Correlation of Transverses Abdominis Strength and Endurance with PEFR and BHT in Healthy Adults

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Abstract: Introduction: Ventilation involves inhalation and exhalation, aided by abdominal muscles such as the transversus abdominis (TA), which support breathing and posture. Breath-holding time (BHT) increases intra-abdominal pressure, influencing thoracic expansion and Peak Expiratory Flow Rate (PEFR), both dependent to respiratory muscle strength. This study examines the correlation between lumbar core muscle strength and pulmonary function in healthy adults.

Objectives: The aim of this study is to assess the "Correlation of Transverses Abdominis Strength and Endurance with PEFR & BHT in Healthy Adults".

Methodology: A cross-sectional study was conducted in Ahmedabad among healthy adults aged 18–25 years, excluding those with orthopaedic, neurological, or cardiorespiratory disorders. After consent, age and BMI were recorded. Lumbar core strength was assessed using a pressure biofeedback unit, BHT in sitting position, and PEFR was recorded three times, with the highest value used.

Results: Data were analyzed using SPSS v20 with a 5% significance level. Pearson correlation test showed significant but weak relationship between BHT and strength ($p = 0.001$), no significant relationship between BHT and endurance ($p = 0.791$), weak positive correlation between PEFR and endurance ($r = 0.291$, $p = 0.024$), and no meaningful correlation between PEFR and strength ($r = 0.231$, $p = 0.075$).

Conclusion: This study suggests that lumbar core strength influences BHT, but it's impact on PEFR and endurance, is limited in healthy adults. Further research is needed to explore these relationships in different populations.

Keywords: Core Muscle Strength, core muscle Endurance, Breath Holding Time, Peak Expiratory Flow Rate

I. INTRODUCTION

The core consists of a group of trunk muscles that surrounds the spine and abdominal organs.(1) The core muscles are the group of muscles in the torso that stabilize the spine, pelvis, and shoulder girdle, providing a solid base for posture, balance, and movement. They consist of two main groups: deep core muscles (stabilizers, e.g., transversus abdominis and multifidus) and superficial core muscles (movers, e.g., rectus abdominis and external obliques).(2)

Core strength is the ability of the trunk muscles to generate force. It can be assessed in terms of maximum strength, power, or the ability to maintain force over time, known as strength endurance.(3) Core endurance refers to the capacity to sustain posture or perform repeated movements over an extended period. It plays a crucial role in maintaining core stability, allowing efficient and sustained force generation and transfer during both athletic activities and daily functional movements.(3)

Ventilation is a vital physiological process that involves both inhalation and exhalation, particularly important during forced breathing as seen in exertion or respiratory tasks. During forced expiration and inspiration, the abdominal muscles provide critical support to the respiratory system by stabilising the trunk and assisting airflow.(4)

The Transversus Abdominis (TA) is actively recruited during both forced expiration and early inspiration, not just the former, indicating its integral role in respiratory mechanics.(5) Among these, the Transversus Abdominis (TA) the deepest of the abdominal muscles plays a dual role by contributing to spinal stability and by increasing intra-abdominal pressure (IAP), which enhances the mechanical efficiency of the respiratory system.(4)

The TA operates in close functional synergy with the diaphragm and pelvic-floor muscles, forming a core "cylinder" that stabilises the lumbar spine and thoraco-abdominal region during both posture and respiration. Its contraction compresses the abdominal cavity and elevates intra-abdominal pressure, promoting forced expiration and improving diaphragmatic descent during inspiration.(6) Thus, insufficient strength or endurance of the TA might limit optimal respiratory performance and affect measures of lung function.

