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Abstract

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Osteopathic Manipulative Medicine (OMM) techniques that address the diaphragm are commonly taught in Osteopathic medical schools. The application of these techniques is based on the theory that the physician can alter the mechanics of respiration. We hypothesized that OMM treatment of the diaphragm will allow greater diaphragmatic excursion of the diaphragm into the chest resulting in decreased residual volume (RV).

Study design consisted of two groups; treatment and sham treatment. Pulmonary function tests (PFTs) were administered to each subject upon admission to the study. Our data was collected from a MedGraphics PF/Dx 1085D series whole body plethysmography machine. Following a short rest period, the subject received either an OMM treatment or a sham treatment. A post treatment series of PFTs were then administered to the subject. A Paired T test comparing pre and post values within each group showed that RV, TLC, and TGV significantly decreased after the OMM treatment. There were no significant changes in the sham treatment group. Univariate Analysis of Covariance between groups also showed that changes in RV remained significant. From these data we conclude that OMM treatments addressing diaphragm function are effective in altering the mechanics of respiration and particularly in decreasing residual volume.

THE EFFECT OF

OSTEOPATHIC MANIPULATIVE MEDICINE

ON PULMONARY FUNCTION AND LUNG VOLUMES IN HEALTHY ADULTS

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THESIS

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TABLE OF CONTENTS

Abbreviations

BMI	Body Mass Index
ERV	Expiratory reserve volume (1,000 ml)
FEV1	Forced Expiratory Volume in One Second
FRC	Functional residual capacity (2,200 ml)
FVC	Forced Vital Capacity
HVLA	High Velocity Low Amplitude
IC	Inspiratory capacity (3,500 ml)
IRV	Inspiratory reserve volume (3,000 ml)
LVMA	Low Velocity Medium Amplitude
OMM	Osteopathic Manipulative Medicine
OMT	Osteopathic Manipulative Treatment
RV	Residual volume (1,200 ml)
TLC	Total lung capacity (5,700 ml)
TGV	Thoracic gas volume
TV	tidal volume (500 ml)
VC	Vital capacity (4,500 ml)

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

Introduction

Osteopathic Manipulative Medicine (OMM) techniques that address the diaphragm are commonly taught at Colleges of Osteopathic Medicine[1]. These lecture presentations include descriptions of the relationship between the structure and function of the diaphragm[2]. The techniques that are taught are theorized to cause changes in the mechanics of respiration by changing the shape of the diaphragm. There is, however, little scientific evidence describing the actual physiological effects of these techniques. For this project I hypothesized that OMM treatment of the diaphragm will alter the mechanical function of respiration as reflected in changes in lung volumes, specifically that greater excursion of the diaphragm into the chest during respiration will result in decreased residual volume (RV). My objectives in conducting this study were first to demonstrate the physiologic effects of Osteopathic Manipulative Medicine techniques for the diaphragm in a healthy patient population, and second to assess the feasibility of conducting a larger study with both healthy and clinical subjects.

Principles of Osteopathic Manipulative Medicine

In 1874 A.T. Still began to proselytize the Osteopathic Concept.[3] His efforts were unique at the time because of his emphasis on the relationship between structure and function in the human body. A.T. Still's claim was that through manipulation of the body a physician could alter structure and restore function, thus allowing the body to return to its normal state of homeostasis and health. His efforts were controversial for the time as he discouraged the use of many of the standard allopathic treatments. [4] The theories of medicine that he espoused were based on four key principles[5]:

1. The body is a unit; the person is a unit of body, mind, and spirit.
2. The body is capable of self-regulation, self-healing and health maintenance.
3. Structure and function are reciprocally interrelated.
4. Rational treatment is based upon the understanding of the basic principles of body unity, self-regulation, and the interrelationship of structure and function.

Application of these principles led to the development of manipulative techniques that were intended to address systemic illnesses. A central feature of many systemic disease states is dysfunction of the respiratory system and thus, specific techniques that alter key structures in the respiratory system were developed.

Previous studies of Manipulation therapy on pulmonary function

The fundamental concept of structure and function as it applies to treatment of the diaphragm is the subject of this research. Although there is abundant anecdotal evidence supporting the effect of Osteopathic manipulative Treatment (OMT) and the techniques evaluated in this study, very little actual research into the physiologic effect of these treatments has been conducted.[6] In 1940 Detwiler used Osteopathic Manipulative Treatment on healthy subjects and demonstrated favorable changes in the vital signs of his subjects, but his study lacked a control group for the treatment.[7] Ortely and associates designed a similar study in which they assessed vital signs, and pulmonary function in six subjects.[8] He reported changes in tidal volume for four of the six subjects. Ortely also found that the manipulation techniques he employed, mainly High Velocity Low Amplititude (HVLA), had no effect on expiratory and inspiratory reserve volumes, vital capacity, or forced expiratory reserve volumes.[8]

Murphy and colleagues preformed some of the most extensive work regarding the effect of OMT on pulmonary function.[9,10] In one set of experiments, she employed a technique described as 'thoracic mobilization' and compared the effect of this treatment on standard spirometry and nitrogen dilution measures. She found that thoracic mobilization techniques tended to decrease the functional residual capacity and residual volume of the lungs while increasing total thoracic compliance. Murphy also found an increase in tidal volume and respiratory rate after treatment.[9]

In another set of experiments, Murphy used I-131 labeled human albumin to study the effects of thoracic mobilization on pulmonary capillary circulation. Her study is based on the assumption that ventilation would match perfusion, in a healthy subject. She reported that thoracic mobilization increased the density of radioactivity throughout the lungs. This finding suggests that enhanced movement of the chest-wall improves ventilation as shown by these changes in lung perfusion.[10] A full publication of her work with methods and data could not be found. All the references to her work are taken from abstracts of meetings at which the results were originally presented. The lack of a detailed description of the protocols and results severely limits the insight derived from Dr. Murphy's work yet her work is widely cited in osteopathic literature. This example of incomplete publication highlights the need for more rigorous investigation and publication of results on the effects of OMM on normal and abnormal physiology.

There is a much broader array of research that has been done concerning the use of Osteopathic Manipulative Treatment on various pathological conditions. These studies tended to treat OMT as a fluid and individually customized treatment plan without much detail regarding the techniques that comprise the treatment plan. They theorize that if an OMM treatment plan is applied correctly, it will improve the patient outcome; for example, in 1918 one study compared mortality rates of patients during an influenza outbreak; those not treated with OMT suffered mortality rates of 5%; those treated with OMT had a mortality rate of 0.25%. [11] The clinical result is evident and obviously beneficial. OMT, when compared to the available therapies at that time, reduced mortality, but the mechanism of how OMT achieved these results is not defined.

