Celebrating our First Year

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Key Phrases
Practice-based research, practice-led research, quality improvement

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EDITORIAL

As we enter into our second year of publication for *Clinical Practice in Athletic Training*, and as the Journal continues to grow and expand, I wanted to take the time and notify the readership about a leadership change within the Editorial Board. As of this June, I will be assuming the role of Editor-in-Chief. We are immensely grateful for the leadership, dedication, and commitment that Dr. Cameron Powden has demonstrated in taking our shared vision and solidifying a place for clinicians to share their practice-based research. His guidance and oversight in laying the ground work were instrumental to our first year's success. Dr. Cameron Powden will be moving into the section editor role for our Evidence-to-Practice Review manuscript type. However, as with any transition in life, this period offers a unique opportunity to reflect on all the growth and momentum that we have gained.

In our inaugural year of publication we have 18 published articles across the 3 issues. These articles have been viewed or downloaded over 4,200 times in the span of our first year. We have had the pleasure and opportunity to publish unique practice-based and translational research in each of the manuscript categories that we offer, helping to give clinicians and patients a voice in translating evidence to practice. Our video podcast series #ATAnswers has over 350 views. Lastly, our social media presence continues to grow as we have over 1000 followers across our social media outlets (Twitter: @ClinATJourn; Instagram: @clinatjournal).

As we reflect on our first year of publication for *Clinical Practice in Athletic Training*, it is evident that we would not have experienced this growth without the help and contribution of all the individuals that serve the Journal. We, as the editorial board, are extremely grateful for all the hard work from all our section editors in the service that they have provided to establish author guidelines and facilitate submissions. Thank you for your continued support, contributions, and dedication to clinical practice research.

Additionally, we would like to thank Dr. Zachary Winkelmann for the devotion and enthusiasm for the term he served as Managing Editor (January to August of 2018). Throughout his time as Managing Editor, Dr. Winkelmann was able to secure and foster vital relationships that fueled much of the early growth the Journal experienced. Further, Dr. Winkelmann oversaw the securing of our ISSN and indexing as the Journal was launched. We would like to thank our Copy Editor, Susan Frey, MS, MLS, GC for her unique skill set and commitment to ensuring the highest quality writing and style guide for the Journal. Her attention to detail and work ethic are significant to the continued quality assurance of the articles we are publishing. Finally, we would like to thank our Graphic Designer, Denny Wongosari, MS, LAT, ATC, LMT, for his contribution in creating our logo, social media graphics, and marketing materials.

Below we recognize our section editors and reviewers who have contributed to the Journal over the past year:

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Clinical Experts Statement: The Definition, Prescription, and Application of Cupping Therapy

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Key Phrases
College and university patient population, therapeutic devices, manual techniques, cupping therapy

Author Characteristics
The first author, Andrew S. Cage, has obtained his International Cupping Therapy Therapist certification and is a member of the International Cupping Therapy Association. Mr. Cage also has several peer-reviewed publications as well as international, national, regional, and local presentations on the use of cupping therapy in sports medicine and rehabilitation. Mr. Cage has presented numerous times on evidence based approaches on the use of cupping therapy and uses cupping therapy extensively in his clinical practice. Further, Brandon Warner and Diana Gallegos, have also received certifications in cupping therapy and myofascial decompression and use cupping therapy in their clinical practice regularly. Both Mr. Warner and Ms. Gallegos have several peer-reviewed publications and presentations at the national, regional, and local levels.

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INTRODUCTION

Cupping therapy is an ancient modality the use of which has been documented as early as 3300 BC.[1] In the past two decades, dry cupping therapy has grown in popularity in the United States and other countries where Western Medicine is the primary source of healthcare.[1] A large amount of this popularity can be attributed to increased media interest resulting from elite level athletes receiving cupping therapy.[2,3] Even though cupping therapy has gained popularity as a treatment device in the United States, there is still no consensus on the ideal parameters for applying a cupping therapy treatment to patients competing in amateur or professional athletics.[1] The lack of consensus related to this medical issue can be attributed at least in part to a lack of high quality studies, lack of randomized controlled trials involving subjects participating in organized athletics, and a lack of standardized methodology.[1,4,5]

Within the medical and healthcare field, various methods of creating consensus statements on best practices are commonly used and accepted.[6-9] These techniques have been used to publish consensus statements in areas including respiratory, urologic, and geriatric medicine.[6-9] In instances in which there are deficiencies or contradictions within the current literature, the Delphi technique is one method of determining consensus that can be employed.[6] Therefore, the purpose of this clinical expertise commentary was to use the Delphi technique to develop a clinical expertise statement on the definition and description of cupping therapy, as well as the prescription and application of dry cupping therapy when providing athletic training services. This statement was to be created with the intent of serving as a guide for clinicians until gaps in literature could be addressed.

METHODS

A review of the available literature was conducted using PubMed and GoogleScholar to locate published materials that could contribute to an initial list of statements to utilize in the Delphi process. The review focused on: description and definition of cupping therapy, prescription of

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cupping therapy, and application of cupping therapy. The literature search looked for English language studies that had been published after 2013. Ultimately, 31 sources were utilized in the creation of the literature review.[1-5,10-35]

Upon completion of the review of literature, a panel of 10 athletic trainers who held a post-professional credential in cupping therapy were invited to participate in a series of online surveys and forums. Demographic information for the panel of experts can be found in **Table 1**.

Table 1. Panel demographic information

Sex	Male (N=5), Female (N=5)
Age (Years)	31.3 ± 5.01
Certified Athletic Training Experience (Years)	7.0 ± 3.71
Patients Treated Weekly with Cupping Therapy	9.1 ± 4.01

Age, Experience, and Patients Treated presented as means with SD.

After collecting demographic information from the panelists, the Delphi technique was utilized in a similar manner to that which was performed by Maher et al.[6] Panelists with a history of regularly performing formally trained cupping therapy as part of their daily athletic training practice were identified by the primary investigator and independently recruited to participate. Panelists received an electronic copy of the literature review, and were asked to review it for one week. Panelists were then surveyed on a series of statements regarding the definition and description, prescription, and application of cupping therapy on their patient population. Panelists were asked to rate each statement based off of whether or not they felt it warranted inclusion in the overarching clinical expertise statement (1 = Definitely do NOT include to 9 = Definitely include). Using the protocol outlined in **Table 2**, all statements were analyzed by the primary investigator to determine if they warranted inclusion, exclusion or modification. Following the first round, panelists received a web-based spreadsheet that outlined the results of the first survey. The spreadsheet also included areas for panelists to comment on what they felt should be modified in the statements that had not qualified for inclusion in order for them to be included in the final clinical expertise statement. After modifications were made to the remaining statements, the second survey was sent to the panelists asking them to re-rate the revised statements. Upon completing the second round of surveying, consensus was reached on all included statements based off each included statement having a median rating of 8 or higher.

Table 2. Statement inclusion key

Statement Result	Threshold Applied
Definitely Include	1. ≥ 80% of panel rated statement = 9 2. Median rating of ≥ 8
Maybe Include	1. ≥ 70% of panel rated statement = 9 2. Medial rating of ≥ 7
Definitely exclude	1. ≤ 80% of panel rated statement = 1 2. Median rating of ≤ 2
Review	1. Major revisions suggested by panelist. 2. < 70% of panel rated statement = 9

RESULTS

Following the review of literature, 67 statements were developed. These statements addressed the definition and description of cupping therapy, prescription of cupping therapy (specifically, indications and contraindications), and the application of cupping therapy. All 10 panelists participated in the demographics survey, as well as the first and second round of rating statements. Seven out of 10 panelists provided comments and suggested revisions for the statements that did not warrant inclusion or exclusion after the first round of rating. Additionally, five panelists were contacted in a one-on-one fashion to request clarification on comments or to provide clarifications on the investigator's remarks.

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After the rating of the original 67 statements was completed, 31 statements remained unmodified, four were excluded, and 32 were presented to the panel for revisions. A total of six of the statements regarding the description and definition of cupping therapy were combined into a single statement. Additionally, a single statement was created regarding mediums from five statements following agreement on oils were the preferable mediums to lotions. Statements regarding the number of pumps to use with plastic cups on experienced and inexperienced patients were combined into two respective statements. Additionally, the statement regarding the use of cupping therapy on the appendages of a pregnant patient was modified to include physician consent as a necessity.

Of the remaining 30 statements from the first round of rating, eight modified statements were reviewed and rated in the second round. During this round of rating, all eight were unmodified and included in the final overarching statement. As all remaining statements had reached a consensus, it was concluded that there was no need to undergo a second round of revisions and ratings. Thus, the final 39 statements are presented in **Table 3**, **Table 4**, and **Table 5** as the panel's clinical expert statement on the description, prescription, and application of cupping therapy in athletic training.

DISCUSSION

The purpose of this study was to develop a clinical statement on the description and definition, prescription, and application of cupping therapy in athletic training. The literature review results in 67 initial statements. Following 2 rounds of rating, 39 statements were included in the final clinical expert statements. Ultimately, the goal of this consensus clinical expert statement was to attempt to reach a level of agreement based off of expert opinion in the absence of high-quality evidence. This method was chosen based off the success of using it in other healthcare professions to create consensus statements for conditions and interventions that did not have clearly set guidelines.[6] The Delphi technique has been used by other authors to reach consensus statements on a variety of medical conditions.[6-9] Maher[6] noted this technique had exceptional utility when used for establishing guidelines for conditions that were not well documented in research-based literature.

Upon completion of the first round of review, revisions were made to the statements that qualified for modification based off of input from the panelists. Revisions were made to condense and clarify the description and definition of cupping therapy, the use of cupping therapy on the appendages of pregnant patients, the amount of suction used on patients with and without experience with cupping therapy, and the types of mediums used for applying cupping therapy. These statements are intended to serve as a tool for athletic trainers looking to incorporate cupping therapy into their clinical practice. Through review of these statements, athletic trainers may be able to practice cupping therapy with the knowledge that these aspects of the practice have been reviewed by a clinician-driven panel.

The authors encourage all athletic trainers and allied healthcare practitioners looking to practice cupping therapy to carefully review and consider each of these statements. The information contained within these statements is not inclusive of all individual scenarios and circumstances. Extenuating variables such as patient health, state and federal regulations, cultural beliefs, and patient values may affect the ability of a clinician to implement these statements into their practice. The authors strongly encourage individuals to seek out formal education and training in cupping therapy prior to administering treatments to patients. The statements contained within this document should be viewed as a resource and not a rigid set of guidelines for practicing cupping therapy.