Peak Expiratory Flow Rate (PEFR) is a simple, non-invasive measure that represents the maximum speed of expiration. It serves as an indirect indicator of expiratory muscle strength and airway resistance, reflecting the combined function of respiratory muscles, airway resistance, thoracic compliance, and the integrity of the expiratory flow pathways.(7,8)

Breath-holding refers to the voluntary or involuntary suspension of breathing. It is commonly studied to understand respiratory physiology, diving responses, and the adaptive mechanisms of the human body under conditions of limited oxygen availability.(9)

The duration of breath-holding, measured in seconds, depends on several factors including lung volume, respiratory muscle function, disease conditions, and training level. It is often used as an indicator of pulmonary function due to its positive correlation with spirometry indices, reflecting the efficiency and capacity of the respiratory system.(10) Normal duration is 45-55 seconds.(11)

Breath-hold time (BHT), which represents the duration an individual can voluntarily hold their breath, is closely linked to diaphragm function and core stability. The diaphragm, forming the superior boundary of the core, plays a vital role in respiration and trunk stabilization. Understanding the relationship between core endurance and respiratory function is essential, especially in activities demanding prolonged postural control and endurance. Previous research indicates a positive association between core strength and breath-hold time, suggesting that individuals with stronger core muscles may demonstrate greater breath-holding capacity due to improved respiratory muscle coordination and efficiency.(12)

Moreover, research has demonstrated a relationship between core muscle function and respiratory performance. Strengthening the Transversus Abdominis (TA) has been shown to enhance both respiratory function and lumbar stability in healthy adults. Kim and Lee (2013) reported that deep abdominal muscle strengthening exercises significantly improved lung function parameters and trunk stability, highlighting the crucial role of the TA in coordinating respiration and spinal control.(6)

In addition, studies have shown that core stabilization exercises combined with breathing control can significantly improve both pulmonary function and abdominal strength. Cavaggioni et al. (2015) reported that different types of core exercises enhanced respiratory parameters such as vital capacity and forced expiratory volume, while also increasing abdominal fitness levels.[2] This finding reinforces the interdependence between core stability and respiratory efficiency, emphasizing the role of core training in improving overall functional performance.(13)

Despite growing evidence linking core stability and respiratory efficiency, there remains a lack of research specifically examining the relationship between Transversus Abdominis (TA) strength and endurance with Peak Expiratory Flow Rate (PEFR) and Breath-Holding Time (BHT) in healthy adults. Understanding this association is essential, as the TA plays a crucial role in both trunk stabilization and respiration through regulation of intra-abdominal pressure and diaphragmatic support. Establishing a correlation between TA performance and respiratory measures could help identify the contribution of core musculature to pulmonary efficiency even in healthy populations.

Therefore, the present study aims to assess the correlation between TA strength and endurance with PEFR and BHT in healthy young adults. This investigation is important to highlight the clinical relevance of core muscle assessment in physiotherapy practice and to support the integration of core training into respiratory and postural rehabilitation programs.

II. METHODOLOGY

A cross-sectional observational study was performed at SBB College of Physiotherapy, Ahmedabad. Study was done in accordance with the terms of the Declaration of Helsinki. Written informed consent was obtained from all participants before enrolment.

The study included 60 participants aged 18–25 years, in accordance with the age range set by the Society for Adolescent Health and Medicine. Individuals of Body Mass Index (BMI) (18.5–22.9 kg/m²) range were included in the study as per the WHO-Asian classification.

Individuals with major neurological, cardiological, or musculoskeletal disorders were excluded to eliminate potential factors that could affect posture or respiratory function.

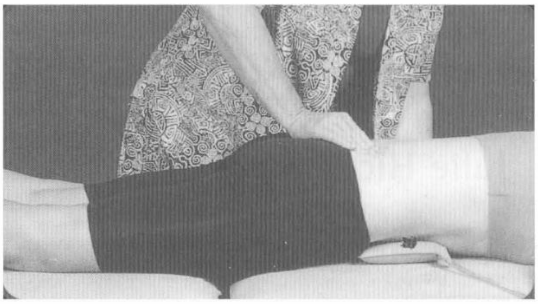
PROCEDURE:

