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Diaphragm Training and Evaluation as a Therapeutic Tool by Athletic Trainers in Orthopedic Rehabilition

Marisa Rashel Foltz

DIAPHRAGM TRAINING AND EVAULATION AS A THERAPEUTIC TOOL BY ATHLETIC TRAINERS IN ORTHOPEDIC REHABILITATION

A Masters Thesis

Presented to

The Graduate College of

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In Partial Fulfillment

Of the Requirements for the Degree

Master of Science, Athletic Training

By

Marisa Rashel Foltz

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Sports Medicine and Athletic Training

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ABSTRACT

Athletic trainers (AT) incorporate diaphragm training techniques into treatment protocols; however, further understanding of the techniques' purpose and application is needed. An investigation of clinical reasoning for use of diaphragm training and evaluation as therapeutic tools in rehabilitation was conducted. Research questions sought to identify AT perspectives and rationale for incorporating these techniques, explore how ATs gain knowledge, and identify evaluation and educational methods utilized in rehabilitation. A qualitative investigation employing a phenomenological approach was used to address the research questions. Procedures included convenience sampling, one-on-one semi structured interviews, transcription, and coding that led to overall theme development. Thirteen ATs from collegiate and rehabilitation clinic settings were interviewed. Trustworthiness was ensured using triangulation, member- and peer- checks. From the clinician narratives, three main themes emerged regarding the incorporation of diaphragm training into rehabilitative treatment: 1) to improve performance; 2) to correct disordered breathing; and 3) to decrease tension. Clinicians perceived the benefits of diaphragm training as advantageous as evidenced by patients' observed outcomes. Techniques were learned through both formal and informal methods. Three primary evaluation methods were used to assess the diaphragm: 1) observation; 2) goniometry; and 3) palpation, while the main methods of patient education were: 1) instructional; 2) manual; and 3) biofeedback. This study provides current and future AT with an understanding of the utilization and application of diaphragm training.

KEYWORDS: diaphragm, breathing, treatment, breathing disorders, muscle tension

This abstract is approved as to form and content

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INTRODUCTION

Background

The first thing we do in life as humans is breathe. Life begins and ends with breath. The main purpose of breathing or respiration is to provide nutrient transfer between the outside air and the cells within our bodies. This occurs with oxygen and carbon dioxide transfer, through air, within the lungs, circulatory system, and the cellular level. What if air movement and nutrient transfer were not the only roles that breath plays within the body? Breathing may also have a strong connection to other systems, our emotions, and even our ability to move and perform. Determining the affect breathing can have on our daily function depends on our understanding of ourselves and the function and role our respiration and plays within the human organism.

Breathing has been a focus of medicine for centuries. Ancient yoga techniques, which focus on the human breath and its connection to our body's energy, have been traced back as far as 8000 years.[1] "Breathing retraining is a widely used technique in a number of anxiety and stress reduction therapies," and is a vital component of cognitive behavioral therapy.[2] Disciplines such as martial arts and the early Eastern religions have included slow respiration techniques and training methods to increase efficiency and for the positive benefits that come from quality respiration.[3] The mechanisms for breath to affect the human body seem endless.

How one breathes can be used as an indicator of health and well-being. Clifton-Smith and Rowley have stated that "a disordered breathing pattern can be the first sign that all is not well."[4]

How else can it be implemented as a benefit for our lives, daily activities and needs? Can it provide athletic trainers and other medical professionals with another methodology of treatment? Could it have a positive impact on our patients, their overall performance and quality of life? These are the questions that medical health professionals can ask and explore.

Determining one's health status is an important role of all health care professionals and athletic trainers (AT) are no exception to that rule. According to the National Athletic Trainers' Association (NATA) ATs are health care professionals who provide services to the physically active in regard to: "injury prevention, emergency care, clinical diagnosis, therapeutic intervention and rehabilitation of injuries and medical conditions."[5] Typical patients seen by ATs are athletes (recreational, amateur, or professional), who have suffered from a musculoskeletal injury, or seeking performance enhancement, strength, and conditioning.[5] A large portion of their responsibility and job role lies in the treatment and rehabilitation of injuries. Assessment of injuries, evaluation of factors leading to injury, and clinical decision making to address those issues is an everyday occurrence for these healthcare professionals.

Health care providers must use clinical reasoning and decision making processes to determine the best course of action for treating a patient. There are many factors that go into the clinical decision making. One important factor relies on the clinician's ability to execute quality clinical reasoning. Clinical reasoning is defined by Higgs et al. as the "sum of the thinking and decision-making process associated with clinical practice."[6] It is a skill that practitioners must learn and understand in order to make their clinical diagnosis, plans for treatments, and for management of injury/illnesses. It involves the

ability to: combine all variables related to the injury, asses the needs and interests of the patients and all others involved, provide reason and rationale for all decisions made (whether is it based on evidence or prior knowledge and experience), and maintain professionalism regarding the morals and ethics concerned.[6] For one to be able to perform this skill, and perform it well, one must have competency in all of the areas and tasks listed above. Having an evidenced based knowledge set, the ability to comprehend all factors involved, and an understanding of how they all come together has to be learned and applied to their practice. However, one must start with a good grasp of knowledge and the available evidence to begin the clinical decision making process.

Medicine is constantly evolving. The research literature is also changing daily.[7] Advances and new information are being discovered continually and staying current regarding the newest research is crucial. ATs are called to provide the best care possible for our patients. How do we know the care we are providing is the best available? It is through a dedication to scholarship that provides us with the evidence we need to support our clinical decisions. This notion supports the integration of evidence-based medicine. Evidence-based medicine has been defined as: "patient centered, clinically relevant research found in the medical literature on diagnostic tests, treatment techniques, preventive programs, and prognostic markers. Evidence-based medicine focuses on research dealing with the day-to-day practice of patient care."[7]

It is this evidence that should be used to develop one's rationale for the clinical decisions they make and the methods they use with their patients. However, medical decisions cannot be based on the research alone but also combined with the knowledge of the clinician and the needs of the patient.[7] ATs as a profession have continually learned

from each other and their own experiences. Learning what others have done, where they gained their knowledge, and how they applied those new ideas is another way for them to learn and grow as practitioners.

I am an athletic trainer who has recently graduated from an accredited undergraduate program, and I am starting to build my skills and knowledge as a certified athletic trainer. Through my years as a student and now as a practicing clinician, I have noticed a trend in the southwest Missouri area, of ATs incorporate diaphragm evaluation and training techniques within their rehabilitation programs. "The diaphragm is well known for its role as the principle muscle of respiration."[8] Diaphragm training such as "diaphragmatic breathing" and other breathing therapies have been used as a therapeutic tool in the effort to improve breathing quality and efficiency for those suffering from breathing pattern disorders, respiratory diseases, psychological disorders, and oxidative stress.[9-14] There is evidence that suggests the diaphragm plays an integral part in increasing intra-abdominal pressure, spinal stability, and core stability.[15-21] Diaphragm and respiration efficiency have also been correlated with decreases in risk for developing future back pain and incontinence.[22,23] Training the diaphragm to function more efficiently is hypothesized to provide these positive outcomes[24] and possibly offset the correlation a dysfunctional breathing pattern or disordered breathing has with increased risk of low back pain, sacroiliac joint pain, chronic cervical pain, and incontinence related health problems.[22,23, 25-28] However, many of the training techniques discussed in the research used to increase diaphragm efficiency and function are performed within simple postures, in isometric activities, and with no load present on the organism.[29,30] Courtney R[31] explains the problems she sees in the breathing therapy research. "The evidence for

the ability of breathing therapies to correct breathing dysfunctions and support the functions of breathing is relatively sparse as research has tended to focus on disease or psychological outcomes rather than investigate effects on breathing parameters."[31]

Lastly, Brown RP and Gerbarg PL also describe the flaws they have seen within the research.

> "Many research studies have used small samples and outdated methodologies. Rigorous studies have been done on only a fraction of the available breath techniques and these have measured limited sets of parameters. The use of mixed combinations of breathing techniques, inadequate documentation of breathing patterns, and differences in length of practice and level of experience of the subjects make it difficult to compare or apply findings from studies of one breathing practice to another."[32]

How then do these training programs and techniques that relate to natural human movement and provide the essential evidence to impact sport and athletic performance? What role does the diaphragm have in orthopedic rehabilitation?

As a student in my undergraduate program, I spent a significant amount of time training with and observing ATs working in a rehabilitation clinic in southwest Missouri. I started to see many techniques that involved the training and use of the diaphragm in their treatment protocols. Many of the patients were being seen for orthopedic injuries which did not seem to be related to their ability and capacity to breathe. However, their breathing functionality seemed to be a concern of these clinicians and an important aspect of their overall health. I began to question the rationale and methods behind these techniques and started my own research on the topic of diaphragm training. I then began to see paucity within the research. I also started questioning biomedical and physical therapy specialists who had differing opinions of and experience with the structure and function of the diaphragm. Why the differing in opinion?

My personal experiences and knowledge has brought me to an understanding of this therapeutic dilemma. I see a phenomena and trend in orthopedic rehabilitation of incorporating application and evaluation of diaphragm training alongside the treatment of orthopedic injuries. Some agree that diaphragmatic dysfunction is related or has a strong connection to dysfunction within the human body as noted above. Rationale for the evaluation and focus of intervention, time, and resources on this anatomical structure is broad and varies among health professions. Not only does the rationale differ among professions, but so does the purpose and desired outcome for these treatment methods. Understanding the rationale for making clinical decisions and what the benefits are for using these techniques in rehabilitation is a motive for further exploration.

Purpose of Study

The purpose of this study is to investigate athletic trainers' clinical reasoning for use of diaphragm training and evaluation techniques as therapeutic tools in orthopedic rehabilitation, and to determine if the reasoning and rationale is aligned with evidence-based research. Another purpose for this investigation is to provide medical health professionals with an extensive review of the literature on these topics and increase awareness and understanding of the diaphragm's uses and possible purpose in rehabilitation.

This, then, leads to my research questions:

1. What are clinicians' perspectives and rationale for incorporating (or not incorporating) diaphragm training and evaluation as a therapeutic tool for the rehabilitation of musculoskeletal injuries?

2. How and where do clinicians gain their knowledge and perspectives in these treatment methods and techniques?

3. What types of diaphragm training methods or techniques are clinicians utilizing during patient rehabilitation?

Significance of Study

Our understanding of the body and its functions is constantly evolving and changing. Medicine, as a result, is required to remain current and to continue to evolve in order to provide the most efficient and effective treatment available to patients. Providing evidence-based interventions for each patient is ethically required of ATs as medical professionals. Continuing to question each other and ourselves with every decision we make is crucial. Knowing the roles of an essential anatomical structure and how its function and purpose affect the organism as a whole is also critical. Breathing is a basic need for all organisms and plays a part in other basic human necessities. Having the capability to asses, evaluate, and treat dysfunctions observed in breathing and the diaphragm may be a central factor in rehabilitation. We need to investigate the phenomena of diaphragm training as a profession in order to discern its purpose in our everyday activities and to develop a clear understanding of the roles the diaphragm plays and how it ties into our rehabilitation of orthopedic injuries. Lastly, part of evidence-based practice is incorporating and learning from those who are experts in our field and employ their expertise daily. Combining their experiences, research findings, and our own experiences is how to develop as clinicians and a profession as a whole.

Limitations

Data collected in this study is from ATs working in the state of Missouri who are currently or have, within the past 5 years, worked in an orthopedic rehabilitation clinic

providing care to active populations. The participants were employed in hospitals or private clinics and worked as under-contract employees or internal staff members. This narrow population sample could be seen as a limitation affecting the generalizability of the study's findings and the ability to relate qualitative findings to other areas of the country and the profession. Each clinic also has cite-specific goals, priorities, points of importance, and protocols that can affect how each subset of clinicians is compared to one another and the population of ATs as a whole. The participants were recruited using convenience sampling methods, which could have affected the ability to capture the sample as a whole, possibly skewing and biasing interview findings. My employment as an AT could also influence and lead me to personal bias. This concern for bias was addressed during tool development, collection and analysis of the data. All data was viewed and analyzed using author's 'lens' making it vulnerable to personal biases of the researcher. Throughout the investigation, in addition to the lead researcher, all data was examined by experts within the profession of athletic training and by my colleagues. I am an inexperienced qualitative researcher with my own biases concerning these topics and those may be seen in the findings. I have personally seen the benefits of using diaphragm training in orthopedic rehabilitation and believe it has a purpose and benefits my patients in a positive way. My goal was to capture the perspectives and opinions of other experts within the field and their experiences with diaphragm training and education.

Assumptions

The assumption was made that ATs within the state of Missouri are using or incorporating these types of techniques within their treatment programs for their patients.

Assuming this, it was presumed that each AT has their own unique perspective on the purpose and rationale for the use or nonuse of diaphragm training in orthopedic rehabilitation. A final assumption was made regarding the difference that is believed to exist in the methods in which ATs are learning about these techniques and when, within their career, they obtained that knowledge.

Definition of Terms

- Breathing Pattern Disorders - Abnormal or dysfunctional breathing/respiratory patterns.[10]
- Diaphragm: "A large muscle found between the abdomen and chest cavity responsible for breathing."[37 pg44]
- Robustness: "The ability for systems to significantly change their parameters (i.e. stiffness) without loss of their stability."[32]
- Posture: "Is understood to be an active maintenance of body segments against the action of external forces, from with gravity has the greatest impact.[10]
- Postural Stabilization: "Is the active (muscle) maintenance of body segments within the gravitational field and against the activity of external forces, controlled by the CNS."[10]

LITERATURE REVIEW

Understanding what the diaphragm is and the purpose it plays within the organism is an important step in determining its further purpose in the rehabilitation of orthopedic injuries. An extensive review of the literature exists. However, the connections to what is known and what is unknown concerning this structure need to be addressed in order to truly understand the benefits it can have and how it can be utilized by athletic trainers. This chapter provides a relevant review of the literature concerning what is known about the diaphragm in addition to identifying the areas of uncertainty, paucity, and disagreement involving its roles and purpose in medicine.

This review of the literature below is divided into sections concerning: (I) anatomy of the diaphragm, (II) roles of the diaphragm, (III) diaphragm assessment and evaluation, (IV) breathing therapy and diaphragm training, (V) past and current uses of diaphragm training among allied health professions, (VI) current uses of diaphragm training in orthopedic rehabilitation, and (VII) contraindications for implementing diaphragm training. The first section titled anatomy of the diaphragm discusses the structure, sites of attachment, and innervations of the diaphragm. The second section describes the roles the diaphragm plays within the human body and is subdivided into sections including: respiration and gas exchange, roles involving the body's viscera such as peristalsis, and vomiting, and its functional component in providing postural stability through the trunk, the spine, and through the creation of intra-abdominal pressure. The third section explains the different methods and tools used in medicine over the years for assessing and evaluating the efficiency and quality of the diaphragm's overall function. Section four defines breathing therapy and diaphragm training as it is used in medicine today and is

further subdivided into explanations of how other health professions have used and are still using breathing therapy and diaphragm training within their scope of medicine. These other professions include: yoga, psychology in their treatment of psychological disorders involving stress and anxiety, and respiratory therapy (main purposes are in helping those whom suffer from breathing pattern disorders and respiratory diseases such as asthma and COPD.) Section six explains how orthopedic rehabilitation is using diaphragm training in today's treatment protocols to assist those experiencing a number of conditions consisting of: low back pain, neck pain, sacroiliac (SI) joint pain, a decrease in core and trunk stability, movement dysfunction, and decrease in performance. Lastly, section seven discusses the contraindications that have been seen in the literature concerning diaphragm training.

Anatomy of the Diaphragm

First and foremost, the diaphragm is a muscle that is innervated by the Phrenic nerves (C3-C5). It is an asymmetrical double-dome shaped like structure that separates the abdominopelvic cavity from the thoracic cavity.[34] It is asymmetrical due to the liver pushing upwards from underneath on the right side of its structure and the heart pushing down from the left.[35] As a muscle, its primary role is to contract, pulling on its attachment points and drawing them closer to its insertion points. During the contraction, the diaphragm draws downward into the abdominal cavity, allowing room for the lungs in the thoracic cavity to expand. As these structures are drawn together a three-dimensional change occurs within the thoracic and abdominal cavities that returns to its normal resting state when the diaphragm relaxes.

The diaphragm on the lower edges of its structure forms a continuous rim of attachment points. The three specific bony origins of its structure are the xiphoid process, ribs seven through 12, and anterior surfaces of lumbar vertebrae.[34] However, over 90 percent of the diaphragm attachment points originate on flexible tissues including: "the costal cartilages of ribs six through ten, and the arcuate ligaments, which span the tenth rib's cartilage, to the floating eleventh and twelfth ribs, and from there to the spine."[35 pg72] The diaphragm's insertion point is essentially itself. It inserts onto its own central tendon, which is a non-contractile aponeurosis made of fibrous tendinous sheets.[35] This tendon then forms with the fibrous pericardium located above it to help maintain the structure of the diaphragm.

The diaphragm is also part of a complex fascial network that runs throughout the human body. Specifically, the diaphragm is an important aspect of the deep front fascial line that connects it with the psoas muscle deep within the abdominopelvic cavity.[36] Thomas Meyers goes further in his text "Anatomy Trains" to describe how this connection plays a major role in support for the human structure and how that support affects overall function.

"The connection between the psoas and diaphragm – just behind the kidneys, adrenal glands, and celiac (solar) plexus, and just in front of the major spinal joint of the thoracolumbar junction (TLJ: T12-L1) – is a critical point of both support and function in the human body. It joins the 'top' and 'bottom' of the body, it joins breathing to walking, assimilation to elimination, and is, of course, via the celiac plexus, a center for the 'gut reaction'"[36 pg198]

The diaphragm's action related to respiration and its physical placement within the body primes this unique structure to be an important aspect to many different functions within the human body. Next, we will explore the roles and purpose of the diaphragm and the current literature that supports it.

Roles of the Diaphragm

When one begins to discuss the purpose of the diaphragm within the human body, many quickly imagine the necessary role it plays in respiration. True, this structure plays an important role within the respiratory system, however, it does encompass other uniquely viable roles. It performs distinctive roles in visceral function and protection, as well as a component of posture and stability within one's structure. Whenever the diaphragm is not performing efficiently between or within these different roles, the organism moves closer to dysfunction and a decrease in efficiency and in the ability to perform competently occurs. Chaitow makes the proposition about the interconnection of how the structure and function of an organism's respiration work together and fight against a constant continuum where change to either aspect generates an effect on the other.[10] This is the same for all individuals regardless of their age, gender, race, occupation, or level of activity. In that, lies the purpose of attention and evaluation within the medical profession.

Respiration. "The diaphragm is well known for its role as the principle muscle of respiration."[8pg927] It's main purpose in respiration is related to the action of inspiration. Hodges et al describes the diaphragm as the "primary muscle of inspiration."[16pg539] Respiration and gas exchange occur with the contraction and relaxation of the diaphragm. Pressure in the chest decreases as the diaphragm contracts during inspiration, which then

forces air through the airway and into the lungs. The lungs fill with air, pressure in the chest increases, the diaphragm then relaxes, and the air leaves the lungs back out through the airway.[37] Leslie Kaminoff in her article “What Yoga Therapists Should Know About the Anatomy of Breathing” states: “Like any other muscle, the contracting fibers of the diaphragm pull its insertion and origin (the central tendon and the base of the ribcage) toward each other. It is this action that is the fundamental cause of the three-dimensional throaco-abdominal shape changes of breathing.”[35pg72-73]

This change in shape or expansion within the abdomen is what is often being referred to as “belly breathing” or abdominal breathing. However, this only occurs if the structure of the ribcage (its origin) is stable and the central tendon (its insertion) remains mobile. It is likely that dysfunction can occur within this system and can have negative impacts on the human body. Harper et al. describes some of the negative effects on the individual when the diaphragm becomes dysfunctional. "When diaphragm function is impaired, accessory muscles must assume this role but are much less efficient resulting in shortness of breath with exertion in patients with diaphragm dysfunction."[8pg927] Other negative consequences and compensations can occur with diaphragm dysfunction and are discussed later in this chapter. Concerning the diaphragm's role in gas exchange, it is just as susceptible to dysfunction as its other roles.

Chaitow describes respiration as ultimately being "a chemical matter."[10pg61] “The body extracts oxygen from the inhaled air and exhales carbon dioxide.”[10pg61] It is the job of our breath to keep the balance between these two chemicals within our body. If either chemical were to increase or decrease outside of our "zone of homeostasis"[10pg61] many negative effects can occur including: fainting, loss of consciousness, seizures, fatigue,

decrease in performance, and eventually even death. If these changes occur, it results in deviations of the body's pH producing metabolic alkalosis and acidosis. If these breathing compensations or deviations from the normal human design continue to occur regularly, they can become habit, creating a perpetual dysfunctional breathing pattern that needs to be acknowledged and addressed by medical health professionals.

