Examining Structural and Functional Relationships to Improve Respiratory Mechanics: Implications for Nebulizer Therapy for COPD, Asthma, and CF

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Structural Implications for Nebulizer Therapy for COPD, Asthma, and Cystic Fibrosis Patients:

Clinical Focus:
- Obstructive Lung Diseases
  - COPD
  - Asthma
  - Cystic Fibrosis
- Outpatient Treatment
  - Nebulizer therapy

Current Nebulizer Guidelines:
- Sit up right
- Deep, slow breathing
- Treatment Duration
  - 15-30 minutes
Deep and Slow Breathing → Reduces Airflow Velocity:

1. Reduces drug impaction and sedimentation in the proximal airways.
2. Improves targeting of drugs to distal airways (Corticosteroids, Mucolytics, Antibiotics, etc.).
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Goal: Improve Respiratory Mechanics for Outpatient Nebulizer Therapy

Current Nebulizer Guidelines:
- Sit up right
- Deep, slow breathing

Treatment Duration
- 15-30 minutes

Deleterious Effects of Postural Fatigue or Non-Compliant Posture
- Forward leaning may restrict:
  - Thoraco-abdominal wall motion
  - Promote rapid and shallow breathing
  - Attenuate treatment efficacy

Fast forward may restrict:
- Thoraco-abdominal wall motion
- Promote rapid and shallow breathing
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Goal: Improve Respiratory Mechanics for Outpatient Nebulizer Therapy

Seated Forward Leaning
- Forward leaning, especially in obese patients, may restrict thoracic wall and diaphragm motion. This will lead to rapid and shallow breathing.

Standing
- Standing, with the effects of gravity, may augment thoracic wall and diaphragm motion. This will lead to slower and deeper breathing.
Goal: Improve Respiratory Mechanics for Outpatient Nebulizer Therapy

Hypothesis: Standing may attenuate restrictive mechanics, increase tidal volume, and therefore improve drug delivery to distal airways.

Clinical Specific Aims
Determine if standing:
1. Increases tidal volume
2. Improves thoraco-abdominal wall motion

OMM Research Aims
Demonstrate structural changes:
1. Modify restrictive mechanisms and measures such as tidal volume and thoraco-abdominal excursion
2. Does not change obstructive function mechanisms such as FEV$_1$, FVC, FEV$_1$/FVC%
Inclusion Criteria:
- 21-65 years of age
- Male height 5’6” - 6’2”
- Female height 5’1” - 5’8”

Exclusion Criteria:

Subject Recruitment:
Midwestern University Community

Study Power:
- All Subjects N = 25
- Male Subjects N = 14
- Female Subjects N = 11

Pulmonary Function Assessed with Spirometry
(ATS/ERS Guidelines)

Cross-Over Study Design, Selectively Randomized Body Position Sequence, Spirometry Testing Protocol:

IRB approval (MWU#2687), written informed consent obtained from all participants.
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Quantify Changes in Restrictive Mechanics: Real-Time, Simultaneous Assessment of Thoraco-Abdominal Excursion

Thoracic and Abdominal Excursions

Respiratory Belts Placement:

Upper Thoracic
3rd intercostal space

Lower Thoracic
Xiphoid process tip

Abdominal
Umbilicus

Excursion Measures:
Changes in circumference (millimeters) were converted to percentages to determine the contribution of each region to tidal volume.

Clinical and Osteopathic Significance:
Respiratory and OMM studies classically focus on changes in Obstructive measures (FEV₁/FVC Ratio).

Real-time changes in thoraco-abdominal wall motion provide a viable assessment tool for changes in Restrictive mechanics.
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Introduction  Methods  Results  Discussion

Results Overview:

Effect of Posture on Restrictive Respiratory Mechanics

Effect of Posture on Obstructive Pulmonary Measures

Click Here for More Tidal Volume Results

Click Here for More Excursion Measures Results

Click Here for More Pulmonary Function Measures Results
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Standing Increases Tidal Volume with a Gender Effect:

Standing Increases Tidal Volume: All Subjects Data (N = 25; p < 0.002)
Male Subjects Data (N = 14; p < 0.001)
Female Subjects Data (N = 11; p = 0.213)

The male phenotype, with larger chest volume, may contribute to the larger increase in tidal volume.

A power analysis suggests a N = 48 in the female group would be required to obtain significance in female subjects.
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Introduction

Methods

Results

Discussion

Standing Increases Thoracic Excursions but Reduces Abdominal Excursion:

Seated

Standing

Upper Thoracic (UT)

Lower Thoracic (LT)

Abdominal (AB)

All Subjects (N=25)

Male Subjects (N=14)

Female Subjects (N=11)

UT

24%

24%

24%

LT

38%

38%

39%

AB

38%

38%

37%

Tidal volume increased because of greater upper and lower thoracic excursions (p<0.001). Contrary to our hypothesis, abdominal excursion was reduced (p<0.001); possibly due to contraction of abdominal musculature for postural stability.
All Subjects Data (N = 25)

These data demonstrate that changes in restrictive mechanics (improved musculoskeletal posture) upon standing do not appreciably change airway diameter assessed by:

- $\text{FEV}_1$ \(p = 0.934\)
- $\text{FVC}$ \(p = 0.089\)
- $\text{FEV}_1/\text{FVC}$ Ratio \(p = 0.163\)
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Structural Implications for Nebulizer Therapy for COPD, Asthma, and Cystic Fibrosis Patients:

Clinical Significance:
1. Patients with COPD, Asthma, and Cystic Fibrosis rely upon medication delivery to terminal airways.
2. Postural fatigue or non-compliant posture may attenuate treatment efficacy.
3. Nebulizer therapy in the outpatient setting could be augmented in patients (capable of standing) by increasing tidal volume and drug delivery to terminal airways.

Osteopathic Relevance:
These data demonstrate how structural changes primarily modify restrictive respiratory mechanics. OMM studies targeting improvements in respiratory function should include both restrictive and obstructive assessments.

OMM Significance:
These data demonstrate structure and function are reciprocally interrelated.