



Adding Ujjayi Pranayama to osteopathic manipulative treatment on pulmonary functions and functional capacity in college students with upper cross syndrome

Incorporación de la técnica Ujjayi Pranayama al tratamiento osteopático manipulativo para mejorar las funciones pulmonares y la capacidad funcional en estudiantes universitarios con síndrome cruzado superior

Authors

Mohamed S. Zidan ^{1*}
 Amira Ezzat M. Abd-ElHay ^{2*}
 Ahmed M. Elfahl ¹
 Rashed S. Al-Kafian ¹
 Mohammad M. M. Arafah ¹
 Mohamed M. Elsharkawy ³
 Sahar M. Hassan ^{4,5}
 Heba Elfeky ⁶
 Marwa Ahmed Saad Radwa ⁷
 Hadeer A. Morsi ⁸

¹ Al-Zaytoonah University of Jordan, Amman, (Jordan)

² Al al-BAYT University (Jordan)

³ Ajloun National University, Ajloun, (Jordan)

⁴ Cairo university hospitals, Cairo, (Egypt)

⁵ Qassim University, Buraidah, (Saudi Arabia)

⁶ Al-Ahliyya Amman University, (Jordan)

⁷ Galala University, Suez, (Egypt)

⁸ Kafrelsheikh University (Egypt)

Corresponding author:

Amira Ezzat Mohamed Abd ElHay

dr.amira.ezzat.pt@gmail.com

Mohamed S. Zidan

drmozhidan2015@gmail.com

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Abstract

Background: Ujjayi pranayama and osteopathic manipulative treatment (OMT) both enhance respiratory function and musculoskeletal alignment. For individuals with Upper Cross Syndrome these methods can have a significant impact.

Objective: to investigate how much does adding Ujjayi Pranayama into osteopathic manipulation (OM) on pulmonary functions and functional capacity in college students diagnosed with upper cross syndrome (UCS).

Methods: Two-armed, parallel-group RCT with concealed allocation and blinded assessment of outcomes conducted on forty participants with UCS randomly divided into two groups. Ujjayi pranayama and OM administered to the experimental group while the control group received only osteopathic manipulation. Both groups underwent 45-minute sessions, five times a week for eight weeks. We measured ERV, PEF, MVV and IC by portable spirometer.

Results: Adding ujjayi pranayama to OM showed significant greater improvements in PEF (MD change was 0.76 ± 0.07 L/s vs. 0.49 ± 0.09 L/s in control ($p=0.025$)), ERV (MD change 0.29 ± 0.06 L vs. 0.08 ± 0.01 L in control ($p=0.002$)), 6-Minute Walk Distance Test (6 MWDT) (MD change 23.60 ± 2.05 meters vs. 14.70 ± 1.54 meters in control ($p=0.001$)), TUG (MD change was -2.20 ± 0.20 sec vs. -1.15 ± 0.11 sec in control ($p=0.001$)). Some parameters showed no statistically significant differences in changes between groups: MVV: Difference and % change was not significant ($p=0.250$ and $p=0.461$). IC: Borderline difference in mean change ($p=0.058$) but % change was not significant ($p=0.201$).

Conclusion: Ujjayi pranayama to OM resulted in superior improvements in both respiratory functions in upper cross syndrome, rather than osteopathy alone.

Keywords

Ujjayi Pranayama, osteopathic manipulative treatment, pulmonary functions, upper cross syndrome.

Resumen

Antecedentes: Tanto el pranayama Ujjayi como el tratamiento osteopático manipulativo (TOM) mejoran la función respiratoria y la alineación musculoesquelética. En personas con síndrome cruzado superior, estos métodos pueden tener un impacto significativo.

Objetivo: Investigar el efecto de la adición de pranayama Ujjayi a la manipulación osteopática (MO) sobre la función pulmonar y la capacidad funcional en estudiantes universitarios diagnosticados con síndrome cruzado superior (SCS).

Métodos: Ensayo clínico aleatorizado (ECA) de dos brazos y grupos paralelos, con asignación oculta y evaluación ciega de los resultados, realizado con cuarenta participantes con SCS, divididos aleatoriamente en dos grupos. El grupo experimental recibió pranayama Ujjayi y MO, mientras que el grupo control recibió únicamente manipulación osteopática. Ambos grupos participaron en sesiones de 45 minutos, cinco veces por semana durante ocho semanas. Se midieron el volumen espiratorio forzado en la respiración (VER), el flujo espiratorio máximo (FEM), la ventilación voluntaria máxima (VVM) y la capacidad inspiratoria (CI) mediante espirómetro portátil.

Resultados: La adición de ujjayi pranayama a la OM mostró mejoras significativamente mayores en el PEF (cambio en la MD: $0,76 \pm 0,07$ L/s frente a $0,49 \pm 0,09$ L/s en el grupo control ($p = 0,025$)), el VRE (cambio en la MD: $0,29 \pm 0,06$ L frente a $0,08 \pm 0,01$ L en el grupo control ($p = 0,002$)), la distancia recorrida en la prueba de marcha de 6 minutos (6MWDT) (cambio en la MD: $23,60 \pm 2,05$ metros frente a $14,70 \pm 1,54$ metros en el grupo control ($p = 0,001$)) y la prueba TUG (cambio en la MD: $-2,20 \pm 0,20$ s frente a $-1,15 \pm 0,11$ s en el grupo control ($p = 0,001$)). Algunos parámetros no mostraron diferencias significativas entre los grupos: MVV: La diferencia y el porcentaje de cambio no fueron significativos ($p = 0,250$). $p=0,461$). IC: Diferencia marginal en el cambio medio ($p=0,058$), pero el cambio porcentual no fue significativo ($p=0,201$).

Conclusión: La aplicación de Ujjayi pranayama a la osteopatía produjo mejoras superiores en ambas funciones respiratorias en el síndrome cruzado superior, en comparación con la osteopatía sola.

Palabras clave

Pranayama Ujjayi, tratamiento manipulativo osteopático, funciones pulmonares, síndrome cruzado superior.



Introduction

Upper Cross Syndrome (UCS) is a condition defined by a specific pattern of muscular imbalances in the upper body. The upper crossed syndrome (UCS) is characterised by rounded shoulders and a protruding chin posture, resulting from a muscular imbalance that influences head position, spine alignment, and shoulder girdle stability. When the head moves forward along the sagittal plane of the cervical spine, it is in front of the trunk. This is called forward head posture. This misalignment makes the centerline of the head move forward and up, which puts more stress on the neck because it has to hold more of the head's weight (Hasnin et al., 2025). This syndrome can cause other health problems, like neck pain, myofascial trigger points, impingement syndromes, cervicogenic headaches, rotator cuff dysfunction and reduced lung capacity (Gaid et al., 2024). Pain in UCS is easy to come back and last a long time. Chronic pain has a significant effect on the psychological well-being of patients over time, and upper crossed syndrome patients are more likely to experience negative emotions such as anxiety which can seriously affect their quality of life (Hawamdeh et al., 2023). Similarly, Audoux et al. (2023) demonstrated that interventions targeting musculoskeletal dysfunction can improve biopsychosocial outcomes, including stress, anxiety, sleep quality, and perceived well-being, highlighting the somatic manifestations of psychological burden. These may result in irregular respiratory patterns and psychological issues (Cai et al., 2017).