Breathing pattern changes (rate and depth) are not always the cause of these conditions, however, they can be the body's way of resolving other medical conditions that result in changes in the body's chemistry. Medical factors such as ketoacidosis and diarrhea promote deep, fast breathing patterns in order to decrease the body's CO_2 levels and increase pH levels. Other conditions such as excessive vomiting, steroid use, and diuretics forces the body to decrease its rate of respiration in order to increase its CO_2 levels and decrease its pH.[10pg63-64] However, if the breathing pattern compensations brought on by these medical conditions do not eventually regulate themselves back to a normal state, those habitual compensations can become more permanent leading to further issues, that if left unaddressed, can again, have negative effects on other functions.

Visceral. The diaphragm's visceral roles within the body are not as well-known, nonetheless still vital to our everyday function. The ability of the diaphragm to pressurize effectively within the thorax and abdomen is necessary for a number of functions within the human body. Josephine Key states the diaphragm has functional expiratory patterns and acts of elimination. The expiratory patterns are listed as vocalization, singing, laughing, and sneezing. While the acts of elimination are coughing, nose blowing,

vomiting, defecation, and birthing. She also discusses the importance of the diaphragm to aid in maintaining continence during impact activities like running and jumping.[30]

The diaphragm also helps in the protection of the abdominal contents. As pressure is created in the abdomino-pelvic cavities due to synergistic co-contraction of the surrounding musculature, it becomes necessary for the diaphragm to simultaneously contract against that pressure to minimize the displacement of abdominal contents from pushing into the thoracic cavity.[16] The diaphragm's role in increasing intra-abdominal pressure and control also plays a vital part in coughing and expelling air. The relaxation of the diaphragm also allows for positive-pressure development in the throrax, a necessary component to the coughing maneuver[38] The diaphragm's ability to control and generate pressure within our abdomen as well as timing and proportion is what drives these functions.

These changes in intra-abdominal pressure also aid in the movement and flow of body fluids and digestive processes, specifically peristalsis and vomiting. "The movement of the diaphragm downwards with each inhalation gives the internal organs a gentle massage. Every breath displaces and gently moves the viscera with an ebbing and flowing motion."[39 pg22] If the diaphragm becomes restricted and provides insufficient movements to massage the internal organs, they can become stagnant and increase further restriction between the internal tissues and the movement of those fluids.[39] Vomiting is also produced due to the changes in intraabdominal pressure created by the respiratory and thoracoabdominal musculature. The cocontraction of the main inspiratory (i.e. the diaphragm) and exipratory (i.e. the abdominal wall muscles) typically occurs in two different phases, retching and expulsion. The relaxation of the portion of the diaphragm

that surrounds the esophagus is also necessary for the vomiting mechanism to occur.[40] Next we will discuss the diaphragm's role in posture and the creation of support for the core and trunk.

Posture. Knowing the attachment points of the diaphragm and the function it plays within the fascial network of the body, we have learned that the diaphragm plays a supporting role in one's posture. In order for us to understand the diaphragm's responsibility in maintaining one's posture, we must understand what ideal or optimum posture looks like. Kuchera M and Kuchera W. in 1997 define optimum posture in their text "Foundations for Osteopathic Medicine."

> "Optimal posture is a balanced configuration of the body with respect to gravity. It depends on normal arches of the feet, vertical alignment of the ankles, and horizontal orientation (in the coronal plane) of the sacral base. The presence of an optimum posture suggests that there is perfect distribution of the body mass around the centre of gravity...Structural and functional stressors on the body, however, may prevent achievement of optimum posture. In this case homeostatic mechanisms provide for 'compensation' in an effort to provide maximum postural function within the existing structure of the individual. Compensation is the counterbalancing of any defect of structure or function."[41 pg969-977]

Chaitow also describes the diaphragm's important role in postural control within the individual.

> "During exercise or any postural activity, eccentric activity of the stabilizing muscles occurs except for diaphragm and pelvic floor which activate in a concentric manner. The diaphragm descends in a caudal direction, pressurizing intraabdominal content from above, pelvic floor activates against; muscles of the chest and abdominal wall activate eccentrically like a belt, thus intra-abdominal pressure is increased, stabilizing the spine. "[10 pg14]

Keeping optimum structure and posture is a crucial for proper function. If there are insufficiencies within the diaphragm's structural components, however, the diaphragm then becomes inefficient in performing its other roles, such as respiration. Chaitow discusses how structural inadequacies, such as poor posture, is a key factor in causing

breathing pattern disorders.[10] Different postural compensations have been connected with poor breathing quality; forward head posture being one of them. "Forward head posture can also indicate the presence of short flat diaphragm and weak abdominals."[31pg79] Other postural considerations are discussed in the following sections concerning the diaphragm's role in creating intra-abdominal pressure and its ability to provide core/trunk stability.

As discussed previously the diaphragm is critical part of the Deep Front Fascial Line (DFL). Thomas W. Meyers, in his text Anatomy Trains, discusses the importance of the DFL as it relates to postural function. He states that "The DFL plays a major role in the body's support:

- Lifting the inner arch;
- Stabilizing each segment of the legs, including the hip;
- Supporting the lumbar spine from the front;
- Surrounding and shaping the abdominopelvic balloon;
- Stabilizing the chest while allowing the expansion and relaxation of breathing
- Balancing the fragile neck and heavy head atop it all."[36 pg185]

All of these supporting roles are important in producing optimum posture. The changes in physiological, psychological, and neuronal states that are caused by breathing pattern disorders will directly have an affect the musculo-skeletal system in more ways than one.[4] Next we will discuss the diaphragm's more specific roles in maintaining posture by producing intra-abdominal pressure, creating trunk/core stability, and finally its role in spinal stability.

Creation of Intra-Abdominal Pressure. Research has shown the contraction of the diaphragm during respiration and during co-contraction of the abdominal and pelvic floor musculature creates trans-diaphragmatic pressure within the abdomino-pelvic cavity.[16] More of their research continued to study the generation of intra-abdominal pressure and the various muscles that are responsible for creating that innate internal stabilizing mechanism. The muscles they identified are: transverse abdominis, the diaphragm, the pelvic floor muscles, and lumbar multifidus.[15,18,19] The diaphragm, respiratory, trunk, and pelvic floor muscles have to work as one complete unit in order to establish intra-abdominal pressure within the individual. If normal function to any of these structures is effected, then one's ability to breathe efficiently and effectively control pressure changes within the abdominal cavity is lost.[19]

Research has also shown the diaphragm to reflexively stabilize and provide trunk and abdominal support when large extremity movements are initiated. They showed the diaphragm will contract to create intra-abdominal pressure just prior to the initiation of extremity movement in order to provide support during postural adjustment. These contractions were also found to transpire regardless to the respiratory phase occurring at that moment. This evidence also suggests that postural function can interfere with the respiratory function of the diaphragm. Small extremity movements did not correlate with a response to diaphragm contraction leading researchers to believe that diaphragmatic response requires a certain movement threshold magnitude to produce this reflexive contraction.[16]

Trunk and Core Stability. "Diaphragmatic breathing is the most fundamental demonstration of core function."[29] However, ‘the core’ has been a difficult concept to

define in literature. Some describe it as the muscles that surround the abdominal region. While others describe only deep internal structures as components of the core. It simply cannot be construed as the abdominal muscles but instead, a synergy of muscles co-activating in response to challenges to the system.[30] These challenges can be external (postural adjustments to environmental stimulus or pre-meditated movements) or internal (digestion processes, respiration, elimination, etc.) Josephine Key describes the core to "reach from the ischial tuberocities up to the mid thorax where the diaphragm and transversus abdominis attach superiorly."[30 pg2] Therefore, "a balanced postural and functional relationship between the thorax and pelvis affords 'ideal' internal dimensions of 'the core' promoting optimal function between the thoracic and pelvic diaphragms."[30 pg3] She also describes the core as having three inter-dependent functions. The first being the breathing mechanism and its role in creating intra-abdominal pressure. The second is named the postural control mechanism and it is responsible for the co-activation of muscles surrounding the spine in order to control the axial column. Third, is the control of posture and movement through the proximal limb girdles. Here she explains how pelvic control affects the trunk stability and vice versa.[30]

Research has shown the diaphragm to play an integral part in postural control and core stability. Hodges et al showed that an increase in EMG outputs for the activation of the diaphragm was recorded prior to the activation of the deltoid during large arm movements. These readings did not change regardless of the respiratory phase. "This provides evidence that the postural function of the diaphragm interferes with the respiratory activity of this muscle,"[16] even though respiration itself does create a challenge on stability with the movement of the ribcage and abdomen during respiration.

Those changes, which are the result of normal respiration, are counterbalanced by the movements and activation of the trunk and lower limbs. This coordinated recruitment is described as an 'active process' to control for postural sway and decrease respiration's disturbance on posture.[42]

Thomas W. Meyers in his text "Anatomy Trains" discusses that the deep front functional line plays a role in balancing the myofascial tensegrity system within the body. The diaphragm, being an integral part of that fascial line, continues to help provide support to the structure and stability with movement. The deep functional line also provides stability by supplying subtle positioning changes to the core structure which enables the more superficial structures to work easily and efficiently with the axial skeleton.[36] This leads us into our third subdivision of posture: spinal stability.

Spinal Stability. "In terms of the spine, stable behavior is critical for the spine to bear loads, allow movement, and at the same time avoid injury and pain."[33 pg262-267] Spinal stability is also controlled via stiffness of the muscles surrounding the spine and the attachment points of those structures. Shirley, Hodges, and Eriksson et al describe how spinal stiffness is modulated by both the intra-abdominal pressure created by respiration and adjustments in trunk muscle activity. They also argue that spinal stiffness is regulated by the diaphragm due to its attachment to the lumbar vertebra via its crual fibers.[21] Kolar et al. in their study "Analysis of Diaphragm Movement During Tidal Breathing and During Its Activation While Breath Holding Using MRI Synchronized With Spirometry" confirmed the diaphragm functions not only in a respiratory capacity but also plays a role in postural control. They found we are capable of moving our diaphragm voluntarily, but the amount of control and amplitude varies between individuals. This leads to the

possibility of voluntarily training the diaphragm and possibly the inclusion of diaphragm training to improve postural control and ultimately stability within the spine, trunk, and core.[43]

Once again, Chaitow discusses the multifaceted roles of the diaphragm and how one role can affect the others if not functioning effectively. “Diaphragmatic and transversus abdominis tone are key features in provision of core stability, however it has been noted that reduction in the support offered to the spine, by the muscles of the torso, may occur if there is both a load challenge to the low back, combined with a breathing challenge.”[25 pg34] Our breathing patterns and respiratory efficiency of the diaphragm also affects the diaphragm’s ability to provide structural support and protection to the spine. Hodges, Heinjnen, and Gandevia 2001 found that after approximately 60 seconds of hypocapnia, the postural and phasic functions of both these structures decrease significantly or become absent altogether. A compromise in the role of these structures can lead to increases in injury risk to structures in the spine and ultimately reduced postural control.[44] Breath holding is a common compensation or disordered breathing pattern that has been seen in many individuals who lack spinal stability, core stability, or suffer from an ineffective diaphragm. However, the diaphragm’s primary role, as discussed previously, is in respiration. One must breathe to survive. Due to this prioritization, one’s ability to stabilize the spine can be compromised when the structure is challenged.

> "The body will prioritize breathing over stabilization. This presents a risk to less fit motor systems resulting in a high degree of variability in stability and could result in temporary losses in stiffness. However, those with fit motor systems seem to meet the simultaneous breathing and stability challenge with less variance of stability."[29 pg35]

As the demand of physical activity, force load, or respiratory drive increases however, the diaphragm's role in respiration will outweigh its need to provide stability and the organism will suffer as a result.[19] Breathing is vital and will always come first. The diaphragm's other postural supporting roles, creation of intra-abdominal pressure, creation of trunk/core and spinal stability will take a back seat to this necessary function of survival. In order for one to determine if their diaphragm is functioning properly, we must have a tool or process for assessment and evaluation. The following section will address why breathing patterns should be assessed and current methods used in rehabilitation today.

Diaphragm and Breathing Assessment/Evaluation

"Breathing patterns reflect the functioning of the respiratory system and the biomechanical system as well as the cognitive state."[4 pg75] Therefore, the assessment and treatment of patient's breathing patterns should be an essential portion of the health care process and focal point of rehabilitation. Chaitow states that breathing is "the bridge between mind and body," and "breathing pattern disorders (BPD) are whole person problems."[10 pg5] In order to assess the efficiency of breathing patterns we must have a standard for optimal breathing. Chaitow describes the components of an optimal breathing pattern as previously described by Jones, Alice, Dean, et al in 2003:

- During quiet breathing, respiratory efficiency is achieved as the diaphragm descends into the abdominal cavity during inhalation, increasing the vertical dimensions of the thorax as the ribs rise and move laterally, expand the transverse dimensions of the thorax.

- The diaphragm relaxing, and returning to its domed position on exhalation follows this sequence, as the abdomen and chest wall return to their staring positions.

- Meeting the metabolic demands of the body optimally requires a steady, rhythmical pattern within respiratory rate of 10-14 breaths per minute; involving a ration of inspiration to expiration of 1: 1.5-2.

- The mechanical effort produced by the respiratory musculature, during ideal breathing, involves only minimal work or effort.[45 pg424-431]

Diagnosis of breathing pattern disorders is still a debated topic in research, and currently, there is no single test for the clinical diagnosis of breathing pattern disorders.[46] However, most agree that a disordered breathing pattern affects multiple aspect of proper human function and should be addressed.

When it comes to clinical measures for assessing dysfunctional breathing, clinicians typically utilize a wide range of observation and palpation techniques, many of which have not been properly validated with evidence based practice.[47] One commonly used observational technique for breathing assessment is the Hi-Lo Test. Humphrey Bacchus, a clinical masseur and neuromuscular therapist, describes clinical benefits for using the Hi-Lo test in assessing breathing in his article "Breathwork and Sports Performance."

> "The Hi-Lo test provides an immediate insight into how the diaphragm and rib cage moves during inhalation. Thoracic breathing draws air into the lungs when the shoulders, clavicle and upper ribs move upwards. This produces a very shallow breath because the first movement of the diaphragm descending downward into the abdomen (and creating more space in the thorax) is not activated. This is also known as paradoxical breathing – when the stomach should be moving outwards along with the ribs on inhalation, the upper chest moves out instead, the shoulders rise and the capacity of oxygen intake into the thorax is reduced."[39 pg24]

Many describe this paradoxical breathing as either chest-breathing or abdominal breathing. These different breathing types are described on a continuum and individuals

lie on any point of that scale between breathing completely with their chest and solely breathing with their abdomen or diaphragm. The accessory breathing muscles include used in cheat breathing are the pectorals, scalenes, trapezius, sternocleidomastoid, and upper intercostal muscles. The two difference breathing patterns are described more as a continuum as opposed to two entirely different patterns and individuals can lie on any point of that continuum.[10 pg81] Listed below are the procedures to perform the Hi-Lo Test as explained by Bacchus:[39]

1. Have your patient lie supine on a treatment table.
2. Ask them to place their right hand over the center of their abdomen and their left hand over the middle of their sternum.
3. Once they are relaxed, follow their breath. Watch the movement of both their hands during the inhalation and exhalation phase. The breath should start with a downward movement of the diaphragm into the abdomen, with their right hand moving upwards and their left hand remaining steady.
4. If during the inhalation the left hand moves upwards and away from the chest cavity before any movement of the abdomen, it suggests that the patient is breathing paradoxically.
5. Repeat the above with the patient taking long, deep breaths. This will exaggerate any breathing patterns they have.

It is also important not just to observe or assess breathing visually by observing your patient's breath but to also palpate the structures related to respiration and check for elasticity, tone, trigger point development, and postural adaptations. This can offer clinicians a better overall view of the health of our patients and their breathing efficiency.[43] Chaitow gives multiple examples of palpation assessment tests to determine breathing quality. A description of procedures is listed in his text giving clinicians directions on how one can palpate and observe lateral expansion of the abdomen, rib elevation with palpation of the anterior thorax and posterior lumbar musculature, and

palpation of each respiratory muscle for restrictions and adhesions. An alternative test for palpation and determination of asymmetrical breathing patterns by assessing movement of the first rib bilaterally is also described. Through palpation of the first rib during inhalation, exhalation, or both and determining if an asymmetry exists, one can assess breathing quality and asymmetries bilaterally.[10] He lists many other assessment tools that can be used and the results can be combined to create an overall assessment of a patient's breathing pattern, postural alignment, and connective tissue restrictions that can affect breathing.

Other methods have been used to assess breathing pattern disorders, specifically hyperventilation, which is a common breathing pattern disorder that is assessed in healthcare settings today. Concerning hyperventilation, it has been suggested that ambulant monitoring of CO2 be considered as a potential gold standard to determine whether or not breathing is a factor in patient presentation.[48] Conversely, there is still debate on the existence of hyperventilation syndrome and the best practice for its evaluation and diagnosis. The gold standard for hypocapnia, however, is through measurement of arterial blood gases.[49] The test in invasive and requires blood sampling and the use of a testing laboratory to provide accurate analysis and diagnosis. Also, the test results only provide the level of CO2 found in the test sample for that single moment in time and not an overall average during a specific activity or overall daily function.[50] This form of assessment would be highly ineffective for the rehabilitative setting most Athletic Trainers perform within. "However, continuous values can be obtained using capnometry or capnography, which tests CO2 levels in exhaled air at the end of exhale, termed End Tidal CO2."[50 pg278] It is believed that capnography could add valuable

information for clinicians about the breathing status of their patients and help determine need for intervention. In her study "Breathing Evaluation and Retraining as an Adjunct to Manual Therapy" she concluded that the use of capnography as a screening tool for breathing dysfunction may improve patient outcomes for those where manual therapy, exercise, and education did not resolve their dysfunctional breathing patterns and corresponded symptoms.[50] Hyperventilation syndrome is also commonly evaluated using the Nijmegen Questionnaire. This Questionnaire includes 16 items that include questions concerning respiratory symptoms and peripheral and central neurovascular or general tension symptoms.[51]

Others within research have also concluded the need for breathing dysfunction evaluation and its purpose in rehabilitation. Rosalba Courtney et al. concluded in their Study "Relationships Between Measures of Dysfunctional Breathing in a Population with Concerns About Their Breathing" that "comprehensive evaluation of breathing dysfunction should include measures of breathing symptoms, breathing patterns, resting CO2 and also include functional measures such as breath holding time, and response of breathing to physical and psychological challenges including stress testing with CO2 monitoring."[52 pg24] Bradley H, and Esformes[43] J assessed breathing pattern disorders and compared their results to a functional movement based screen in order to determine if functional movement correlates with poor breathing efficiency. To determine if a participants experienced breathing pattern disorders, they used a combination of tools in order to measure their breathing efficiency. These were end tidal carbon dioxide readings, Nijmegen Questionnaire scores, respiratory rate, breathes per minute at rest, and breath-hold time.

Others have chosen to take a different route when determining diaphragm and breathing efficiency and instead, look at anatomical structure and postural measurements. Josephine Key describes the importance of observing how one's body is structured and how this can inform a clinician as to the activity level of the diaphragm and the balance between the diaphragm and transversus abdominis.[30] Being able to identify through observation one's pelvic tilt, the thoracic extension or thoracic hollowing that occurs with slouching can help one determine if the diaphragm is functioning properly in its role with postural stability. Continuing with postural stability and core control, others use evaluation methods that specifically evaluate the core and if it is functioning properly as a means to determine diaphragm efficiency. Bliss L, and Teeple, P[53] describe a few of these tests such as the prone bridge, lateral bridge, seated torso flexion hold (trunk flexor endurance test), trunk extensor endurance test, and star excursion test. These tests are then used as training methods and progressed in order to train the diaphragm and core for optimum function.

"First, the patient's primary stance should be observed. The initial alignment of the chest and pelvis are critical for both the quality of the breathing pattern and the postural-stabilization function."[10pg93] Need to observe and evaluate the chest-spine-pelvic alignment to determine effective postural arrangement for optimal breathing patterns. Presence of a pelvic tilt and dysfunctional chest position/angle will affect stabilization of the spine and diaphragm activity. Thus impacting the breath.

More research needs to be conducted in order to determine best practices for breathing evaluation and how these methods can be applied to rehabilitation settings and treatment practices. Nevertheless, a starting point has been identified with a few methods

that have been determined to be effective in assessing breathing patterns. Practice and experience with these methods, along with future research, can give Athletic Trainers increased insight and knowledge on breathing pattern evaluation and how these methods can add to our overall patient assessment and treatment of injuries. Once breathing is assessed and distinguished as “good” or “bad,” we then, as clinicians, can begin the training and treatment process to correct those dysfunctions and improve the overall function of our patients. The following section discusses breathing therapies used today among allied health professions and the evolution of diaphragm training from those bodies of knowledge.