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Table 3. Agreed Upon Definition of Cupping Therapy[1,4,5,12,17,21]

Cupping Therapy Description/Definition
1. Cupping therapy utilizes suction from one of a variety of methods.
2. Cups used for cupping therapy can be made of materials including plastic, glass, rubber, silicone, and wood.
3. Some methods of creating suction on the tissue being treated include: pumping air from a plastic cup, creating an oxygen deficit in a glass cup with an open flame, and manually manipulating a silicone cup.
4. Cupping therapy utilizes negative pressure to have a mechanical effect on treated tissues.
5. Traditional cupping therapy was a commonly used technique prior to the 20th century. During the turn of this century, trends indicate that there was a decline in use, possibly due to the advancement of medical research or the ambiguity of bloodletting procedures. However, this ancient practice has begun to re-emerge as a viable option for orthopedic injuries. This increase may be contributed to the 2016 Olympics or continued research in optimizing outcomes for athletes.
6. There is some evidence to suggest that cupping therapy can decrease musculoskeletal pain.
7. There is some evidence to suggest that cupping therapy can increase regional and local blood flow.

Table 4. Agreed Upon Prescription of Cupping Therapy[1,2,5,13,15,22,29]

Indications
1. Musculoskeletal pain is an indication for the use of cupping therapy.
2. Neurological pain is an indication for the use of cupping therapy provided direction is given by the patient's neurovascular specialist.
3. Muscle tightness is an indication for the use of cupping therapy.
4. Myofascial adhesions within a muscle are an indication for the use of cupping therapy.
5. Subacute and chronic muscular injuries are an indication for the use of cupping therapy.
Contraindications
1. Open wounds are a contraindication for the use of cupping therapy.
2. Pregnancy is a contraindication for cupping therapy over the lower back or torso.
3. Cupping therapy treatments on the appendages of pregnant patients should be done with caution, and when possible with physician consent.
4. Neurovascular compromise is a contraindication for the use of cupping therapy in the absence of referral by a neurovascular specialist.
5. Cupping therapy should not be performed on a muscle that has suffered an injury within the past 24-72 hours.
Cupping therapy for athletic related injuries
1. There is a need for a larger number of high-quality studies on the use of cupping therapy in athletic training.
2. Several case studies have been published that suggest cupping therapy may be a viable treatment option for athletics related injuries.
3. In the absence of high-quality studies specific to athletics related injuries, clinicians and educators must rely on studies conducted on participants from the general population.
4. There is no time required for patients to refrain from participation in sport-related activities following use of cupping therapy, provided they complete an adequate dynamic warm up and are not experiencing soreness above patient tolerance.

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Table 5. Agreed Upon Considerations of Cupping Therapy[1,4,5,12,15,29]

Application
1. When treating a minor, it is necessary to educate the patient's parent or guardian and obtain consent from said guardian prior to performing cupping therapy.
2. Cupping therapy should be performed by or under the supervision of a properly educated healthcare professional.
3. Depending on the location, goal, and patient allergies, clinicians should use mediums such as coconut oil, grapeseed oil, and seedless massage oil to minimize patient discomfort during cupping therapy treatments.
4. An area with more body hair may require the use of more oil, but may still be more difficult to achieve suction on.
5. Therapeutic effects can be seen after as little as 10-minutes of treatment when using static cupping therapy depending on therapeutic goals.
6. Static cupping therapy can be performed safely for up to 30-minutes depending on patient comfort and therapeutic goals.
7. When using plastic pump cups with patients who have not been cupped before, starting with 1 pump based on patient comfort is recommended.
8. Clinicians should use an amount of suction that does not elicit a painful response when treating patients who have not received cupping therapy treatments before.
9. Depending on therapeutic goals and patient tolerance, clinicians can generally use more suction when treating patients who have receive cupping therapy treatments before.
10. Clinicians can affect the amount of suction achieved during fire cupping by decreasing the amount of time from when the flame is removed from the cup and when the cup is placed on the intended treatment area.
11. Provided a patient's soreness has not increased and patients can tolerate the amount of suction, clinicians can utilize cupping therapy in the presence of muscular soreness.
Reasons to Discontinue/Adverse effects
1. If a patient expresses discomfort during cupping therapy, the clinician should discontinue treatment.
2. If blisters begin to form during cupping therapy, the clinician should discontinue treatment.
3. If blisters do form during cupping therapy, standard wound care treatment is appropriate provided there are no signs of infection.
4. If a patient begins to become lightheaded during cupping therapy, the clinician should discontinue treatment.
5. Presence of ecchymosis related to a previous cupping therapy treatment does not disqualify a patient from being treated with cupping therapy again provided the patient is not experiencing soreness.
Following treatment
1. Patients should be instructed to hydrate properly following cupping therapy.
2. Patients can reasonably expect to feel soreness similar to what would be expected after a deep tissue massage following cupping therapy.

Although the panel was able to reach consensus on the included statements, this study did have limitations. The literature review was designed to provide panelists with an overview of the most current literature. However, there was not a number of high-quality studies assessing the effects of cupping therapy. Additionally, the majority of these studies did not follow a standardized methodology that may have given the panel the opportunity to provide learner guidelines regarding the application of cupping therapy. Due to this limitation, the literature review was reviewed by a clinician with extensive experience with cupping therapy in order to ensure the literature review was completed in the most comprehensive and insightful way possible. Furthermore, the use of athletic trainers with their primary job setting as college/university may limit the generalizability to other job settings. Athletic trainers practicing in settings where the majority of their patients are minors may have additional considerations they need to make. Future research should incorporate panelists from other athletic training settings to increase the generalizability of

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these statements. A final limitation that is that the Delphi technique has been suggested to not meet the same standards as other scientific methods.[6] That being said, the controlled feedback and clinician input that is characteristic of this technique is ideally suited for creation of a consensus statement on a treatment technique that currently has gaps and contradictions within the available literature.

CONCLUSIONS

The remaining 39 statements provide an expert statement on the definition and description, prescription, and application of cupping therapy for athletic training clinical practice. This clinician-driven expert statement using the Delphi technique provides a framework for safe and effective cupping therapy practices based off of best available evidence and clinician expertise. This statement is presented with the intent of providing direction for decision making regarding the prescription and application of cupping therapy.

THE CUPPING THERAPY PANEL OF EXPERTS

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Clinician-Administered Versus Self-Administered Suboccipital Release on Superficial Backline Function

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ABSTRACT

The effectiveness of trigger point release in the suboccipital region to improve hamstring mobility has been established in the literature, but the research has not clarified whether self-administered soft tissue techniques produce the same improvements to mobility as when the clinician delivers the manual trigger point release. The purpose of the study was to assess whether the same increase in hamstring mobility within the superficial backline function that is achieved with a clinician-administered suboccipital trigger point release can also be obtained through a patient/self-administered method. The study employed a randomized, descriptive laboratory design in which 60 participants reported for a single data collection session and were randomly assigned to either a clinician-administered or self-administered treatment group. There was a statistically significant main effect for the intervention ($F(1,58) = 18.24$, $p < .001$, eta = .239) indicating that both the clinician-administered and the self-administered groups improved in their hamstring mobility from pretest to posttest; but there was not a statistically significant interaction of time and group ($F(1,58) = 18.24$, $p = .360$, eta = .014) indicating that the effectiveness of suboccipital trigger point release on hamstring mobility did not differ between groups. The significant finding in this study is that toe touch distance – indicating improved hamstring mobility – increased for all participants following a suboccipital trigger point release. The significant clinical implication from the study is that improvement in hamstring mobility was similar whether the suboccipital trigger point release was clinician-administered or self-administered. If a clinician properly instructs a patient on how to perform a trigger point release in the suboccipital region, the self-administered intervention can be just as effective at improving hamstring mobility as when the clinician performs the release. This finding allows clinicians to extend the scope of their treatment by empowering patients to effectively treat their own myofascial trigger points.

Key Phrases
Clinician-rated outcome, manual techniques, myofascial release

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INTRODUCTION

Trigger points are hyperirritable, localized areas of tightness within a band of skeletal muscle that can cause referred pain.[1] Referred pain is experienced in 1 area of the body, although the cause of the pain originates in a different area of the body. Trigger points arise from the degradation of proper body alignment which is typically the result of poor posture.[2-4] In these cases, the body necessarily recruits other muscles to compensate for body misalignment in order to maintain static positions.[2-4] These misaligned static positions leave muscles contracted and the compensatory muscular contraction frequently leads to hypersensitivity in the form of trigger points. [2-4]

Individuals who spend hours a day seated at a desk, hunched over a computer, or curled around a mobile device routinely engage a forward head posture. A forward head posture requires that posterior neck muscles be engaged to maintain static tension in order to keep the head upright.[2-3] This compensatory action within the nervous system can manifest as active trigger points. Trigger points are thought to be formed when sarcomeres, which are considered the

building blocks of muscles, become overactive.[2-5] When this overactivity occurs and these myofilaments stop sliding over one another naturally, the sarcomere continues to stay in a switched-on position. This state of contraction leads to muscle pain, hypertonia, and stiffness, which is called a trigger point.[3-5] Evidence is clear that the restriction to tissue caused by trigger points negatively affects the mobility of other parts of the body by causing extra tension along the connecting fascial tissue.[1-4]

Fascia comprises sheets of web-like tissue surrounding muscles and joints, connecting different sections of the body to one another, allowing the body to function as 1 unit.[5-10] As illustrated in **Figure 1**, the superficial back line is a fascial tract consisting of 4 pieces connecting large sections of the body to one another. Two pieces attach at the supraorbital ridge, go over the top of the head, down both sides of the spine, and attach again on the lower leg. The second 2 pieces travel from the distal section of the femur, down the posterior aspect of the lower leg, and attach at the metatarsal heads of each foot.[8] These structures consist of the epicranial fascia, cords of the erector spinae, the sacrotuberous ligament, the hamstrings, the triceps surae, and the plantar fascia. The primary function of the superficial backline is to create the extension and hyperextension needed for an individual to maintain an upright posture. Clinical theory describing myofascial chains such as the suboccipital back line originates from the assumption that the muscles of the human body do not function as independent units.[10] Instead, muscles are interconnected in identified chains and linked through fascial structures creating a system of structural continuity.[10] Following this philosophy, trigger points that disrupt this function by causing pain or negatively affecting the mobility of 1 area of the superficial back line – such as the suboccipital muscles – will affect mobility along this facial tissue of the superficial backline, affecting even the distal region of the hamstrings.[8]