The demographic information (age, gender, height, weight, BMI, and occupation) was collected. Lumbar core strength was evaluated in the prone position using a Pressure Biofeedback Unit (PBU). During the assessment, participants lay prone with their arms by the sides and the head in the midline position. The PBU was positioned under the abdomen, ensuring that the navel was centred and the distal edge aligned with the anterior superior iliac spines. (Fig:1) [14,15]

For measuring Peak Expiratory Flow Rate (PEFR), a Cipla Peak flow meter was used. Participants were instructed to inhale deeply, clamp their nostrils to prevent air leakage, and then exhale forcefully and completely into the mouthpiece in a single, strong blow. The mouthpiece was held securely between the teeth and lips to avoid air escape. After each trial, the mouthpiece was replaced and the device reset to its initial position. Three trials were performed for each participant, and the highest value among the three readings was recorded for analysis.[16]

Breath-holding time was assessed with participants in a relaxed sitting position. They were instructed to take a deep inspiration, pinch the nose with the thumb and forefinger, and hold their breath.

Figure:1 transversus abdominis muscle, performed in the prone position using the pressure biofeedback unit



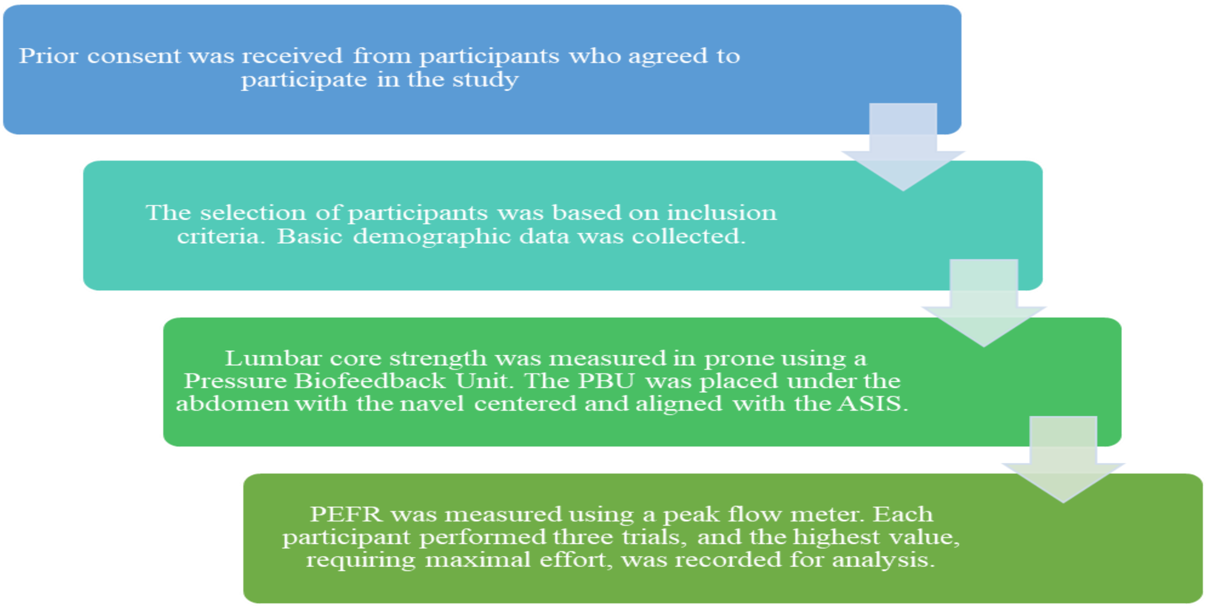


Figure 2: Method of the study

III. DATA ANALYSIS

Statistical analysis was conducted using Microsoft Excel and SPSS version 20. Descriptive statistics (mean and standard deviation) were calculated for demographic and outcome variables. Data normality was checked using the Shapiro–Wilk test. Since the data were normally distributed, Pearson's correlation coefficient (r) was used to assess the relationship between Transversus Abdominis (TA) strength and endurance with Peak Expiratory Flow Rate (PEFR) and Breath-Holding Time (BHT). A p-value <0.05 was considered statistically significant.