Diaphragm Training and Breathing Therapy

Breathing therapy and diaphragm training needs to efficiently consider all of the diverse roles and functions of the diaphragm and incorporate those needs within the entire course of treatment. Goals of diaphragm training are to enhance or train the roles and efficiency of the diaphragm. Courtney R, in 2009, describes the three main rationales for breathing therapy are:

> "1) to correct some aspect of dysfunctional breathing; 2) support one or several of the functions of breathing and thus stimulate healing or 3) provide a means for regulation of mental and emotional states. The territory covered by breathing therapies is large covering a broad area ranging over psychology, physiology, spirituality and biomechanics."[31 pg83]

Current allied health professions using diaphragm and breathing therapy/training are yoga, respiratory therapy and psychology/psychiatry. Next, we will briefly discuss how each of these professions incorporate these types of treatment therapies in their practice

and how we as Athletic Trainers can learn from these methods and relate them to the treatment and rehabilitation of orthopedic injuries.

Diaphragm Training in Allied Health Professions.

There are different allied health professions who have used diaphragm breathing as a method of treatment, currently, and for many years. Three distinct professions who discuss these techniques the most throughout the literature are yoga, psychology/psychiatry, and respiratory therapy.

Yoga. "Yoga techniques enhance well-being, mood, attention, mental focus, and stress tolerance."[54 pg711] Much of yoga and yoga techniques involve breathing training and control. One form of breathing exercises termed Pranayama comprises voluntary controlled breathing movements that are repeated to elicit different responses within the body.[32] Chaitow describes how pranaymas breathing training alters the breath. It involves changes in rate, alternate nostril breathing, exhalation during which a sound is produced, volume changes of breathing, breathing with a constricted glottis, breath holding, and mouth breathing.[10] One study investigated the use of pranayama breathing training in elite athletes and their performance levels. Those who participated in the breathing exercises achieved higher work rates with reduced oxygen consumption than a control group of elite athletes who did not practice pranayam.[55] Cowen, S in "Funcational Fitness Improvements After A Worksite-based Yoga Initiate"[56], investigated 108 firefighters and the effects of incorporating a yoga training program on functional movement, perceived stress, breathing control, reported musculoskeletal pain, and balance/core strength. The program included pranayama (breathing), asana (posture), and savasana (relaxation) training. They found significant improvements in functional movement scores, trunk

flexibility, and perceived stress scores. 17% reported less musculoskeletal pain, 16% reported improved breathing control, and 15% reported better core strength and balance.

Another form of yoga breathing techniques is Sudarshan Kriya Yoga. Gerbarg and Brown have found Sudarshan Kriya Yoga, which combines specific breathing techniques, to be helpful in patients with a wide range of medical disorders including chronic fatigue, chronic pain, fibromyalgia, neck and back pain, TMJ pain, cancer, diabetes, multiple sclerosis, and asthma.[32] "There is sufficient evidence to consider Sudarshan Kriya Yoga to be a beneficial, low-risk, low-cost adjunct to the treatment of stress, anxiety, post-traumatic stress disorder, depression, stress-related medical illnesses, substance abuse, and rehabilitation of criminal offenders."[54 pg711]

Detailed descriptions of four main Sudarshan Kriya Yoga breath techniques are summarized below:

1. *"Ujjayi* or "Victorious Breath" is sometimes called "Ocean Breath" because the sound created by the gentle contraction of the laryngeal muscles and partial closure of the glottis is reminiscent of the sound of the sea. This slow breath technique (2 to 4 breaths per minute) increases airway resistance during inspiration and expiration and controls airflow so that each phase of the breath cycle can be prolonged to an exact count. The subjective experience is physical and mental calmness with alertness."

2. "During *Bhastrika* or "Bellows Breath" air is rapidly inhaled and forcefully exhaled at a rate of 30 breaths per minute. It engenders excitation followed by calmess."

3. "Om" is chanted three times with very prolonged expiration."

4. *Sudarshan Kriya* or "Proper Vision by Purifying Action" is an advanced form of cyclical breathing at varying rates – slow, medium, and fast."[54 pg711]

The strong connection yoga has with our cognitive minds and emotional state brings us to our next topic concerning the use of diaphragm training in the healthcare field of psychology.

Psychology and Psychiatry. "The shape, depth, rhythm, and volume of our breath are all a reflection of our habits, training, intentions, body position, and state of mind."[35 pg75] Pg.75 Our breath has a large impact on the other systems of our bodies, including how we think, feel, and act. Our external environment can also affect how we breathe. "Changes in respiration rate and depth due to sensory changes in our environment do not happen consciously. However, these adjustments to the breathing cycle occur as the body anticipates an outside danger or need for action."[10 pg80] "Changes that can occur as breathing adjusts to external and internal conditions include: depth and rate of breathing, breath-holding, and location of breathing (whether it centralizes in the chest or abdomen)."[10 pg5] Boiten F in "The Effects of Emotional Behavior on Components of the Respiratory Cycle"[57] demonstrated how different elicited emotions can affect related respiratory responses. Participants watched different film clips where significantly different emotional responses were expressed. Respiratory measurements (inspiratory time, expiratory time, inspiratory pauses, duty cycle time, total cycle duration, and tidal volume) also differed between film clips showing that our emotions affect how we breathe. By reducing the negative mental input brought on by stress/anxiety, one can change the disruption that is produced and create, again, a functional respiratory system.[10]

But what came first? Was it the sensory input of our environment that affected our breathing patterns or was it our disordered breathing patterns that affected our overall state of wellbeing? As the breath is altered from its optimal state, changes in blood chemistry occur and this can affect the amount of oxygen that reaches the brain. This adjustment to the level of oxygen reaching the brain will affect neurological functions

which then decrease calcium and magnesium ion levels within the body.[10] "Low levels of carbon dioxide (respiratory alkalosis or hypocapnia) influence not only the physiology of the body but also emotions – including fear, anxiety and stress."[39 pg24] Next we will discuss how breathing techniques have been used in the treatment and management of stress and anxiety disorders.

Anxiety is defined as "a feeling of worry, nervousness, or unease, typically about an imminent event or something with an uncertain outcome:"[58] Psychologists and physiatrists have been using different techniques, methods, and medications to help in the treatment and management of anxiety and stress. Breathing techniques have been associated with reducing an individual's arousal state, increasing their sense of well-being, and improving their ability to cope with stress and anxiety.[9] One common symptom of stress is hyperventilation.

> "Hyperventilation is a natural compensatory response to acidic blood, but hyperventilation may also be initiated and maintained by strictly mental stimuli, so that whatever factors drive anxiety may also drive breathing. Strong emotions such as anxiety, apprehension, time urgency, resentment and anger manifest somatically in many people as increased breathing as if preparing for action. If muscles contract, the increase CO2 produced will balance the loss of CO2 from heavier breathing. But in the absence of exertion, low CO2 and respiratory alkalosis is the likely result. If this imbalance becomes chronic, the same renal compensation occurs as with metabolic alkalosis-dumping more bicarbonate into the urine. This adjustment constitutes a new equilibrium, as if the over breathing is expected to continue. This adaptation most likely adds to the difficulty in restoring normal breathing habits."[10 pg66]

Stress can have other negative effects on our respiration and diaphragm function. William B Falkner[59] conducted a study using fluoroscopic dye to investigate the response of respiration and the diaphragm when stressful situations were elicited in 5 patients. He was able to show that in situations of elicited emotional stress, the diaphragm became hypertonic, flattened, and immobile.

It is for these reasons and other that psychologists have turned to breathing re-training to help correct these dysfunctions and in turn help to calm the mental state of their patients and teach them methods for relieving their anxiety symptoms. “Controlled respiration can help the system to return to physiological rest state.”[31 pg82] Next, we will look specifically at how diaphragm and breathing therapy has helped in the treatment of dental and testing anxiety.

Research has shown that approximately 35 million Americans experience dental anxiety that is severe enough to prevent them from seeking necessary treatment.[60] One group of participants suffering from dental anxiety, were taught a deep diaphragmatic breathing technique to use during their next few visits to the dentist in order to help decrease dental anxiety. No significant differences were found between the control group and breathing group on anxiety levels following the intervention. However, a trend toward decreased overall anxiety score were noted. Testing anxiety also exists for many of us and can affect our abilities to perform to our greatest potentials. “The worry or emotional arousal that can accompany test anxiety causes the student to become centered on the “self” during an exam rather than the task, thus possibly negatively influencing future academic performance if no coping techniques are adopted.”[14] Diaphragmatic breathing is known to counteract the fight or flight response symptoms that are often associated with anxiety.[61,62] Meditation is also used to help counteract stress and anxiety and diaphragmatic breathing is a key component to any practice of meditation.[14]

Medical Students, who took part is routine diaphragmatic breathing exercises while taking exams reported having decreased test anxiety, nervousness, doubt, and difficulties in concentration.[14] Another study investigated a group of pharmacy and biochemistry

students and the effectiveness of a stress management program and on reducing their anxiety, anger, stress, coping strategies, helplessness, salivary cortisol and psycho-physiological reactivity levels. The stress management program included psycho-education, stress coping resources and training, deep breathing, relaxation, and guided imaginary techniques, cognitive restructuring and time management techniques. Concerning the breathing, all participants were given formal training in deep breathing in different stressful situations. Results did show a decrease in respiratory rates in participants following the program in both stressful and relaxation conditions. Anxiety and stress levels also decreased following the program as well as salivary cortisol levels.[11] However, it is hard to determine if one or many aspects of the stress management program produced these results.

Respiratory Therapy. Respiratory therapy is another common allied health profession that is currently using diaphragm training and other breathing re-training techniques to improve overall breathing quality and effectiveness within the body. These techniques are often used in the treatment of asthma, chronic obstructive pulmonary disorder, and breathing pattern disorders. “Conditions like COPD, asthma and other conditions associated with increased inspiratory drive and inefficient expiration can lead to trapping of air in the lungs or hyperventilation. When this occurs the diaphragm becomes shorter and loses its curvature, as it is forced to take a lower resting position in the thorax.”[63] This makes the diaphragm ineffective in changing the shape of the rib cage and abdomen in order to produce optimum respiration. In “Breathing Retraining for dysfunctional breathing in asthma: a randomized controlled trial” a private practice conducted a research experiment on a group of patients diagnosed with asthma and were

suggested, due to specific signs and symptoms, to have dysfunctional breathing. The experimental group was taught by a physiotherapist to perform diaphragmatic breathing exercises which focused on slow breathing and a dominant use of the diaphragm for respiration. They were then encouraged to practice their breathing for 10 minute periods every day. The study did suggest, with some significant data, that breathing retraining improved the health related quality of life scores for those patients who were previously diagnosed with asthma and had Nijmegen questionnaire scores for suggestive dysfunctional breathing.[64]

Breathing pattern disorders have also been looked at within research and treated with diaphragm training techniques. First, let us define what normal breathing is.

> "Normal breathing, in the physiological sense, means that our everyday, moment-to-moment respiratory activity is consistent with our metabolic requirements. Since our metabolism changes with activity, so must our breathing patterns. When our breathing does not change to accommodate changing conditions, this is, by definition, disordered breathing."[35 pg75]

Faulty breathing can also be defined, but it relates to each individual differently depending on their situation and body compensations. "Faulty breathing patterns present differently, depending on the individual. Some patients are more inclined to mental distress, fear, anxiety, and coexisting loss of self-confidence. Others may exhibit musculoskeletal and more physical symptoms such as neck and shoulder problems, chronic pain and fatigue."[4]

Many present with some level of combination between the two such as hyperventilation. Garssen B, De Ruiter C, and Van Dyck R[65] conclude that "breathing retraining and related procedures are therapeutically effective, but probably due to principles other than originally proposed, namely decreasing the tendency to hyperventilate."[pg141]

> "Hyperventilation is defined as a higher degree of ventilation than is necessary to meet the demands of the body, caused by an increase in respiratory rate and/or depth. This excessive ventilation leads to a decrease in alveolar and arterial carbon dioxide pressure (PCO_2) and in increase of pH in the blood and the cerebrospinal fluid (respiratory alkalosis)."[65pg.141-142]

Symptoms of hyperventilation can include palpitations, shortness of breath, light-headedness, sweating, and syncope.[39] The development of hyperventilation syndrome creates a positive feedback loop that can only be broken in two separate treatment methods.

> "(1) Reduction of respiratory rate, and (2) cognitive reattribution of physical symptoms to hyperventilation instead of other more catastrophic cases. Several intervention methods focusing on these components have been developed: general relaxation training, training in slow and/or abdominal breathing, biofeedback training, auditory regulation, voluntary hyperventilation, and several types of cognitive therapy."[65pg143]

Clinicians dealing with patients with orthopedic or musculoskeletal injuries often have other disorders and dysfunctions that can relate directly or indirectly to the injury being sought for treatment. We as athletic trainers can learn from these different allied health professions and begin to apply some of these methods into our own practice in order to treat each individual as a whole as opposed to one specific injury. Many of us know that injuries are often related to other dysfunctions and compensations found elsewhere in the body and in order to prevent future injury it would behoove us to treat each of these disorders in order to improve the whole patient and in turn, improve patient outcomes.

Diaphragm Training in Orthopedic Rehabilitation

Breathing treatment and training is being used today in the rehabilitation of orthopedic injuries but it is not often discussed in research nor have patient outcome

measures or tools been formulated to determine the effectiveness of these methods. Regardless, current methods should be discussed and the experience of those clinicians using these techniques should be respected as well as the improvements they have made in the overall treatment and care of their patients and patient satisfactions. Physiotherapy currently uses these methods and has had great results in patient satisfaction and observable improvement in patient functions. They discuss how "diaphragmatic breathing remains the foundation of their treatment, but it is no longer the only aspect of their treatment."[4] In the following sections we will discuss the different ways diaphragm training is being used today in regards to the goals clinicians wish to accomplish and according to the different roles the diaphragm plays within the human body.

Improve Breathing Quality. With the diaphragm's main role being in respiration, many who choose to use diaphragm training choose to use it for the purpose of improving their patient's breathing quality. Once an individual's breathing pattern has been determined as dysfunctional or disordered, clinicians can then use diaphragm training techniques to correct those patterns and restore their breathing patterns to more efficient and effective ones.

Chaitow proposes four basic principles necessary in restoring normal energy-efficient and balanced breathing patterns and are listed here: 1) Awareness of faulty breathing patterns, 2) relaxation of the jaw, upper chest, shoulders, and accessory muscles, 3) abdominal/low-chest nose breathing pattern re-education, and 4) awareness of normal breathing rates and rhythms, both at rest and during speech and activity.[10] The first step is recognizing one has a disordered breathing pattern and helping them become aware of their breathing. Once they are aware of the compensatory methods they are

utilizing such as increased accessory respiratory muscle activation, they can then begin to feel when they are using those compensations and learn how to decrease that tension and alter how they breathe. Step three involves them learning how to use the diaphragm and to expand the abdomen while they breathe and in addition, step four focuses on being able to control that new breathing pattern.

As suggested previously by Laurie McLaughlin in "Breathing evaluation and retraining in manual therapy," capnography can be successfully used in healthcare settings outside of the hospital and critical care settings to determine breathing efficiency. It can also be used as a biofeedback measure for patients to improve the effectiveness of their respiration and retrain their disordered breathing. "Testing can be performed in various postures, during concentration, after continuous speaking, and at different breath rates and volumes. Activities or positions that reproduce symptoms can be tested to determine if poor breathing is elicited."[50 Pg 279] Once those certain difficult postures or activities are identified, the capnograph can be used as a biofeedback tool and patients can retrain their breathing using the feedback it provides.

Laurie McLaughlin suggests a breathing retraining method that involves several different phases (Table 1) and targets multiple aspects that affect respiration and effective breathing. In her study "Breathing Evaluation and Retraining as an Adjunct to Manual Therapy" she evaluated 29 outpatients with neck or low back pain and found they had low ETCO2 levels. They applied the method described above in an average of 2 to 15 sessions with each of these patients and found they were able to retrain breathing and improve ETCO2 levels, decrease pain and increase overall function in all patients. She was able to make the connection that the diaphragm and other muscles of respiration also

have postural functions and if one of those roles is failing, the other would be affected.[50] Low back, neck, and sacroiliac joint pain is still a growing problem in a large population of individuals and the possibilities of diaphragm training becoming a tool to help treat these patients is increasing and leads us to our next topic of discussion.

Table 1. Phases of Breathing Intervention

Phases	**Description**
Analysis	Identify symptoms related to poor breathing chemistry Identify triggers (pain, stress, situations, thoughts, emotions, etc.) Identify faulty breathing behaviors (upper chest, no pause between breaths, etc.)
Education	Role altered breathing can play in symptom production Information about their breathing as identified in the analysis What constitutes 'good' breathing What is involved in changing from poor to good breathing
Awareness	What symptoms show up when breathing becomes altered What external situation and internal states (thoughts, emotions) trigger the altered breathing How their breathing mechanics change in response to the triggers How their mechanics are different when they are breathing well
Biofeedback	Capnography to monitor end tidal CO2 and wave form tracking information about breath rate, ratio of inhale to exhale (exhale should take longer), and pattern (should be smooth and rhythmic) Use the information to engage in negative play where faults are exaggerated then minimized to gain awareness and control Home use of a capnography designed for biofeedback can help skill acquisition
Behavior Modification	Modify poor breathing in response to subtler and subtler cues through increased awareness of the symptoms and mechanics of both poor and good breathing Daily practice of good breathing to reinforce new learning
Manual Therapy	If restrictions are identified in the articular or myofascial tissues of the trunk or cervical spine, use manual therapy to free the tightness and provide extensibility If poor motor control is identified in the trunk or cervical spine add an exercise program Postural correction may be required to optimize ventilation mechanics
Time	Many people respond in 5-6 sessions of breathing retraining over the course of a month although more difficult presentations may require more sessions.

Decrease Low Back Pain. A connection in research has been made correlating dysfunctional breathing patterns or disordered breathing with increases in risk of low back pain, sacroiliac joint pain, chronic cervical pain, and incontinence related health problems.[22,23, 25-28] Hodges et al.[66] also concluded that trunk muscle stability, spinal stability, continence and respiration are interrelated. If one has back pain, they are unlikely to stabilize during normal activities using their spinal muscles and instead compensate to avoid pain by using their abdominal muscles, core muscles, and diaphragm.[67] Josephine Key in her article "'The Core': Understanding it, and Retraining Its Dysfunctions" also speaks to this same hypothesis stating that "most people with spino-pelvic pain syndromes generally have relatively low level function and cannot organize the basic elements of 'core control'.[30] If those low levels of function are not corrected and continue to be compromised, back pain can develop.[23] Pain can then affect how we function, move, and even breathe as we develop compensations to move away from that pain. "Altered motor control associated with back and neck pain appears to negatively impact breathing mechanics, which may have negative consequences on respiratory chemistry."[50 Pg. 276] This last comment summarizes this topic well. "If you don't breathe well and posture well, you are more likely to get chronic low back pain and develop incontinience."[30]

The literature not only shows a connection between poor breathing patterns and musculoskeletal pain but it also suggests that this relations may be corrected by the coordination and challenge of trunk muscle activity in order to improve postural control, respiratory dysfunction, and dysfunctions relating to continence.[22,23] "The 'Abdominal Drawing in Maneuver' (ADIM) or "Abdominal Hollowing' is a suggested strategy to

activate the ‘deep muscle corset’ which aims to preferentially recruit the lower transversus while minimally contracting the obliques. Subjects are asked to ‘pull in the lower abdomen’ keeping a ‘neutral spine.’” [30 pg6] If this exercises is performed correctly, the diaphragm is also recruited. Kim, E and Lee H[24] also demonstrated in their research that strengthening exercises of the deep abdominal muscles not only enhanced diaphragmatic function, it increased respiratory volume, and increased lumbar spine stabilization. These exercises involved breath holding measures following inspiration and repeated these exercises for multiple sets and reps for a period of four weeks. In addition, Obayashi H, et al.[68] found that respiratory-muscle exercises helped decrease spinal curvature angles and ultimately straightened the spine leading to increase postural control. Lastly, poor head and neck postures have also been corrected with training and this ultimately facilitated more normal breathing patterns.[69]

With the connection of decreases in spinal and trunk stability and low back pain, there exists a possibility of rehabilitation techniques that focus on either side of the problem and ultimately improve overall function of these patients. The question then remains is, must one decrease back pain in order to improve core, trunk, and spinal stability or must one improve the patient’s overall stability to eventually decrease the back pain? There may be other factors that play a role in this continuum as well that need to be addressed. More research and investigation is needed in order to connect the benefits of diaphragm training to decreasing low back pain, however, a clear connection between the two is has been shown in research, and leads to further inquiry.

Decrease Sacroiliac Joint Pain. Sacroiliac (SI) joint pain has also been a commonly treated musculoskeletal injury that shows a connection with poor breathing

patterns. This joint is an important joint that is designed to keep our pelvis stable and allow for safe load transfer through the pelvis and into the lower extremities.[26 pg. E1] It has also been concluded that impaired kinematics of the diaphragm and pelvic floor are observed in those with SI jt. Pain.