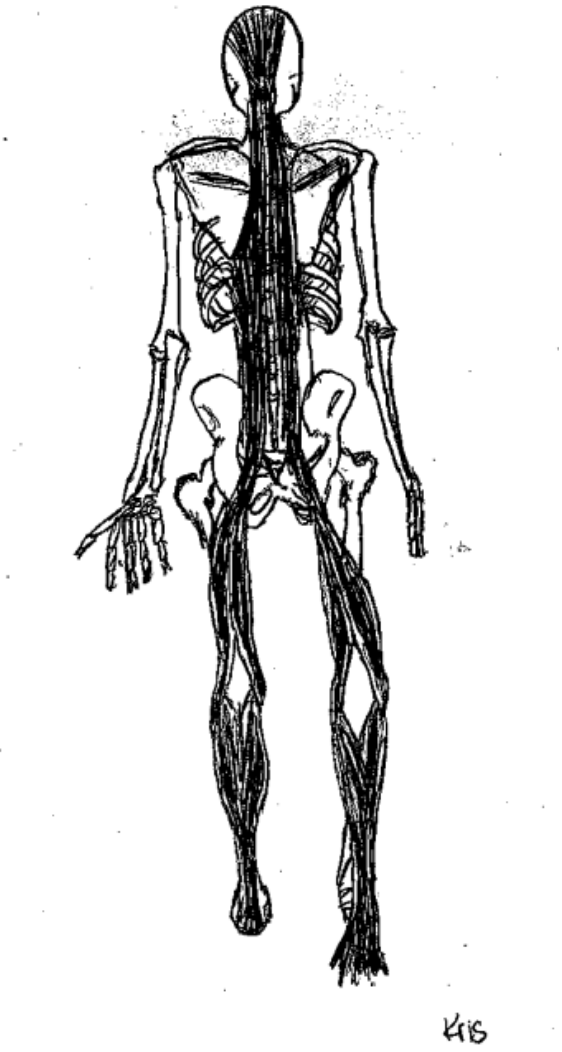

Figure 1: Illustration of Superficial Backline Fascia

Because sections of the body are connected by different fascial tracts, activation of a trigger point within a given muscle can affect the motion of other joints within the same fascial tract.[2-4] For example, a trigger point in the serratus anterior can cause referred pain in a patient's medial elbow on the ipsilateral side.[11] In the case of

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improperly stabilized forward head posture, tension can develop along the entire superficial backline as additional muscles are recruited to maintain an upright posture. However, trigger point release in the suboccipital region can reduce neural tension and act as a reset button for the nervous system, allowing patients to properly stabilize their head and neck.[4,8] This decrease in neural tension allows greater flexibility of movement and better function of the superficial backline.

Manual trigger point release is one of the many myofascial release methods used by clinicians to reduce pain and increase tissue extensibility in muscles with identified trigger points.[11-16] The particular manual trigger point release technique of interest to this study was in the suboccipital region.[4] Trigger point release in the suboccipital region restores head and neck motion by applying light pressure to any trigger point in the occipital muscles while the patient lies supine on a treatment table. In most cases, clinicians apply pressure manually using their fingertips to any area of tissue in the suboccipital region that feels tight or elicits pain.[11-14] Devices such as lacrosse balls or dowel rods can also be used to release trigger points, in place of the clinician's fingertips.[11-14] Studies have shown that, following a trigger point release treatment, overall function of the superficial back line (measured by hamstring flexibility) immediately increases.[2,4]

Although the trigger point release technique in the suboccipital region is typically administered by a clinician, the technique can be readily employed by patients themselves. However, research into the effectiveness of trigger point release in the suboccipital region has not clarified whether self-administered soft tissue techniques produce the same improvements to mobility as the clinician delivering the trigger point release. The purpose of the study was to assess whether the same increase in hamstring mobility within the superficial backline function that is achieved with a clinician-administered suboccipital-region trigger point release can also be obtained through a patient-administered method.

PATIENTS

The study employed a randomized descriptive laboratory design in which participants reported for a single data collection session. Following institutional IRB approval, participants were recruited from a Division I university in the Midwest through verbal announcements. Participants included a convenience sample ($N = 60$) of 18-24 year-olds who were randomly assigned to either a control group ($n = 30$) or an experimental group ($n = 30$). The sample comprised 31 males (51.7%) and 29 females (48.3%). All participants gave written consent and were subject to inclusion criteria of having no current pain or injuries to the neck or back; however, all participants were assessed for the presence of trigger points in their suboccipital muscles and all of them had trigger points, although none were painful enough to preclude their participation in this study. All of the original 60 participants (100%) were included in the study.

INTERVENTION

On the day of the study, all participants reported to a classroom laboratory at the university and signed in on an attendance sheet. Those who signed in on an odd-numbered line were assigned to the clinician-administered (control) group, and those who signed in on an even-numbered line on the attendance sheet were assigned to the self-administered (experimental) group. Each participant (both control and experimental group) completed 3 baseline measurements using the slide ruler box and the researcher recorded the mean score as the pre-test score. A meta-analysis of the criterion-related validity of the slide ruler

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box sit-and-reach test presents evidence that this is an effective method for measuring hamstring extensibility (mobility), and that the clinician should use the average of 3 tests in their reported score.[15] Following baseline measurements, the researcher worked individually with each participant.

Participants in the clinician-administered group were asked to lie supine on a treatment table while the researcher performed a trigger point release technique in the suboccipital region on the participant for 2 minutes. The researcher was an athletic trainer with 2 years of practice, who had completed all coursework in a post-professional masters athletic training program that emphasized manual therapies and included training in myofascial release including trigger point release therapy. To perform the trigger point release technique in the suboccipital region, the researcher held their forearms in a supine position at the same level as the participant. Using the fingers of both hands, the researcher started in the thoracic spine area and gently massaged the soft tissue while moving fingers superiorly through the cervical spine stopping when the base of the occiput was reached. Once the occiput was reached, the researchers moved their fingers inferiorly about ½ - 1 inch (over the C1/C2 area) then while cradling the posterior cervical area, palpated with the fingers for areas of tightness which identified trigger points. The researcher confirmed these were trigger points by asking the participant if this pressure caused pain. While on the trigger point(s), the researcher then applied gentle pressure anteriorly for approximately 30 seconds to 1 minute per trigger point until they felt the tissue start to release and soften.[4,8,14]

The participants in the self-administered group were asked to lie supine on a treatment table. The researcher performed a trigger point release technique in the suboccipital region for 5 seconds using the same method of application as the control group. This was done so that the participant could identify the feeling they should replicate during the trigger point release. During this time, the participant was asked to take note in feeling what pressure over the trigger point felt like and how much pressure the clinician was applying. Each participant was then given a 1 inch diameter plastic dowel rod that they placed in the suboccipital region of their head. They were instructed to reproduce the same sensation as they had felt by the clinician for 2 minutes. Therefore, the actual trigger point release was performed utilizing the plastic dowel rod as a self-administered technique, and the initial hands-on portion done by the researcher was just maintained long enough to teach the participant how to replicate this sensation on their own.

Immediately following completion of the clinician-administered or self-administered trigger point release intervention in the suboccipital region, all participants were again measured on standing forward flexion. Participants were measured 3 times on their standing forward flexion distance score using the slide ruler box. The mean score was recorded as the post-test superficial backline function score. All participants were then thanked for their participation and dismissed.

OUTCOMES MEASURES

The researchers in this study utilized toe touch distance as the single measurement of hamstring mobility. Standing forward flexion distance was measured using a slide ruler box and served as the baseline (pre-test) measurement of the participants' superficial backline function. To obtain this measurement participants were instructed to stand with their feet together and knees locked on top of a platform next to the slide ruler box. They were then instructed to bend forward from the hips, while keeping the distal extremity locked, and attempt to touch their toes and hold for a single breath cycle (eliminating

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bouncing movements) before returning to the start position. The participants' extended fingers moved the slide on the scale to a final position and the measurement was recorded in centimeters. The participants repeated this task 3 times; both pre-test and post-test following the intervention and the mean score was recorded as the final measurement of hamstring mobility. All measurements and subsequent intervention were conducted by a single trained evaluator to control for variability and bias. Kippers[18] found toe touch to be a valid and reliable test to measure active trunk and hamstring range of motion across all body types. Further, another study concluded that toe touch distance could be used as the sole measurement of hamstring mobility to accurately assess for an increase of mobility following clinician-administered trigger point release in the suboccipital region.[4]

RESULTS

Before conducting hypothesis testing these data were examined for potential violations of the assumptions of the repeated-measures ANOVA. Data were assessed for outliers using boxplots; no outliers were found. A Shapiro-Wilk test showed that both the pretest ($p = .46$) and the posttest data ($p = .10$) were normally distributed. While conducting the mixed repeated measures ANOVA (pretest to posttest, control vs. experimental), Box's Test of Equality of Covariance Matrices was non-significant ($M = 5.72$, $p = .138$), indicating that the covariance matrices were equivalent, so all ANOVA interpretations were done using multivariate tests.

There was a statistically significant main effect for the intervention ($F(1,58) = 18.24$, $p < .001$, eta = .239) indicating that both the clinician-administered and the self-administered groups improved from pretest ($M = 4.74$, $SD = 7.96$) to posttest ($M = 6.79$, $SD = 7.58$). But there was not a statistically significant interaction of time and group ($F(1,58) = 18.24$, $p = .360$, eta = .014) indicating that neither group outperformed the other. These findings show that the intervention was successful at increasing mobility an average of 2 centimeters regardless of whether the intervention was conducted by a clinician or by the patient. The magnitude of the mobility increase is displayed in **Figure 2**.