Its prevalence is rising among young individuals globally, primarily due to extended durations of suboptimal posture linked to activities such as smartphone and computer usage. Recent research indicates that the prevalence of UCS among youth populations may vary between 21% and 48%, contingent upon the demographic and lifestyle variables examined. A study from 2024 found that about 30% of college students showed signs of UCS. This shows that people are becoming more worried about musculoskeletal health in younger groups. Among university students in northern Jordan, 24% had upper limb pain and disability. Multiple factors were found to be significantly correlated with with upper limb pain and functional disability among university students, including smartphone usage, computer usage, and the existence of musculoskeletal issues, such as upper cross syndrome (Almomani et al., 2019). These conditions may contribute to an increase in upper thoracic kyphosis, which can consequently reduce the volume of the thoracic cage (Han et al., 2016). Such alterations may also restrict the motion of the diaphragm and other muscles involved in active respiration (Lin et al., 2006). Moreover, Huesing et al. (2023) and Afari et al. (2014) provide a systematic framework for identifying psychological risk factors associated with persistent somatic symptoms. Moreover, Osses-Anguita et al. (2023) explored the prevalence of awake and sleep bruxism among university students and its association with anxiety, depression, stress coping, and emotional regulation, emphasizing how psychological stress can manifest somatically in young population. Postural abnormalities are commonly associated with a decline in lung volumes and capacities, which adversely affects chest expansion and alveolar ventilation. This reduction ultimately leads to decrease oxygen partial pressure, diminished exercise tolerance and lower respiratory efficiency (Okuro et al., 2011). Pulmonary function tests (PFTs) are essential, non-invasive diagnostic tools used to assess and monitor respiratory function, facilitating the identification and evaluation of various pulmonary conditions (Katz et al., 2018).

The manual osteopathic approach to treating UCS should include all the techniques that can help with the symptoms of the syndrome. The techniques used should be aimed at reducing restrictions, joint problems, muscle spasms, and pain that is caused by symptoms. Manual osteopathic treatment takes a lot of different approaches, so there are a lot of different techniques that can be used. A good way to start therapy to reduce pain would be to use soft tissue and myofascial release (MFR) techniques to relax tight, facilitated muscles. This would depend on how bad the patient's dysfunction is (Lindsay and Robertson 2008). After relieving trigger points and muscle tension, joint mobilisation (MOB) of the cervical, thoracic, and lumbar spine, as well as bilateral shoulder, scapula, and clavicle, can help ease the limitations caused by the chronic bad postures that people with upper crossed syndrome tend to have. Finishing treatment with muscle energy techniques (METs) that focus on weak, long muscles to actively strengthen them and fix muscle imbalances. Yoga is a unique mind-body approach to respiratory health that combines physical postures (asanas), controlled breathing techniques (pranayama), meditative practice (dhyana), and relaxation practices. It is different from other types of exercise (Nicholas and Nicholas 2012). Abd ElHay et al. (2025) emphasized the significance of postural alignment, especially with regard to forward head position, which might affect musculoskeletal health



which is strongly connected to Upper Cross Syndrome (UCS). Also, AlAnazi and Mani (2025) study on musculoskeletal pain in desk-based workers is pertinent to UCS and Cobos-Bermeo et al. (2025) discovered strong correlations between musculoskeletal diseases and anthropometric factors, highlighting the relevance of posture in functional capacity. Hassan et al. (2025) investigated telerehabilitation for carpal tunnel syndrome, which offered novel rehabilitation strategies which show the advantages of Ujjayi Pranayama in addition to osteopathic manipulation for improving pulmonary functions and functional ability. Pedraza-Ricra et al. (2025) studied the kinanthropometric traits affect spinal health and their results showed how structural elements affect the efficacy of therapies. Janagiraman et al. (2025) emphasized the need of treating muscular imbalances which consider a key component of UCS therapy during their comparison of muscle stretches for cervical pain treatment. Recent studies indicate that yoga-based interventions can positively influence pulmonary function among both healthy individuals and patients with respiratory or related disorders (Li et al., 2018). Prior research has indicated enhancements in metrics such as forced vital capacity (FVC), vital capacity (VC), peak expiratory flow rate (PEFR) and forced expiratory volume in one second (FEV1) subsequent to consistent yoga practice in both healthy (Akhani et al., 2019; Kuppusamy et al., 2017) and clinical cohorts (Swami et al., 2010; John et al., 2022; Sangeethalaxmi & Hankey, 2023). Ujjayi pranayama (UP), also known as Ocean breathing also known as "victorious breathing", has been reported to provide multiple health benefits. Ujjayi is a Sanskrit term meaning "to be victorious". It is made up of the words "ud," which means "superior" or "power," and "jaya," which means "victory," "success," or "conquest (CYTA, 2002). Because it makes sounds like ocean waves when you breathe in and out, it is commonly called the ocean breathing technique. People who do UP do it by itself or with a few other types of breathing as part of an intervention program. Sheethal et al., (2012) documented enhancements in the respiratory system and favourable physiological effects resulting from the practice of pranayama, of which UP was an integral component. Results indicate enhanced vital capacity, peak expiratory flow rate and maximal ventilation among participants after three months of practice (Panwar et al., 2012). Ujjayi pranayama has been shown to counteract cardiovascular changes associated with stress and anxiety through normalization of the cardiovascular autonomic balance (Mahour and Verma, 2017).

In our current social climate, the prevalence of upper cross syndrome among college students is rapidly increasing, primarily due to the excessive use of mobile phones and social media. This, in turn, has led to respiratory dysfunctions among the affected students, and this trend is becoming a social problem.

Our study attempts to verify the effects of adding ujjayi pranayama to osteopathic manipulative treatment on pulmonary functions and functional capacity in college students with upper cross syndrome.

The study hypothesized that (a) There was no significant difference in ERV,(b)There was no significant difference in PEF,(c) There was no significant difference in MVV,(d) There was no significant difference in IC, (e) There was no significant difference in Berg balance scale, (f) There was no significant difference in Timed up and go test and (g) There was no significant difference in 6MWDT.

Method

The study was approved by the institution's Research Ethics Committee AlZaytoonah University of Jordan .Its number (IRB#2/6/2024-2025). It was registered in the clinical trial registry (NCT07052552). Participation was voluntary, and written informed consent was obtained from all subjects before participation. The study was conducted at Al Zaytoonah University Faculty of Applied Medical Sciences from August 2025 to October 2025.