> "Participants with SI joint pain exhibited increase minute ventilation, decreased diaphragmatic excursion, and increase pelvic floor decent, as compared with pain-free subjects. Considerable variation was observed in respiratory patterns. Enhancement of pelvis stability via manual compression through the ilia reversed these differences."[26 Pg.E1]

These changes are due to compensation strategies to avoid pain but still provide stability to the structure by forcing the closer of the pelvis.

O'Sullivan and Beales[27] developed an individualized motor learning treatment program for subjects (Figure 1) who expressed SI joint pain. Following the intervention, they were able to show improvements in diaphragm kinematics and pelvic floor efficiency during active straight leg raise (ASLR) tests. "An inability to consciously elevate the pelvic floor pre-treatment was revered. These changes were associated with improvement in pain and disability scores."[27 pg.1]

"Breathing pattern disorders could be a risk factor for the development of the dysfunction, a result of the dysfunction itself, and an important, clinically measurably attribute to consider in those with musculoskeletal pain."[46] Regardless of the cause for the dysfunction, diaphragm training has been shown to improve these dysfunctions and reduce pain with normal activities. Research should continue to investigate the possibilities of diaphragm training and the treatment of individuals with musculoskeletal pain such as in the low back, neck, and SI joint. Once these dysfunctions are controlled,

clinicians can then move forward with objectives and goals to improve daily function and later performance in these individuals.

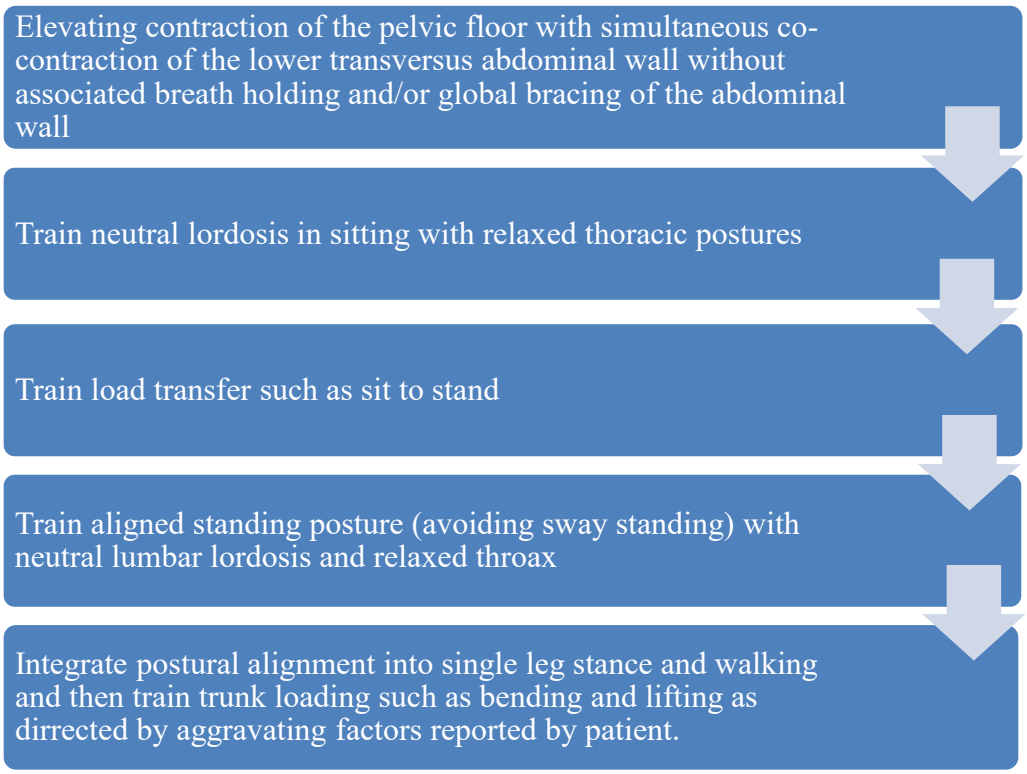

Figure 1. Components of the Motor Learning Intervention Flowchart from O'Sullivan PB, Beales DJ. Changes in pelvic floor and diaphragm kinematics and respiratory patterns in subjects with sacroiliac joint pain following a motor learning intervention: a case series. *Manual Ther.* 2007;12(3):209-218. doi:10.1016/j.math.2006.06.006.

Improve Performance. Improving performance is a goal many clinicians have when dealing with the physically active population. Many of those physically active individuals even seek us out in order to improve their performance levels on the field, court, or gym. For them, improving their mobility, stability, strength, and movement is crucial to continue to do what it is they love. For athletic trainers and other clinicians working with these populations, our treatment goals and objectives revolve around these

measures and current literature and experts today are using diaphragm training techniques in order to achieve these patient outcomes.

Improve Mobility. Diaphragm training and breathing re-training is being used today in orthopedic rehabilitation for the goal of improving mobility. Though this is not a role of the diaphragm specifically, it is indirectly affected by respiration and diaphragm movement. Decreases in range of motion and mobility have been shown in individuals who suffer from breathing pattern disorders. One author specifically discusses how our organ tissues and fascia can become restricted and adhesions can form that affect our overall movement. "A change in the breathing pattern and thoracic breath (chest breathing) can result in stagnation of the organs and fascia. As well as thinking about the connective tissue that surrounds every single muscle fibre, muscle fibre bundle, and muscle group."[39 pg 22] Our fascia, which spreads to every inch of our bodies and connects our muscles, bones, tendons, and skin, if restricted, can affect our movement patterns and ultimately performance if left untreated.

Gray Cook[70] discusses not how breathing can affect soft tissue restrictions but instead, how those restrictions and adhesions can affect our breathing. He also discusses the importance of evaluating and monitoring one's breathing pattern during movement correction or rehabilitation exercises and being able to observe changes that occur and correct those changes as well before they become habit.

> "When we stretch, compress, foam roll or bend the stiffest and tightest parts, we tend to breathe poorly. We tense, and our breathing becomes shallow and even faster in some cases. We show our stress in our breathing, and this actually increases our tension and makes the mobility work ineffective or even counterproductive. Be very aware of this. We know better and still make this mistake, so don't expect clients and patients to not slip into stress breathing – continuously observe and remind them of this."[70 pg265]

He teaches clinicians to instruct their patients to perform slow steady breaths. Making sure they are inhaling and exhaling on a one-to-three ratio during their exercises. Once they are able to perform that breathing pattern effectively during that exercise, he increases the demand of that exercise by either changing the posture, adding load to the exercise, or increasing the movement challenge. He again, evaluates the breathing pattern to ensure no changes or compensations have been made. Expressing that mobility exercises do not have high metabolic demands and so do not require increased respiratory needs. Breathing should be relaxed and natural. If changes have occurred or compensations have developed, he addresses those changes prior to increasing the demand and progressing the exercise. "Some will breathe too fast and some will hold their breath. The long exhale ratio is a guide to coach relaxation."[70 pg.265]

We must also think about fascia restrictions and how they can affect our breathing and breathing patterns. As discussed previously, the diaphragm is part of the Deep Front Fascial Line and these fascial sheaths surround the lungs and diaphragm. Any restrictions found within in these structures can affect one's ability to breathe effectively. Thomas Meyer in his text "Anatomy Trains" describes how a shortening of the Deep Front Fascial Line can restrict full hip extension as well as "produce an overall shortening in the body, encourage collapse in the pelvic and spinal core, and lay the groundwork for negative compensatory adjustments in all other fascial lines."[36 pg.185] Restrictions and muscular tension found within these structures must also be addressed. A few techniques have been used to improve these restrictions such as myofascial release, manual therapy, massage, rib mobilization, thoracic spine mobilization, and others.

Increase Trunk and Core Stability. "The importance of an efficient and stable core is promoted by most physical therapists, athletic trainers, and coaches despite the paucity of studies supporting its efficacy. Core stability is presently a theoretic concept that is becoming more popular as experience authenticates its benefits."53 The "core" is still being determined and defined within literature. What we do know is that the muscles of the abdomen, diaphragm, spine, and pelvic floor co-contract and work together to provide individuals with trunk stability. Bliss, L and Teeple, T list the muscles responsible for the creation of 'the core: 1) anteriorly are the abdominals, 2) posteriorly are the paraspinals and gluteals, 3) the pelvic floor musculature is positioned inferiorly, 4) hip abductors and rotators make up the lateral aspect of the core, and 5) the diaphragm is positioned in the superior aspect of the core.

Core control is defined as "the ability to generate optimal intra-abdominal pressure to support both breathing and the provision of three dimensional postural and movement control of the torso – particularly control of the pelvis on the legs."[30 pg7] Breathing is affected by the core's ability to effectively generate pressure as well as help to stabilize the body. These roles of the core can also be affected by poor breathing patters. This creates a teeter-totter affect where one can positively or negatively affect the other. Breathing pattern disorders and lack of efficiency of the diaphragm can compromise the diaphragm's ability "to create the fine tuning adjustment required for postural support.[31 pg 80] This connection between the core and the diaphragm leads to the necessity of training both the diaphragm and the core to function properly in order to improve the effectiveness of the other.

Different techniques are used to train or enhance the abdominal musculature and diaphragm as it pertains to core and trunk stability. “Diaphragmatic breathing is also an essential component of training the core musculature as the diaphragm is the roof of the core. The athlete is taught to breathe with the diaphragm rather than the accessory muscles of the upper rib cage.”[53 pg182] Key J[30] describes, in detail, an exhalation exercise she uses for training the diaphragm and core to produce a stable and neutral pelvis. This then positions the diaphragm in the optimal location for effective diaphragmatic breathing.

> “The best way to initially activate the anterior lateral abdominal wall, in particular transversus, is through improving active exhalation to bring the thorax caudally on a stable pelvic. Initially the client may need assistance with this. He then has to learn to maintain this more ‘neutral’ position through anterior-lateral abdominal wall activation while also breathing down not up! And then further. To be able to maintain the above while generating sustained lower pelvic unit activity and intra-abdominal pressure with regular basal breathing pattern – in particular a more extended exhalation.”[30 pg9]

By continuing these exercises, they will then develop endurance and a capacity to support stabilizing synergy. This activity is then further progressed to unsupported lower limbs. From there, these exercises are repeated in a seated position, focusing on abdominal breathing; pushing forward and out sideways. Lastly, loads can be added to the system to challenge the patient’s ability to control stability with their breath by adding limb movements and overall body movement patterns. Other training methods suggested by Bliss, L Teeple P[53] is to first train the athlete to stabilize the lumbopelvic region using isometric exercises such as prone bridge, lateral bridge, star excursion test, trunk flexor endurance test and trunk extensor endurance test. Then are then progressed by adding strengthening exercises such as curl-ups, side bridges and bird-dogs. These are first performed on the ground, then progressed to positions of function, less stable base of

support, and by the addition of movements in all planes of motion. Once these progressions are made, clinicians can then transition into proprioceptive training and lastly plyometrics. Many other have developed their own training methods and techniques concerning the diaphragm and it ability to improve core and trunk stability. Many of these are not tested by evidence and are used in practice today based on clinician experience and personally observed outcomes. More evidence and research is required to evaluate these training methods to determine effectiveness and means of application in rehabilitation.

Decrease Muscular Tension. Diaphragmatic breathing exercises have been shown to decrease muscle tension in accessory respiratory muscles. These include those muscles of the neck, upper chest, and shoulder. Individuals who display mouth breathing patterns as opposed to nasal breathing patterns display an increased level of activity with accessory inspiratory muscles and in addition to inactivity of the diaphragm, due to a lack of synergy with abdominal muscles, develop hypertrophy in those muscles.[71] Hruska[71] proposes that the existence of thoracic (chest) breathing results in an increase tension and hypertonicity of accessory breathing muscles, can prevent the diaphragm from returning to its optimum position and decrease breathing efficiency. After introducing naso-diaphragmatic breathing exercises to a physical therapy program that consisted of muscular stretching and strengthening exercises they were able to decrease electromyographic activity of accessory respiratory muscles (sternocleidomastoid, sub-occipitals, and upper trapezius) in those mouth and chest breathing subjects. The electromyographic activity of these muscles, following the treatment program, reached levels similar to those found in quiet breathing positions.

> "These findings can be a result of better postural alignment, specifically regarding the head forward posture, and an adequate respiratory pattern with less participation of inspiratory assessor muscles obtained with the treatment. Moreover, the improvement on the muscular balance seems to contribute for a reduction of the recruitment of cervical muscles in these children during nasal inspriatation."[71 pg1342]

They also suggest postural training for these individuals to help correct forward head postures which can also lead to overuse and increase muscular tension of respiratory and cervical musculature.[71]

Improve Movement. Breathing pattern disorders have been shown to be prevalent in individuals whom suffer from musculoskeletal dysfunction.[23,25,28,72] Breathing and movement must be able to work efficiently together in order to perform at our highest potential. If even one of these becomes dysfunctional, injury rates increase, pain occurs, and compensations become repeated patterns of movement. By correcting these compensatory patterns in our breathing and movement, we can re-train the body to move and breathe efficiently again together and train our patients to perform at higher levels than they could before.

> "Breathing is our most fundamental motor pattern. At birth we have an abdominal breathing pattern – where diaphragm descent creates a negative intra-thoracic pressure drawing air into the lungs. To 'get up' against gravity we need to develop postural control – the underlying platform supporting all our movements. In the developmental sequence, breathing becomes integrated into our evolving patterns of posturo-movement control. Breathing and postural control are inextricably linked – each supports the other."[30 pg3]

The muscles of the trunk and core (including the diaphragm) act as one unit at the center of functional kinetic chains.[73] This stable trunk allows for force production and transfer between the different segments of the body and is essential for proper movement patterns. The diaphragm's role in the creation of intra-abdominal pressure and structural roles due to its attachments points must work efficiently in order to provide the stability

needed for these force transfers. Found that "inefficient breathing could results in muscular imbalance, motor control alterations, and physiological adaptations that are capable of modifying movement."[46 pg28] There results showed that movement scores, using the Functional Movement Screen as their functional assessment tool, were significantly higher among diaphragmatic breathers than thoracic breathers. They also found that 87.5% of participants who scored higher than 14 on their FMS were classified as diaphragmatic breathers. "These results demonstrate the importance of diaphragmatic breathing on functional movement."[46 pg34] This research adds to the importance of diaphragm evaluation and training within rehabilitation. If one wants to improve movement in their patients, they also need to improve their breathing patterns and quality and understand the strong connection the two have on each other.

Conclusion

According to Laurie McLaughlin in "Breathing Evaluation and Retraining in Manual Therapy" Breathing evaluation and retraining "has proven to be a valuable adjunct to manual therapy approaches in management of musculoskeletal problems." However, other researchers are calling other healthcare professionals to begin assessing breathing patterns in our overall patient assessments and to begin treating these disorders. Breathing instruction and treatment is commonly delivered in treatment as an afterthought, and perhaps it should not be.[30]

> "Routine assessment of athlete's breath in treating injury and postural dysfunction does not seem to happen, despite its significant role in the body and performance. Perhaps we need to develop a specific interest in the role of the breath and its

> relationship to the thorax, abdomen and pelvis, rather than just pass by it with a perfunctory glance and modest assessment of the movements of the rib cage, stomach and shoulders. By learning to spend time with every athlete in our care, exploring their breath, we are opening up a whole new world of possibilities with respect to their health and performance."[39 pg24]

The following section will discuss the methodology and procedural methods used throughout this investigation. Detailed explanations for data collection, analysis, and verification will also be included as well as a detailed description of the phenomenon and the participants interviewed for the project.

METHODOLOGY

Research Design

Miles, Huberman, and Saldana explain the main purpose and significance of qualitative research as a way to describe and explain human processes and to help the researcher go beyond initial perceptions in order to construct conceptual frameworks that can be used to describe how we influence the world in which we live.[74] "The main task is to describe the ways people in particular settings come to understand, account for, take action, and otherwise manage their day-to-day situations."[74 pg9] The qualitative approach utilizes different empirical materials and approaches in order to investigate and understand different problems observed in the human sciences. "This means that qualitative researchers study things in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings people bring to them."[75 pg2]

I chose to use the qualitative research method for this investigation due to its strengths and the type of data produced. Ragin C in 1987[76] describes how quantitative analysis often revolves around working with few variables with many cases. It seeks to ask *why* and looks to compare different groups whereas qualitative research focuses on the *how* or *what*. "Qualitative data, with their emphasis on people's lived experiences, are fundamentally well suited for locating the meanings people place on events, processes, and structures of their lives and for connecting these meanings to the social world around them."[74 pg11] I seek to explore a topic that has no clear variables. There are no theories to explain the problem being investigated. I wish to describe, in detail, the essence of a particular phenomenon and how it impacts the experiences and choices made by athletic

trainers on a daily basis. This was my reason and purpose for choosing to design a qualitative research study and to investigate the use of diaphragm training as a tool for rehabilitation.

Qualitative Perspective. The phenomenological approach attempts to study a problem by having the investigator within the field and perception of its participants in order to study, experience, and find the meaning of the phenomenon through the perspectives and experiences of the participants.[77] The purpose of this study was to understand the rationale for the use of diaphragm training as a rehabilitation tool, how each clinician learns these techniques, and which techniques they chose to employ with different patients in different types of situations. In order to fully describe clinician's perceptions, clinical decision making process, and understanding of these tools and techniques, one must understand and appreciate each clinician's thought process and surrounding environment. Describing, in detail, their own experiences and how they apply that knowledge in their particular settings is vital to understanding this phenomenon. The phenomenological approach was chosen due to its strengths in providing this type of data and due to its investigative procedures that allows for the researcher to enter into the view of its participants and produce detailed explanations of their experiences.

Researcher's Role. My role as the researcher starts with my own past experiences with the topic of diaphragm training. As a student in my undergraduate education, I began to see different preceptors and clinicians using different methods and techniques in order to improve the effectiveness and efficiency of the diaphragm. These were topics that were not discussed in my formal education and I wished to understand more about

these practices and their purpose in rehabilitation. I began to ask these questions during my observations of different clinicians who utilized these tools:

- Where did they learn these techniques?
- What is their reasoning for utilizing these tools?
- How do they decide when a patient needs or does not need this type of training?
- When in a patient's rehabilitation process do they chose to use these methods?

It was this curiosity that led me to do my own research and study of the topics. I quickly found that research on these techniques with injury rehabilitation was not extensive and those methods had not been measured or studied in comparison to patient outcomes. With no clear variables or starting point regarding the research, I set out to understand what I had observed concerning this phenomenon. I had seen a few clinicians use these techniques and I desired to know why.

Understanding my role as the researcher, I had to proceed with caution concerning my own biases and perceived understanding of the phenomenon I sought to investigate. Being self-aware or modeling reflexivity is an important aspect to qualitative research. This means that the writer is conscious of his or her biases, values, and experiences that are brought to a qualitative research study.[78] Once I identified my own biases and perspectives regarding diaphragm training, I was able to set those aside and move forward with developing the research questions described earlier and the methods for collecting and analyzing the data.

Methods Used

Participant Access. "In a phenomenological study, the participants… must be individuals who have experienced the phenomenon being explored and can articulate their conscious experiences."[79 pg111] Subjects were chosen through a criterion sampling method in which all subjects were athletic trainers who worked in the Southwest Missouri Area in either rehabilitation clinics or the collegiate or university setting. The location of subjects was chosen due to convenience and knowledge of individuals who have utilized diaphragm training. Permissions from Missouri State University's Institutional Review Board were obtained (Appendix A: Aug 17,2015) prior to gaining access to the individuals who would volunteer to become participants. Known athletic trainers working within this area were contacted via e-mail and were requested to volunteer for a research investigation involving a one-on-one interview concerning the use of diaphragm training as a method for rehabilitation. After the first attempt of contact was performed, those contacted were asked to pass the request for research participants to others within the area they knew who met the prerequisite criteria. The factors that excluded participants from volunteering in this investigation were if the athletic trainer was not currently or has not had experience working in the clinical rehabilitation, collegiate or university setting. All participants required to hold current state licensure and national certification as an athletic trainer.

Consent Procedures. An informed consent document was sent to each clinician contacted explaining the purpose of the study, research procedures, benefits and risks involved. This document also included statements addressing each participant's right to voluntarily withdraw from the study at any time, verification to protect all personal

information, as well as provide them a place to sign and date the form (Appendix B). Subjects, whom willingly volunteered to be participants for the research study, were asked to bring the consent form with them to their interview. Each interview began with a re-reading of the consent document prior to the recording of the interview and verbal consent for recording was also obtained as the first step in each interview conducted.