DISCUSSION

This study supports existing research findings that hamstring mobility, as measured by toe touch distance, significantly increases following trigger point release in the suboccipital region.[2,4] In a randomized clinical trial, Aparicio[2] found the suboccipital trigger point release technique significantly improved hamstring function as measured by toe touch distance, straight leg raise, and popliteal angle. Further, studies showed that when a release was performed on a trigger point which was causing an area of restriction that was within a fascial tissue structure, such as the superficial back line, it had

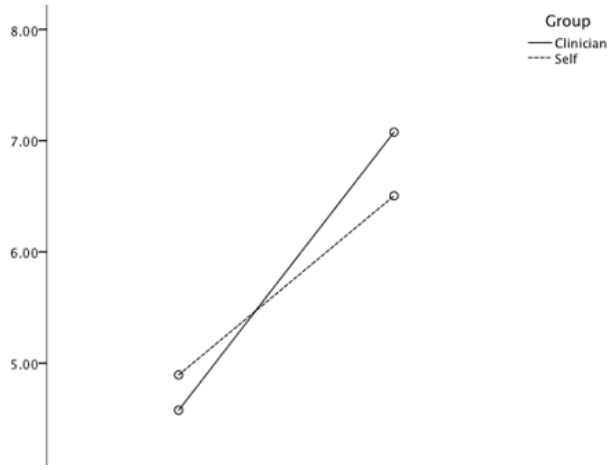

Figure 2: Increases in Superficial Backline Function Distances by Group (in)

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a positive effect on other areas that connected to this line.[16-18]

This study demonstrates that a properly taught, self-administered suboccipital trigger point release is equally effective as a clinician-administered treatment. The finding that both clinician-administered and self-administered suboccipital trigger point release delivers immediate improvements in mobility has implications for treating back pain. In a similar study examining the effectiveness of reducing trigger point sensitivity in the neck and upper back, the investigators measured pain intensity following a prescribed home-based program of ischemic pressure and stretching.[19] The authors concluded that when monitored periodically by a clinician, home-based programs using self-administered therapy techniques are an effective method for reducing trigger point pain.[19]

While this study has shown that this manual technique can improve the overall function of the superficial back line, it should be noted that the reason why is still unclear. One possible reason for this outcome could be that the released tension relaxes the tissue in a way that allows more movement throughout the entire fascial line. The chain itself has too much tension, and this tension should be relieved to gain more motion.

The single-iteration methodology employed in this study demonstrates that immediate release is possible. However, this study does not show how long that relief will last, nor does it address the effects of multiple self-applications of the technique. Additional research should examine how long relief continues after a single application of the technique and should introduce a longitudinal component to study whether patients who trained to perform suboccipital trigger point release on themselves can use repeated applications of the technique to reduce back pain or other symptomology. Furthermore, this research opens the possibility of exploring other trigger point release techniques known to be effective when delivered by clinicians and exploring their amenability to self-administration by patients.

CLINICAL APPLICATION

This study demonstrates that a properly taught self-administered suboccipital trigger point release was equally effective as a clinician-administered treatment. The current study adds to the existing findings in three ways. First, this study demonstrates that when trigger points in the suboccipital area are released, an increase in mobility observed immediately. Second, this study demonstrates that immediate increases in mobility can be attained when the trigger point release technique in the suboccipital region is employed by a properly trained patient in the absence of a clinician. Third, the amount of training needed to teach a patient to effectively perform the trigger point release technique in the suboccipital region requires less than a minute.

In a clinical environment dominated by managed care clinicians in a therapy setting are limited in treatment times and number of clinic visits with their patients; therefore, it is of great benefit when a clinician can identify manual therapy techniques, such as the suboccipital trigger point release, that can be taught to their patients and successfully administered outside of the clinical setting. This allows the clinician time within the scheduled therapy session to focus their intervention on other clinical goals.

The significant finding in this study is that, following a suboccipital trigger point release, toe touch distance increased for all participants. These findings indicate that if a clinician properly instructs a patient on how to perform a suboccipital trigger point release, the intervention is just as effective as when the clinician performs the suboccipital trigger point release. Future research should explore the long-term effects of

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suboccipital release on toe touch over time, as well as the reason behind these effects, as the current study only measured the immediate effects and not the direct cause of them.

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Regionally Interdependent Applications of Total Motion Release® and Active Rotational Shoulder Range of Motion in Overhead Athletes

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ABSTRACT

Healthy athletes commonly engage in pre-participation warm-up strategies designed to physiologically and mechanically prepare the body for training and competition. Alterations in rotational range of motion (ROM) of the dominant shoulder in overhead athletes, resulting in total rotation ROM loss, correlate with performance deficit, injury risk, and lost training time. Researchers have suggested that interventions using Total Motion Release® (TMR®) increase shoulder ROM more effectively than traditional warm-up methods. A randomized pre-test post-test trial was used to explore the effects of a regionally interdependent application of TMR® via a forward flexed trunk twist (FFTT) and seated straight leg raise (SLR) compared to a traditionally designed athletic warm-up on active shoulder internal rotation (IR) and external rotation (ER) in healthy overhead athletes measured with the *Clinometer*© smartphone application. Participants included twenty-two NCAA Division I, III, Club, and Secondary School senior student-athletes (9 javelin, 7 volleyball, 6 baseball; 13-females, 9-males; age= 19.3±1.1 years; height= 178±11.4 cm; weight= 76.4±11.2 kg), randomly assigned to TMR® (TMRG; n=11) and traditional warm-up (TWG; n=11) groups. The TMRG performed 3 sets of FFTT and SLR, each held for 20 seconds to the side of ease. The TWG completed a traditionally designed athletic warm-up including running, athletic drills, and dynamic and static stretching. The TMRG experienced significantly greater increases in dominant shoulder IR, non-dominant shoulder IR, and non-dominant shoulder ER (mean $_{change}$ =+9.5°, +7.5°, +4.7°), than the TWG (+1.7°, -6.7°, -4°) respectively. Intervention time to completion was also different between groups (TMRG = 7mins TWG = 25mins). This study indicates that an indirect TMR® application produces efficient meaningful changes in rotational active range of motion (AROM) of the shoulder in overhead athletes.

Key Phrases
Injury risk reduction, performance exercise, throwing athletes

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INTRODUCTION

Dynamic, forceful, and repetitive movement of the shoulder among overhead athletes may cause osseous and soft tissue adaptations as well as kinematic changes within the joint and surrounding musculature.[1-8] As a result, overhead athletes may present with increased external rotation (ER) and decreased internal rotation (IR) of the dominant shoulder.[1,3-7] Range of motion (ROM) adaptations, via the reduction of total rotational ROM, may elevate risk of shoulder injury, result in lost training and competition time, and raise the potential for decreases in performance via common injury patterns.[9,10]

Researchers suggest the goals of performance readiness be accomplished via the progressive sequencing of warm-up activities including low-intensity aerobic exercise, stretching, high load dynamic drills, and sports specific exercises.[11-13] It is recommended that this sequence elevate the heart rate, increase peripheral tissue temperature, address specific aims such as increasing ROM through static or dynamic stretching, and then incorporate specific skill based drills required by the training or competitive environment of the participant.[12,13] Interventions to improve shoulder ROM and increase performance readiness are employed

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by athletes regardless of ability and health status. These often include static stretches that have traditionally focused on local structures.[1,7,8,12,14] Though these types of interventions are regularly employed, improvements in shoulder IR are often found to be less than 5°.[14-16] While immediate increases in shoulder ROM have been found, static stretching has often not been found to produce lasting changes in ROM or increase performance in athletic populations.[12-16] Despite these findings, researchers have traditionally advocated that both healthy and at risk individuals engage in daily stretching programs, often as part of warm-up activities, in order to improve or maintain shoulder ROM.[4,12,14-17]

Focusing on specific tissues and localized areas of the body, while ignoring the complexity of the neuromuscular system, may reduce the efficacy of traditional warm-up protocols.[18-21] Instead, heeding the interconnected nature of the neuromuscular and fascial systems may be the key to producing meaningful injury prevention and performance enhancement strategies. Researchers have established that alterations in one region of the body affect not only local outcomes, such as positional changes in joints, tension dynamic changes across soft tissues, and alterations in stability,[22-24] mobility,[25-27] and motor control,[28,29] but invariably produce adjustments in other, interdependent, body regions.[26,27,30-32] The term regional interdependence (RI) is used to describe this phenomenon.[32] While the RI model is primarily concerned with musculoskeletal factors, it may also involve neurophysiological effects.[31,32] Therefore, neuromuscular adaptation is of particular interest when movement is the primary driver of intervention, as is the case during therapeutic exercise or warm-up programs prior to training or competition.

Total Motion Release® (TMR®), a movement based orthopedic intervention, utilizes RI, potentially via cross education,[22-25] neural coupling,[28] and the common core hypothesis,[29] as well as the fascial interconnectedness of the trunk and upper limbs,[33-35] to produce changes in ROM, pain, and dysfunction, through targeted pain-free movement.[30] The TMR® system is based on the theory that pain alters motor control, movement patterns adapt to dysfunction created by pain, and that the body seeks symmetry and will correct dysfunctional movement patterns in the absence of pain.[30] Participants using TMR® are asked to perform movements bilaterally and then self-rate to compare the motions on a scale of 0-100.[30] On this scale, 0 represents an absence of pain, dysfunction, or strength deficit, and equal quality and quantity of ROM. In contrast, a score of 100 represents extreme pain, complete dysfunction or unilateral strength deficit, or substantial loss of quality or quantity of ROM.[30] Once these self-determined ratings have been established, the motion with the highest rating (i.e., the most 'dysfunctional' movement or 'bad side') is addressed by performing the same motion to the side of ease (i.e., 'good side') through set and repetition schemes determined by the clinician or based on patient comfort.[30] The movement is completed so long as the motion is not bilaterally painful or dysfunctional, which would be a contraindication to use that movement within the TMR® system.[30] The use of TMR® may have benefits as a performance readiness and injury prevention strategy due to the proposed effects regarding increased ROM,[26,27] and may help patients/athletes achieve symmetry in paired movement patterns.[26]

Although TMR® research is scarce, its use has been found to quickly increase shoulder ROM in baseball players when using arm raise and trunk twisting motions.[26,27] However, TMR® as an

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intervention strategy, is often applied in a regionally interdependent fashion.[30] Therefore, further research is warranted to determine the effects of TMR® as an intervention for increasing shoulder ROM in overhead athletes. Specifically, it is necessary to assess if these positive changes in ROM are the result of direct application of TMR® movements at the upper extremity. Therefore, the purpose of this study was to explore the regionally interdependent effects of an indirect application of TMR® using forward flexed trunk twist (FFTT) and active straight leg raise (SLR) techniques on shoulder AROM compared to a traditional athletic warm-up among healthy overhead athletes.