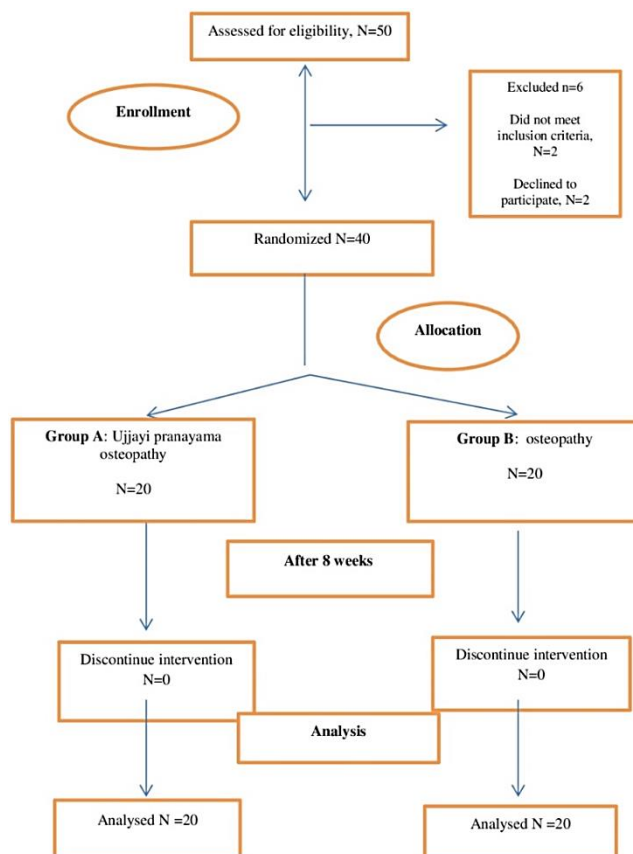
Participants

Forty male college students with upper cross syndrome were recruited. The physical therapy department at Al-Zaytoonah University, after clinical examination and a comprehensive medical history evaluation by an orthopedist, conducted the recruiting. The trial comprised patients aged 20 to 29 years, and the capacity to provide informed consent. Participants with a history of spinal or shoulder fractures, prior surgery, other significant diseases, or severe cardio-cerebrovascular conditions were excluded from the study, difficulty following up on testing, and individuals who participated in additional exercise within the two weeks prior to the study as this could have influenced the results of this study.



Additionally, individuals diagnosed with neurological or systemic diseases that could affect movement or posture were excluded. Participants taking medications known to influence musculoskeletal performance were not eligible for inclusion. Participants who were unwilling to participate or unable to follow study instructions were also excluded. Throughout the study, nine participants failed to meet the inclusion criteria, while four participants opted out of participation.

Figure 1. Flowchart outlines the methodology



The sample size was calculated prior to the study using the G*POWER statistical software (version 3.1.9.2; Franz Faul, University of Kiel, Germany). The mean of the BBS was calculated using data from a preliminary pilot study including 6 participants who were randomly assigned to one of two treatment groups, with three subjects in each. With an alpha of 0.05, 80% power, and an effect size of 0.44, the study required a total sample size of 50 participants.

Procedure

The procedures of the current study were explained to the patients, and they signed an informed consent form. All were assessed at baseline and eight weeks.

A hand-held lung function spirometry (SP 80B, China) to assess pulmonary functions (American Thoracic Society, 1995 and Miller et al., 2005). To get the primary outcome measures (ERV, PEF, MVV, IC), the patient was seated in a comfortable position and shown how to use the device before the measurements were taken. The first attempt was not taken into consideration as the therapist noticed the patient's blow, nose clip, and lip seal around the mouthpiece and the readiness of the device. If the first attempt was done correctly, the patient was told again to take a deep breath, put their mouth on the mouth piece, and then blow as hard as they could into the device. If the second attempt was not done correctly, a third attempt was considered in the same manner. However, If the third try didn't work, though, a new demonstration was done to show how to use the device correctly, and at least 15 minutes after the failed attempt, another assessment was done.

Primary outcome measures

ERV

The Expiratory Reserve Volume (ERV) is the volume of gas maximally that can be exhaled after end-inspiratory tidal breathing (Feyrouz et al., 2003).

PEF

Peak expiratory flow: represents the peak airflow rate achieved during a maximal forced expiration (L/sd) [23].

MVV

Maximal Voluntary Ventilation (MVV) measurement is defined as the maximal volume of air that can be moved by voluntary effort in 1 minute (Shah et al., 2019).

IC

Inspiratory Capacity: represents the total volume of air that can be inhaled after a normal tidal exhalation, it equals the sum of the inspiratory reserve volume (IRV) and tidal volume (VT), expressed in liters (L). (Feyrouz et al., 2003).

Secondary outcome measures

Functional capacity (6 MWDT)

The 6-minute walk test (6MWT) is a convenient and reliable tool for evaluating patients' exercise capacity (Harold et al., 2025). The test was conducted according to the standardized protocol of the American Thoracic Society (ATS) guidelines (ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories, 2002). Participants were instructed to walk, covering as much distance as possible along a 30-meter flat, straight corridor for six minutes. Before starting the test, baseline heart rate, blood pressure, oxygen saturation (SpO₂), and rate of perceived exertion (RPE; Borg Scale) were recorded. A stopwatch, pulse oximeter, measuring tape, and standardized cones were used to mark the turnaround points. During the test, participants were encouraged using standardized verbal cues every minute (e.g., "You are doing well, keep up the good work"), as recommended by the ATS. The investigator closely monitored for any adverse symptoms such as dyspnea, chest pain, dizziness, or leg fatigue. The test was terminated if the participant experienced any discomfort or requested to stop. By the end of the six-minute duration, the overall distance covered (in meters) was recorded as the 6-Minute Walk Distance (6MWD). Post-test vital signs and RPE were also reassessed to ensure safety and recovery (American Thoracic Society, 2002 and Holland et al., 2014)

Timed up and go test:

The 'timed up and go test (TUG) is a widely accepted, performance-based measure used to evaluate mobility, balance, and fall risk through assessment of lower extremity function (Talia et al., 2010). The procedure was carried out in accordance with the standardised protocol described by Podsiadlo and Richardson (1991). Each participant was positioned in a standard armchair (seat height ≈ 45 cm) with the back supported by the chair and the arms resting comfortably on the armrests. Participants were instructed, upon the verbal cue "Go", to stand from the chair walk 3 meters, turn, walk back and sit down at a self-selected pace. The total completion time was measured in seconds using a digital stopwatch. Before testing, participants were given one practice trial to ensure understanding, followed by one recorded trial for analysis. The assessor closely monitored the participant throughout the test for any signs of imbalance, fatigue, or dizziness, and ensured safety by standing nearby without providing physical assistance unless needed. A shorter completion time indicates better functional mobility and balance performance (Podsiadlo & Richardson, 1991 and Shumway-Cook et al., 2000).

Treatment Procedures:

The intervention procedures were organized into two main categories.

Therapeutic procedures (preparatory treatment application)



The patient's weight, height, and BMI were recorded and they were informed about the treatment procedures and their purpose; contraindications (mentioned in the exclusion criteria) were excluded.