IV. RESULTS

A total of 100 healthy participants were included in the study with a mean age of 21.53 ± 1.58 years and a mean BMI of 21.12 ± 1.48 kg/m². The mean height and weight were 160.06 ± 6.98 cm and 54.72 ± 6.08 kg, respectively.

Table 1: Demographic Data of the Participants

VARIABLE	MEAN±SD
Age (years)	21.53±1.58
Height (cm)	160.06±6.98
Weight(kg)	54.72±6.08
BMI(kg/m²)	21.12±1.48

The data represent a young, healthy adult population with normal BMI and anthropometric characteristics, minimizing potential confounding variables.

Table 2: Mean and Standard Deviation of Core Muscle and Respiratory Parameters

TABLE-2	MEAN±SD
Peak expiratory flow rate (PEFR)	319.75±75.70

Breath holding time (seconds)	41.26±15.55
Core muscle strength (mmHg)	23.08±7.22
Core muscle endurance (seconds)	18.23±8.88

The mean Peak Expiratory Flow Rate (PEFR) of 319.75 ± 75.70 L/min indicates normal expiratory capacity in young adults, reflecting optimal respiratory muscle function. The mean breath-holding time (BHT) was 41.26 ± 15.55 seconds, suggesting good respiratory control. Average core muscle strength and endurance values highlight a balanced trunk muscle performance within the study group.

Table 3: Showing correlation of core muscle strength(mmHg) and endurance (Time) with peak Expiratory Flow Rate (PEFR) and Breath Holding Time (BHT)

CORRELATION	r-value	p-value	INTERPRETATION
PEFR with Core muscle strength (mmHg)	0.231	0.075	A statistically significant correlation between PEFR and Core muscle strength with a weak positive correlation.
PEFR with Core muscle endurance (seconds)	0.291	0.024	A statistically significant correlation between PEFR and Core muscle endurance with a weak positive correlation.
Breath holding time (seconds) with Core muscle strength (mmHg)	0.429	0.001	A statistically significant correlation between BHT and Core muscle strength with a moderate positive correlation.
Breath holding time (seconds) with Core muscle endurance (seconds)	0.035	0.791	A statistically significant correlation between BHT and Core muscle endurance with a weak positive correlation.

Table 3 demonstrates the relationship between PEFR, core muscle strength, and endurance using the Pearson correlation test. A weak positive correlation was found between PEFR and core muscle strength (r = 0.231, p = 0.075), indicating that participants with greater transversus abdominis strength tended to have higher expiratory flow rates, though the correlation was not statistically significant.

A statistically significant weak positive correlation was observed between PEFR and core muscle endurance (r = 0.291, p = 0.024), suggesting that improved core endurance contributes to better expiratory performance. A moderate positive and statistically significant correlation was noted between BHT and core muscle strength (r = 0.429, p = 0.001), indicating that individuals with stronger core muscles demonstrated greater breath-holding capacity, likely due to enhanced intra-abdominal pressure and respiratory control. In contrast, the correlation between BHT and core muscle endurance (r = 0.035, p = 0.791) was not statistically significant, showing that endurance had minimal influence on static breath-holding ability.