PATIENTS

With the approval of a university Institutional Review Board, a non-blinded randomized control trial design was utilized to examine and compare the effects of an indirect TMR® intervention and a traditionally designed warm-up. All participants were informed of the risks and benefits of the investigation prior to signing informed consent documents and were aware that they could withdraw their participation at any time. A total of 22 student-athletes were recruited from NCAA Division I University volleyball and track and field teams, a NCAA Division I University Club Baseball team, a NCAA Division III track and field team, and secondary school baseball and volleyball teams. Gender and sport differences between groups are presented in the CONSORT flow chart (**Figure 1**).

Participants were included if they were between the age of 18 and 25, could complete all warm-up activities and ROM testing procedures, were a member of a Secondary School, Junior/Community College, NAIA, NCAA I, II, III, club baseball, baseball, volleyball, or track and field team, and had been competitive in their discipline for at least 3 years. Participants were excluded from this study if they had had any orthopedic surgery three months prior to data collection at the hip, knee, ankle, spine, shoulder, or elbow. Individuals with orthopedic injuries older than three months that remained symptomatic were also excluded. Participants were also excluded from this study if they were found to be unable to complete shoulder ROM testing or had painful motion with both left and right trunk rotation or left and right straight leg raise as these are contraindication within the TMR® system.[30] All participants were also able to complete a full traditionally designed athletic warm-up. If the participant was being advised by their medical or coaching staff not to take part in such activity, was unable to complete any portion of the traditional warm-up, or wished for their ROM or demographic information to not be utilized, withdrawal from participation was accepted. All volunteers met the pre-screened inclusion criteria with no participants dropping or being excluded once data collection had begun.

INTERVENTIONS

The study was conducted in a single session for each participant. All interventions were performed before any sport-specific or warm-up activities had occurred for the day. Randomization was accomplished by using a first generator by randomization.com, participants randomly assigned to either the TMR® group (TMRG; n=11) or the traditional warm-up group (TWG; n=11). A Certified Strength and Conditioning Specialist (CSCS) collected all measurements and data in their second year studying in a masters of science in athletic training program. All measurements and interventions were conducted indoors in athletic training facilities and gymnasiums. Pretest measurements

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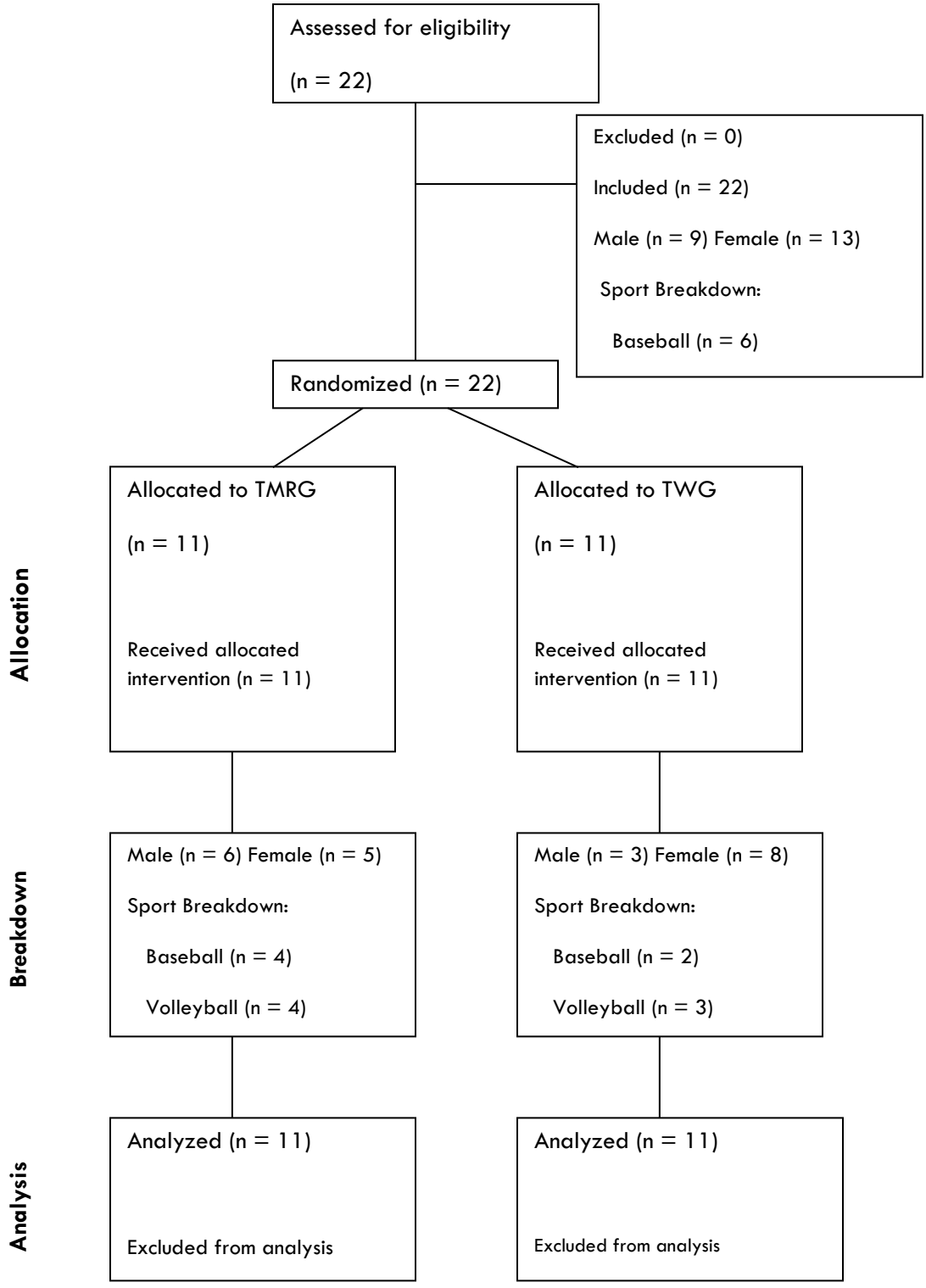
Figure 1. CONSORT diagram showing the breakdown of participants by intervention, gender, and sport.



of active shoulder IR and ER were measured on the dominant and non-dominant sides before performing either intervention. Following baseline AROM measurements, the participants in the TMRG performed one seated straight leg raise (SLR) (**Figure 2**) with each leg and one FFTT (**Figure 3**) with the arms across the chest placing the palmar surface of the hand at the anterior axilla, the hips slightly flexed as if performing a dead lift, and the torso at an angle which caused no discomfort in the lumbar region to each side. Hip angle, depth, and postural control were not controlled for as the TMR® system asks for the participant to reach their perceived end range requiring changes in joint angles during intervention.[30] The participant then determined which side or motion provided the most ROM, best quality of motion, was pain free, or free of restriction.[30]

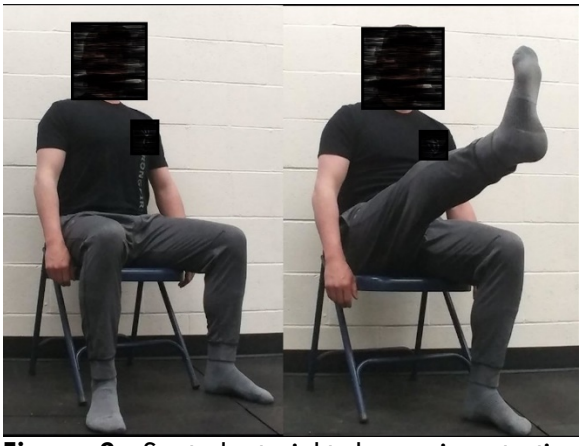


Figure 2. Seated straight leg raise starting position and ending position.

Figure 3. Forward flexed trunk twist movement.

Total Motion Release® Group (TMRG Intervention)

Participants in the TMRG established a side of ease for both the seated TMR® SLR and FFTT through self-determination. After the easier side had been determined, participants performed the seated SLR (3 sets of 20-second static holds at end range) and the FFTT (3 sets of 20-second static holds) in the direction of the side of ease beginning with the most dysfunctional of the two patterns. After each set, there was a 30-second rest interval. Static holds of 20 seconds at end range were chosen to mitigate the fatigue associated with completing multiple high-volume repetition and set schemes as part of this intervention.[36] Participants in the TMRG were given instruction by a level 3 TMR™ trained investigator and were cued to 'sit back, rotate, and breathe' throughout the FFTT and 'to lift the foot up and breathe' during the SLR. Following the intervention, AROM measurements were reassessed. Each participant accomplished the TMRG intervention, including testing on the side of ease, in approximately 7 minutes.