The procedure of ujjayi pranayama and osteopathic manipulative treatment:

Forty sessions over 8 weeks (Five sessions per week). Each session took 45 minutes. To Ujjayi pranayama and osteopathic manipulative treatment as follows:

To ensure time-matched interventions and experimental equivalence, the total session time was distributed as follows:

Table 1. Ujjayi Pranayama and Osteopathic Manipulative Treatment Group

Phase	Duration	Description
Initial assessment and warm-up	5 min	Postural evaluation, tissue palpation, light mobilization
Osteopathic manipulative treatment	25 min	Focused on key OMT techniques (soft tissue, mobilization, MET) applied sequentially for cervical, thoracic, and shoulder complex dysfunctions
Ujjayi Pranayama training and practice	15 min	Conducted under therapist supervision in a seated position: slow nasal inhalation and exhalation with slight glottic constriction to produce oceanic sound, incorporating 3–4 cycles/min for 15 minutes total
Cool-down and reflection	0-2 min	Light diaphragmatic breathing and feedback to ensure calm recovery

Table 2. Osteopathic group: Osteopathic manipulative treatment only

Phase	Duration	Description
Initial assessment and warm-up	5 min	Postural evaluation, tissue palpation, light mobilization
Soft tissue and myofascial release	10 min	Applied to the upper trapezius, pectoralis, levator scapulae, and suboccipital muscles
Articulatory and mobilization techniques	10 min	Cervical, thoracic, and scapulothoracic mobilizations
Muscle Energy Techniques (MET)	10 min	Post-isometric relaxation for tight muscles and activation of weak ones
Integrative breathing and postural re-education	5 min	Diaphragmatic activation and ergonomic retraining
Rest and documentation	5 min	Monitoring of response and feedback

Instrument

A stopwatch, pulse oximeter, measuring tape, and standardized cones were used to mark the turnaround points.

Ujjaya pranayama:

Prior to the data collection, the subjects were familiarized with the laboratory environment and the experimental procedure. On the day of the test, all participants reported to our laboratory in the morning, approximately two hours after consuming a light breakfast. The ambient temperature of the laboratory was kept at 25±10 through the testing sessions. After 15 minutes of supine rest, the participants were seated comfortably with an erect posture, maintaining a straight back and closed eyes during assessment focusing attention inward to promote relaxation, with the researcher making sure that the subject breathing in and out through the nose while gently constricting the glottis to produce a soft, ocean-like sound, maintaining an equal inspiratory and expiratory duration (1:1 ratio) during the first two weeks and gradually progressing to a 1:2 ratio thereafter and keeping the mouth closed, the subject Start by inhaling - long, slow, deep breaths through both his nostrils. His breath should be gentle and relaxed as he slightly contracts the back of his throat so that the air passage becomes narrower, making the breath thin and long, followed by slow, deep expiration. The breathing rate was maintained at approximately 3–4 cycles per minute, emphasizing smooth diaphragmatic expansion during inspiration and passive recoil during expiration with breath holding in between. No breath-holding or forced breathing was introduced to prevent hyperventilation or autonomic imbalance (Telles et al., 2014; Saoji et al., 2019 and Saoji et al., 2020). Each session included an initial 3-5-minute relaxation phase, 10–15 minutes of active Ujjayi breathing as shown in Table 1, and a final 3-5-minute quiet rest period to integrate physiological effects. Each subject participated in early morning practice



sessions lasting between 20 and 25 minutes per day, two hours after a light breakfast, under the supervision of the therapist (Lathadevi et al., 2017). This controlled glottic resistance during both inhalation and exhalation increases intrathoracic pressure and enhances diaphragmatic recruitment, thereby improving thoracic mobility, vagal tone, and cardiorespiratory coupling (Jerath et al., 2006; Pal et al., 2014 and Sarkar et al., 2017).

Osteopathic manipulative treatment:

To find tender points, palpate the patient's muscles, especially the upper trapezius and pectoralis muscles and diaphragm. Then, carefully guide the patient's body into a passive position that reduces the pain at the tender point. This often involves a combination of movements, such as shortening the muscles of the neck, shoulders, and diaphragm. For the Upper trapezius, we placed the patients in a supine position, supported the occiput, side-bend the head toward the ipsilateral shoulder, and slightly rotate away while adding slight flexion and extension for 90 seconds until tenderness reduced by 70-90% and after 90 seconds, we gently returned the patient to a neutral position. For pectoralis major and Minor, placed the patient into supine with shoulder abducted and slightly externally rotated (for pectoralis major) and for pectoralis minor we placed the shoulder into forward and elevate the winging scapula to shorten the muscle and to reduce the tenderness by holding the position for 90 sec then gently returned the patient to neutral position and for diaphragm muscle, we placed the patient into supine position with knee flexed to relax lumbar and abdominal tension, we Placed one hand (monitoring hand) over the tender point under the costal margin. With our other hand, we elevated the patient's thorax and slightly flexed the trunk toward the tender point. Instructed the patient to exhale fully while we maintain gentle cephalad and posterior pressure under the costal margin. Maintaining the patient's shoulders slightly flexed to relax anterior chest tension. Fine-tune until tenderness is reduced by about 70-90% (patient reports relief). Hold the position for 90 seconds while monitoring the tissue. After 90 seconds, slowly release the pressure and allow the patient to return to neutral over 3-5 seconds. Re-palpate to confirm tenderness reduction (Greenman and DeStefano, 2021).

Data analysis

An unpaired t-test was performed to compare subject characteristics between groups. The Shapiro-Wilk test was utilized to verify normal data distribution, and Levene's test was conducted to check for homogeneity of variances between groups. The Multivariate Analysis of Variance (MANOVA) was implemented to compare PEF, Expiratory reserve volume, 6 MWDT, timed up, MVV, and IC between groups. The significance level for all statistical tests was established at $p < 0.05$. All statistical analyses were conducted using version 25 of SPSS for Windows (IBM SPSS, Chicago, IL, USA).

Results

Subjects' characteristics

Table 3 and Figure 2 present the comparison of demographic data between the control and experimental groups. Regarding age, both groups showed identical mean values (23.75 ± 2.71 years for the control group and 23.7 ± 2.71 years for the experimental group) with no significant difference ($p=1.000$). Weight was slightly higher in the control group (82.75 ± 5.88 kg) compared to the experimental group (81.70 ± 5.89 kg), yet this difference was not statistically significant ($p=0.576$). Similarly, height was marginally greater in the control group (173.45 ± 4.73 cm) than in the experimental group (172.80 ± 5.14 cm), with no significant difference ($p=0.679$). Finally, BMI values were comparable between groups (27.49 ± 1.40 for control vs. 27.36 ± 1.53 for experimental), showing no statistical significance ($p=0.772$). Overall, the demographic characteristics were well matched between groups, confirming homogeneity at baseline.

Table 3. Comparison between the control group and experimental group according to demographic data.