Studies conducted by chiropractors trying to determine the effectiveness of manipulation in treating asthma generally found little or no objective effects, even though subjective improvement in symptoms has been reported.[12, 13] In 2001 a meta-analysis of 48 articles from varied sources including respiratory therapists, chiropractors and Osteopathic physicians was conducted by Hondras and associates.[13] Only five studies met the criteria of being a randomized clinical trial and were compared in the analysis; none of the studies found a significant treatment effect. The conclusion was that there was insufficient evidence to support the use of manual therapy to treat asthma.[13] They made recommendations that more complete and better designed studies need to be conducted.[13]

The majority of studies that were evaluated by Hondras were deemed unfit for inclusion into the meta-analysis.[13] Many of these studies claimed positive results, but were poorly designed or controlled[13]. The inherent difficulty in designing a study that effectively isolates a manipulative treatment effect could result in a false negative, and may have confounded a number of studies. There are so many confounding factors and dependent variables in these studies that many of them failed to produce reliable results. It appears that the scope of many of these studies may have been too broad. The clearest example of this can be found in the manual medicine research that has been done on patients with asthma.[13, 16] Studies that find improvements in symptoms in the treatment group frequently find similar improvements in the control group. The sham treatment received by the control group is often similar to other manipulative medicine modalities. This illustrates the difficulty in designing a sham treatment that does not resemble manipulative techniques employed by other practitioners. It is also suggests that mere contact with the treatment provider may be enough to alter a patient's response to treatment or sham treatment.[16]

Need for Better Experimental Design

Basic science non-clinical trials are needed that specifically identify the physiologic effect of OMT techniques. With this type of data and an understanding of the disease processes being studied we may be able to better predict which treatments or regimens will be effective. Using sound research techniques and appropriately designed studies we will be able to design clinical trials for these often studied disease states that are more likely to detect reliable results. An appropriate example of this kind of clinical research is given by Wheatly and associates who considered the specific effects of rib raising on Forced Expiratory Volume in one second (FEV1) and Forced Vital Capacity (FVC) in both healthy and asthmatic subjects.[14] Wheatly found that the rib raising technique increased lung function in all subjects, but showed a trend towards a significantly greater improvement in the asthmatic subjects.[14] He executed a straightforward clinical trial that demonstrated the quantifiable effects of a specific OMT technique on two populations.

A well designed clinical trial should be founded on a series of well designed basic studies that identify the physiologic effects of selected OMT techniques. For the present study, I chose to investigate the OMT techniques that have been developed to treat the diaphragm. These techniques are widely taught in Osteopathic medical schools and are central to many of the treatment regimens that have been previously studied.[1]

Theoretical Basis for Diaphragm-Directed OMT

Dysfunction of the diaphragm is at the center of many of the systemic disease states that are treated with OMM.[2] A flattened and hypertonic diaphragm will actually decrease the lateral diameter of the rib cage during inspiration (called paradoxical rib motion). This kind of restriction may dramatically decrease the efficiency of respiration, however, this has not been systematically investigated. The diaphragm functions as the primary muscle group of respiration and is responsible for almost 100% of the inhalation effort during quiet respiration and approximately 60% of the muscle activity during active or labored respiration.[15] As the diaphragm contracts it increases the diameter of the thorax in all three dimensions.[15] According to Osteopathic literature, the thoracic and abdominal pressure differential created by the diaphragm during respiration is the primary driver of central lymphatic flow.[15, 4] The effectiveness of the OMT for the diaphragm is easily evaluated in terms of pulmonary function, it is accessible, and there have been numerous techniques designed to treat it. Therefore the diaphragm is an ideal element of human anatomy to study and, for which, can be proposed significant physiologic consequences of treatment.

The textbook, Osteopathic Principles in Practice, provides a concise description of the conditions necessary for the diaphragm to function properly. In this text it is proposed that "diaphragm action is most efficient when the diaphragm is well-domed, its nerve supply provided by the phrenic nerve is not compromised, and the lymphatic pathways are unhindered".[15] The techniques used in this study employ a variety of Osteopathic treatment modalities all designed to increase the length and decrease the tone of inspiratory musculature. Theoretically, these structural changes may have physiologic effect that improve respiratory function.

Osteopathic techniques that are used include direct, indirect, or a combination of both. Direct techniques involve application of activating forces that carry or direct the structure through a restrictive barrier. Indirect techniques involve application of activating forces that carry or direct the structure away from a restrictive barrier.
Direct techniques can be applied with several different activating forces: High Velocity Low Amplitude (HVLA), Springing or Low Velocity Medium Amplitude (LVMA) and respiratory force. Springing involves repetitive LVMA thrusts along a vector that leads into the restrictive barrier. HVLA is also directed into the restrictive barrier but consists of a single high energy thrust. Respiratory Force can be used in either direct or indirect techniques and requires the patient to hold his or her breath in the phase of respiration that accentuates the treatment modality being used. An indirect treatment that uses respiratory force would require the patient to hold his or her breath in the phase of respiration that relaxes the somatic dysfunction and/or encourages motion of the somatic dysfunction in the direction it wants to go.

Osteopathic Manipulative Treatment of the diaphragm consists of addressing myofascial restrictions across the diaphragm, treatment of cervical vertebra 3, 4, and 5 to free the phrenic nerve, and addressing restrictions in the motion of structures to which the diaphragm makes its attachments. Anteriorly and laterally those attachment are made with the xiphoid process and the internal surface of the tips of ribs seven through twelve. Posteriorly, the diaphragm attaches to the medial and lateral arcuate ligament and, via the crux of the diaphragm, to the vertebral bodies and disks of L 1, L 2, and sometimes L 3. There are three apertures in the diaphragm through which the esophagus, the aorta, and the vena cava pass. The diaphragm receives its enervation from the phrenic nerve coming from cervical nerve roots three, four, and five, and it shares its sensory enervation with the mediastinal pleura the fibrous pericardium and the parietal layer of the serous pericardium[17]

A viscerosomatic reflex in the cervical region is often found in patients with pericardial or diaphragmatic irritation[4]. The classic example is cervical pain and somatic dysfunction following laparoscopic surgery. The pneumoperitoneum distends and irritates the diaphragm and this irritation is reflected in the cervical segments. The viscerosomatic reflex between C 3-5 and the diaphragm runs both ways as demonstrated in a study by Henshaw. [18] He found that Patients who received mid-cervical OMT before going to surgery experienced only a 5% rate of pulmonary complications. Patients who did not receive OMT experienced a 30% to 40% complication rate[18].

