assessment of the long-term impacts of core strength on pulmonary function and the effects of strength training interventions. Investigating additional physiological parameters such as diaphragm strength and respiratory muscle endurance would offer a more comprehensive understanding. Moreover, examining gender-specific differences and comparing the effects of various core strengthening techniques could provide valuable insights for both clinical and fitness applications. Incorporating biomechanical assessments or advanced imaging could further clarify the relationship between core stability and respiratory mechanics.

Clinically, this study highlights the value of integrating core-strengthening exercises into physiotherapy programs aimed at improving respiratory function. Such interventions may be particularly beneficial for individuals with Chronic Obstructive Pulmonary Disease (COPD), asthma, or other respiratory conditions, where core training can serve as a useful adjunct to traditional pulmonary rehabilitation.

### Limitation(s)

Despite these promising findings, certain limitations must be acknowledged. Variability in participants' physical activity levels, BMI, and posture may have influenced outcomes. These factors are known to impact both trunk biomechanics and lung function, warranting further investigation. In addition, environmental influences such as air quality and altitude were not accounted for, which could also affect respiratory measurements.

## CONCLUSION(S)

In conclusion, the study reinforces the association between core strength and lung function, emphasising the potential benefits of targeted interventions to enhance respiratory efficiency through core muscle training. Further research with diverse populations and comprehensive physiological assessments is warranted to deepen our understanding and application of these findings in both clinical and general health settings. The findings indicate a significant correlation between core strength and pulmonary function, suggesting that stronger core muscles may contribute to better lung capacity. This could be attributed to the role of core muscles in stabilising the thoracic cavity and facilitating efficient breathing mechanics. Given these findings, incorporating core-strengthening exercises into regular physical activity may be beneficial for enhancing respiratory function in young adults.

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