Demographic data	Control Group (n=20)	Experimental group (n=20)	T- Value	p-value
Age (years)				
Mean \pm SD	23.75 ± 2.71	23.7 ± 2.71	0.000	1.000
Range	20-29	20-29		
Weight (kg)				



Mean ± SD	82.75±5.88	81.70±5.89	0.564	0.576
Range	73-95	70-92		
Height (Cm)				
Mean ± SD	173.45±4.73	172.80±5.14	0.416	0.679
Range	162-181	162-180		
BMI [wt./(ht) ²]				
Mean ± SD	27.49±1.40	27.36±1.53	0.291	0.772
Range	25.2-29.7	24.2-29.8		

Using: t-Independent Sample t-test for Mean ± SD; p-value >0.05 is insignificant; *p-value <0.05 is significant; **p-value <0.001 is highly significant

Figure 2. Comparison of Demographic Data Between the Control and Experimental Groups."

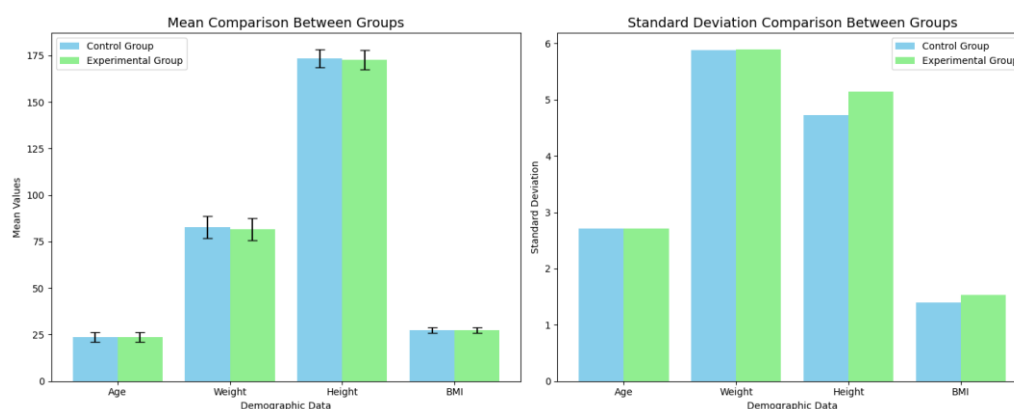


Table 4 and Figures 3 to 5, illustrate the comparison between control and experimental groups in pre-intervention functional and respiratory capacities. The highest mean values were observed in the 6-minute walk distance test (6 MWDT) with 560.50±25.23 meters in the experimental group, followed closely by the control group at 554.45±23.75 meters (p=0.440). Peak expiratory flow (PEF) showed means of 5.84±0.41 L/s and 5.71±0.61 L/s for the experimental and control groups, respectively (p=0.415). Maximal voluntary ventilation (MVV) showed 69.90±4.53 L/min in the experimental group and 67.82±5.14 L/min in controls (p=0.183). Inspiratory capacity (IC) values were 2.34±0.26 L for the experimental group and 2.24±0.27 L for controls (p=0.239). Other measures, including the time up and go test, showed no significant differences, with p-values all above 0.15. Overall, no statistically significant differences were observed between groups across all measured pre-intervention variables (all p>0.05), indicating baseline equivalence.

Table 4. Comparison between the control group and experimental group according to pre-intervention for functional and respiratory capacities.

Pre-intervention for Functional and Respiratory Capacities	Control Group (n=20)	Experimental group (n=20)	Test value	p-value
PEF (L/S)				
Mean±SD	5.71±0.61	5.84±0.41	-0.823	0.415
Range	4.7-6.8	4.9-6.6		
Expiratory reserve volume (L)				
Mean±SD	1.53±0.42	1.69±0.44	-1.206	0.235
Range	1-2.2	0.9-2.4		
6 MWDT (METERS)				
Mean±SD	554.45±23.75	560.50±25.23	-0.781	0.440
Range	495-584	500-589		
Time up and go test (Sec)				
Mean±SD	9.25±0.79	9.15±0.81	0.395	0.695
Range	8-10	8-10		
MVV (L/MIN)				
Mean±SD	67.82±5.14	69.90±4.53	-1.358	0.183
Range	55.2-74.1	59.8-76.5		
IC (L)				
Mean±SD	2.24±0.27	2.34±0.26	-1.197	0.239
Range	1.8-2.6	1.9-2.8		

Using: t-Independent Sample t-test for Mean ± SD; p-value >0.05 is insignificant; *p-value <0.05 is significant; **p-value <0.001 is highly significant

Figure 3. Comparison Between Control and Experimental Groups for PEF, IC, and Time Up and Go Test