A treatment protocol that is designed to address the motion of the diaphragm would incorporate elements of all the treatment modalities discussed above. The physician must diagnose and treat restrictions in all of the anatomic structures that are essential to the functioning diaphragm.

Specific Aims

1: To demonstrate the physiologic effects of OMM techniques for the diaphragm in a healthy patient population.

2: To assess the feasibility of conducting a larger study with both healthy and clinical subjects.

Hypothesis

Primary:

OMM treatment of the diaphragm will alter the mechanical function of respiration as reflected by changes in lung volumes. Specifically greater excursion of the diaphragm into the chest during respiration will result in decreased residual volume (RV).

Secondary:

Inspiratory Capacity (IC) will remain constant or slightly increase. Expiratory Reserve Volume (ERV) will increase as RV decreases. Total Lung Capacity will remain constant or increase as IC increases. Thoracic Gas volume will remain constant. Forced Vital Capacity will increase as RV decreases. Force Expiratory Volume in 1 sec (FEV1) will remain relatively constant. See table.

Table

Inspiratory Capacity	IC	≈ ↑
Expiratory Reserve Volume	ERV	↑ as RV ↓
Residual Volume	RV	↓
Total Lung Capacity	TLC	≈ ↑ as IC ↑
Thoracic Gas Volume	TGV	≈
Forced Vital Capacity	FVC	↑ as RV ↓
Force Expiratory Volume 1 sec	FEV1	≈

(Authors expected changes is lung volumes.)

Chapter II

METHODS AND PROCEDURES

Subjects

The studies in this proposal were approved by the University of North Texas Health Science Center Institutional Review Board. This was a prospective, placebo-controlled, double blinded study. Subjects between the ages of 18 and 65 were recruited. Inclusion criteria consisted of healthy adults with no history of pulmonary disease. Subjects with active pulmonary diseases like asthma, COPD, or emphysema were excluded. Pregnant women and subjects with a history of recent abdominal or any thoracic surgery were excluded. Thirty-six healthy volunteers were divided into two groups that were matched for age, gender, and BMI. One group received the OMT treatment protocol and the other received a sham treatment protocol.

Subjects that met the inclusion criteria were admitted to the study and asked to complete a background health information survey. Each subject signed an informed consent form and was assigned to either the treatment group or the sham treatment group. Baseline pulmonary function tests were preformed on all subjects that were admitted to the study. The subject was allowed to rest for 15 to 20 min after completing the pulmonary function test and before moving on to the treatment phase. Depending on the subjects assigned group, they were treated with either the treatment protocol or the sham treatment protocol. Both protocols lasted approximately 20 min. Post-treatment pulmonary function tests were then preformed on all subjects.

Measurements

Pulmonary function tests were conducted using a MedGraphics PF/Dx 1085D series whole body plethysmography machine. Standard spirometry and plethysmography data were collected. (See appendix for an example of the collected data) An experienced technician administered all of the plethysmography tests and was blinded as to which group the subject was in. The outcomes measures that were collected from the plethysmography machine are: inspiratory capacity, expiratory reserve volume, residual volume, total lung capacity, thoracic gas volume, forced vital capacity, and forced expiratory volume over one second.

Treatment Protocol

Treatment Protocol: The subject was treated with OMM techniques that targeted the anterior and posterior attachments of the diaphragm. Direct and indirect modalities were utilized until a release was palpated. The cervical spine, C3-5 was also treated in order to address phrenic nerve restrictions. Techniques were preformed as described in the Kimberly manual.[19] The specific techniques employed are described below. All OMT was proceeded by a palpatory diagnosis and the treatment was modified to correct the specific somatic dysfunction that was found.

Abdominal Diaphragm (Redoming)

Supine--indirect method---respiratory force (4961.31A) [1]

1. Patient is supine and the physician stands at the side of the table
2. Physician grasps the lateral sides of the patient's rib cage with his/her palms with the fingers spread apart or places one hand posteriorly behind the diaphragm and the other hand anteriorly over the subxiphoid region
3. Physician carries the rib cage into left or right rotation to the point of balanced ligamentous tension. He/she then adds components of left or right side bending and flexion or extension until all three planes are at ligamentous balance
4. The respiratory phases are tested and the patient is instructed to hold his/her breath as long as possible in the phase that provides the best ligamentous balance until maximal tissue response has bee obtained
5. Recheck

Supine—direct method---respiratory force (4931.31B)[1]

1. Patient is supine and the physician stands at the side of the table
2. Physician grasps the lateral sides of the patient's rib cage with his/her palms with the fingers spread apart
3. Physician carries the rib cage into left or right rotation to the point of maximum ligamentous tension. He/she then adds components of left or right side bending and flexion or extension until all three planes are at the fascial barrier
4. Patient's respiration is observed and palpated to determine which hemidiaphragm is most restricted
5. Patient is instructed to, "Take some deep breaths." The physician maintains the abdominal diaphragm at the fascial barrier in three planes while resisting the inhalation effort on the side the has the best motion, forcing the restricted side of the diaphragm to move
6. Recheck

Supine—Direct--- mechanical (Foundations pg. 953)[2]

1. Grasp the inferior lateral rib cage. With thumbs pointed towards each other and caudad to the xiphoid process.
2. Follow the diaphragm motion as the pt. exhales. (posterior/anterior) Hold the end position and resist movement during inhalation
3. During exhalation follow the diaphragm to a new barrier
4. Repeat three times, then move thumbs laterally along the costochondral margin to a new restriction and repeat

Supine—direct method---LVMA (springing) (rib raising) (4933.11D)[3]

1. Patient is supine and the physician stands at the head of the table
2. Patient reaches around the physician and grasps his/her waist
3. Physician reaches under the patient, spreads his/her fingers and places the hands on the patient's mid-thoracic region
4. Physician squats down, carrying the patient's thorax into extension while lifting the thorax anteriorly, raising the ribs using the elbows as a fulcrum
5. Rib raising is continued to the patient's tolerance or until the desired fluid response is obtained
6. Recheck