Figure 3: Correlation Coefficients for Core Muscle Strength and Endurance with peak Expiratory Flow Rate (PEFR) and Breath Holding Time (BHT)

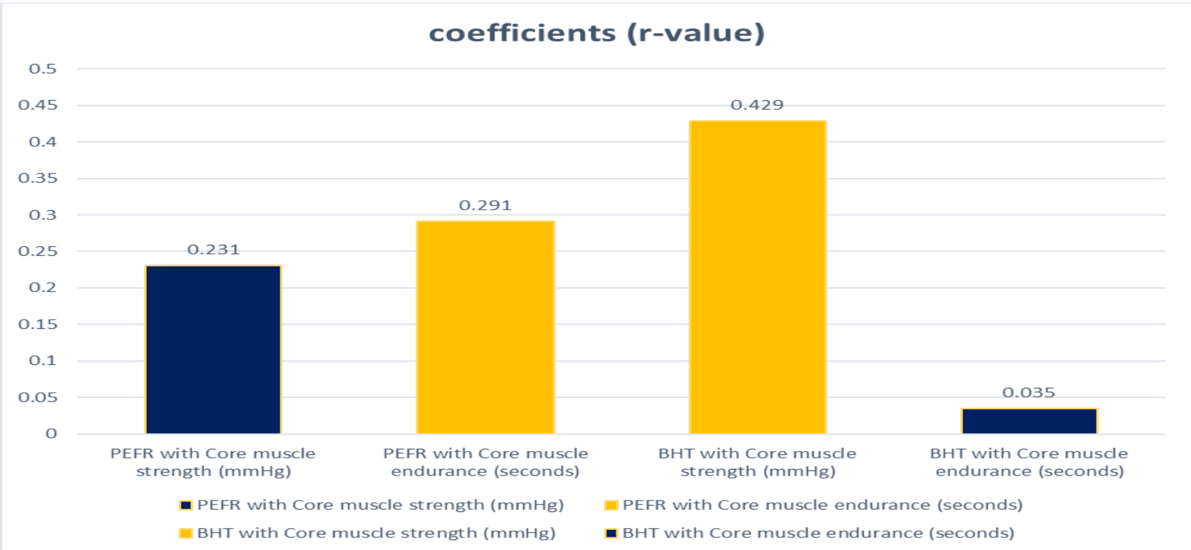


Figure 3 shows the correlation coefficients (r-values) between core muscle strength and endurance with PEFR and BHT. Yellow bars represent statistically significant correlations (*$p < 0.05$*), while blue bars indicate non-significant relationships (*$p \geq 0.05$*). The figure clearly demonstrates that BHT has the strongest positive association with core muscle strength, followed by a weaker yet significant correlation between PEFR and core muscle endurance.

V. DISCUSSION

The present study found that Transversus Abdominis (TA) strength showed a significant but weak correlation with breath-holding time (BHT), while no significant association was observed between TA endurance and BHT. This suggests that greater TA strength may contribute modestly to improved voluntary breath control. In contrast, TA endurance showed a weak positive correlation with peak expiratory flow rate (PEFR), indicating a limited role of core muscle endurance in influencing expiratory performance.

However, TA strength did not significantly correlate with PEFR, implying that in healthy young adults, respiratory functions such as PEFR are influenced more by pulmonary factors than by core muscle parameters. Overall, the results highlight a minor yet observable link between core stability muscles and certain respiratory functions.

The modest correlation observed between transversus abdominis (TA) strength and breath-holding time (BHT) in the present study is consistent with the concept that core musculature including the TA plays a stabilising role for the trunk, influences intra-abdominal pressure (IAP), and thereby interacts with respiratory mechanics.

Patel et al. (2021) reported a similar finding in their study "Correlation between core strength and breath holding time in normal young adults" where they observed a moderate positive correlation ($r = 0.351$, $p = 0.006$) between core strength and BHT in healthy young adults, concluding that better core strength may permit longer breath-hold durations. Our findings of a significant, though weak, correlation align with this earlier work, albeit with a smaller effect size. The proposed mechanism is that during breath-holding, co-activation of the TA and other abdominal muscles increases IAP, providing trunk stability and supporting the diaphragm's optimal positioning, thereby potentially enhancing breath-holding capacity.(12) Similar mechanisms have been described by Hodges and Gandevia (2000), who demonstrated that the TA is recruited in anticipation of trunk or respiratory demands, emphasizing its dual role in postural and respiratory control.(17)