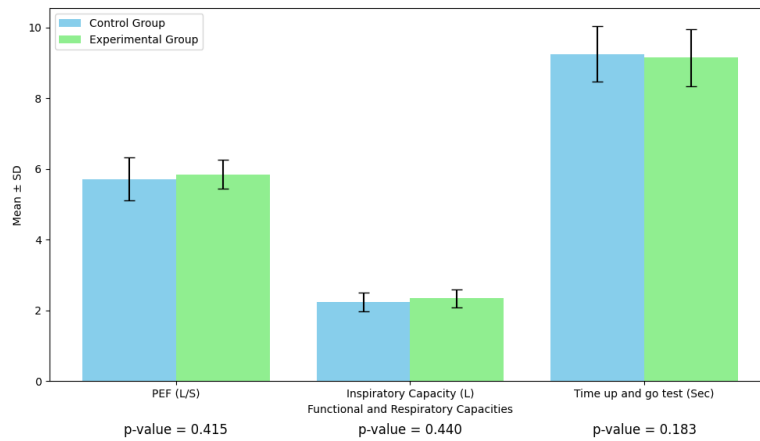


Figure 4. Comparison of 6 MWDT Between Control and Experimental Groups

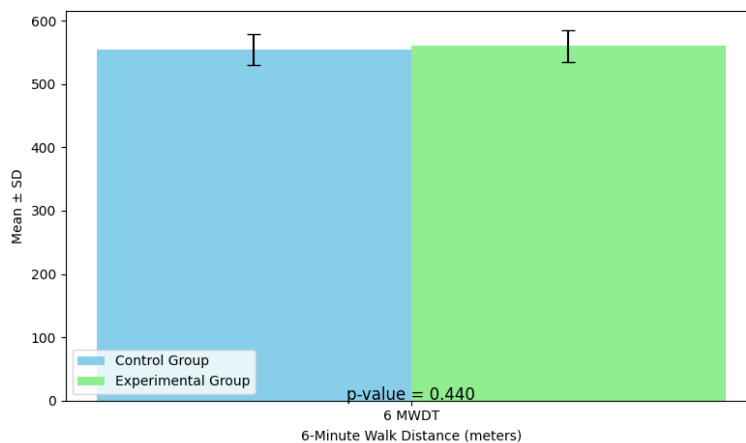


Figure 5. Comparison of MVV Between Control and Experimental Groups

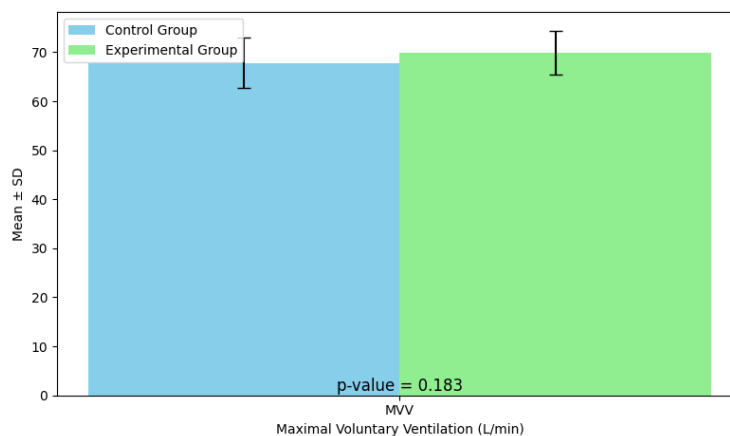


Table 5 and Figures 6 to 8, compare the post-intervention functional and respiratory capacities between the control and experimental groups. The experimental group showed that Maximal voluntary ventilation (MVV) was significantly higher in the experimental group (81.14 ± 3.65 L/min) versus the control group (77.55 ± 3.89 L/min, $p=0.005$). Peak expiratory flow (PEF) was significantly higher in the experimental group (6.59 ± 0.52 L/s) than in controls (6.20 ± 0.48 L/s, $p=0.019$). Expiratory reserve volume (ERV) was greater in the experimental group (1.98 ± 0.41 L) versus the control group (1.62 ± 0.41 L, $p=0.009$). Inspiratory capacity (IC) also showed a significant increase in the experimental group (2.69 ± 0.26 L) compared to controls (2.49 ± 0.26 L, $p=0.019$). Functional capacity assessed by the 6-minute walk distance test (6 MWDT) revealed significantly longer distances in the experimental

group (584.10 ± 21.64 meters) than the control group (569.15 ± 21.69 meters, $p=0.035$). The time up and go test demonstrated significantly lower times in the experimental group (6.95 ± 0.94 seconds) versus the control group (8.10 ± 0.64 seconds, $p=0.001$). Overall, the experimental group exhibited statistically significant improvements in nearly all post-intervention functional and respiratory parameters compared to the control group, indicating the added benefit of diaphragmatic proprioceptive neuromuscular facilitation.

Table 5. Comparison between the control group and the experimental group according to post-intervention for functional and respiratory capacities.

Post-intervention for Functional and Respiratory Capacities	Control Group (n=20)	Experimental group (n=20)	Test-value	p-value
PEF (L/S)				
Mean±SD	6.20±0.48	6.59±0.52	-2.446	0.019*
Range	5.4-7.1	5.5-7.4		
Expiratory reserve volume (L)				
Mean±SD	1.62±0.41	1.98±0.41	-2.769	0.009*
Range	1.1-2.3	1.3-2.5		
6 MWDT (METERS)				
Mean±SD	569.15±21.69	584.10±21.64	-2.182	0.035
Range	512-594	542-612		
Time up and go test (Sec)				
Mean±SD	8.10±0.64	6.95±0.94	4.506	0.001**
Range	7-9	6-9		
MVV (L/MIN)				
Mean±SD	77.55±3.89	81.14±3.65	-3.010	0.005*
Range	70.1-82.6	73.1-87.4		
IC (L)				
Mean±SD	2.49±0.26	2.69±0.26	-2.441	0.019*
Range	2-3	2.2-3.1		

Using: t-Independent Sample t-test for Mean ± SD; p-value >0.05 is insignificant; *p-value <0.05 is significant; **p-value <0.001 is highly significant

Figure 6. Comparison Between Control and Experimental Groups for PEF, ERV, IC, and Time Up and Go Test (Post-Intervention)

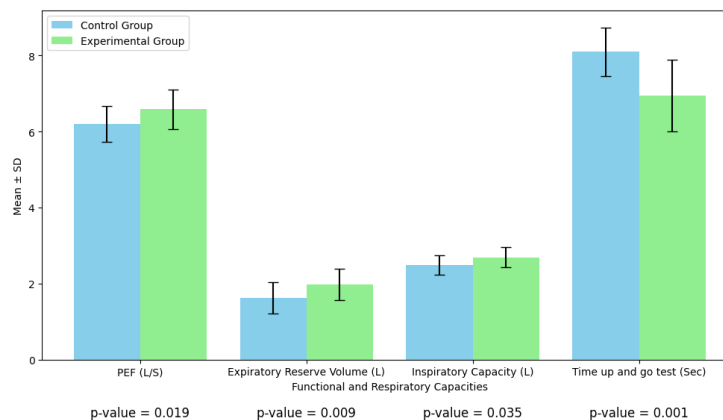


Figure 7. Comparison of 6 MWDT Between Control and Experimental Groups (Post-Intervention)

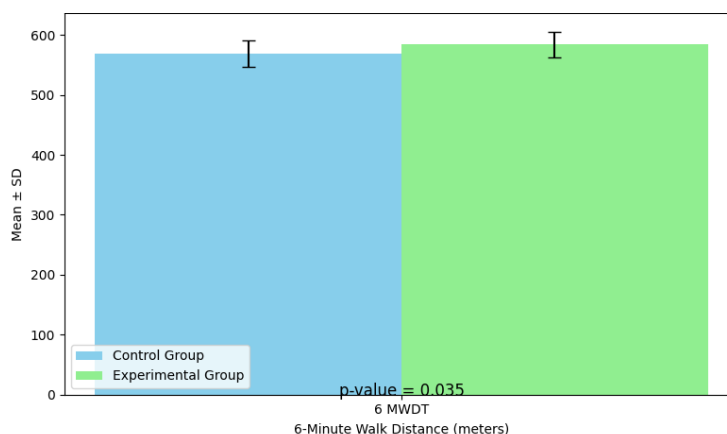
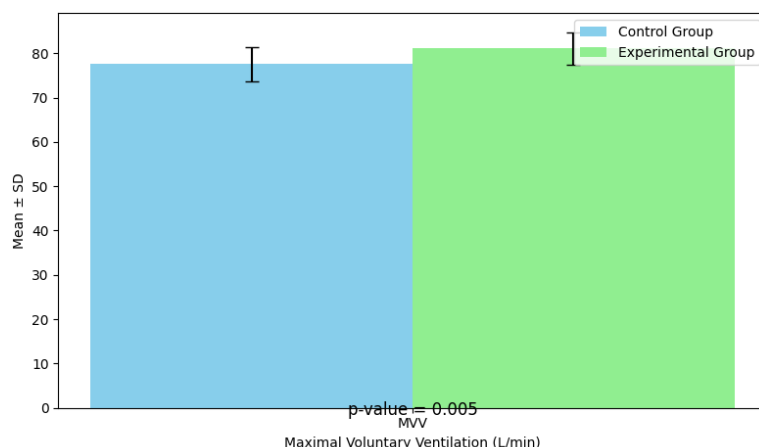


Figure 8. Comparison of MVV Between Control and Experimental Groups (Post-Intervention)