Cervical Spine C 3-5

Supine—indirect method---respiratory force (4221.11A-4)[4]

1. Patient is supine and the physician sits at the head of the table
2. Physician supports the patient's head with his/her forearms and contacts the articular pillars bilaterally with the index fingers
3. Physician side bends to the left, rotates to the left and flexes or extends as needed to balance ligamentous tension in all three planes at the dysfunctional segment
4. The respiratory phases are tested and the patient is instructed to hold his/her breath as long as possible in the phase that provides the best ligamentous balance
5. Step 4 is repeated until the best motion is obtained (average is 3 times)
6. Recheck

Supine—directed method---ME (isometric) (4221.11B-2)[5]

1. Patient is supine and the physician sits at the head of the table
2. Physician places the pad of his/her thumb on the lateral margin of the right articular pillar of the dysfunctional vertebra. He/she pushes the articular column to the left, inducing right sidebending to the restrictive barrier. The other hand grasps the head for counterforce

3. Physician flexes or extends the neck as needed to localize the dysfunctional segment
4. Patient is instructed to "Push your head to the left" while the physician offers isometric counterforce
5. Physician has to maintain the force long enough to sense that the patient's contractile force is localized at the dysfunctional segment (typically 3-5 seconds)
6. Patient is instructed to gently cease the directive force and the physician simultaneously ceases his counterforce
7. Physician waits for the tissues to relax completely and side bends the dysfunctional segment to the new restrictive barrier
8. Steps 4-7 are repeated until the best motion is obtained (average is 3 times)
9. Recheck

Sham Treatment Protocol

Sham Treatment Protocol: The subject was treated in the supine position with a nonspecific light touch abdominal exam, and an intentionally ineffective Occipital-Atlantal decompression of the cervical spine. The Occipital-Atlantal decompression was rendered ineffective by eliminating the activating force and maintaining a neutral position of the cervical spine. The duration of the Treatment Protocol and the Sham Treatment Protocol were approximately equal.

Analyses

Data were entered into an electronic data base and evaluated using an SPSS statistical package. Descriptive statistics were obtained for all of the data. A paired samples T-test was used to evaluate significant changes in pre-treatment and post-treatment outcomes for each group. Analysis of Co-Variance (ANCOVA) was used to identify statistically significant differences between the treatment and sham treatment group. Statistical significance was set at a p value of 0.05.

CHAPTER III

Results

Thirty-four subjects finished the study with complete data that could be evaluated. The descriptive statistics are contained in Table 1 and 2. The compositions of the two groups were compared for differences in BMI, gender and age. According to the T test for equal variances there was no statistically significant difference in the composition of the treatment group compared to the sham treatment group, all variables $p > 0.05$, see table 3.

Table 1

Descriptive Statistics

		group		Total
		Treat	No Treat	
gender	Male	6	5	11
	Female	11	12	23
Total		17	17	34

Table 1: Gender and Group cross tabulation. Shows the number of male and female subjects in each group.

Table 2

Descriptive Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
BMI	Treat	17	24.147	4.4362	1.0759
	No Treat	17	24.688	4.5682	1.1080
age	Treat	17	28.59	5.100	1.237
	No Treat	17	31.47	10.754	2.608

Table 2: Shows the mean age and mean BMI of the study subjects.

Table 3

Independent Samples Test for group comparisons

		t-test for Equality of Means				
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
BMI	Equal variances assumed	-.350	32	.728	-.5412	1.5444
age	Equal variances assumed	-.999	32	.326	-2.882	2.887

Table 3 key: Independent Samples Test for group comparisons showing no significant difference between the treatment and sham treatment group. ($p<0.05$)

The mean values for residual volume, expiratory reserve volume, inspiratory capacity, and total lung capacity for the treatment group are given in Figures 1, and for the sham treatment group in Figure 2. The mean standard deviation is given in Table 4. The mean predicted volumes for the dependent variables in Figures 1 and 2 were generated by the plethysmography software based on the physical parameters of the individual subjects. The percent change of pre-treatment and post-treatment values and the direction of that change is given in Figure 3 and Table 4.

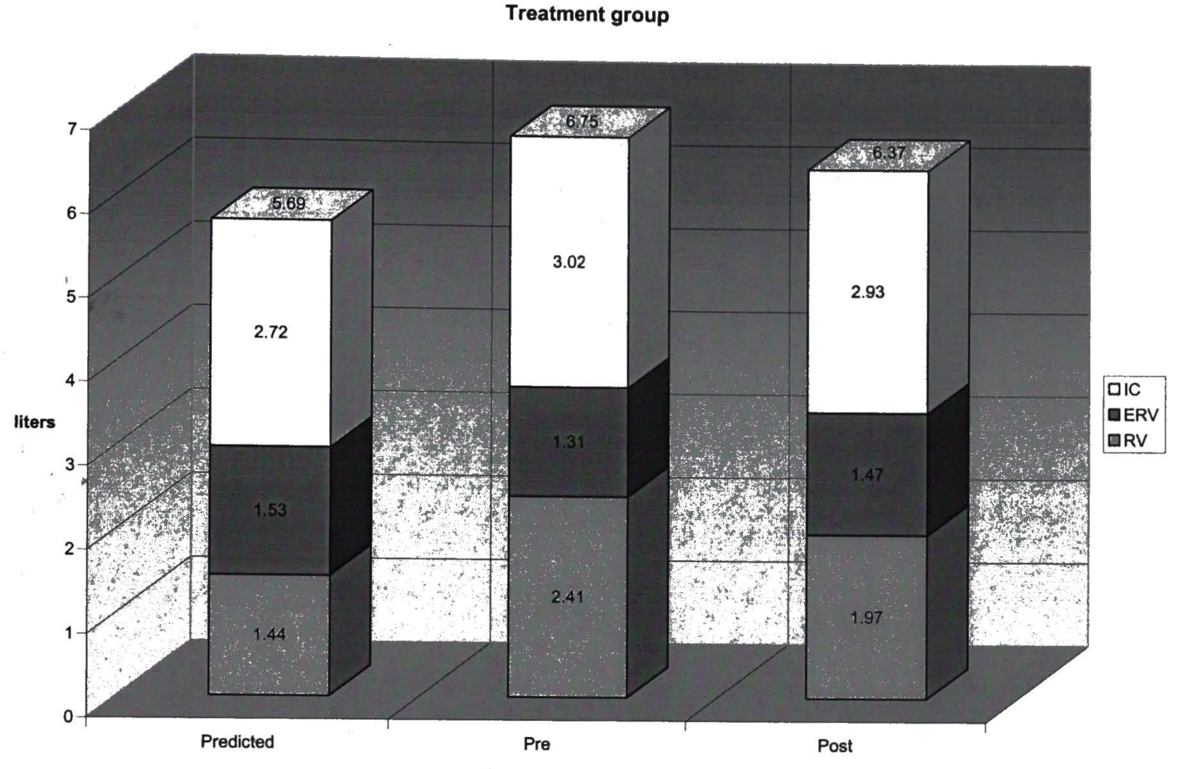
Group Comparison : Paired Samples Test.