On the other hand, the weak or non-significant correlation between TA strength and PEFR observed in the present study is also reflected in findings from earlier literature. For instance, Patel et al. (2016), in their study "Correlation between abdominal muscle strength and pulmonary function in subjects with low back pain" reported a weak positive correlation ($r = 0.34$, $p = 0.007$) between abdominal muscle strength and PEFR.(18)

Similarly, Ishida et al. (2014) examined the "Correlation between peak expiratory flow and abdominal muscle thickness" and reported modest associations between abdominal muscle thickness and expiratory flow measures, suggesting that structural and functional aspects of the abdominal musculature can influence expiratory performance. These findings suggest that while abdominal and core muscles play a supportive role in expiratory function, the effect size tends to be modest, and respiratory outcomes like PEFR are likely influenced by multiple physiological and biomechanical factors, including airway resistance, lung recoil, and overall thoracic compliance. Thus, the literature supports a functional relationship between core muscle characteristics and respiratory measures, though this relationship appears to be indirect and multifactorial.(19)

Kim et al. (2020) reported that the Transversus Abdominis (TA) plays a vital role in maintaining postural stability and respiratory control. Activation of the TA during breath-holding elevates intra-abdominal pressure, stabilizes the trunk, and supports the diaphragm, allowing better maintenance of lung volume and controlled cessation of inspiration. This coordinated function supports prolonged breath-holding, explaining the observed correlation between TA strength and Breath-Holding Time (BHT) in the present study.(20)

Similarly, Cavaggioni et al. (2015) explained that Peak Expiratory Flow Rate (PEFR) reflects the maximum speed of expiration, primarily driven by lung recoil and expiratory muscles such as the rectus abdominis, internal and external obliques, and intercostals. The TA contributes indirectly by stabilizing the trunk and maintaining pressure transmission, indicating that TA strength alone may not substantially influence PEFR in healthy adults with normal respiratory function.(13)

The present study highlights that Transversus Abdominis (TA) strength has a significant influence on Breath-Holding Time (BHT), suggesting that improving core muscle strength can enhance voluntary breath control. This finding is clinically relevant for physiotherapists, as incorporating core stabilization and TA activation exercises may help improve breathing efficiency, trunk stability, and breath control in healthy individuals as well as in patients undergoing rehabilitation after abdominal or thoracic surgeries. Since TA strength and endurance showed minimal association with Peak Expiratory Flow Rate (PEFR), core strengthening alone may not directly enhance expiratory flow. Therefore, physiotherapy programs aimed at improving overall respiratory function should combine core training with specific respiratory muscle exercises to achieve optimal functional outcomes.

The present study has certain limitations. Its cross-sectional design limits the ability to establish cause-and-effect relationships between Transversus Abdominis (TA) strength and respiratory parameters. The study included only healthy young adults, which may have reduced variability in both core and respiratory function, limiting generalizability to other age groups or clinical populations. TA strength and endurance were assessed using a pressure biofeedback unit, which may not have isolated TA activity completely, as other abdominal muscles could have contributed. Additionally, factors such as physical activity level, posture, and thoracic mobility were not controlled and might have influenced the outcomes.

VI. CONCLUSION

The present study found a significant but weak correlation between Transversus Abdominis (TA) strength and Breath-Holding Time (BHT), suggesting that stronger core muscles may modestly improve voluntary breath control in healthy adults. However, TA endurance and Peak Expiratory Flow Rate (PEFR) showed no significant association, indicating that expiratory performance is influenced more by pulmonary and airway mechanics than by core muscle strength. These results highlight the functional connection between core stability and respiratory control, though the impact appears limited in healthy populations.

For future research, longitudinal and interventional studies are recommended to examine whether combined core and respiratory muscle training can produce greater improvements in pulmonary function. Expanding the study to include different age groups, clinical populations, and activity levels may provide a deeper understanding of the relationship between core strength and respiratory performance.

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