The experimental group showed greater improvements in most parameters compared to the control group: PEF (Peak Expiratory Flow). The Experimental group showed a larger difference (0.76 ± 0.07 L/s vs. 0.49 ± 0.09 L/s, $p=0.025$) and a non-significant trend for greater % change. Expiratory Reserve Volume: Substantial improvement in experimental group (0.29 ± 0.06 L vs. 0.08 ± 0.01 L, $p=0.002$), with a similar trend for % change. 6-Minute Walk Distance Test (6 MWDT): Experimental group improved by 23.60 ± 2.05 meters vs. 14.70 ± 1.54 meters in control ($p=0.001$), and showed significantly higher % change. Time Up and Go Test: Experimental group showed greater reduction in time (-2.20 ± 0.20 sec vs. -1.15 ± 0.11 sec, $p=0.001$), indicating improved mobility, with a highly significant difference in % change. Some parameters showed no statistically significant differences in changes between groups: MVV (Maximal Voluntary Ventilation): Difference and % change were not significant ($p=0.250$ and $p=0.461$). Inspiratory Capacity (IC): Borderline difference in mean change ($p=0.058$), but % change was not significant ($p=0.201$).

Table 6. Comparison between the control group and the experimental group according to changes in functional and respiratory capacities.

Changes in Functional and Respiratory Capacities	Control Group (n=20)	Experimental group (n=20)	Test-value	p-value
PEF (L/S)				
Difference	0.49 ± 0.09	0.76 ± 0.07	-2.341	0.025*
Change%	9.02 ± 1.74	12.78 ± 1.26	-1.750	0.088
Expiratory reserve volume (L)				
Difference	0.08 ± 0.01	0.29 ± 0.06	-3.376	0.002*
Change%	5.83 ± 1.17	19.48 ± 3.90	-3.352	0.002*
6 MWDT (METERS)				
Difference	14.70 ± 1.54	23.60 ± 2.05	-3.471	0.001**
Change%	2.69 ± 0.29	4.27 ± 0.41	-3.148	0.003*
Time up and go test (Sec)				
Difference	-1.15 ± 0.11	-2.20 ± 0.20	4.606	0.001**
Change%	-12.26 ± 1.06	-23.88 ± 1.99	5.148	0.001**
MVV (L/MIN)				
Difference	9.73 ± 0.82	11.24 ± 1.00	-1.167	0.250
Change%	14.74 ± 1.54	16.42 ± 1.66	-0.744	0.461
IC (L)				
Difference	0.27 ± 0.04	0.36 ± 0.03	-1.954	0.058
Change%	12.50 ± 1.91	15.61 ± 1.44	-1.300	0.201

Using: t-Independent Sample t-test for Mean \pm SD; p-value >0.05 is insignificant; *p-value <0.05 is significant; **p-value <0.001 is highly significant

Discussion

The study's results shows that adding Ujjayi Pranayama to osteopathic Manipulative Treatment (OMT), showed significant greater improvements in PEF (MD change was 0.76 ± 0.07 L/s vs. 0.49 ± 0.09 L/s in control ($p=0.025$)), ERV (MD change 0.29 ± 0.06 L vs. 0.08 ± 0.01 L in control ($p=0.002$)), 6-Minute Walk Distance Test (6 MWDT) (MD change 23.60 ± 2.05 meters vs. 14.70 ± 1.54 meters in control ($p=0.001$)), TUG (MD change was -2.20 ± 0.20 sec vs. -1.15 ± 0.11 sec in control ($p=0.001$)) although some

parameters showed no statistically significant differences in changes between groups: MVV: Difference and % change were not significant ($p=0.250$ and $p=0.461$). IC: Borderline difference in mean change ($p=0.058$), but percentage change was not significant ($p=0.201$). A college student with upper cross syndrome. These findings indicate that the integration of Ujjayi breathing and OMT yields additional advantages relative to OMT alone. The combination of ujjayi pranayama with osteopathic manipulative treatment (OMT) for individuals with Upper Cross Syndrome (UCS) presents a novel approach to enhancing pulmonary function. This study underscores the potential synergistic effects of combining these two therapeutic modalities. Ujjayi pranayama, a form of controlled breathing used in yoga practices that involves taking slow, deep breaths with a little constriction at the back of the throat. This technique is known to enhance respiratory efficiency by increasing lung capacity and improving oxygen exchange. When combined with OMT, which focuses on relieving musculoskeletal restrictions and improving overall body mechanics, the combined approach appears to work better together for UCS, particularly in improving pulmonary function (Naci et al., 2022). The findings suggest that adding ujjayi pranayama to OMT may provide even more benefits through several mechanisms. Firstly, the pranayama practice promotes diaphragmatic breathing, which may alleviate the muscle tension frequently linked to UCS. This relaxation of the accessory breathing muscles could make the rib cage move more freely and improve ventilation. Secondly, the mindfulness aspect of ujjayi pranayama may help lower stress levels, which is known to have a bad effect on breathing patterns. By promoting a state of relaxation, patients may experience a reduction in sympathetic nervous system activity, further benefiting pulmonary function. (Campanelli et al, 2020). Moreover, the study's findings indicate that the combined treatment not only targets the mechanical aspects of UCS but also tackles the functional limitations related to respiratory health. The improvement in pulmonary functions may be attributed to the enhanced thoracic cavity expansion facilitated by OMT and the improved respiratory muscle function from pranayama. This dual approach could be especially helpful for people with UCS who have trouble breathing because of bad posture and tight muscles (Nakao et al., 2021). Finally, adding ujjayi pranayama into osteopathic manipulative protocols offers a holistic approach that aligns with the principles of osteopathy, which emphasize the connection between body structure and function. By incorporating this breathwork technique, practitioners can potentially offer a more patient-centered treatment that encompasses both the physical and psychological components of UCS. Future research could explore the long-term effects of this integrated therapy on pulmonary function and overall quality of life in UCS patients, providing additional insights into its effectiveness and applicability (Bordoni et al,2021). One of the primary findings from the study is the enhancement of functional capacity in patients who received the combined treatment. Ujjayi pranayama, a form of controlled breathing that makes a soft sound by gently constricting the throat, is known to boost the activity of the parasympathetic nervous system, which helps people relax and lowers their stress levels. When integrated with OMT, which aims to correct musculoskeletal imbalances and improve body mechanics, the calming effects of pranayama may help muscle relax and align better, making the manipulative techniques work better (Castellote-Caballero et al, 2024). Furthermore, adding ujjayi pranayama may offer psychological benefits that contribute to the overall treatment outcomes. Patients practicing this breathing technique often report increased self-awareness and a sense of control over their physiological responses, which can be particularly beneficial in managing chronic conditions such as UCS. This aspect of self-regulation in pranayama may enable patients to participate more actively in their recovery process, leading to sustained improvements in their functional capacity (Jayawardena et al, 2020). Healthcare practitioners should contemplate the integration of holistic methodologies, such as pranayama, into traditional osteopathic treatments. This integration not only corresponds with the growing trend towards personalized and patient-centered care but also supports the idea that addressing both physical and mental aspects of health can yield more effective and enduring treatment outcomes. This methodology may facilitate additional research into the integration of other complementary therapies with conventional medical practices to improve patient care in various musculoskeletal disorders (Mohamed et al., 2024). However, there are several reasons why its application in this area might be contentious. Firstly, the evidence supporting the effectiveness of ujjayi pranayama on enhancing pulmonary function is largely anecdotal and lacks rigorous scientific validation. Unlike controlled medical interventions that undergo extensive testing and peer review, many studies on yoga and pranayama techniques are not standardized, making it difficult to draw concrete conclusions about their efficacy specifically for pulmonary health. (Goorts et al., 2021). Furthermore, the practice of ujjayi pranayama involves deep, controlled breathing, which may not be suitable for individuals with certain