For the treatment group, the observed changes between the pre-treatment and post-treatment values for RV, TGV, and TLC were found to be significant ($p < 0.05$). The difference between FEV1 and ERV was not significant ($p = 0.111$ and $p = 0.172$). For the sham treatment group none of the observed changes between pre-treatment and post-treatment values were found to be significant ($p < 0.05$).

Group Comparison : Univariate Analysis of Covariance.

This test was preformed in order to investigate if the difference between the treatment and sham treatment groups was significant while controlling for differences between the pre-treatment values for each subject. The difference in post-treatment scores of RV was found to be significant ($p = 0.03$). The difference in post-treatment scores of TGV approached significance ($p = 0.085$), see Table 5.

Figure 1

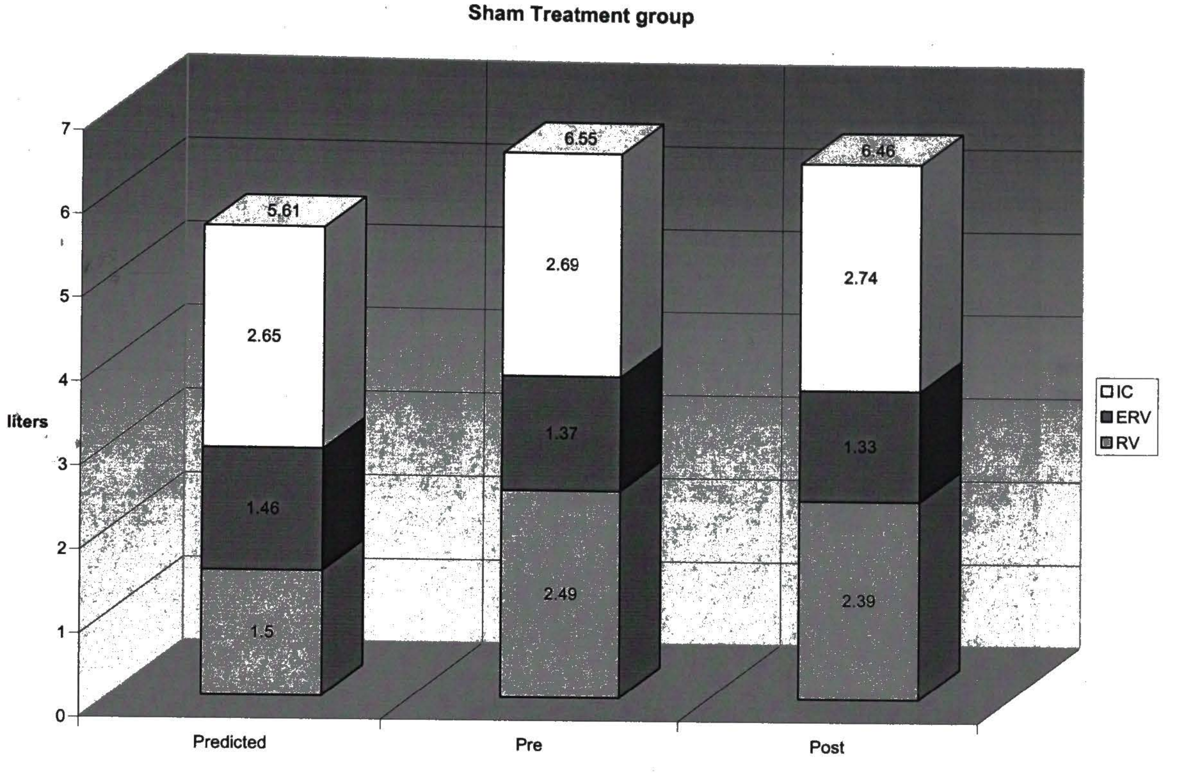


Treatment group

	Predicted	Pre	Post
RV	1.44	2.41	1.97
ERV	1.53	1.31	1.47
IC	2.72	3.02	2.93
TLC	5.69	6.75	6.37

Figure 1: This graph and table give the mean recorded values for the predicted PFTs, the pre treatment PFTs, and the post treatment PFTs. Values for IC, ERV, RV, and TLC are given in Liters. It shows the relative changes between pre and post treatment values in the treatment group. Variance is given in table 4.