Data Collection Procedures. Creswell[79] explains that qualitative research involves the use and collection of empirical materials. These include things such as case study, personal experiences, observed behaviors, visual texts, and interviews. "For a phenomenological study, the process of collecting information involves primarily in-depth interviews."[79 pg122] One-on-one interviews were chosen as the primary method of data collection due to their many advantages. These types of interviews allow for long open ended answers and a chance for each participant to express their perspectives fully and provide them the opportunity to entirely describe the phenomenon as they have experienced it, within their clinical setting. One challenge to in-depth interviews is experiencing a hesitant or shy participant who may be less articulate and lack the ability to provide adequate information to clearly express their perspectives or experiences. An attempt to control for this challenge was made by providing each participant the opportunity to choose their location for the interview that was familiar to them and was secluded from distractions and other individuals whom may pass by or influence the subject's answers. Another challenge to qualitative data collection relating to in-depth interviews regards the time and energy required to conduct the interview and collect the responses of multiple subjects. Each interview was recorded using two tape recording devices to control for malfunction of the devices. A trial interview was conducted with a

committee member, whom also met the inclusion criteria, and another whom did not, to eliminate other field issues when gathering data. This determined the amount of time required to perform each interview and allowed me to practice reading through the research questions and the utilization of the recording devices.

Interview questions were developed by myself and were evaluated by committee members and other peers to determine presence of bias, clarity, and effectiveness for the questions to collect the data required to answer research questions. Demographic questions (Appendix C) were also developed to determine inclusion criteria of each participant and to provide basic information that describes the work experience of the clinician, types of patients they treat, and years of experience as an athletic trainer.

Each of the interview questions (Appendix D) were written with the purpose of answering one of the three research questions developed, in order to explore and describe the phenomenon being studied. The first research question states: what are clinicians' perspectives and rationale for incorporating (or not incorporating) diaphragm training and evaluation as a therapeutic tool for the rehabilitation of musculoskeletal injuries? Question three in the interview directly asks this question. However, more detailed answers and explanations were also gathered and used to describe their perspectives and rationale for the use of diaphragm training as a rehabilitation tool using questions one, four, five, nine, ten, and eleven. By asking each clinician's perception of the roles and purpose of the diaphragm and which roles they choose to target, helped describe what their rationales were for the purpose of diaphragm training and what outcomes they wished to obtain with their approach to rehabilitation. Question six, asking for perceived risks and challenges to diaphragm training, also explained possible reasons for not

incorporating these methods with certain patients or in certain situations. These responses provided further explanations concerning the phenomenon being studied and what each clinician experiences in their unique setting.

My second research question was answered and described by each participant by collecting responses to questions 12-17. These questions asked the subjects to describe the exact modes and locations for gaining their knowledge in these methods and their purpose for patient rehabilitation. Questions 18-20 ask for these same types of responses but in an indirect way to help gain a broader picture of the phenomenon and how the clinicians within this area are gaining their knowledge and perspective of this topic.

Lastly, questions two, seven, and eight directly relate to the third research question which asks what types of diaphragm training methods or techniques are clinicians utilizing during patient rehabilitation? First, they ask if they are utilizing these methods, then it asks what specific methods they are using in their practice, and third, it asks if they are using evaluation methods on their patients to determine the need for diaphragm training and what specific methods those are. In all, asking each clinician how they gained their knowledge on this topic, their justification for using these methods, and what particular methods they choose to use, we felt, would clearly describe the phenomenon of diaphragm training and its use and purpose as a rehabilitation tool for Athletic Trainers.

Interviews were ceased when data became saturated and common responses between participants to interview questions began to emerge. Dukes (1984)[80] recommends studying 3 to 10 subjects for in-depth interviews regarding phenomenological studies. According to Creswell[79] 10 subjects within a qualitative study design is a reasonable size. 13 subjects in total were interviewed in the collection of this

data and all interviews were used in writing the results and describing the phenomenon being investigated. Following each interview, responses were transcribed verbatim and saved in password protected files for future analysis. Tapes were then erased to destroy evidence and personal identifying information linking each participant with their interview responses.

Data Analysis Procedures. In qualitative research analysis "the researcher attempts to capture data on the perspectives of local participants from the inside through a process of deep attentiveness, of empathetic understanding, and of suspending or bracketing preconceptions about the topics under discussion."[74 pg9] Each qualitative tradition of inquiry approaches data analysis in its own unique way. These different forms of analysis are utilized in order to investigate the type of research questions formatted and to interpret the different types of empirical materials that are utilized in each. "Phenomenological data analysis proceeds through the methodology of reduction, the analysis of specific statements and themes, and a search for all possible meanings."[79 pg52] The method of analyzing qualitative data focuses around three main phases: data condensation, data display, and conclusion drawing/verification. The analysis procedure first, focuses around the condensation of data, in order to strengthen and clearly present the expressions of the subjects in an understandable and summarized format. "Data condensation refers to the process of selecting, focusing, simplifying, abstracting, and/or transforming the data that appear in the full corpus of written-up field notes, interview transcripts, documents, and other empirical materials."[74 pg12] The data is then displayed or illustrated in a way that is accessible to the reader and is presented in a design that is compact but encompassing. Lastly, the third aspect of data analysis involves drawing

conclusions and verifying the authenticity of the interpretations made by the researcher. Often, however, all three of these steps are conducted simultaneously as the data is analyzed. Often as data is condensed, new ideas are formed on how the data should be displayed which then requires further data condensation. Also, preliminary conclusions are often drawn in order to add additional descriptions to the data display, which then further examines possible conclusions to be drawn.

The methodology of data analysis used within this qualitative research reflects a phenomenological analysis methodology developed by Colaizzi[81] and later described by Riemen[77]. The procedural steps are described below.

1. Interview responses were recorded for each subject using two tape recording devices to control for malfunction or in case the recording devices did not work properly and all raw data were transcribed verbatim.

2. Every response given by the participants were read and reread in order to attain the meaning of the relayed message and perceptions of the clinicians.

3. The significant sentences, phrases, and statements that directly pertained to the phenomenon being investigated were extracted from each response. Responses containing similar statements or repeated ideals between subjects were eliminated.

4. Meanings for each statement were determined and themes were formulated.

5. Themes were then clustered and organized, according to their meaning, to allow for common themes regarding participant's perspectives and ideals to develop.

    a. Each developed cluster was then validated to determine if all original responses expressed were accounted for in each theme and that no newly proposed ideals or interpretations were added to the original expressed experiences of the subjects.

    b. If any discrepancies or contradictions were found between the clusters of themes and the original transcribed data, then further referencing and rereading of the original data was performed for additional clarity and understanding of the proposed ideals described in the subject's interview responses.

6. Through the condensations of the data into clustered themes, an exhaustive description of the phenomenon was developed.

7. Each research question was analyzed using these same procedures.

8. A final validation of the condensed data was attained by returning to five of the participants and verifying with them that the formulated and perceived themes matched their original described experiences and perspectives of the phenomenon. The subjects expressed that the described condensed results contained the essence of their perspectives and understanding of the studied phenomenon.

9. An exhaustive description of the phenomenon was formed into illustrated diagrams and tables to be presented to readers in a condensed and uncomplicated arrangement.

Verification of Data. An important process to any research investigation is the determination of validity, measure of trustworthiness of the results, and validation that what was investigated and described in the results was accurate and without bias. Often we define these terms as validity and reliability. However, Shenton[82] explains how these cannot be addressed in the same manner within qualitative research or naturalistic investigation. Guba[83] sought to use different terminology to describe these constructs within qualitative investigation and since has been accepted by many qualitative researchers. The qualitative terms credibility, transferability, dependability, and confirmability are used in comparison to the quantitative terms internal validity, external validity (generalizability), reliability, and objectivity.

According to Merriam, credibility pursues to answer the question, "How congruent are the findings with reality?"[84] The use of established research methods, familiarizing oneself with the culture of the phenomenon and the participants being investigated prior to the investigation, the use of random sampling, adopting procedures of triangulation, ensuring honesty of participants during data collection, having peers validate the research

process and conclusions, participating in member checks, using an experienced qualitative investigator, and the comparison of findings with previous research to determine congruency of results to already established research are all examples of provisions qualitative researchers can take in order to meet this first criteria.[82]

Many of these provisions were utilized throughout this investigation in order to support the credibility of the research findings. I was already familiar with the phenomenon and had a working knowledge of the participants who used these techniques and their basic perspectives for its purpose in rehabilitation. The utilization of established methods such as using peer review and member checks to determine the validity, quality, and effectiveness of the interview questions and the analysis of data also increased the credibility of the research design itself. These methods provided an external check to the research process. Creswell[79] describes a peer reviewer as "an individual who keeps the researcher honest; asks hard questions about methods, meanings and interpretations; and provides the researcher with the opportunity for catharsis by sympathetically listening to the researcher's feelings."[pg202] Member check are also critical tools for establishing credibility to qualitative research. This step involves the participants in the validation process by providing them with the results and conclusions collected in the study and allowing them to judge the accuracy of those findings themselves.[79] Strengthening the interpretations determined by the researcher. Lastly, an extensive literature review was performed prior to the conduction of the one-on-one interviews and was referred and compared to the results throughout the research and writing processes.

External validity is a difficult construct for qualitative research. Shenton[82] explains that "since the findings of a qualitative project are specific to a small number of particular

environments and individuals, it is impossible to demonstrate that the findings and conclusions are applicable to other situations and populations."[pg 69] However, if other researchers believe their situations to be relatable to that which was previously investigated, they should be able to relate their own findings to that of the previous. This construct refers to transferability. Transferability requires each researcher to provide a detailed and sufficient contextual report of their participants and the environment in which they were observed. This provides others a means of generalizability. The researcher must also provide a detailed description of the phenomenon they are investigating to allow for comparison for others who wish to investigate a similar phenomenon. I was dedicated to diligently providing readers and other investigators with as much detailed information as possible concerning those I investigated and the environments and settings in which they perform these techniques. Much explanation was also given to describe the phenomenon, in which I examined, so as to paint a clear and precise picture of my research questions and rationale for taking on this project. However, Shenton[82] explains that "ultimately, the results of a qualitative study must be understood within the context of the particular characteristics of the organization and, perhaps, geographical area in which the fieldwork was carried out."[pg70]

The last two constructs of data verification are dependability and confirmability. For a research investigation to be repeatable, one must know a detailed description of the processes and procedures taken to produce the obtained findings. These detailed reports enables other researchers the ability to repeat the same investigations and produce similar results.[82] Dependability is obtained through these steps in the research process. The research design used and implementation of its procedures are clearly listed and

described within the methods section of this report so as to allow others to reproduce the investigation and add to future research.

"The concept of confirmability is the qualitative investigator's comparable concern to objectivity. Here steps must be taken to help ensure as far as possible that the work's findings are the result of the experiences and ideas of the informants, rather than the characteristics and preferences of the researcher."[82 pg72] This involves the self-reflection of the investigator and the admittance of biases and preconceived perceptions regarding the phenomenon and participants being investigated. Providing the readers with the ongoing reflection of the primary investigator and relaying of perspectives and biases allows for others to determine if the results were the work of the researchers understanding or the experiences and sentiments of those investigated. Throughout the report I express a reflective commentary of my findings and how I came to each of the conclusions discussed later in this written work. The goal of adding these procedures was to confirm the validity of the results and to ensure their reality.

RESEARCH FINDINGS

The purpose of this chapter is to describe and display the findings collected during this investigation. While I do have my own biases and interpretations of the data as well as prior perceptions concerning this topic and experience with many of the participants interviewed during this investigation, the information presented below are from the participants without any external explanation or input. After examining these findings, a description of the studied phenomenon was established. The goal of this chapter is to discuss the phenomenon of diaphragm training as a rehabilitation tool by athletic trainers currently working in the field today.

Research Question One

What are clinicians' perspectives and rationale for incorporating (or not incorporating) diaphragm training and evaluation as a therapeutic tool for the rehabilitation of musculoskeletal injuries?

Clinician's perspectives and rationale for incorporating diaphragm training varied between the subjects and each clinician expressed a slightly different purpose for using these training methods. Three main themes for the use of diaphragm training expressed by participants were 1) to enhance performance, 2) restore breathing patterns, and 3) to restore proper tension thresholds within the body.

Interview questions nine, ten, and eleven in the interview specifically asked each clinician what roles and purpose they understood the diaphragm to have and if they chose to target those specific roles when performing diaphragm training. Six main

roles/purposes for the diaphragm emerged within the data expressed by the athletic trainers. These include: respiration, stability/posture, mobility/range of motion, strength, movement, and gastrointestinal function. Overwhelmingly, the diaphragm's role was discussed by participants. "I think first and foremost of it as a muscle of respiration," and "it is there to help you breathe" were common responses among the different participants. One such response expressed the diaphragm as a having a key role in the exchange of oxygen involved in breathing and how this process affects their ability to perform. "The efficiency when you're taking in O2 and how your body is able to do that affects your performance. Your physical performance, especially cardiovascular and any kind of sprints or just physical exercise in general, is going to affect just about any form of physical activity." This individual also goes on to express other forms of physical performance that can be affected by the efficiency of one's respiration such as weight lifting, cardiovascular fitness, sprinting, and any other kind of exercise. While respiration was described as its main function, but the other five functions were often described between subjects.

Stability and posture were described by over half of the subjects as being one of the main roles the diaphragm plays within the human body. It was often described as a "local stabilizer" or playing a major role in "reflexive stabilization." One participant explained how the diaphragm attaches to over 50 different muscles within the body and how that factors into its ability to sense changes in posture and positioning of the body. Some described it synonymously with the "inner core," while another described how the diaphragm's connection with respiration provides neurological feedback to the brain and its effect on stability. "Diaphragmatic breathing, it allows, it triggers your body and your

brain to stabilize on a reflexive level form the inside out. If you can stabilize from the inside out, it allows everything else to work more efficiently."

These last four roles, mobility, movement, strength and gastrointestinal function were not expressed in the participant's descriptions as often but were still noted as common themes between subjects. The diaphragm was described as "playing a role with shoulder mobility," and how one's range of motion, in general, can be affected if the diaphragm is not functioning properly. The diaphragm was also tied to one's strength and how strength can decrease as the function of the diaphragm decreases. The diaphragm's role in movement related, again, back to its role in stability and how energy can be transmitted through the body with the proper rigidity of the core and how this allows for improved changing of direction. The diaphragm was also described, simply, as playing a role in how we move. Lastly, one participant mentioned that in her past experience, she noted that some of her patients described that their gastrointestinal motility increased when she had them perform diaphragm training methods either in the clinic or at home. Through this experience, she believes that the diaphragm can play a role in digestion and the motility of that system.

As stated before, the main purpose for diaphragm training as a tool used in rehabilitation was to enhance the roles of the diaphragm and improve its efficiency within those different roles. As the interviews continued, even though the diaphragm was described as having many purposes within the body, only three main reasons for using diaphragm training as a rehabilitation tool were expressed: to enhance performance, restore breathing patterns, and to restore proper tension thresholds within the body. It was to address these three purposes that clinicians chose to use these types of training

methods in their rehabilitation procedures and treatment plans. Within these three main purposes, minor themes were also noted as rationale for diaphragm training (Figure 2).

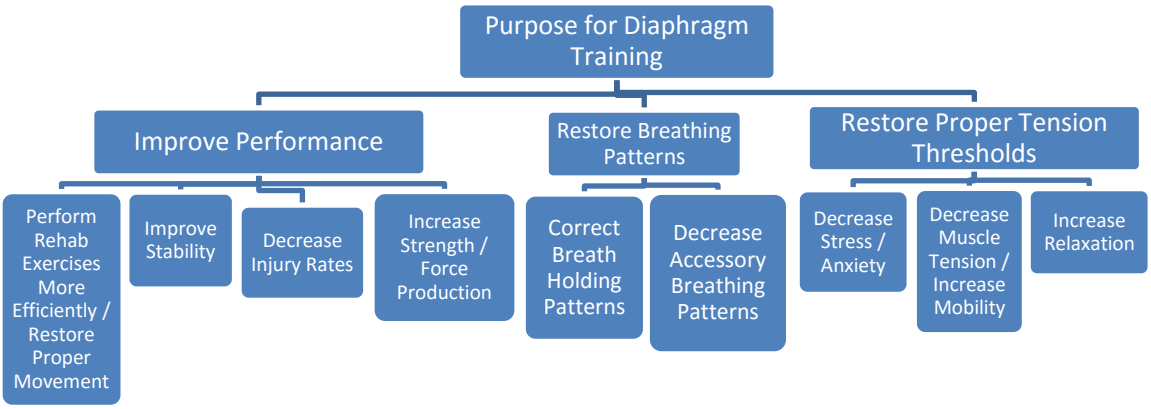

Figure 2. Research Question One Major and Minor Theme Development Flowchart.

Many clinicians chose to use diaphragm training techniques in order to improve the performance levels of their patients or to improve function. These techniques were often used in rehabilitation in order to improve their patient's ability to perform rehabilitation exercises and/or to restore proper movement techniques. One participant stated that it "promotes the proper use of the musculature," while another discussed how it allows for "a reengagement of deep abdominal muscles that often times can get lazy because it's just not getting engaged." Seeing their movement improve as well as their breathing patterns improve while they move was an expressed benefit to using these techniques and a primary motivation to incorporate diaphragm training within rehabilitation for many of the clinicians interviewed. Clinicians looking to improve performance also explained how their patients were able to progress through rehabilitation exercises with more

control and more fluid movement patterns after incorporating some of these techniques. "With time I think you keep seeing that progression and that they're doing high level activities but they're still able to maintain a normal breath and respiration rate." Lastly, a few clinicians expressed they would use these techniques with every patient in every treatment and how the benefits to using these methods far outweighed other techniques they have used in their previous experience.

Another minor theme expressed by clinicians was the noted improvements in their patient's stability when performing exercises. One clinician used diaphragm training to improve one's reflexive stability while another stated that it provides their patients with a base to develop enhanced core stability. "Once you get them into that diaphragmatic breathing, they report that the exercises feel better and that they report more stability," was a response expressed by an Athletic Trainer working in the collegiate setting. Seeing these improvements in stability led several clinicians to using these techniques more frequently in their protocols with the overall goal to improve performance and function for their patients.

The last two minor themes noted by the interviewed participants were decreases in injury rates and an increase in measured strength and force production. It was often mentioned by clinicians that they chose to use these methods with weight lifting and strength training because of an increase in their ability to exert force was witnessed. One participant stated that "once an athlete learns how to breathe correctly they can actually do more weight and progress better." Other participants stated they preferred to teach these techniques in the weight room to prepare their patients to lift properly and to teach them how and when to breathe in order to produce optimal force production. By using

these techniques and preparing their patients for weight lifting and other physical activities one participant expressed that she saw fewer injuries in the lower back and neck regions because they were no longer straining those areas to lift heavy weight and produce increase levels of force. Even though many of those interviewed expressed their rationale for using these techniques was to improve performance, it was often noted in their explanations that if they restored their breathing patterns or if they helped teach their patients when to breathe and how to breathe diaphragmatically that it became easier for them to move properly, develop more reflexive stability, and produce more force. These responses appeared to revolve around the second major purpose and rationale for using diaphragm training as a rehabilitative tool and that is to restore breathing patterns.

One participant stated in their interview that diaphragm training "teaches people how to breathe correctly." This statement says it all when it comes to the purpose for using diaphragm training as a treatment tool for athletic trainers. "Trying to train the diaphragm to breathe properly," or "to correct faulty breathing," were other responses given for diaphragm training's place in the rehabilitation world. The goals noted were to teach and train patients to breathe abdominally or diaphragmatically in order to reduce the use and strain of accessory muscles with respiration. Breathe holding and chest breathing were also faulty respiration patterns that clinicians noted that led them to want to train the diaphragm to work more efficiently. "The benefit mainly is that I'm seeing them breathe regularly and consistency through the abdomen or diaphragm area and not this more chest or shoulder breathing." Another participant explained "the other time that I see it, or definitely implement it, is when I, in an initial assessment, I'm just able to pick up they have a disordered breathing pattern." These responses expressed how these

clinicians would note an inefficiency with the diaphragm, in its role in respiration, and decision to target that disorganization within their breath to improve overall function. In the end, one clinician said it best. "It's to get more oxygen to the body."

In order to restore those proper breathing patterns, many noted the challenge they had to overcome was dealing with a patient who suffered from a high tension threshold. These patients were often described as those who excessively used their upper trapezius, thoracic accessory breathing muscles, and cervical musculature in order to breathe. Even when in a relaxed position or environment these patients would assume an expression of increased muscular tension with normal natural breathing. Many of the clinicians interviewed stated they would use diaphragm training as a means to teach these patients how to breathe properly by decreasing their muscular tension and increase the mobility of the abdomen and diaphragm musculature to allow for diaphragmatic breathing to occur. One participant stated that "one benefit is to decrease tension and help patients relax." By using these techniques another clinician stated that they were able to "decrease upper trap usage/tension during breathing." Again, one clinician explains this purpose for diaphragm training completely. "To help them breathe without using accessory muscles, back muscles, and shoulder muscles. Getting people to have a more natural breath whenever they initiate breathing rather than a high tension, high threshold type breathing." By using these techniques to decrease muscular tension, clinicians began to notice increases in mobility. If these patients were able to decrease their tension, they were also able to decrease their restrictions related to their breathing and were able to increase their overall range of motion. By decreasing muscular tension, these clinicians were able to restore proper tension thresholds in their patient and ultimately improve their breathing patterns.