respiratory conditions. For instance, those with asthma or chronic obstructive pulmonary disease (COPD) may find the technique exacerbates their symptoms due to the increased respiratory effort required. The modulation of breath in ujjayi pranayama can lead to hyperventilation in some individuals, potentially resulting in dizziness, shortness of breath, or even anxiety attacks, thereby negating any purported benefits.

Another point of contention is that ujjayi pranayama, like many yoga practices, requires precise technique and guidance, which might not be readily accessible to everyone. Without proper instruction, practitioners could inadvertently perform the technique incorrectly, leading to ineffective outcomes or even harm. Additionally, the subjective nature of yoga practice makes it difficult to measure progress in a standardized manner, posing challenges for its inclusion as a reliable method for improving pulmonary function. Considering these factors, it is crucial to approach the integration of ujjayi pranayama into pulmonary health regimens with caution and to prioritize evidence-based practices that have been proven safe and effective through rigorous scientific research.

(Rathore et al., 2025) argue that Ujjayi Pranayama, a controlled breathing technique, significantly enhances pulmonary function. This is critical for students with Upper Cross Syndrome, a condition characterized by forward head posture and rounded shoulders that can impair respiratory mechanics. By incorporating pranayama into osteopathic manipulation (OM), these authors suggest improvements in lung capacity and efficiency due to increased diaphragmatic movement and thoracic expansion. Audoux et al., 2023: Integrated discussion on stress, anxiety and somatic symptoms in students and Osse-Anguita et al., 2023: Included comparative analysis of psychological factors, stress coping and behavioral manifestations. Also, Usha et al. (2022) advocates for this integration highlight improvements in functional capacity, including enhanced endurance and physical performance. Ujjayi Pranayama is known to increase oxygen uptake and efficiency, which, when combined with OM's focus on musculoskeletal health, could enhance overall physical capabilities in students. Also, Patel & Veidlinger (2023) proved that the stress-reducing effect of Ujjayi Pranayama. Stress can exacerbate muscular tension and postural issues related to Upper Cross Syndrome. By incorporating pranayama, OM sessions can offer a more holistic approach that addresses both physical and psychological aspects leading to better musculoskeletal health. However, some authors against this idea, (Mütze et al., 2025) argue that there is insufficient empirical evidence to conclusively support the integration of Ujjayi Pranayama with OM for this specific condition. They emphasize the need for more rigorous clinical trials to establish efficacy and safety, suggesting that current evidence is largely anecdotal or based on small-scale studies. Moreover, (Abazari et al., 2025) decided that the variability in individual responses to pranayama. Critics highlight that not all students may benefit equally from Ujjayi Pranayama due to differences in respiratory capacity, comfort with the practice, or personal preferences. This variability might limit the effectiveness of a standardized integrative approach in addition to, (Jiang et al., 2025) argue that the goals of OM and pranayama might not always align perfectly. OM focuses on structural and mechanical corrections, while pranayama emphasizes breath control and relaxation, which might not directly address the primary musculoskeletal issues of Upper Cross Syndrome. While integrating Ujjayi Pranayama into osteopathic manipulation (OM) for college students diagnosed with upper cross syndrome offers promising enhancements in pulmonary functions and functional capacity, there are notable limitations to consider. Firstly, the variability in students' ability to correctly perform Ujjayi Pranayama may affect the consistency of outcomes. Additionally, the lack of long-term studies makes it challenging to assess the sustained impact of combining these practices. The small sample size and potential for selection bias further limit the generalizability of the findings. Lastly, individual differences in physical condition and adherence to practice regimens may introduce variability that could skew the results, necessitating further comprehensive research to establish definitive conclusions.

Conclusions

The present study demonstrated that ujjayi pranayama offers an added therapeutic benefit when combined with osteopathic manipulative treatment. This integrated approach should be considered in rehabilitation programs aimed at college students with upper crossed syndrome, particularly those showing early signs of pulmonary or functional compromise.



This randomized controlled clinical study investigating the impact of adding ujjayi pranayama to osteopathic manipulative treatment on pulmonary functions and functional capacity in college students with upper crossed syndrome has numerous limitations that must be recognized. The study's sample size may be inadequate for extrapolating the findings to a wider population, potentially compromising the external validity of the research. The trial's duration may be insufficient to evaluate long-term outcomes and the lasting effects of ujjayi pranayama. Results may vary due to different levels of participant adherence to the intervention program. Ultimately, although the study tries to take into account other factors that could affect the results, the complex relationship between upper cross syndrome and lower lung function and functional capacity makes it hard to separate the effects of ujjayi pranayama alone. These limitations suggest that further research, encompassing larger sample sizes, extended follow-up periods, and more objective measures, is necessary to corroborate and improve the current findings.

Ujjayi pranayama, a part of the ancient Indian art of yoga aimed at the respiratory muscles, has shown promising results in the clinical management of pulmonary functions and functional capacity among college students with upper crossed syndrome. Ujjayi pranayama may serve as a non-invasive, adjunctive therapeutic approach for healthcare practitioners addressing upper crossed syndrome-related decrease in pulmonary functions and functional capacity. It can improve functional capacity for doing normal daily activities and pulmonary functions, which can lead to better patient outcomes and a better quality of life. It emphasises the holistic strategy to enhance pulmonary functions and functional capacity by integrating behavioural, aerobic exercise, and physiological aspects. Nonetheless, further investigation is required to establish standardised methodologies and confirm long-term effectiveness across varied patient populations.

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Authors' and translators' details:

Mohamed S. Zidan	drmohzidan2015@gmail.com	Author
Amira Ezzat Mohamed Abd ElHay	dr.amira.ezzat.pt@gmail.com	Author
Ahmed M. Elfahl	a.ahmed@zuj.edu.jo	Author
Rashed S. Al-Kafian	rashed.alkafian@gmail.com	Author
Mohammad Maher Mohammad Arafah	arafah058@gmail.com	Author
Mohamed M. Elsharkawy	m.sharkawi@anu.edu.jo	Author
Sahar Hassan	s.hassan@qu.edu.sa	Author
Heba Elfeky	h.elfeky@ammanu.edu.jo	Author
Marwa Ahmed Saad Radwa	marwa.radwan@gu.edu.eg	Author
Hadeer Morsi	Hader_Awad@pt.kfs.edu.eg	Author