Figure 2

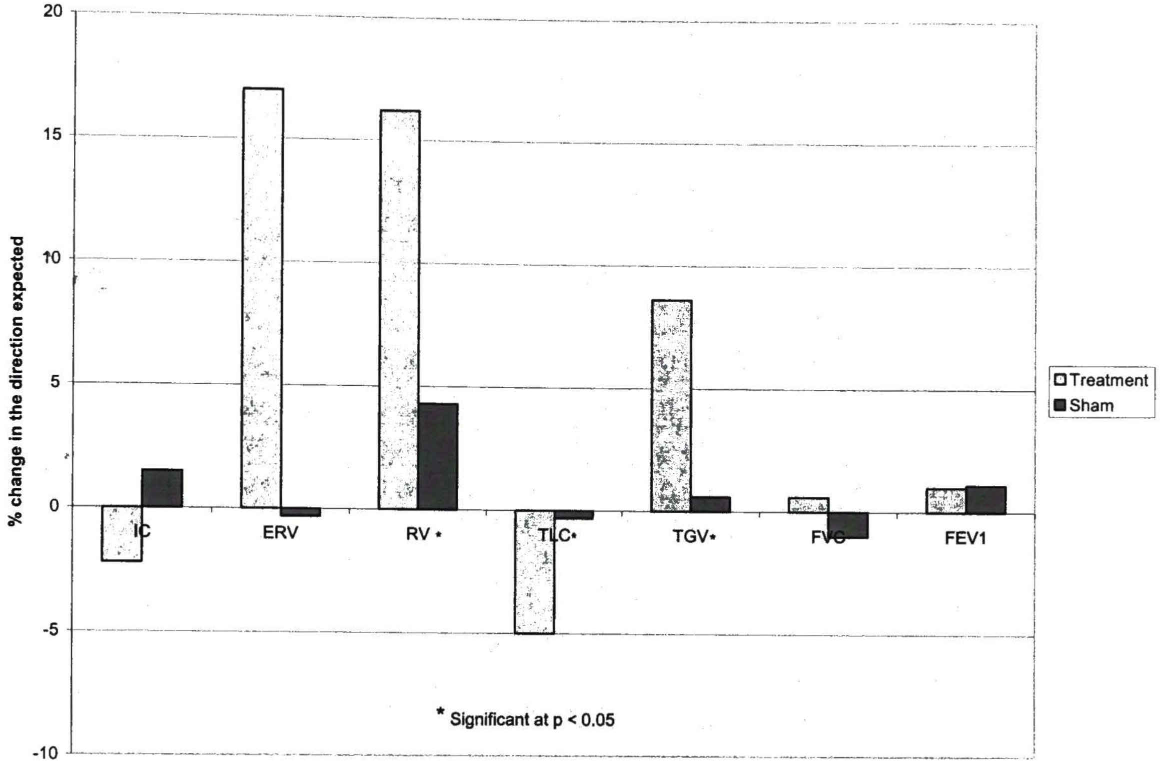


Sham Treatment group

	Predicted	Pre	Post
RV	1.5	2.49	2.39
ERV	1.46	1.37	1.33
IC	2.65	2.69	2.74
TLC	5.61	6.55	6.46

Figure 2: This graph and table give the mean recorded values for the predicted PFTs, the pre treatment PFTs, and the post treatment PFTs. Values for IC, ERV, RV, and TLC are given in Liters. It shows the relative changes between pre and post treatment values in the sham treatment group. Variance is given in table 4.

Figure 3



	Treatment	Sham
IC	-2.2	1.5
ERV	17	-0.3
RV	16.2	4.3
TLC	-5	-0.3
TGV	8.6	0.6
FVC	0.6	-1
FEV1	1	1.1

Figure 3: This figure shows the percentage change between pre and post treatment values for each of the variables that were evaluated. A positive deflection on the graph represents a change (either increase or decrease) in the direction that we predicted.

Table 4

Pre - Post Changes in physiological variables

Treatment group

	Liters	% change	SD	$p < 0.05$
IC	0.09	-2.2	0.094	
ERV	0.16	17.1	0.358	
RV	0.44	-16.2	0.22	✓
TLC	0.37	-5	0.086	✓
TGV	0.34	-8.6	0.134	✓
FVC	0.01	0.6	0.031	
FEV1	0.04	-1	0.023	

Sham Treatment group

	Liters	% change	SD	$p < 0.05$
IC	0.05	1.5	0.078	
ERV	0.04	0.3	0.388	
RV	0.1	4.3	0.31	
TLC	0.09	-0.3	0.091	
TGV	0.14	-0.6	0.135	
FVC	0.05	-1	0.033	
FEV1	0.03	-1.1	0.026	

Table 4: Shows the paired samples test data. The column labeled Liters gives the actual change in volume that was recorded. A check mark in the $p<0.05$ column indicates a significant result.

Table 5

Univariate Analysis of Covariance between groups

ANCOVA

	p values	$p < 0.05$
IC	0.298	
ERV	0.28	
RV	0.032	✓
TLC	0.216	
TGV	0.085	
FVC	0.084	
FEV1	0.807	

Table 5: Shows a list of the p values that were obtained from a Univariate analysis of covariance. This test identified the variables where the pre to post change in the treatment group was significant when compared to the sham treatment group.

CHAPTER IV

Discussion

The results of the study suggest that OMM treatment of the diaphragm does alter the mechanical function of respiration as reflected by changes in lung volumes. Specifically, greater excursion of the diaphragm into the chest during respiration results in decreased residual volume. The decrease in residual volume suggests that treating the diaphragm with OMT enables it to relax more completely during exhalation. A flaccid, well-domed diaphragm will move further into the thoracic cavity allowing the lungs to empty an average of 16% more than the sham treated counterparts.

The structural and physiological factors that effect residual volume are: airway resistance, thoracic compliance, and diaphragm tone. Increased airway resistance results in air trapping during exhalation and is the hallmark of Chronic Obstructive Pulmonary Disease (COPD). Chronically inflated lungs cause other medical problems, these patients have a decreased tidal volume and a reduced capacity to exchange gas. Decreased gas exchange leads to hypoxia. The decreased tidal volume also reduces the pressure gradient between the thoracic and abdominal cavities. The loss of this pressure gradient will adversely affect lymphatic flow and could contribute to peripheral edema.

Thoracic compliance is a measure of the relative ease with which the thoracic cavity expands and contracts during respiration. Restricted movement of the rib cage or thoracic spine will decrease inspiratory capacity and increase residual volume. Elevated diaphragm tone can increase the residual volume by causing the diaphragm to flatten preventing its complete excursion into the chest; this effectively holds the lungs open.

The changes that were observed in total lung capacity (TLC) were significant in the paired T test, but not what was predicted. I hypothesized that inspiratory capacity and expiratory reserve volume would increase or remain the same, residual volume would decrease, and total lung capacity would increase. However, TLC decreased an average of 5% in the treatment group. This result was not significant in the Analysis of Co-Variance. ERV was expected to increase the same amount as RV decreased thus preserving the total lung capacity. Any increase in TLC would likely have been the result of an increase in inspiratory capacity.

The percentage change in ERV was larger than the percentage change observed in RV but the actual change in lung volumes was in the opposite direction. ERV increased from pre-treatment to post-treatment by an average of 17% (or 0.16 Liters), and RV decreased from pre to post by an average of 16% or (0.44 Liters). Inspiratory capacity (IC) remained essentially the same decreasing an average of only 2.2% or (0.09 Liters).

Collecting these data account for the 5% (or 0.37 Liter) decrease in TLC. Further studies are needed to determine the cause of this decrease and whether it is the result of the OMT employed or the rigor of the experimental protocol.