Traditional Warm-Up Group (TWG Intervention)

Researchers suggest that a pre-training or pre-competition warm-up should include sequential phases designed with the specific goals of elevating the heart rate and increasing peripheral tissue temperature, addressing mobility and ROM through static or dynamic stretching, and incorporating specific skill based or sport specific drills.[11,13] The TWG in this study followed a protocol fashioned after these recommendations using static stretches shown in the literature to increase IR and decrease posterior capsular tightness at the shoulder.[14,15] Static stretching was done in the terminal phase, as increases in rotational ROM was the end goal of the TWG.[37] The TWG completed the warm-up protocol (**Table 1**) after baseline AROM measurements were assessed. Following the intervention, AROM measurements were reassessed. Each participant completed the TWG intervention in approximately 25 minutes. To complete the

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Table 1. Traditional Warm-Up Protocol

Warm-up Exercise	Repetitions
Phase I	
Jog	3min at 25%
Phase II	
Walking Knee Hug	10m
Alternating Forward Lunge w/ Rotation	10m
Alternating Reverse Lunge w/ Rotation	10m
Alternating Walking Quadriceps Stretch	10m
Power Skips	10m
Alternating Lateral Lunges	10m
Walking dynamic forward overhead arm circles	10m
Walking dynamic reverse overhead arm circles	10m
Walking horizontal cross body arm swings	10m
Phase III	
Sprint (50%)	2 x 30m
Sprint (75%)	2 x 30m
Sprint (90%)	2 x 30m
Phase IV	
Alternating seated cross body stretch	3 x 30s each
Alternating seated upper trapezius stretch	3 x 30sec each
Alternating side lying sleeper stretch	3 x 30sec each

protocol, each participant in the TWG completed a 4-phase warm-up. Phase I consisted of a 3-minute steady state jog.[11] Phase II was comprised of a series of dynamic full body warm up drills with upper and lower extremity dynamic stretches, dynamic movements in all three planes of motion, and a focus on full range shoulder motion.[11,12] Phase II was completed in three continuous rounds with a 30-second rest interval. Phase III included two rounds of 30 meter runs at 50%, 75%, and 90% of perceived max intensity, each done with a 30-second rest interval.[11] Phase IV was comprised of 3 rounds of 30-second alternating static stretches for the shoulder done to produce a 30-second rest interval on the uninvolved side while the involved side was stretched.[11-14] Static stretches included a seated cross body stretch, a seated upper trapezius stretch, and a side lying sleeper stretch with the arm at 90 degrees of adduction, 90 degrees of shoulder flexion, and 90 degrees of elbow flexion.[14,15]

OUTCOMES MEASURES

Active shoulder IR and ER were measured using the *Clinometer*© digital smartphone application (Plaincode Software Solutions, Stephanskirchen, Germany) which is accurate to 0.1°. A smartphone was affixed to the participant's forearm just proximal to the wrist, utilizing an Ailkin Running Sports Armband for Droid Turbo™ Android Smartphone by Motorola© to make use of the *Clinometer*© digital application (**Figure 4**). Shin et al [38] demonstrated the *Clinometer*© app to have high intra-rater reliability when measuring active shoulder ER (ICC=0.98, 95% Confidence Interval [CI]=0.95-0.99 and IR (ICC=0.96, 95% CI=0.96-0.99) among evaluators. Significantly correlation with goniometer measurement have also been shown through Pearson Correlation Coefficient (PCC) evaluation for both active shoulder ER (PCC=.95) and IR (PCC=.92).[38] Inter-observer reliability was comparable to goniometry as well for both active ER (ICC= 0.87, 95% CI=0.79-0.92) and active IR (ICC=0.67, 95% CI=(0.43-0.82).[38]

Figure 4. Ailkin Running Sports Armband for Droid Turbo™ Android Smartphone by Motorola©

The examiner stood opposite the desired movement, near the head during active IR and at the torso during active ER to allow the examiner access to the functional use of the smartphone *Clinometer*©.[38] Each participant was asked which arm they primarily used during their competitive activity to determine dominance. For ER and IR measurements, the participant was instructed to lie supine on a table. An adjustable belt was placed across each participant's chest at the level of the sternoclavicular joint to limit trunk compensation into extension, rotation, or flexion during ROM testing (**Figure 5**).[39] Participants were positioned with the shoulder abducted to 90°, the elbow flexed to 90°, and the forearm supinated with support from the table along the proximal 50% of the humerus (**Figures 6** & **Figure 7**). Once positioned, the participant was instructed to either internally or externally rotate the arm, making sure to minimize excessive scapular and trunk motion by maintaining contact with the table at the humerus and posterior trunk. The measurement was recorded when the participant verbally confirmed reaching perceived end range.[38] All measurements occurred in the same order, beginning with dominant shoulder IR, dominant ER, non-dominant IR, and finally non-dominant ER.

Before completing this study, intra-rater reliability pilot testing was conducted using the *Clinometer*© application, armband, and chest strap. The examiner measured shoulder IR and ER five times with the smartphone application and averaged the values. The examiner placed the smartphone in the correct position for measurement and positioned the participants for proper measurement. Measurements were conducted on each participant (n=10) twice over a 5-day period. A two-way mixed effects model Intraclass Correlation (ICC) was used to assess intra-rater reliability for the investigating clinician responsible for data collection using the *Clinometer*© application. The standard error of the mean (SEM) values were calculated for shoulder IR and ER using the formula ($SEM = SD\sqrt{1 - ICC}$). where SD is the standard deviation from the test.[40] Minimal Detectable Change (MDC) was calculated using the formula ($MDC = SEM \times 1.96 \times \sqrt{2}$).[2, 22] The ICC, SEM and MDC values were excellent for both measurements, and comparable

Table 2. Intra-rater reliability for shoulder Internal & External Rotation using the *Clinometer* application (N = 10).

Active Range of Motion (AROM)	Intraclass Coefficient (ICC)	Standard Error Measurement Value (SEM)	Minimal Detectable Change Value (MDC)
Shoulder Internal Rotation	0.99	0.32	0.87
Shoulder External Rotation	0.96	0.80	2.22

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to previously research by Shin et al. for active ER (SEM=3.01, MDC=2) and active IR (SEM=1.86, MDC=3) (**Table 2**).[38,40,39]

Statistical Analysis

All data were analyzed using the Statistical Package SPSS version 21 (IBM Corp. Armonk, NY, USA). Normality was confirmed using the Shapiro-Wilk test. Levene's test for homogeneity of variances was non-significant for dominant IR (p=.504), non-dominant IR (p=.376), and non-dominant ER (p=.696). A one-way ANOVA was used to determine the difference between groups for change in shoulder IR and ER from pre-to post-intervention, to calculate effect size and observed power, and to assess group means comparisons. A priori α level of $p \leq .05$ was utilized for all statistical analyses. Effect size calculations were completed using partial Eta-squared. Partial eta squared values lower than 0.0099 were considered small, while 0.0588 was the benchmark for medium, and values greater than 0.1379 were considered large effect sizes.[42]

RESULTS

All of the 22 participants recruited for the study met inclusion criteria and completed the study in its entirety. Analyses of variables at baseline testing did not reveal any significant differences between groups in age (p=.349), weight (p=.188) (**Table 3**), pre-intervention dominant shoulder IR (**Table 4**), non-dominant shoulder IR (**Table 5**), pre-intervention dominant shoulder ER (**Table 4**), or non-dominant shoulder ER (**Table 5**). However, there was a significant difference between the mean height of participants in both groups (p=0.003) (**Table 3**). **Table 6** shows the differences in shoulder IR and ER pre-intervention. On average female participants had greater IR

Figure 5. Adjustable Belt Used to Stabilize Patient.

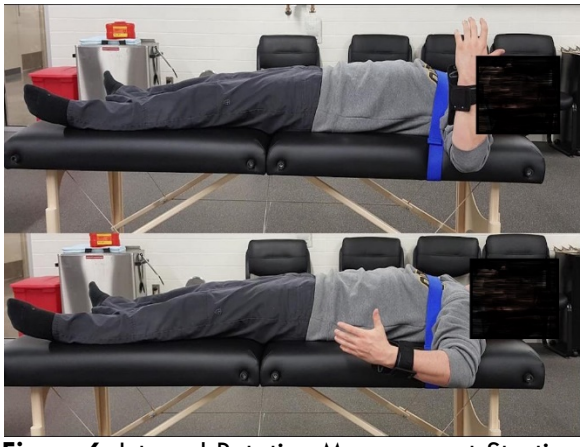

Figure 6. Internal Rotation Measurement Starting and Ending Position.

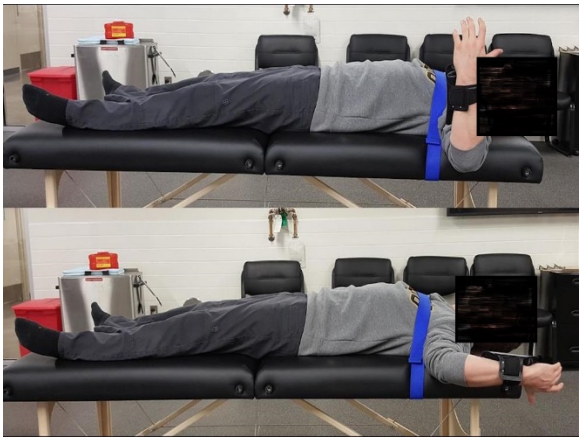

Figure 7. External Rotation Measurement Starting and Ending Position.

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Table 3. Descriptive Statistics

	Height (cm)	Age (years)	Weight (kg)
Participants	178±11.4	19.3±1.1	76.2±10.9
TMRG	184.7±10.4	19.5±1.3	79.3±10.8
TWG	171.6± 7.6	19±0.9	73.1±10.7

(TMRG) total motion release group, (TWG) traditional warm-up group

Table 4. Dominant Shoulder Range of Motion by Group

Active ROM	IR Pre	IR Post	ER Pre	ER Post
TMRG	96°±16.2°	106.4°±17.2°	117.7°±6.5°	120.1°±8.7°
TWG	101.8°±14.3°	103.5°±12.9°	114.5°±15.8°	117.1°±8.7°
p value	*p*=0.384	*p*=0.169	*p*=0.012	*p*=0.935

(IR) internal rotation, (ER) external rotation, (TMRG) total motion release group, (TWG) traditional warm-up group

Table 5. Non-Dominant Shoulder ROM by Group

Active ROM	IR Pre	IR Post	ER Pre	ER Post
TMRG	101.5°±16.1°	108°±14.7°	107.63°±13.2°	112.5°±12.4°
TWG	108.8°±9.5°	103°±11.9°	110.9°±10.4°	106.8°±13.2°
p value	*p*=0.068	*p*=0.176	*p*=0.773	*p* =0.824

(IR) internal rotation, (ER) external rotation, (TMRG) total motion release group, (TWG) traditional warm-up group

Table 6. Range of Motion Differences by Gender

Gender	DOM IR Pre	DOM ER Pre	NON DOM IR Pre	NON DOM ER Pre
Male	88.6°±16.09°	110.5°±9.26°	96.1°±14.45°	101.7°±10.91°
Female	105.7°±9.02°	119.4°±12.91°	111.6°±9.3°	115°±12.08°

(DOM) dominant shoulder, (NON DOM) non-dominant shoulder, (IR) internal rotation, (ER) external rotation

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and ER for both dominant and non-dominant shoulders.