However, there were other methods and rationale expressed by clinicians to restore proper tension thresholds without focusing on decreasing muscular tension specifically. The last minor themes noted for using diaphragm training were to decrease stress and anxiety as well as increase relaxation.

Many use diaphragmatic breathing and diaphragm training to help with stress and anxiety. Whether that was during rehabilitation or with other life stresses outside of treatment. One clinician noted that in their "overall in life their stresses will decrease. They'll be happier...they are able to cope with the high stresses of the activity to workouts or life in general; to be able to come back and find their happy place." This clinician used these techniques to help their patient focus on how their body was coping with rehabilitation in general and how to rid their minds of other distractions and to become more self-aware of what they were feeling and how their body was coping with certain exercises and movement patterns. This clinician also explained how he, personally, would use these training techniques as a way to decrease anxiety when dealing with stressful situations outside of work. One particular situation in which he used these methods was when he went to the dentist. Using diaphragm training techniques, he was able to decrease his dental anxiety and ultimately improve his overall experience while at the dentist. Other clinicians noted their patients express feeling “much better in general.” "I do think that they tend to look more relaxed when their breathing diaphragmatically versus chest breathing," explained one participant. While another stated that it “helps them relax in-between sets.” One participant, who works in a rehabilitation clinic, even described an experience he had with a patient who fell asleep on their treatment table after starting his diaphragmatic training exercises because of the relaxing affect that it can

have on some individuals. These methods to increase relaxation, decrease stress/anxiety, and to decrease overall muscle tension, ultimately pointed toward correcting and restoring proper tension thresholds in patients and this was observed to be a major reason and purpose for the use of diaphragm training as a tool for rehabilitation.

Even though many of the Athletic Trainers interviewed for this project expressed reasons and a purpose for using diaphragm training as a rehabilitative tool for its ability to improve performance, restore proper breathing patterns, and to restore proper tension thresholds, many others discussed their reasons and rationale for not incorporating these methods in their treatment of musculoskeletal injuries. These responses came from interview questions three and six specifically. Some expressed they had no formal training on these types of treatment methods and so they chose not to use them. Another expressed they felt there was not enough valid evidence to support the use of these techniques and until more evidence was produced chose not to incorporate diaphragm training as a treatment tool. The main reasons expressed by those interviewed for not incorporating diaphragm training in their rehabilitation protocols was due to the challenges these types of methods create for them and their patients during rehabilitation.

The main challenges described by clinicians were time constraints, lack of patient compliance, and the difficulties experienced when teaching these methods. One clinician simply stated the reasons he often does not use these methods are "time and compliance. Hard to progress, and takes time to progress." Others in the small collegiate setting explained that they would like to use these methods, but because of the nature of the small college setting they are unable to use them to their full potential. One explained: "in this setting [small college] most people are just really impatient, and they have a certain

amount of time before practice or during their designated treatment time that they just don't want to stick around to figure out an hour's worth of breathing patterns....It's just not conducive to the small college arena that we have."

While another stated:

> "the down side of it would be that, just time consumption. We have limited amount of time with our athletes limited amount of time that we can be, even if we are in a clinic, able to bill, there's still only so much time and units we can spend with any one person. So the downside, I think, is that this can be slippery concept to actually teach and a client or a patient. So time efficiency wise, may not be always a great choice."

This participant, who still tries to use these methods as a rehabilitative tool, clearly explained that “diaphragmatic breathing is not something that can be very easily treated on a daily basis or on a regular basis.” Here, the main challenge expressed is time. Others discussed how patient compliance was one of the biggest challenges for them when teaching these methods. One clinician expressed what their experience had been when dealing with patients and their understanding of diaphragm training and its benefits.

> "I haven't had good luck in using it in rehab because in rehab people don't understand why breathing in the prone position or the supine position is beneficial. So, umm, they struggle to see how it fits together with their ankle injury or their knee injury, or whatever is not attached directly to breathing patterns."

Another clinician put it simply, "it's hard to get them to buy into it." Lastly, the third greatest challenge for clinicians and rationale for not incorporating diaphragm training is that it is simply difficult to train. The next statement describes the experience of one clinician who struggled using these techniques with her patients.

> "Definitely seen a lot of challenges with athletes who have been doing this [breathing improperly] their whole lives and have built poor patterns and movement quality over the years and you know that they have never really focused on their breathing and didn't realize the importance of it. They’re

> definitely more of a challenge than those who have had a good basis of breathing patterns."

Another clinician describes the frustrations they felt when trying to implement diaphragm training into their rehabilitation and treatment plans. "Some of the challenges I see is that I can get someone breathing really well one day and then the next day they come back to rehab and they're back to square one. And so, I think that's one of the most frustrating things is that sometimes it takes a little while to really get them to start incorporating that." While another clinician describes how it takes time and constant practice to re-learn how to breathe properly. For these reasons, some of the clinicians interviewed for this project explained why they chose not to incorporate these methods or why they chose to use other tools and focus on other aspects of their treatment plans rather than use diaphragm training techniques.

Research Question Two

How and where do clinicians gain their knowledge and perspectives in these treatment methods and techniques?

Each clinician had their own experience concerning their approach to gaining their knowledge and perspectives with diaphragm training. These can be described into two separate themes, formal training and informal training. Within formal training, participants described different methods for obtaining this knowledge such as: 1) undergraduate education, 2) graduate education, and 3) post graudate certifications, courses, or seminars. With informal training, the main sub themes that were presented were: 1) co-workers or other allied healthcare professionals, 2) athletic training students

from Missouri State University, 3) home study (reading/research), and 4) personal experience.

Less than half of the participants interviewed expressed receiving formal training in the use of diaphragm training methods as a tool for rehabilitation. Even fewer described learning these techniques in undergraduate and graduate education. Those who experienced formal training often described learning those methods from post graduate courses, seminars, or conventions where the topic of diaphragm training was discussed. Some of the conferences and courses described were Functional Movement Screens, Rock Tape, Postural Restoration Institute, and National Athletic Trainers' Association convention speakers. Others discussed learning these techniques from symposiums or yoga classes. There were five participants, however, who did discuss their experience in learning diaphragm training methods in graduate school. Four out of the five interviewed expressed learning these techniques during their graduate coursework at Missouri State University. Responses such as, "when I came to Missouri State for [graduate] school, this was the first time I had heard about it [diaphragm training]," "mostly just throughout the graduate program here at Missouri State," and "masters classes" [at Missouri State University]," expressed the overwhelming connection to the coursework at Missouri State University and their teaching of these methods. The other participant who learned these techniques in graduate school, not at Missouri State, learned them from a certified Athletic Trainer in his program who focused on these types of training methods. Most often discussed however, was the informal training methods that gave these participants their knowledge and understand of diaphragm training and its purpose in rehabilitation.

The main informal methods participants underwent to gain their own perspectives and knowledge on diaphragm training was through their experiences with their co-workers, other professionals, Athletic Training students from Missouri State University, home study, and their own personal experiences. Each experience was different for each clinician when it came to learning these techniques from others they respected or work side-by-side with. One participant described her introduction to the topic was through her "clinical practice, through colleagues, and fellow clinicians." Another described seeing Athletic Trainers and Physical Therapists "using it in webinars and blogs." While others expressed learning it from co-workers, clinical preceptors, and in services provided by their places of employment. One interesting method of learning these topics was expressed by two participants who had Missouri State Students working for them as interns. "Initially I was introduced to it by a student at Missouri State," was one explanation given by one of these participants while the other stated that "being around Missouri State kids, listening to them talk about it," was how she learned about these techniques. Not all of the participants, however, learned these techniques from others. Many learned these methods from their own personal experiences and self-study.

In this investigation self-study was described as reading or researching outside of formal education in order to gain knowledge of a current topic or technique. Five subjects described participating in home study methods in order to gain their knowledge on diaphragm training. "Just doing my own research, webinars or just trying to find articles to read," was how one participant described her experience. Another clinician described how he did the research himself and read a text called Supple Leopard, and how that increased his interest to wanting to learn more about the topic. Some described reading

research literature about the topic but a few of those participants expressed the difficulty in finding quality research and stated there was not a lot of research out there that discussed it.

Lastly, six participants expressed using trial and error methods either with themselves or their patients in order to investigate diaphragm training and how it impacted their own function and that of their patients. One simply described her experience in this way, "no informal training, just practice and experience through my rehabilitation." Trial and error was the method this next participant used to investigate the use of diaphragm training as a rehabilitative tool. “Just trying to incorporate the things that either I've seen at conferences or read and did continuing education, and just trial and error. What works, what doesn't work, and what I've found is that nothing consistently works with each person." One clinician, to fight the challenge she faced with her patients of compliance and understanding of diaphragm training and the benefits it can have, began using the techniques on herself, saw a difference and change in herself, and used those experiences to educate her patients. “I can take those personal experiences and share them with my athletes so that they kind of gain a deeper understanding that I'm not just crazy, there is a reason that we are doing this." Lastly, one participant, working in the collegiate setting, who suffered from a disk herniation, began using diaphragm training as a means to correct her movement patterns and decrease her pain from her injury. She began to feel a difference in herself and generally began to feel better and do more at work with less restrictions. From there, she began to add those techniques she used into her treatment plans with her patients and continued to see the benefits from these techniques.

In the end, even though each Athletic Trainer had a different experience with learning diaphragm training techniques and how to implement them into rehabilitation as a treatment tool, many are using it in their practice today and have begun teaching others around them the techniques they have learned and its purpose as a rehabilitative tool. The last question still remains and is a vital part in understanding the phenomenon of diaphragm training and that is, what specific diaphragm training methods and techniques are clinicians using in their rehabilitation in order to produce these treatment benefits and patient outcomes? This then leads us further into our investigation and toward our third and final research question.

Research Question Three

What types of diaphragm training methods or techniques are clinicians utilizing during patient rehabilitation?

Each clinician used different methods for training the diaphragm but a few commonalities were noticed between the subjects and their responses. First, a difference was noted between methods used to evaluate the efficiency and effectiveness of the diaphragm and methods used to train and improve the function of the diaphragm. Concerning evaluation techniques, there were three commonly use methods (themes) and those are 1) observation, 2) use of a goniometer, and 3) basic palpation. Three major themes were identified concerning the instruction and training of the diaphragm and those were 1) instructional methods, 2) biofeedback, and 3) manual therapy techniques. In this first section we will discuss the common evaluation techniques used by athletic trainers followed by the common training methods utilized in the treatment.

Observation was the primary method of evaluation among the clinicians. One clinician explained how they used this method when assessing their patient's effectiveness for diaphragmatic breathing.

> "Disordered breathing to me is when their doing a low level of activity and I'm not seeing any diaphragmatic activity, you know visually, looking at them externally. I'm seeing all of this chest, shoulder rising or so it's usually that chest breather under low level type activities or it's the breath holding when they shouldn't be."

A few participants also discussed the importance of observing one's breathing patterns in different positions and with different activities, stating that it is postural dependent and may change with higher levels of activity and demand. Palpation was also noted as an evaluation technique. "I will palpate and have them stabilize that abdominal area and I can feel whether or not they are basically pushing out against you." This technique was used more in determining their patient's ability to use the diaphragm as a local stabilizer and evaluate the diaphragm's ability to hold tension when necessary. Lastly, one participant explained that he used a goniometer to measure the increases in range of motion and rib plate flare to determine if his patients are utilizing their diaphragm in the most optimal way. Though only three main evaluation methods were described during this investigation, the training methods discussed had a wider range of techniques and uses among Athletic Trainers and were the main focus of the discussions between the participant and the researcher.

Three main themes were found in this investigation regarding the actual methods and techniques used by Athletic Trainers to train the diaphragm during rehabilitation. Those major themes were instructional methods, biofeedback, and manual therapy techniques. Instructional methods were most commonly used among the clinicians and

ranged from simply demonstrating how to perform diaphragm breathing, having a patient lay on their back and instruct them how to extend the belly during inhalations, and also providing their patients with verbal cues during rehabilitative exercises to remind them to continue to breathe through their diaphragm. Breathing through the abdomen was often explained as "crocodile breathing." One clinician described this as having their patient roll onto stomach then push their abdomen into the ground during their inhalations to feels the extension of their belly and the increase in tension they created in their abdominal region. Others described having their patients lay in supine and visually watch their bellies extend as they took a breath. They were then told to focus on their breathing and to control the amount of time they spent inhaling versus exhaling. Again, the importance of having their patients practice these methods in different positions or with different movement patterns, was explained. These methods were used to "reinforce that feeling," or to solidify their new breathing pattern with actual functional activities. Some would verbally instruct their patients during rehabilitation exercises and explained their purpose for doing that was to "remind them to keep breathing to prevent breath holding during an exercise." Many of these techniques, though all different, used some form of basic instruction in order to teach their patients how to use their diaphragm and improve their overall function.

Biofeedback was also another method often used by clinicians. This technique was usually pared with another instructional technique in order to teach their patient how to change their breathing pattern but then also give them a sense for what their body is doing while they breathe and to increase their self-awareness and how they feel when they breathe. One clinician explained their use of this technique.

> "Definitely, the first methods that I really like to use and that I see the greatest benefits with is getting them into supine and that hand on the chest and that other hand on the belly, because that really gives them a way to sense when that chest starts to move. Because a lot of athletes don't have the perception of what their body is doing and so by getting them to realize that you feel under that hand your chest is moving, don't do that, focus on the belly. Once I get them into other positions, if I notice they start breathing through that chest again, I can have them pause and do that hand position again to remind them how it feels."

Another clinician used this technique in a similar way but instead added her own hand placement and pressure to enhance the tactile feel of the structures moving underneath the clinician's hands.

> "I'll give them some tactile feedback on feeling whether the chest is moving or if the abdomen is moving. One of the things I like to do is just push down fairly firmly on the abdomen and say 'just breathe out I want you push my hand up I don't want you protruding your stomach and bulging it out, I want the stomach to rise because it's filling with air and then when you exhale I want you to slowly let my fist come back down.'"

The other participants, who used this method of training, used them in similar ways to the two described techniques above.

The last technique, manual therapy, was described by only two clinicians as a tool they would use in their different settings to improve diaphragm function. Their focus was on decreasing adhesions located around the diaphragm to allow for it to extend and function more efficiently with no anatomical restrictions. By providing the patient with more tissue extensibility, they were able to increase the mobility of the diaphragm and use it in the most effective manner. The goal is to "mobilize the diaphragm." One clinician did this by having their patients perform different stretching techniques such as leaning over a BOSU ball or manually, through palpation, feel under the rib cage for tissue restrictions and use different myofascial release techniques to relieve those areas from those restrictions. The second clinician discussed how this mobilization of the

diaphragm and the surrounding tissues allowed for increases in mobility in different postures and with different movements. While these techniques were not discussed by many of those interviewed, these techniques are still being used by Athletic Trainers today and, for them, has produced benefits for their patients and because of those outcomes, continue to use them in their practice.

This chapter focused only on describing the responses of the participants and how they explained the phenomenon from their firsthand accounts. The next chapter will turn the focus from the responses themselves to a discussion of the results in order to paint a greater picture and explanation of this phenomenon. This will be accomplished by incorporating the researcher's point of view as well as how these results relate to current literature and research pertaining to diaphragm training.

DISCUSSION

The purpose of this chapter is to draw connections between the responses collected within this investigation, current and past literature, as well as my interpretation of the data. This triangulation of information allows for transferability and credibility of results as well as further understanding of the investigated phenomenon. Findings of each presented theme as it relates to the research questions will be discussed and compared to past and current literature. My own interpretation of the findings will also be interjected in order to create a global understanding of the phenomenon and those investigated.

Research Question One

What are clinicians' perspectives and rationale for incorporating (or not incorporating) diaphragm training and evaluation as a therapeutic tool for the rehabilitation of musculoskeletal injuries?

The incorporation of diaphragm training within research and within the clinical practice as described by participants is varied and is utilized for many purposes as well as for the accomplishment of many patient and treatment goals. The main purpose and goal of diaphragm training is to correct diaphragm dysfunction and improve its effectiveness within its roles. The diaphragm has been described has having many roles within the body and to play an integral part of many others. The understood roles of the diaphragm, as described by participants, were in respiration, stability and posture, mobility and range of motion, strength production, and lastly, gastro-intestinal dysfunction. There is literature to support the roles expressed by participants as well as a few additional roles.

The main role of the diaphragm expressed both in literature and by participants was in respiration. Literature has defined the diaphragm as the principle muscle in respiration[10,34-37,39] with its primary active role relating to the inspiratory mechanism.[16] Participants agreed the main purpose of the diaphragm was in respiration, "it is there to help you breathe," was an expression given by one of the participants interviewed. The same assessment was also described concerning the diaphragm's main action of contraction and descending into the abdomen during inspiration and relax as air is expelled in the process of expiration.[37]

Stability and postural control were other roles both described by research and participants. Participants discussed the diaphragm's role in "reflexive stabilization" and as a "local stabilizer." It was stated by one participant that because the diaphragm attaches to many structures within the body, as well as its involvement within the fascial system, this augments its role and ability to provide the human structure with stability. Anatomy texts also reference the diaphragm's attachment to many structures that are both stable and mobile[34,35] and how this can allow the diaphragm to sense postural changes and reflexively work in order to continue providing stability to the overall structure.[16] Other participants mentioned the diaphragm as being part of the deep front fascial line and the reflexive stability component it plays there. "With the diaphragm being in the deep front fascial line, when you initiate that diaphragmatic breathing maybe stabilizing within that fascial line," responded one participant in her description of the diaphragm's role in stability. Meyer's[36] work details the diaphragm's role in the Deep Front Fascial Line and shows how the fascial system provides the body through this intertwining of connective tissues.

With the diaphragm playing an important role in postural control,[10] if the diaphragm function were to become ineffective or decrease overall, its ability to provide that stability and control would also decrease.[31] One participant working in the collegiate setting describes the diaphragm as our "center." "It is the center of everything. If you don't have that center, like anything, it's just going to topple over or fly off and then more injuries happen." The literature also agrees that as the efficiency or ability for the diaphragm to function within any of its role fails or becomes dysfunctional, for example respiration, then its postural function can also become dysfunctional, and theses affects can happen in either direction.[16,42]

Many researchers have investigated the diaphragm's role in providing intra-abdominal pressure and how this principle function of the diaphragm's unique responsibilities is necessary to provide us with stability. [15,16,18,19] The concept of intra-abdominal pressure and the diaphragm's role in creating it to provide stability was not one described by participants. Perhaps it was understood as a key part in the production of stability and so therefore was not discussed exclusively. One participant described how the diaphragm stabilizes from the inside out. "Diaphragmatic breathing allows, it triggers your body and your brain to stabilize on a reflexive level form the inside out. If you can stabilize from the inside out it allows everything else to work more efficiently." The understanding of its reflexive role in providing stability within the abdominal cavity is there and was expressed, however the term intra-abdominal pressure was not one expressed by participants.

Core stability and function was another main topic discussed in the literature and how the diaphragm plays an integral part in that as well.[29,30,36] This topic was also

touched on briefly by a few participants. “When I think core, I think diaphragm” explained one athletic trainer. Another stated “it's your inner core,” while another explained that it provides us with a base for the development of core stability. Spinal stability, however, was not one discussed by participants but it discussed a great deal in research.[21,25,44] Research also added that a decrease in diaphragm respiratory function leads to decrease in spinal stability function which can affect our overall function.[44] As some participants described core and trunk stability, they may have also included spinal stability as a component of those functions and chose not to discuss the spine specifically. This understanding of spinal stability may have also been grouped into postural control and stability as a whole and so not discussed as a separate function of the diaphragm.

One main role of the diaphragm discussed by those interviewed was the diaphragm’s ability to allow for mobility and range of motion. This was not discussed in literature as a role of the diaphragm but it was explained that if the efficiency of the diaphragm was compromised mobility could be affected and so some chose to train the diaphragm in order to correct mobility restrictions or dysfunctions.[10] The diaphragm was described by one participant as “playing a role with shoulder mobility,” and how one’s range of motion, in general, can be affected if the diaphragm is not functioning properly. The correlation found in research to this ideal relates to the research discussed by Hruska[71] in her study titled “Influences of dysfunctional respiratory mechanics on orofacial pain.” In this experiment, it was demonstrated that those individuals who breathe with their chest as opposed to abdominal or diaphragmatic breathing will have increases in tension and activity in accessory respiratory musculature. They used stretching and naso-diaphragmatic breathing techniques to help decrease these tension

thresholds. Accessory respiratory musculature involves the upper chest, neck and shoulder musculature, and so one would conclude that if patients are breathing with their chest and accessory muscles as opposed to their abdomen, they would have increased tension in their shoulders and therefore a decrease in overall ranges of motion within that joint. They showed increased postural alignment following the use of these techniques which could have occurred due to training of the support role of the diaphragm or due to a decrease in mobility restrictions that were causing that dysfunctional postural pattern.