Limitations

These findings need to be evaluated in terms of several limitations that we discovered as the study progressed. We found that obtaining reliable results with the plethysmography machine required that the subject be physically able to coordinate their breathing with the requirements of the test. Two subjects were removed from the study before there data were evaluated because they had a great deal of difficulty with the test. The practice effect is the second concern. A practice effect is the effect that the first test has on the second test. A full battery of pulmonary function tests is physically demanding. All participants underwent the same protocol but the more deconditioned subjects had greater difficulty with the second test than the first.

There is also a learning curve to consider. Several subjects commented that the second test was easier and that they preformed better because they now had experience and knew how to take the test. A series of baseline pulmonary function tests one or two days prior to the implementation of the treatment protocol would likely have decreased or prevented this problem. Insufficient resources prevented us from conducting additional baseline pulmonary function tests.

There are some special considerations involving the subject population that need to be addressed. Approximately one half of subjects were recruited from the student body of the Texas College of Osteopathic Medicine. These subjects have an intimate and working knowledge of all the OMM techniques that were evaluated in this study; they would not be fooled by any attempted sham treatment. Un-blinding the subjects by letting them know which group they are in would defeat the purpose of the sham treatment group. The TCOM students' knowledge of OMM made them unsuitable for use in the sham treatment group. Therefore my solution was to assign subjects to groups based on their knowledge of OMM.

Statistical power is the final issue. The p values for ERV and FEV1 approached significance but did not attain it, $p = 0.172$ and $p = 0.111$. More subjects might have allowed us to detect a significant change in these variables and in others. The limited availability of the plethysmography machine and time constraints on the principle investigator prevented more subjects from entering the study.

Conclusion

This study found that OMM techniques that address respiratory mechanics cause immediate and significant changes in pulmonary function. The OMM treatments employed in this study were designed to treat the diaphragm by removing restrictions in its motion and allowing more complete excursion of the diaphragm into the chest. In this study population these techniques were effective in altering respiratory mechanics, particularly in decreasing residual volume.

Limitations of the study are relatively small sample size and the inherent difficulty in obtaining a reliable, coordinated effort during spirometry testing. Further studies evaluating rib cage and thoracic spine somatic dysfunction and their effects on pulmonary function would be the next step to this study. All of these factors evaluated together they will allow a more complete understanding of the effects of Osteopathic Manipulative Treatments on the respiratory system.

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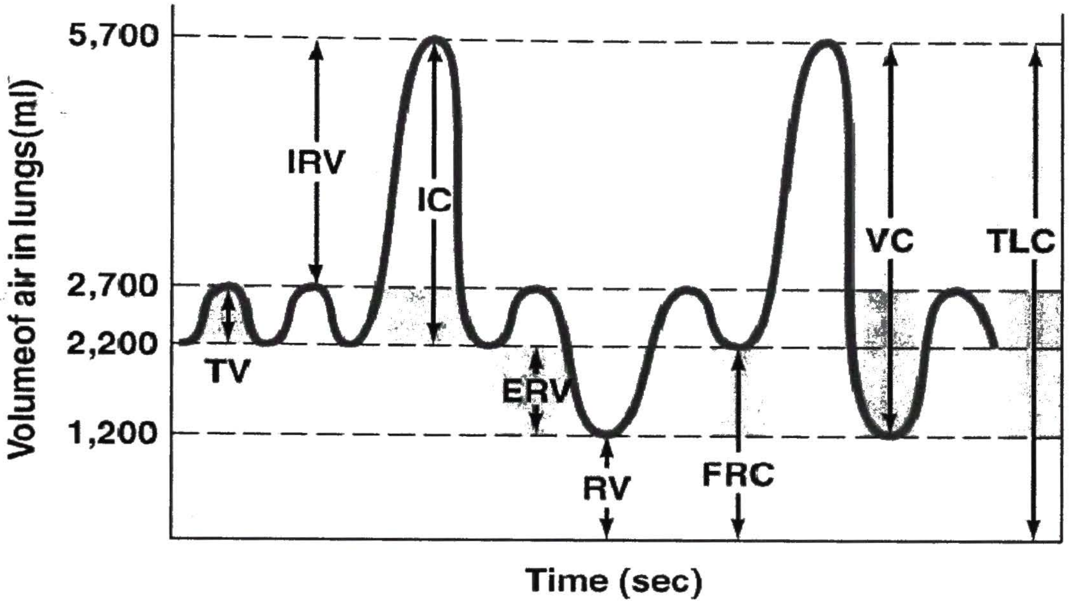
APPENDIX

LUNG VOLUMES



Lung Volumes

TV	tidal volume	500 ml
IRV	Inspiratory reserve volume	3,000ml
IC	Inspiratory capacity	3,500ml
ERV	Expiratory reserve volume	1,000ml
RV	Residual volume	1,200ml
FRC	Functional residual capacity	2,200ml
VC	Vital capacity	4,500ml
TLC	Total lung capacity	5,700ml
TGV	Thoracic gas volume	2,400ml

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Name: Swain, Jeremy   ID: 002   Date: 6/27/2003

Diagnosis
Dyspnea:
Cough   Wheeze:
Yrs Quit   Pks/Day   Yrs Sm   Tbco Prod:
Medications:
Pre Test Comments
Post-Test Comments

	PRE-BRONCH					POST-BRONC	
	Actual	**Pred.**	**%Pred.**	**SD**	**LLN**	**Actual**	**%Chng.**
SPIROMETRY							
FVC (L)	6.20	5.97	104	0.64	4.99	5.96	-4
FEV1 (L)	5.41	4.94	109	0.52	4.12	5.27	-3
FEV1/FVC (%)	87	83	105		69	88	1
FEF 25% (L/sec)	8.96	9.21	97	1.57	7.69	9.79	9
FEF 50% (L/sec)	8.20	6.01	136	1.34	5.02	7.60	-7
FEF 75% (L/sec)	3.21	2.33	138	0.71	1.94	2.71	-16
FEF 25-75% (L/sec)	6.92	5.13	135	1.08	4.28	6.30	-9
FEF Max (L/sec)	9.86	9.43	105	1.48	7.88	10.26	4
FIVC (L)	5.92					5.62	-5
FIF 50% (L/sec)	5.39	5.50	98	1.28	4.59	3.38	-37
FIF Max (L/sec)	5.84					3.72	-36
MVV (L/min)	120	188	64	29	157	134	12
LUNG VOLUMES							
SVC (L)	6.03	5.72	105		4.77	5.48	-9
IC (L)	5.06	3.77	134		3.15	4.15	-18
ERV (L)	0.96	1.95	49		1.62	1.34	39
TGV (L)	3.37	3.73	90	0.72	2.99	3.19	-5
RV (Pleth) (L)	2.41	1.79	135	0.37	1.43	1.86	-23
TLC (Pleth) (L)	8.44	7.50	112	0.79	6.00	7.34	-13
RV/TLC (Pleth) (%)	29	23	123	4	19	25	-12
AIRWAYS RESISTANCE							
Raw (cmH2O/L/s)	0.88	1.45	61	0.48	1.21	0.62	-30
Gaw (L/s/cmH2O)	1.14	1.03	111		0.86	1.62	42
sRaw (cmH2O*s)	3.33	4.76	70		3.97	2.50	-25
sGaw (1/cmH2O*s)	0.30	0.20	149	0.07	0.17	0.40	33