Among the TMRG, a statistically significant increase in dominant shoulder IR ($F(1,21)=6.623$, $p=0.044$), non-dominant shoulder IR ($F(1,21)=20.52$, $p<0.001$), and non-dominant shoulder ER (($F(1,21)=9.108$, $p= 007$) was observed after the intervention compared to the TWG (**Table 7**). A significant group difference was not observed for dominant shoulder ER ($F(1,21)<0.001$, $p=0.982$) and the variable did not meet the assumption for homogeneity of variance. The differences between groups represented a large effect size ($\eta^2 >0.138$) for the increases found in dominant shoulder IR, non-dominant shoulder ER, and non-dominant shoulder IR.[42]

DISCUSSION

While examining the effects of a regionally interdependent application of TMR® in healthy overhead athletes, members of the TMRG experienced significant increases in dominant shoulder IR when compared to participants who completed a traditional warm-up. The dominant shoulder IR and ER improvements found in the current study were not as large as those produced in previous TMR® shoulder ROM investigations.[26,27] However, in the current study, 9 out of the 11 members of the TMR® group experienced an increase in IR greater than 5° on the dominant shoulder without performing any upper extremity activity or warm-up. Interestingly, non-dominant shoulder IR and ER AROM increased significantly in the TMRG compared to the TWG, a result not identified in previous research utilizing TMR®.[26,27]

The improvements in dominant and non-dominant shoulder IR following the TMR® intervention used in this study exceeded shoulder ROM gains reported in much of the stretching literature, while the traditional warm-up protocol achieved similar ROM alterations cited in previous research.[14,16,26,27,43] Participants in the TWG of the current study experienced similar changes in dominant shoulder IR (mean=1.7°± 7°) to Laudner et al.[14] (3.1°), Oyama et al.[43] (3.8°), and Gamma et al.'s [26] findings (2.2°). In contrast, Gamma et al.'s [27] follow-up study found greater gains in the warm-up group (6.2°) than previous research, but this increase was still below the improvement experienced by the TMR® group for both dominant shoulder IR (mean=9.5°) and non-dominant shoulder IR (mean=7.5°) in the current study. The Faul's stretching routine,[16] which incorporates 3-7 second static stretches of shoulder flexion, extension, and ER, has produced gains in dominant shoulder ROM more similar to our TMR® findings. Sauers et al.[16] reported the Faul's stretching routine increased baseball players' ER by an average of 7.6° and IR 9.2°,

Table 7. Change in Shoulder Internal and External Rotation from Pre to Post-intervention Between Groups

Change from Baseline	TMRG	TWG	*p value*	Effect Size (η^2)	Observed Power
DOM IR	+9.5°±9.6°	+1.7° ± 7°	$p = .044$	$\eta^2 = .188$	.534
DOM ER	+ 2.5° ± 5.3°	+2.5° ± 11.9°	$p = .982$	$\eta^2 = .000$	.05
NON DOM IR	+7.5° ± 5.7°	-6.7° ± 9.7	$p < .001$	$\eta^2 = .468$	.99
NON DOM ER	+4.7° ± 6.2°	-4° ± 7.5°	$p = .007$	$\eta^2 = .313$	.819

(DOM) dominant shoulder, (NON DOM) non-dominant shoulder, (IR) internal rotation, (ER) external rotation, (TMRG) total motion release group, (TWG) traditional warm-up group

but we do not know if this protocol results in ROM improvements in the non-dominant arm as was found with the application of TMR® in the current study. While non-dominant ER improvement was found, the result do not suggest that this application of TMR® will significantly increase dominant shoulder ER in overhead athletes. Methodological differences between studies may explain differences in the magnitude of ROM change when compared to previous research on TMR® and shoulder ROM.[26,27] While the length of time to complete the TMR® or traditional warm-up interventions was similar to previous research [26] (7 vs. 25 min), the application of TMR® was different.[26,27] In previous studies [26,27] examining the effect of TMR® on shoulder ROM, researchers combined a trunk twist motion with the arm raise, while the seated straight leg raise replaced the arm raise in the current study. It is possible that the use of the TMR® arm raise, even when performed on the non-dominant side, is more effective than the leg raise in producing changes in shoulder ROM. The arm raise may have either a contralateral or direct effect on shoulder motion and may be more effective than the SLR for increasing shoulder IR or ER due to the cross-education effect, or in the case of dominant side of ease, direct shoulder neuromuscular training paired with the indirect effects of the FFTT.

In addition to differences in TMR® application, other methodological differences were present in participant inclusion criteria. In the first Gamma et al.[26] study, participants presented with less baseline dominant IR (66°±12.06°) and dominant ER (82.4°±11.33°) than was found in the present study (baseline=96°±16.2°of IR and 117.7°±6.5° of ER). The current results could also be affected by gender and sport differences as the previous studies included only male baseball players,[26,27] while the current study included both male and female participants and participants who competed in a variety of overhead sports. It is important to note that our methods for shoulder IR and ER measurement did not call for the control of scapular motion via pinning of the scapula or visual inspection (i.e. stopping the measurement when the scapula begins to rotate and tilt anteriorly).[46-48] Measurement of this type accounts for scapulothoracic function and glenohumeral ROM providing a more integrated and performance driven active measure. Thus, shoulder complex ROM was measured in place of strict glenohumeral ROM. Researchers have compared passive ROM measurements with humeral head stabilization, scapular stabilization, visual inspection, and without stabilization and found that measurement without stabilization increased shoulder IR means by 8-30°.[46,47] As a result, when stabilization methods are accounted for, our IR measurements fall closer to normative values. Additionally, our study features 13 female participants while previous shoulder IR research has been largely conducted in male participant populations.[14,16,26,27,43,46] Multiple studies support our findings suggesting that females have greater IR and ER on average than males regardless of the measuring method (**Table 6**).[47,48] Furthermore, passive measurements of shoulder IR and ER ROM often produce values greater than active by approximately 4 degrees for males and females.[48] Despite the different methodology, the low MDC values for our measurement methods indicate that changes in ROM are unlikely due to measurement error.

Generalization of this study is limited due to the sample size (n=22) and use of collegiate and secondary school athletes. Additionally, neither the examiner nor the participants were blinded to the intervention or measurements. The investigating clinician, while trained in TMR®, was a relative novice using the intervention. A more experienced TMR® clinician may have achieved

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different alterations in ROM. Additionally, no follow-up measures were recorded, so it is unknown how long the ROM gains in either group remained. In spite of such limitations, the significant improvement in bilateral shoulder IR and non-dominant shoulder ER, and strong effect sizes, suggests the results of this study are clinically and practically meaningful. Thus, future research on TMR® is warranted. The time to completion differences between our intervention groups merits exploring interventions that are of a similar duration. Additionally, the duration of ROM improvement following TMR® intervention, along with assessing if multiple interventions produce more meaningful results, should be established. Further research efforts should also focus on single method interventions within the TMR® system and explore the TMR® intervention principle of addressing the side of ease versus the side of restriction. Finally, electromyographic study of activation patterns during trunk rotation may yield information regarding neuromuscular changes following TMR® intervention.

Considerations Regarding TMR® Mechanisms

Our findings, when compared with those in the current literature, [14,16,26,27,43] suggest that indirect RI interventions produce superior increases in ROM for overhead athletes bilaterally compared to a traditional direct methods, and require less time for completion. The findings, when combined with previous work, [26,27] support a hypothesis that increases in shoulder rotational ROM may be able to be driven by interventions directed at the core, which may be related to reducing ROM asymmetries of the trunk. The use of a trunk twist to improve shoulder ROM supports RI research linking the relationship between thoracic spine function and trunk stabilization to shoulder pain, mobility, and motor control.[5,31,32,49] Weakening of muscles that attach to the thoracolumbar fascia may have profound effects on the spine as the fascial structures provide for spinal integrity and mechanical function.[49] Loss of stiffness and mechanical function at the spine places greater stress upon the glenohumeral joint and rotator cuff in throwing athletes as the force needed to accelerate and decelerate the limb is initiated and increasingly dispersed through the glenohumeral joint during forceful overhead power production and deceleration.[49] Insufficient core stability also correlates with a higher incidence of scapular dyskinesis, which is a risk factor for shoulder injuries in volleyball players.[5]

The literature supports evidence of the importance of activation sequencing of the deep core musculature and trunk stabilization through the thoracic cage in counter rotation prior to movement at the upper extremity in overhead athletes.[5,26,27,32,49] Extremity function during forceful counter rotation, acceleration, and deceleration is dependent on the sequential and reciprocal relationship between core stiffness and rotatory control, providing a stable platform at the trunk.[5,18-21,32,49] The FFTT may have had a greater effect on ROM changes than the SLR in the TMRG due to the principle of proximal trunk stability predicating distal limb mobility. Neurological activity through the interconnected tissues of the posterior fascial chain and deep arm fascial chain during the FFTT also likely contributed to significant alterations in shoulder AROM.[33] Trunk twist motions can be performed in a variety of positions including seated, standing, and with the hips hinged or the trunk flexed when utilizing TMR®. Placing the spine in a position of angular shear force during the hip hinge portion of the FFTT utilized in this study forces the trunk to stabilize and protect the spine reflexively. As the trunk stabilizes the spine, a more rigid platform is created throughout the lumbopelvic and thoracolumbar regions, potentially resolving

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stability and motor control dysfunctions at the core, glenohumeral joint, and scapulothoracic articulation.[18-21]

When considering RI interventions like TMR® as neurophysiological processes, RI may be a combined function of three interrelated neuromotor principles: cross education,[22-25] neural coupling,[28] and the common core hypothesis.[29] Currently, it is understood that neuromuscular control and strength production relies on stimuli received and communicated throughout the whole body for optimal function during complex integrated movements.[22,23,28,29] Short term strength gains are due to increased neurological activity, not muscular hypertrophy, and are not dependent on local training effects in tissues.[22-28] Additionally, contralateral strength gains are due to increased motor neuron output rather than muscular fiber adaptations as ipsilateral motor neurons and branched spinal fibers project bilaterally.[22,25] Therefore, repeated or sustained contractions can induce adaptations in the untrained limb.[23,24,28] Such contralateral enhancement of motor control may serve as the fundamental basis of TMR®. Instead of reinforcing the painful, restricted, or dysfunctional movement, TMR® use may allow participants to adapt motor neurons of the spinal cord to the motor pattern perceived as non-threatening, which then 'spills over' to the other side of the body.[22]

CLINICAL APPLICATION

The use of TMR® in our study led to significant improvements in bilateral shoulder IR and non-dominant shoulder ER in overhead athletes. These findings are significant as IR deficit of the dominant shoulder is often associated with reduced performance and injury risk in overhead athletes. Based on the results of this study, the TMR® FFTT and SLR are more effective at immediately increasing bilateral shoulder IR, as well as non-dominant shoulder IR and ER, in overhead athletes than a traditionally designed athletic warm-up protocol. Several factors may contribute to a lack of increase in dominant shoulder ER. Commonly, adaptations in the dominant shoulder of overhead athletes include reductions in IR accompanied by increased ER.[6,44,45] Such paired adaptations in ROM of the shoulder in overhead athletes often contribute to asymmetries correlated with patterns of increased injury risk, performance deficit, and potentially to pathological circumstances such as Glenohumeral Internal Rotation Deficit (GIRD) in overhead athletes.[1-10,44,45] As such, it is plausible that increasing IR without paired increases in ER, moving ROM toward a state of symmetry, is a beneficial adaptation in healthy populations for injury prevention. For overhead athletes, this means that TMR® may potentially prepare the shoulder for throwing, spiking, and serving far better than static and dynamic stretching through rapid increase of shoulder IR through motor neuron adaptation, via increases in trunk stability, rotatory control, and RI alterations throughout the shoulder girdle.