Decreases in mobility have also been shown to occur within the organs and fascia of individuals who display a thoracic breathing pattern. "A change in the breathing pattern and thoracic breath (chest breathing) can result in stagnation of the organs and fascia. As well as thinking about the connective tissue that surrounds every single muscle fibre, muscle fibre bundle, and muscle group."[39 pg22] Those connective tissues surrounding the diaphragm and throughout the body can also (due to lack of exercise, movement, etc.) can become restricted and affect our breathing and breathing patterns. Gray Cook[70] in his text Movement discussed that breathing needs to be monitored when working with mobility restrictions or adhesions.

> "When we stretch, compress, foam roll or bend the stiffest and tightest parts, we tend to breathe poorly. We tense, and our breathing becomes shallow and even faster in some cases. We show our stress in our breathing, and this actually increases our tension and makes the mobility work ineffective or even counterproductive. Be very aware of this. We know better and still make this mistake, so don't expect clients and patients to not slip into stress breathing – continuously observe and remind them of this."[70 pg265]

Once again, this does not discuss the diaphragm as having a role in mobility and range of motion but having an effect on it, if not functioning properly or effectively.

Improving strength gains and increasing force production were other roles of the diaphragm discussed by clinicians. Even though this was not a highly discussed topic in research (connecting the diaphragm and strength directly) it was mentioned by a few experts that the diaphragm is tied to core stability and function, which is vital in the production of strength and transfer of forces. The muscles of the trunk and core (including the diaphragm) act as one unit at the center of functional kinetic chains.[73] This stable trunk allows for force production and transfer between the different segments of the body and is essential for proper movement patterns. The diaphragm's role in the creation of intra-abdominal pressure and structural roles due to its attachments points must work efficiently in order to provide the stability needed for these force transfers.[70] This same point was made by one of the interviewed clinicians who worked within the small colligate setting: "[The diaphragm] helps transfer from a closed chain standpoint, power derived from muscle in the lower extremity transferred up through the body. This provides rigidity that allows transfer of energy to the different motions [and] change in direction."

He discussed the diaphragm's role in movement and related it back to its role in stability and how energy can be transmitted through the body, with the proper rigidity of the core, and how this allows for improved changing of direction. Bliss, L and Teeple, P[53] also discuss the importance of breathing in core training and the last progression listed in their training plans involve assessing diaphragm efficiency with proprioceptive training and plyometrics. The focus is on making sure you don't lose that good breath when you increase the load and difficulty of exercises.

The last role of the diaphragm, described by one participant was its role in gastro-intestinal function. She discussed her experiences working with a patient in the clinic who was seeking her for treatment and rehabilitation of her orthopedic injury. She stated that her patient described having increased motility and elimination of waste products when she practiced her diaphragm training exercises at home. It has also been discussed in research the diaphragm's role in peristalsis, elimination of wastes, coughing, sneezing, and vomiting.[30] Bacchus[39] discusses the gentle massaging of organs the diaphragm provides with each inhale as it presses down into the abdomen against the organs beneath it. This creates an ebb and flow motion that assists in peristalsis and the movement of materials throughout the digestive system.

Discussed above where the roles those investigated understood the diaphragm to have an effect within the body. Through the investigation, however, three main roles of the diaphragm were discussed as their main rationale for incorporating diaphragm training within their rehabilitation. These three main themes for the incorporation of diaphragm training were to 1) improve performance, 2) restore breathing patterns, and 3) restore proper tension thresholds. Within these three main themes, multiple sub themes were expressed as points of focus during treatment of patients for orthopedic rehabilitation. Within improving performance, athletic trainers would focus on improving stability, improving rehabilitation exercise execution, decreasing injury rates, and increasing strength and force production. Concerning the restoration of breathing patterns, clinicians specifically focused on correcting breath holding patterns and decreasing the use of accessory respiratory musculature during normal respiration. Lastly, within the theme of restoring proper tension thresholds, clinicians emphasized decreasing

stress and anxiety, decreasing muscular tension and in doing so increasing mobility, and relaxation.

The first main theme expressed by participants was improvement in patient performance by improving stability. Diaphragm training, in the current literature, has discussed different treatment plans for improving core stability. “The importance of an efficient and stable core is promoted by most physical therapists, athletic trainers, and coaches despite the paucity of studies supporting its efficacy. Core stability is presently a theoretic concept that is becoming more popular as experience authenticates its benefits.”[53] Those athletic trainers interviewed for this project were no exception to this statement. One participant even described how diaphragm training provides their patients with a basis for the development of core stability. Another states that "once you get them into that diaphragmatic breathing, they report that the exercises feel better and they report more stability.” The “core” is still being determined and defined within literature. What we do know, is that the muscles of the abdomen, diaphragm, spine, and pelvic floor co-contract and work together to provide individuals with trunk stability. "Training local stabilizers," was one statement a participant made when describing her reasoning for using diaphragm training.

Another important focus for athletic trainers is towards improving rehabilitation and corrective exercises during treatment. A large portion of rehabilitation involves corrective exercises and movement pattern re-training. This was not necessarily a main focus in literature as rationale for incorporating diaphragm training but the reasons and explanations given by participants correspond with literature concerning discussions of diaphragm training being used to restore proper movement patterns. Research does

discuss how diaphragm efficiency has been positively linked with movement. Bradley and Esformes[46] found that “inefficient breathing could results in muscular imbalance, motor control alterations, and physiological adaptations that are capable of modifying movement.”[pg.28] The diaphragm’s role in movement, as explained by participants, related again, back to its role in stability and how energy can be transmitted through the body with the proper rigidity of the core and how this allows for improved changing of direction. The diaphragm was also described, by one participant, simply, as playing a role in how we move.

The muscles of the trunk and core (including the diaphragm) act as one unit at the center of functional kinetic chains.[73] One participant stated, "I've seen rehab be more effective with using our treatments this way." While another expressed the same sentiments, "when you remind them to breathe and get everything back where it belongs, you can see their exercises perform a little bit better." If clinicians are able to help patients increase their stability and improve their movement patterns, the next step would be to help those patients decrease their future risk for injury.

"Typically I see fewer injuries especially in the low back or even in the neck region, because they’re not straining, to pull heavy weight in an awkward position," expressed one athletic trainer. Research did not show any studies that solidified the use of diaphragm training being directly linked to a decrease in injury rates. However, there was one study that demonstrated that movement scores, using the Functional Movement Screen as their functional assessment tool, were significantly higher among diaphragmatic breathers than thoracic breathers.[46] If clinicians are able to help patients improve postural stability and eliminate movement compensations, then patients would

be have a decrease in overall dysfunction, which in turn would suggest a decrease in injury risk and rates in the future.

Lastly, a few participants expressed their rationale for incorporating diaphragm training to help improve strength and force production in their patients. "Once an athlete learns how to breathe correctly they can actually do more weight and progress better," indicated one clinician. Another explained that they teach diaphragm training so that their patients can learn how to set themselves up correctly to do major lifting patterns such as any kind of squat, deadlift, or pushing motion. Research did not specifically discuss a link between diaphragm training and increases in strength and force production. Nevertheless, we can speculate that if trunk and core stability is improved with diaphragm training, and movement is improved with diaphragm training that one would be able to produce more force and elicit gains in strength with the addition of diaphragm training in their clinical rehabilitation.

The second major theme regarding rationale for the incorporation of diaphragm training was to restore breathing patterns. Research in orthopedic rehabilitation incorporates techniques and methods to help decrease both breath holding patterns and decrease the use of accessory musculature use as well as breathing re-education, biofeedback techniques, and re-training on breathing rates for inhalation and exhalation. Chaitow proposes four basic principles necessary in restoring normal energy-efficient and balanced breathing patterns. These principles include: 1) awareness of faulty breathing patterns, 2) relaxation of the jaw, upper chest, shoulders, and accessory muscles, 3) abdominal/low-chest nose breathing pattern re-education, and 4) awareness of normal breathing rates and rhythms, both at rest and during speech and activity.[10]

Decreasing compensatory methods of breath holding was one major focus of the athletic trainers who were interviewed. This sub theme relates to Chaitow's first basic principle of becoming aware of one's faulty breathing patterns and his fourth basic principle of establishing normal breathing rates. One participant states that "with time I think you keep seeing that progression that they're doing high level activities but they're still able to maintain a normal breath and respiration rate and they're not breath holding." Another clinician states that they would incorporate diaphragm training every time they saw someone holding their breath." Breath holding is a common compensation or disordered breathing pattern that has been seen in many individuals who lack spinal stability, core stability, or suffer from an ineffective diaphragm. Hodges, Heinjnen, and Gandevia[44] found that after approximately 60 seconds of hypocapnia, the postural and phasic functions of the diaphragm decrease significantly or become absent altogether. A compromise in the role of this structure can lead to increases in injury risk to structures in the spine and ultimately reduced postural control. Connecting this evidence with the observations of healthcare clinicians, this aspect of breath holding as a compensatory respiratory pattern is one that needs to be assessed further and re-trained so as to promote normal respiration and effective diaphragm function and control.

Decreasing compensatory methods of utilizing accessory respiratory musculature during relaxed and normal breathing was another main focus for athletic trainers in orthopedic rehabilitation. One goal explained by one athletic trainer for their use of diaphragm training in rehabilitation was "to help them breathe without using accessory muscles, back muscles, and shoulder muscles. Getting people to have a more natural breath whenever they initiate breathing rather than a high tension, high threshold type

breathing." Another discussed the main benefit they saw was that their patients would breathe regularly and consistently with the diaphragm and not resort to chest and shoulder breathing during normal activities. One research study examined subjects who were diagnosed with disordered breathing patterns and were taught by a physiotherapist to perform diaphragmatic breathing exercises that focused on slow breathing and a dominant use of the diaphragm for respiration instead of breathing through their chest and accessory respiratory musculature. They were encouraged to practice their breathing for 10 minute periods every day. The results of the study suggest, with some significant data, that breathing retraining improved the health related quality of life scores for those patients who were previously diagnosed with asthma and had Nijmegen questionnaire scores for suggestive dysfunctional breathing.[64] The goal of decreasing the use of shoulder and neck musculature while breathing also relates to the last rationale theme discussed by participants and that was to restore proper tension thresholds within the bodies of their patients.

Restoring proper tension thresholds encompassed four sub themes expressed by athletic trainers as their focus for utilizing diaphragm training in their practice of orthopedic rehabilitation. The first reason for the use of diaphragm training expressed within this main theme was to decrease stress and anxiety within their patients. Psychology and psychiatry have been using breathing re-training for many years to help with the management of stress and anxiety. Diaphragm training has also been used in the treatment of other anxiety disorders such as dental anxiety, music performance anxiety, and testing anxiety.[9,11,13,14] Research also shows that breathing techniques have been associated with reducing an individual's arousal state, increasing their sense of well-

being, and improving their ability to cope with stress and anxiety.[9] One participant would agree with this research as it relates to his own experience with diaphragm training and the care of his patients. He stated that "overall in life their stresses will decrease. They'll be happier. They are able to cope with the high stresses of the activity or workouts or life in general." This same clinician also expressed that he uses diaphragm breathing techniques, personally, when he has an appointment with the dentist in order to help him relax and decrease his own symptoms from dental anxiety. Though he was the only participant to express the purpose of diaphragm training and it's possibilities with decreasing stress and anxiety for his patients, I felt this was an important point to note within this investigation considering these methods are being used today within other allied health professions for these same reasons and others within our profession would also apply these same methods and techniques for the same goals and objectives.

The next focus for athletic trainers was in the decrease of muscle tension. This was often followed by the notion that if muscle tension was decreased, their patient would then experience an increase in mobility. One participant discussed what his patients would express to him following diaphragm training. "They report...their shoulder[s] aren't as tight. They don't feel as much tension and stress in those shoulders because they are really learning to kind of relax that upper body and really focus on the belly." "Decrease upper trap usage/tension during breathing," was another point expressed by another interviewed clinician. From there, other clinicians started to express their observations concerning the increase in mobility they noted in their patients following these training methods. "If you have them do that [diaphragm training] and their body relaxes, they can get to the end point of their movement, or their end point moves further than if I were to

have them just go through that motion." And another stated, "I know it works to decrease restriction [and] increase range of motion." Diaphragmatic breathing exercises have been shown in research to decrease muscle tension in accessory respiratory muscles. These include those muscles of the neck, upper chest, and shoulder. Also noted in the literature, individuals who display mouth breathing patterns as opposed to nasal breathing patterns display increased accessory inspiratory muscle activity and hypertrophy as well as inactivity of the diaphragm.[71] Methods to help decrease unnecessary accessory muscle use and tension within the shoulder, chest, and cervical musculature can help improve range of motion of the neck during normal and relaxed respiratory patterns as well as the shoulder and thorax.

This increased relaxation, mentioned previously, was discussed as the last common goal and objective for athletic trainers and their patients during rehabilitation. These diaphragm training techniques were also expressed by those interviewed as a way to help encourage their patients to relax during rehabilitation. One clinician discussed using diaphragm breathing exercises to help his patients relax during uncomfortable soft tissue techniques that he felt are vital to his rehabilitation treatments but can be distressing for some patients. Another discussed using these techniques to help his patients relax between exercise sets and repetitions and ultimately help his patients be able to perform a higher number of repetitions and for longer periods of time and gain more out of each treatment session. Gray Cook[70] discusses how breathing should be relaxed and natural. He also discusses the importance of keeping a relaxed, slow, and steady breath during soft tissue treatments and corrective exercise techniques. If a patient/client begins to distress due to uncomforting treatments or difficult exercises, they can actually increase

the tension within the musculoskeletal system and can make mobility and soft tissue work ineffective.

There were a number of challenges and justifications for those interviewed to not incorporate diaphragm training in their orthopedic rehabilitation. Four main themes emerged throughout the expressions and responses of the participants as to why they choose not to use these methods and there are 1) time constraint, 2) patient compliance, 3) not enough evidence and 4) no formal training. Current research has also discussed some of these same challenges when using these training methods and offers support to these views help by those interviewed during this investigation.

The first challenge expressed by athletic trainers is time constraint. "The down side of it would be just time consumption. We have limited amount of time with our athletes… So time efficiency wise, may not always be a great choice." This concept of having a large patient load in a small amount of time was a common theme among those athletic trainers working in the small college setting. They expressed that these tools and techniques are often not the most effective due to the nature of their setting. "In this setting, [small college] most people are just really impatient and they have a certain amount of time before practice or during their designated treatment time that they just don't want to stick around to figure out an hour's worth of breathing patterns....It's just not conducive to the small college arena that we have." Research has also agreed that diaphragm training and re-training of breathing patterns can be time consuming. Negatives and challenges to the rehabilitation of breathing pattern disorders and diaphragm training have been described by Humphrey Bacchus in his article "Breathwork and Sports Performance" as "time-consuming and difficult."[39 pg26] Our

breathing patterns are performed without conscious thought. Any deviation or change from an effective pattern may have taken years to develop and it can take a long time to correct those repeated dysfunctional patterns that have become second nature for us.

The second largest challenge for clinicians is patient compliance. Athletic trainers expressed that their patients did not understand or buy into the idea of breathing re-training when they originally came and sought treatment for their shoulder or knee injury. Helping their patients make the connection between dysfunctional breathing patterns and how those can affect their rehabilitation and future risk for injury can be difficult. One clinician expressed these concerns within her interview. "I haven't had good luck in using it in rehab because in rehab people don't understand why breathing in the prone position or the supine position is beneficial. So, they struggle to see how it fits together with their ankle injury or their, knee injury, or whatever is not attached directly to breathing patterns." While another stated that “it's hard to get them to buy into it." This challenge was not discussed in literature but as a clinician myself, it is easy for me to see how this can be a challenge for clinicians and patient satisfaction. Going to treatment and paying for those services, ultimately, is up to the patient. If they feel they are wasting their time and money on breathing techniques as opposed to exercises that directly affect their injured area, they will stop seeking that treatment, and now you have lost that patient. If these techniques take time to teach and progress, it can put even more pressure on the clinician to show measurable outcomes that explain the effectiveness of these treatments.

Lastly, it was expressed by athletic trainers the lack of evidence available for these types of training methods and that many had not received any formal training concerning these techniques. The lack of evidence has also been mentioned in literature. Perri in

2007[47] expressed that clinicians utilize a wide range of observation and palpation techniques concerning the diaphragm, though many have not been properly validated with evidence based practice.[47] Also, the literature does not express support for evidence based practice concerning diaphragm training and currently there are no clinical patient outcome measures designed to evaluate the effectiveness of these techniques. One clinician stated that she does not use these techniques due to the lack of research behind them. She followed that up with "if there was more research and I saw that this directly affect this issue and I have an athlete with this issue than absolutely I would implement that." It was the lack of evidence and lack of formal training that led me to want to investigate this phenomenon. This was not part of my formal education, yet, I was seeing clinicians and preceptors using these techniques in their treatment plans and as tools for improving their patient's overall rehabilitation experience. I began this investigation due to these challenges I was seeing and have within my own practice and can understand other's hesitation to the utilization of these same techniques.

Research Question Two

How and where do clinicians gain their knowledge and perspectives in these treatment methods and techniques?

Participants gained their knowledge and perspectives on diaphragm training mainly through formal education and information education. Within formal training three main avenues were discussed:1) undergraduate education, 2) graduate education, and 3) post graduate certifications, courses, or seminars. Informal education included opportunities for athletic trainers to learn these techniques from 1) co-workers or other allied healthcare

professionals, 2) athletic training students from Missouri State University, 3) home study, reading and research, and 4) personal experience. This section of the discussion will not be directly compared with the current literature and research as these responses pertain to the specific and personal experiences of each clinician interviewed as their own expression of the phenomenon being investigated.

Undergraduate education was a common method described by those interviewed during this investigation. A few participants discussed learning about the diaphragm and its role within the human body in their undergraduate studies in classes such as anatomy and physiology. A couple mentioned learning these techniques in their athletic training rehabilitation courses. One stated his education started in undergraduate school. “We had a lot of talk about it in my rehabilitation classes and then some preceptors…focus on it more than others." Six participants expressed having formal education on diaphragm training in their graduate studies. Five of those participants expressed learning those techniques from Missouri State University’s Masters of Science in Athletic Training Post-Program where one other expressed learning it from a graduate program out of state. Personally, I also began learning these techniques during my graduate education. However, clinical outcome measures were not discussed nor were these techniques validated with outcome measures. They were often discussed and explained via the experiences of the clinicians who used them and the observed improvements they noted during treatment sessions. Nonetheless, one part of evidence based practice is the clinical experiences of expert clinicians and the improvements they are able to make with their patients. It is important to learn from their experiences, successes, and failures and apply those to our own practice.

Several participants noted learning some of their diaphragm training techniques in seminars, conferences, or other certification courses. "Going to seminars like PRI, breathing restoration course, certification course, and FMS," were a few listed by one participant. Another mentioned that she went to one specific seminar during the National Athletic Trainers' Association 67th Clinical Symposium and Athletic Training Expo in St. Louis, Missouri. She stated that it was interesting to see a different perspective to diaphragm training from that she was learning in graduate school and learn some different manual therapy techniques to use with patients. A few also mentioned learning it when they attended other seminars on related topics were diaphragm training was integrated within the discussions of the course. "I went to a Rock Tape certification that talked about it. Not very long, but it was a component of the seminar." Another responded, "I've been in multiple workshops or conference sessions [were] that topic is brought up…but that's not the focus." Some of the courses and classes described by participants were also courses I had attended and I did also noted the incorporation of diaphragm training education in the seminars.

Most clinicians described learning diaphragm training techniques through informal training methods. Observing other healthcare professionals and co-workers using these techniques and learning from their experiences was a common methods for attaining knowledge on these topics. "I would say the people that I work with, we all use it in different ways." Another described an in-service he had at his small college where his co-workers taught him some of the methods they use and how they apply those methods with different patients. While another stated that "it primarily was introduced to me through my clinical practice, through colleagues, fellow clinicians." Learning from those

I work closely with and consider mentors was a major avenue for myself in learning about these techniques and how they can be applied in the treatment and care of orthopedic injuries. Healthcare professionals can learn so much from each other and the experiences had with different cases and situations. No one can be an expert in every field and so learning from others is a great method to gain knowledge on certain topics and treatment methods. This sharing of knowledge is vital for the spread of ideas and for the continuing of learning opportunities for all health care professionals.