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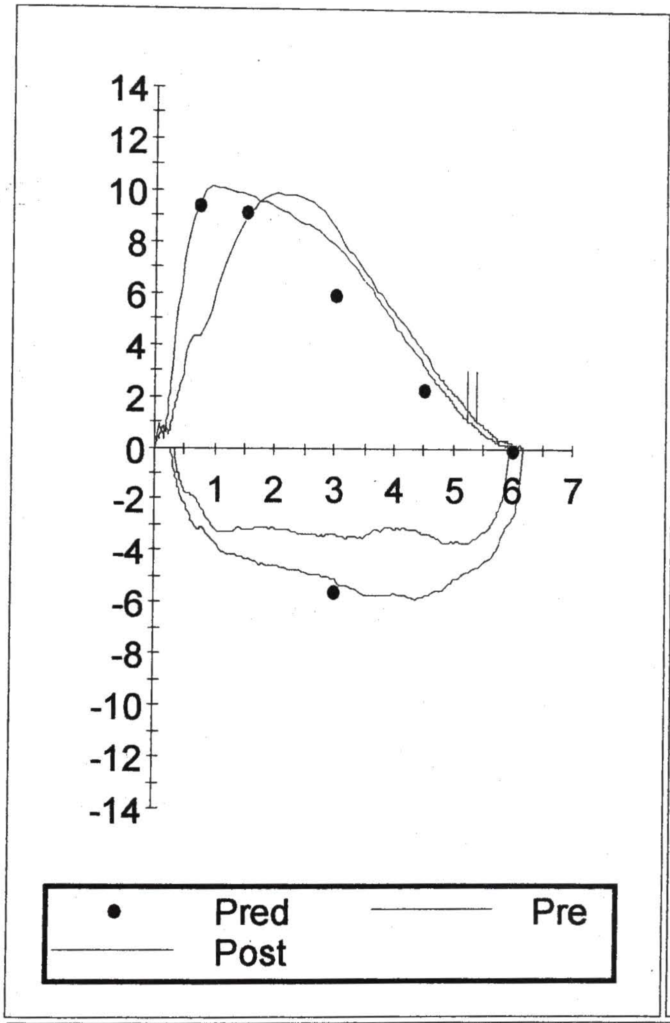
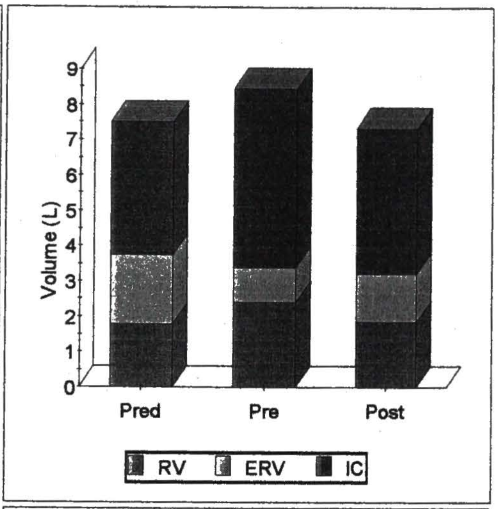
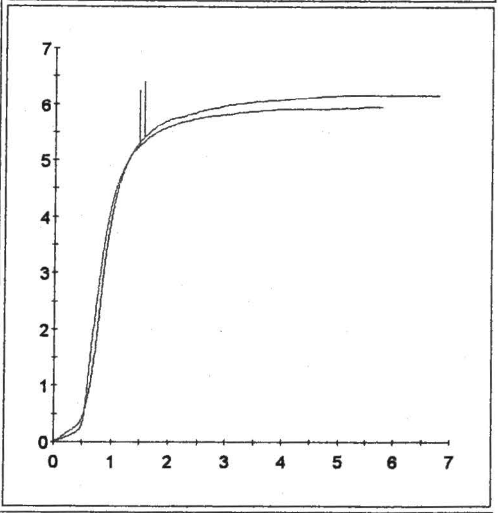
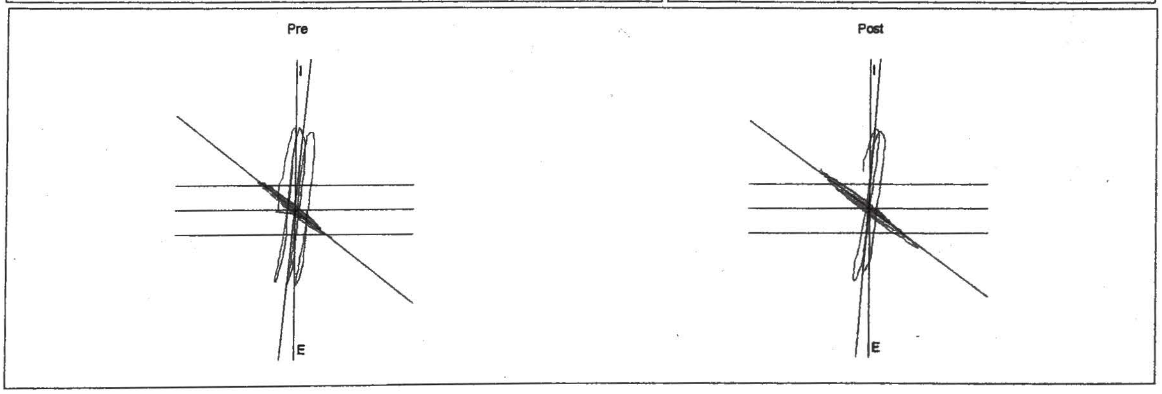
Dr:		Gender	Male	Weight:	245.0 l	Race:	Caucasian









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