Another informal method for learning about diaphragm training as expressed by the participants was from supervising athletic training student observers from Missouri State University. These students, who learned about some of these techniques in class were discussing them at their clinical site and teaching their preceptors about diaphragm training. "Initially I was introduced to it by a student at Missouri State," said one participant who continues to use these techniques in her own practice. Another said they learned about diaphragm training by just being around Missouri State students and listening to them talk and discuss about different techniques and methods that are being taught in their classes. Being a Missouri State graduate myself I can attest to being introduced to these topics and beginning to ask questions about them and having a desire to learn more. Often, students can offer a lot of new knowledge and information for clinical preceptors since those students are learning the current practices and literature in their curriculums and not all practicing athletic trainers have access or are able to keep up with current medical practices and current ideas and perspectives within the field of medicine. This avenue of learning new techniques from athletic training students is one

that is very vital to the building of relationships and the sharing of information and knowledge for both parties.

The last two avenues participants discussed as informal ways they learned about diaphragm training and techniques were through home study and personal experience. Home study included reading books and performing their own search through current and past literature. One participant explained that she learned these techniques "just doing my own research, webinars or just trying to find articles to read." Another stated that "the other part of it I would say just came from reading on it, and continuing education." Personal experience was also mentioned frequently by participants. “Just trying to incorporate the things that either I've seen at conferences or read and did continuing education, and just trial and error. What works, what doesn't work, and what I've found is that nothing consistently works with each person," expressed one clinician. Another stated “I've played around with it more myself, personally, using it on myself and with patients. I've just noticed more disordered breathing with patients as well as with myself.”

Some clinicians expressed using these techniques to help treat injuries or pain they were experiencing themselves in order to evaluate the benefits of these treatments and hopefully obtain some positive outcomes from the use of those treatments. One athletic trainer described her experiences with using the techniques personally and then sharing her successes with her patients.

> "I started to try to do it more too. I noticed that I am a chest and shoulder breather, like massive chest and shoulder breather. And so, I've started to not only incorporate it into my own life because then I can start to realize when I am sitting or when I am starting to move in a certain way that my chest start to move I go ‘oh, I need to make sure that I breathe through the belly.’ And so, I can take those personal experiences and share them with my athletes so that they kind of gain a deeper understanding that I'm not just crazy, there is a reason that we are doing this."

Lastly, another described her experience with back pain and how she was able to overcome that with the use of diaphragm training methods and techniques.

> "I had a disk herniation in my low back and so by just having that hernia I didn't want to have surgery. I was too young and I'm not going down that path if I possibly can. So I decided to do my own rehab and try to focus on it that way... Since I've done that I've actually not really had any back problems. I had really bad sciatica running down my leg or I'll be at work walking around...and that hasn't happened in a few months now...And by doing that I'm doing better in my daily life function."

Even though every person is different and every patient of ours has their own set of dysfunctions and disorders, there is still a lot they can learn from our own experiences with different treatment methods and it helps these individuals put it into perspective and relate to their own challenges and difficulties.

Research Question Three

What types of diaphragm training methods or techniques are clinicians utilizing during patient rehabilitation?

The diagnosis of breathing pattern disorders is still a debated topic in research, and currently, there is no single test for the clinical diagnosis of breathing pattern disorders.[46] When it comes to clinical measures for assessing dysfunctional breathing, clinicians typically utilize a wide range of observation and palpation techniques, many of which have not been properly validated with evidence based practice.[47] The participants interviewed for this investigation discussed three major themes for evaluating diaphragm efficiency: 1) observation, 2) goniometer, and 3) palpation. Within those theme certain tests, tools, or techniques were mentioned and we will discuss them here and relate them back to the current literature on the topic of diaphragm evaluation.

Participants most commonly discussed observation as the preferred evaluation method. Many described watching their patients breathe to determine their breathing patterns. “I kind of just use my sight to see if it looks functional,” said one athletic trainer. Another explained what he is looking for in particular as he assesses his patient’s breathing patterns. “Disordered breathing to me is when their doing a low level of activity and I'm not seeing any diaphragmatic activity, you know visually, looking at them externally. I'm seeing all of this chest, shoulder rising or so it's usually that chest breather under low level type activities or it's the breath holding when they shouldn't be.” Another even explained that he watches his patients breathe in different postures and with different movements in order to determine diaphragm efficiency. “First you watch them breathe in different postures as well because it will change and then you can look at their rib plate. Look at other areas that are indirectly attached or affected by diaphragm.”

One commonly used observational technique for breathing assessment in resaerch is the Hi-Lo Test. “The Hi-Lo test provides an immediate insight into how the diaphragm and rib cage moves during inhalation. [39 pg24] With this technique, clinicians observe both the rib plate and the abdomen to determine which one moves during normal relaxed breathing. One is wanting to see the abdomen increase in size as one inhales and then returns during the exhale with little to no movement occurring at the rib plate. These types of evaluations are easy to perform in any setting and require no equipment and cost to the clinician making them a very inexpensive and easy to use technique in any situation.

The next observational technique discussed was brought up by one participant in particular and that is the use of a goniometer. This was not a tool described in literature as

a method for evaluating diaphragm efficiency but could possibly become an effective tool in the future if more investigation into the technique is performed. He stated that "you can really [measure] with your goniometer rotations or increases in range of motion." With this he discussed looking at the rib cage as well as upper body and shoulder mobility in order to determine if mobility is restricted and if the diaphragm appears to be expanding during the breathing cycle.

Lastly, another tool mentioned by multiple athletic trainers was palpation. Experts in breathing therapies have stated that it is important not just to observe or assess breathing visually but to also palpate the structures related to respiration and check for elasticity, tone, trigger point development, and postural adaptations. This can offer clinicians a better overall view of the health of our patients and their breathing efficiency.[43] One clinician described how they palpate the abdominal area while their patient breathes. "I will palpate and have them stabilize that abdominal area and I can feel whether or not they are basically pushing out against you."

Other methods in research have been discussed for evaluating diaphragm efficiency and breathing quality. The use of blood CO2 measures and capnography have been considered as a potential gold standard to determine whether or not breathing is a factor in patient presentation.[48,49] The Nijmegen Questionnaire is also a commonly used tool for evaluating breathing pattern disorders and corresponding symptoms.[51] The use of multiple methods and tools to determine breathing pattern disorders and diagnosis for patients has also been suggested in research. Rosalba Courtney et al. concluded in their Study "Relationships Between Measures of Dysfunctional Breathing in a Population with Concerns About Their Breathing" that "comprehensive evaluation of breathing

dysfunction should include measures of breathing symptoms, breathing patterns, resting CO2 and also include functional measures such as breath holding time, and response of breathing to physical and psychological challenges including stress testing with CO2 monitoring."[52 pg24] Also, with the connection to functional movement and breathing, many have adapted functional movement screens, core function tests, and postural assessments in order to evaluate breathing efficiency.[10,30,43,53] More research needs to be conducted in order to determine best practices for breathing evaluation and how these methods can be applied to rehabilitation settings and treatment practices. Practice and experience with these methods, along with future research, can give athletic trainers increased insight and knowledge on breathing pattern evaluation and how these methods can add to patient assessment and treatment of injuries.

The last research question also asked participants what specific training methods and techniques they use when they perform diaphragm training methods. Participant responses showed three main methods for training the diaphragm:1) instructional, 2) biofeedback, and 3) manual. The first method and most often discussed method between participants was instructional. They would take time during their treatment sessions to teach diaphragmatic breathing patterns to their patients through direction and demonstration. Most called it abdominal breathing or "crocodile breathing." The starting positions for this instruction was described as either supine or prone. "I prefer laying on their back with the knees bent and I think that's the easiest position for them to start in." Multiple participants described using the prone position in order to give their patients the opportunity to feel their bellies push into the ground during expansion and receive feedback from that sensation. "I like to roll them on their stomach so that they can

practice pushing their stomach into the ground." Others discussed starting in basic postures and them moving into high postural levels to increase difficulty as well as add movement to the pattern for complexity. Leon Chaitow proposes four basic principles necessary in restoring normal energy-efficient and balanced breathing patterns and are listed here: 1) Awareness of faulty breathing patterns, 2) relaxation of the jaw, upper chest, shoulders, and accessory muscles, 3) abdominal/low-chest nose breathing pattern re-education, and 4) awareness of normal breathing rates and rhythms, both at rest and during speech and activity.[10] The first step is recognizing one has a disordered breathing pattern and helping them become aware of their breathing, which I believe these techniques expressed by these participants aims to do just that. Being in a supine or prone position also allows for the patients to relax their accessory musculature and helps them to re-pattern their breathing patterns with the verbal feedback from their athletic trainers.

Verbal cues during exercises was another common response for participants as a diaphragm training methods. The goal of these cues is to remind their patients to continue to breathe during their difficult exercises in order to prevent them from breath holding. "It's definitely something that I say before every exercise, 'hey make sure that when you are doing your dead bugs today, and make sure you are keeping that belly breathing going.'" This is a simple training technique and can provide the patients with constant feedback on their progress with diaphragmatic breathing.

The second most common method described by participants is the use of biofeedback. None of the participants described using any instrument or tool while using these types of methods but instead the patients were asked to position their hands on their

chest and abdomen in order for them to sense where there breathing is coming from and to alter or change their breathing patterns based on the feedback they receive.

> "Definitely the first methods that I really like to use and that I see the greatest benefits with is getting them into supine and that hand on the chest and that other hand on the belly, because that really gives them a way to sense when that chest starts to move. Because a lot of athletes don't have the perception of what their body is doing and so by getting them to realize that you feel under that hand your chest is moving, don't do that, and focus on the belly. Once I get them into other positions, if I notice they start breathing through that chest again, I can have them pause and do that hand position again to remind them how it feels."

Another clinician described using the same biofeedback method to teach his patients but he adds another component to it to help engage the diaphragm and core muscles during the breathing patterns. "I like to use my hands and then I put my hands on top of their hands to press into the same tissue for activation and to feel the tension change. So that they can have a better understanding of what is going on and why it's important."

Biofeedback techniques were also discussed in the research with caprograph as the main method to give patients feedback on the quality of their breathing patterns. It can be applied to any posture or position that the patient has difficulty breathing in and give them the feedback needed to change or alter their respiration. Using the hand on the chest and on the abdomen directly resembles the Hi-Lo test described in the literature as a breathing pattern assessment tool.[39]

The final training method described by participants involved manual techniques. This often involved either mobilizing diaphragm or stretching the structures involved in and around diaphragm to allow the diaphragm to fully expand during inspiration without the presence of restrictions or adhesions in the soft tissues. "Just stretching them out so they would be able to breathe better. Having the mobility and maybe increasing that mobility just for different postural reasons," was one athletic trainer's response to this

question. Another listed some of the techniques she uses in her collegiate setting with her athletes. “Mobilizing the diaphragm. Different stretches. Grab under rib cage, lean over BOSU ball and stretching on the BOSU ball on [their] back.”

Often, the literature mentions these techniques described by the participants but instead of just using one of these techniques clinicians will incorporate multiple techniques in a sequential progression within their treatment protocols. Not often is just one method used to retrain breathing but instead the incorporation of many methods together in a logical order is utilized. Laurie McLaughlin suggests a breathing retraining method that involves several different phases and targets multiple aspects that affect respiration and effective breathing. She describes these phases as analysis, education, awareness, biofeedback, behavior modification, manual therapy, and time.[50] Analysis just involves assessing one’s breathing pattern and determining if it is dysfunctional or functional. Education involves teaching the patient what a good breathing pattern looks like and awareness allows them to understand what types of breathing compensations they are utilizing and comparing those to a quality breathing patter. She likes to use capnography for her biofeedback technique and then uses instructional cues and repeated practice as her behavior modification. Lastly, she includes manual techniques to eliminate soft tissue restrictions and provide tissue extensibility, and then time. A lot of time and practice is required to re-train breathing patterns and she allows for that in her training methods.

Kim and Lee[24] discuss the importance of core training and breathing together as important training methods for improving diaphragm efficiency in both its role in respiration and postural control and stability. None of the participants discussed using

core strengthening exercises in conjunction with their diaphragm breathing methods. This may be an area where education on these methods may help those clinicians already using these techniques improve their training and perhaps improve their treatment outcomes.

Implications For Clinicians

This investigation of diaphragm training and its use by athletic trainers in orthopedic rehabilitation gives other clinicians and fellow athletic trainers a critical and inclusive review of the literature concerning the diaphragm as well as its assessment and re-education. A considerable amount of research and literature exists on the diaphragm, however it is spread out over many different healthcare professions as well as other areas of study such as music training, martial arts, and cognitive treatment therapies. One goal of this investigation was to educate clinicians about the lack and gaps of research concerning the diaphragm in hope of increasing clinicians' desire to perform needed research to add to our understanding of this muscle and the roles it can have within the human body. Lastly, this investigation can help to begin the conversation and to connect those athletic trainers and other clinicians who are using these methods and to discuss their successes and failures with diaphragm training and to ultimately learn from each other and our experiences.

Suggestions for Future Research

Other allied health professionals are using these types of techniques and are seeing results and improved patient outcomes. We need to continue to learn from these

professionals and their evidence based practice in order to apply those tested methods and techniques within our own practice and treatments.

This investigation occurred in one small area of the mid-west and only included athletic trainers in two settings. The study of these methods and techniques needs to occur in other areas of the country and with additional clinicians in order to produce a broader and greater understanding of this phenomenon and how these methods are being used and applied to orthopedic rehabilitation.

This investigation, specifically, only discussed the training methods these clinicians used with their own words and descriptions as opposed to actually observing the use of these techniques within their practice. Perhaps a greater understanding of the application of these methods and the training principles and techniques used would be more understood through observational investigation. Not just understanding the clinical thinking process that is occurring but how they actually work and react to their patients during treatment sessions and during the use of these methods would help give a greater understanding of how these methods can be applied and incorporated during treatment sessions as well as understand how they are progressed over time.

The creation of clinical outcomes based measures for current evaluation and training methods being used is critical. Being able to evaluate methods being used in treatment and be able to correlate the use of those methods with specific outcomes to determine the effectiveness of those methods is necessary to show the importance these techniques can have in the rehabilitation world. Without these measures, one cannot correlate cause and effect mechanisms and whether it was the diaphragm training methods that produced those outcomes or other interventions used during treatment. This

also calls for more research to be conducted comparing different evaluation and training methods that are currently being used in order to determine which methods are most effective and how they compare with different populations and different situations. Some methods may work for some and others may work better in other circumstances. Without increased research and study of these methods, it is hard to determine which methods are most effective, cost efficient, provide timely outcomes, and the ease of application.

Conclusion

The purpose of this qualitative investigation was to learn from athletic trainers' perspectives of the use of diaphragm training in orthopedic rehabilitation. Understanding the benefits and challenges they face, how they apply different techniques with their patients, what treatment goals they aspire to obtain, and how they gained their knowledge and training concerning the diaphragm were all important aspects of this phenomenological investigation. The outcomes of this study provide current and future athletic trainers with an understanding of how these methods are being used and applied in treatment, as well as areas in which athletic trainers can expand their knowledge base and skills as clinicians. Regardless of the paucity of research that exists on clinical-based outcomes and effectiveness evaluation of these different techniques, many athletic trainers use these techniques on a daily basis and continue to use these techniques to benefit their patients. We can learn from these clinicians' knowledge, experiences, successes, and failures and build upon their rich narratives. Learning from each other as healthcare professionals is vital to the advancement of medicine and to the continued growth in our treatment care for our patients. Breathing is an essential role in everyday

function and activity. Assessment and training of the roles and purpose of the diaphragm is imperative for clinicians today and can help to improve treatment outcomes and the overall lives of all those seeking rehabilitation.

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APPENDICES

Appendix A. Institutional Review Board Approval

Approval Date: Aug 17, 2015
Expiration Date: Aug 16, 2016

RE: Notice of IRB Approval
Submission Type: Initial
Study #: IRB-FY2016-1
Study Title: A Qualitative Investigation of the Incorporation of Diaphragm Training and Evaluation as a Therapeutic Tool by Athletic Trainers in Orthopedic Rehabilitation
Decision: Approved

This submission has been approved by the Missouri State University Institutional Review Board (IRB) for the period indicated.

Federal regulations require that all research be reviewed at least annually. It is the Principal Investigator's responsibility to submit for renewal and obtain approval before the expiration date. You may not continue any research activity beyond the expiration date without IRB approval. Failure to receive approval for continuation before the expiration date will result in automatic termination of the approval for this study on the expiration date.

You are required to obtain IRB approval for any changes to any aspect of this study before they can be implemented. Should any adverse event or unanticipated problem involving risks to subjects or others occur it must be reported immediately to the IRB.

This study was reviewed in accordance with federal regulations governing human subjects research, including those found at 45 CFR 46 (Common Rule), 45 CFR 164 (HIPAA), 21 CFR 50 & 56 (FDA), and 40 CFR 26 (EPA), where applicable.

Appendix B. Informed Consent Document

Research Purpose

The purposes of this study is 1) to investigate athletic trainers' clinical reasoning for use of diaphragm training and evaluation techniques as therapeutic tools in orthopedic rehabilitation, 2) determine if the reasoning and rationale given is aligned with evidence-based research, 3) provide medical health professionals with an extensive review of the literature on this topic, 4) increase awareness and understanding of the diaphragm's uses and possible purpose in rehabilitation.

Research Procedure

1. Complete demographic questionnaire prior to interview.
2. Participate in face to face or Skype interviews with lead researcher in a quiet private setting chosen by the participant.
3. Answers to interview questions will be recorded and used as data for answering research questions. No health information will be used or linked to answers given during interview.

Benefits to the participant and/or society;

Benefits for participation for the individual is in the reflection of their own rationale and practices with their patients. Gaining a greater understanding of the diaphragm, its possible purposes and detriments within the rehabilitation process can impact how healthcare professionals treat the patients and the effectiveness of their treatment. Lastly, once results are shared to those whom participated, this study can also provide the subjects an opportunity to learn from each other's experiences and research to build a stronger knowledge base.

Risks to the participant and/or society

Researcher identifies no known risks with participation in this research study.

Data Confidentiality and Disposition

Names of participants will not be used. Participant's region and setting will be noted only for demographic purposes and not linked to participants. Recordings will be deleted once transcription is completed. Records will be kept in a locked secure file within the Sports Medicine and Athletic Training Department for the required duration and then destroyed.

Participation is voluntary and you (the participant) may withdraw without penalty or loss of benefits. The amount of time required to perform the one-on-one interview will be about one hour. Please feel free to ask questions at anytime during the interview. You may also contact the lead researcher with any questions you may have that come up following the interview or at a later time.

Researcher:
Marisa Foltz, ATC, LAT
(417)-880-9573
1827 S. Murphy Ave Joplin, MO 64804

By signing this form below, you acknowledge having read the purpose and procedures of the research study, while understanding the possible risks and the potential benefits of participation. Opportunity for answering any questions will be given before and during the interview. By signing the form below, you are consenting to participate

within the research study, but also understand that your participation is voluntary and that you may leave the study at any time.

Signature:_____
Date:_____

Witness:_____
Date:_____

Appendix C. Demographic Questionnaire

Demographic Questionnaire

Name: _____ Year Certified: _____

Instructions

Please answer these questions honestly and to the best of your ability. Once completed, please print, scan, and e-mail questionnaire to Marisa Foltz ATC, LAT at Marisa110@live.missouristate.edu

1.) Gender: _____

2.) Age: _____

3.) Highest Level of Education: _____

4.) Which setting are you currently employed as an athletic trainer? _____

5.) How many years have you been employed in this position? _____

6.) What are the main reasons patients are referred to you? Choose all that apply (X).
Orthopedic Rehabilitation ( )
Performance Enhancement ( )
Injury Prevention ( )
Other (please explain): _____

Appendix D. Interview Questions

Interview Questions

Diaphragm training is any the use of any technique, tool, or exercise to teach or enhance the roles and purpose of the diaphragm in the human body.

1. Please explain what diaphragm training means to you.
2. Do you incorporate diaphragm training methods or exercises in your orthopedic rehabilitation protocols?
3. **If yes**, what is your rationale for using diaphragmatic training? Or **If no,** why do you chose not to incorporate those methods? (Explain)
4. When do you choose to incorporate those methods?
5. What benefits do you see when you incorporate diaphragm training in your practice?
6. What challenges or risks are involved?
7. What kinds of methods do you use/train/instruct/incorporate?
8. Do you incorporate tools or techniques to evaluate the function and/or efficiency of the diaphragm in your protocols?
9. What are your views regarding the purpose of the diaphragm within the human body?
10. What other roles do you understand the diaphragm to have?
11. Do you target those roles in your diaphragm training?
12. Please describe how you have gained your knowledge/perspective on the use of diaphragm training for your patients.
13. At what level of education did you have training concerning this topic?
14. Have you attended continuing education seminars regarding diaphragm training? If so which seminars?

15. What other informal training have you participated in concerning the diaphragm?

16. What effect has your personal experience had on shaping your perspective regarding this topic?

17. Have you participated in any personal professional development activities such as reading, home study courses, etc.?

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18. Have you noticed a trend in athletic training involving the incorporation of diaphragm training into their practice or orthopedic rehabilitation methods?

19. **If yes**, when did you start noticing this trend? Or **If no,** cease questions.

20. In what professional setting did you first notice it?