The TMR® protocol was completed in less than one third of the time of the traditional warm-up indicating that the incorporation of the TMR® FFTT and SLR can increase shoulder AROM to a larger degree in a shorter amount of time than the common warm-up methods utilized in our TWG. Utilizing TMR® in place of traditional local stretching techniques, as part of a warm-up program, may result in decreased injury risk and increased performance in overhead athletes via increased AROM in crucial areas such as shoulder IR.

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Exercise Induced Laryngeal Obstruction in a Collegiate Runner: A Case Report of a Novel Therapy

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ABSTRACT

A 23-year-old male Division I distance runner presented with several years of exertional stridor (high-pitched inspiratory noise caused by airflow obstruction), previously diagnosed as exercised-induced laryngeal obstruction (EILO), a condition formerly known as vocal cord dysfunction and exercised-induced paradoxical vocal fold motion. Over the course of roughly 3 years, the patient had previously failed conventional and invasive respiratory therapies for EILO including respiratory retraining, inspiratory muscle training, reflux suppression, allergy suppression, amitriptyline, performance psychology, and injection of botulinum toxin to the larynx. At a referral center that specializes in the treatment of EILO, the patient's diagnosis was confirmed through the use of a new procedure called continuous laryngoscopy during exercise. He underwent three sessions of therapeutic laryngoscopy during exercise (which relies on real-time laryngoscopy footage as biofeedback during exercise) and concurrently learned novel breathing techniques to address the problem. It is common to misdiagnose exercise induced respiratory problems based on patients-described symptoms alone. Athletic trainers should be able to recognize EILO cases and feel comfortable contacting and collaborating with expert providers on appropriate treatment. This case is also important in that it documents a treatment failure of laryngeal injection of botulinum toxin for EILO, something not previously reported in the literature.

Key Phrases
Exercise induced laryngeal obstruction, vocal cord dysfunction, respiratory

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INTRODUCTION

Exercise-induced shortness of breath is common in athletes, with up to 70% of athletes reporting a degree of respiratory distress during exercise.[1,2] While asthma, a disease of the small airways, is the most commonly-identified respiratory disease among athletes, between 5% and 8% of all adolescents and young adults struggle because they are experiencing airway obstruction at the level of the larynx (**Video 1**), a condition different than asthma.[3] This upper airway obstruction is known as exercise-induced laryngeal obstruction (EILO), a condition previously referred to as vocal cord dysfunction and paradoxical vocal fold motion. It is characterized by airway obstruction that occurs at a glottic or subglottic level only during exercise (**Video 2**), often causing shortness of breath that can be visualized by athletic trainers.[4,5] Among athletes, EILO has been often misdiagnosed as asthma, whereby in a cohort of 91 athletes referred for asthma symptoms, 31 (35.2%) were actually diagnosed with EILO.[5]

At presentation, EILO symptoms often mimic those of exercise-induced asthma (EIA) with patients commonly complaining of "wheezing" in association with their dyspnea (despite the field observations that they are experiencing inspiratory stridor).[6,7] EILO may be clinically distinguished from EIA by the time course of symptoms. EILO generally is characterized by symptoms that are isolated to high intensity exercise and rapidly resolve.[8] In contrast, EIA generally develops over several minutes and requires up to an hour to resolve.[9] In clinical settings, the physical examination of patients with

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EILO and EIA are generally normal.[10] The similarities between asthma and EILO and the common practice of relying solely on clinical history to differentiate the conditions may lead to misdiagnosis, inappropriate management, and ineffective interventions.[7] However, identification of ineffective therapeutic trials with bronchodilators such as albuterol (almost universally used in the treatment of EIA) can be helpful in directing athletic trainers and other healthcare providers towards alternative diagnoses such as EILO.

The mechanisms of EILO are still unclear and current models hypothesize a variety of possible disease contributors. These factors may include laryngeal mechanical insufficiency, neural dysfunction, and a psychological component.[7] Continuous laryngoscopy during exercise (**Video 3**), a procedure which features endoscopic visualization of the larynx throughout an entire bout of intense exercise, is currently the gold standard for diagnosis of EILO because characteristic upper airway obstruction can be visualized while field symptoms are reproduced in the exercise lab.[11-13] Other methods to identify the condition indirectly including post-exercise laryngoscopy and exercise flow volume loop analysis are used in practice, but present serious limitations to EILO identification.[10]

Standard treatment algorithms do not currently exist for EILO although a number of therapies are used in practice.[10] Removal of irritants and triggers from the athlete's environment, speech therapy, psychological interventions, pharmacological interventions, botulinum toxin injections, supraglottic surgery, and inspiratory muscle training have mixed results with no single treatment or combination of treatments showing consistent effectiveness.[10] The most common treatments appear to be traditional breathing techniques taught in speech therapy. However, traditional breathing techniques often do not provide relief from exertional dyspnea and are often difficult to perform during high-intensity exercise.[10] Therapeutic laryngoscopy during exercise (TLE) is a newly developed procedure that features laryngeal visualization during respiratory retraining that occurs simultaneous to exercise.[12] It has also been found that after the application of traditional breathing techniques, inappropriate glottic adduction still exists during therapeutic laryngoscopy (TLE) treatments.[14] In response to the observation of inconsistent success with traditional therapies and lack of treatment protocols, novel and alternative treatment techniques should be explored.

The EILO biphasic inspiration (EILOBI) techniques represent such a novel and alternative treatment. They were developed through observations made during TLE and designed for use in high-intensity exercise.[15] The EILOBI techniques help trigger laryngeal abduction which reduces the degree of upper respiratory obstruction in athletes with EILO.[16] The following case describes a patient who was unresponsive to many common treatments for EILO, including Botulinum toxin injections, and found the greatest symptom relief with the EILOBI technique This case is important because relief from traditional therapies may not yield the most relief and alternative methods provide better results. Consulting a specialist is the best avenue for patient care.

Patient Information

A 23-year-old male NCAA Division I distance runner (Cross-Country, 3k steeplechase, 5k) with a history of childhood asthma, allergic rhinitis, and supraventricular tachycardia status post ablation presented to the healthcare team (Primary Care Physician, Immunologist, Performance Psychologist, Ear Nose and Throat Specialist, Pulmonologist) with several years of exertional dyspnea. Several months after an initial diagnosis of and treatment for asthma, he continued to experience exertional dyspnea. In the context of characterizing the dyspnea as stridor and the response to treatment as minimal, he was diagnosed with EILO. In addition to EILO, a few potential disease contributors were identified. He was found to have

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gastroesophageal reflux (GERD) and was treated with acid suppression medication and an inlet patch procedure. He was also found to struggle with anxiety and was treated by a local performance psychologist. Despite appropriate treatment of hypothesized disease contributors (allergic rhinitis, gastroesophageal reflux, and anxiety) and conventional treatment for EILO (respiratory retraining) with speech and language pathologists, he continued to struggle with exertional stridor for several months. For this reason, he was also treated with inspiratory muscle training with a POWERbreathe®, amitriptyline, and laryngeal botulism toxin injections on 3 occasions. A POWERbreathe® is an Inspiratory Muscle Training device used for improving the strength and endurance of the muscles used to breathe in; amitriptyline is a prescription drug used to treat depression, anxiety, and nerve pathologies; and botulism toxin injections are used to reduce excess muscle activity caused by dystonia. Despite these interventions which were sequentially introduced over several months, the patient continued to struggle with the primary symptom of exertional stridor through the time of his presentation at the final referral center roughly 5 years after symptoms began.

Activity and Participation

Patient reported occasional "wheezing" while running which progressed into full breathing attacks during his junior and senior years of high school that reduced his ability to run during races to a jog. Over time, these symptoms increased in terms of frequency and severity. When symptom free, which often occurred during practice, he was able to complete a mile in slightly more than 4 minutes. When symptoms occurred, he was often unable to complete races.

Differential Diagnosis and Evaluation

The differential diagnosis of exertional stridor includes all causes of fixed and dynamic intrinsic and extrinsic obstruction of the upper airway. EILO occurring at a glottic or supraglottic level is the most likely lesion. Additionally, laryngeal webs, subglottic and tracheal stenosis, and compression from large vessels or masses can cause stridor. Prior to presentation at the Pulmonologist computed tomography of the chest and swallow evaluations excluded extrinsic compression. Previous exercise testing excluded exertional hypoxemia. Continuous laryngoscopy during exercise at the final referral center confirmed the diagnosis of EILO affecting both glottic and supraglottic structures.

Body Structure and Function

The patient was usually asymptomatic at the time of evaluation by athletic trainers in the clinic. The patient described periodic symptoms commonly associated with EIA or EILO, mainly "wheezing" with dyspnea. The few times athletic trainers were able to evaluate the patient during an episode, he presented with stridor, difficulty breathing, and altered voice pitch. These symptoms subsided within minutes of ceasing activity.

Activity and Participation

Due to her medical history, the mileage assigned for this specific student-athlete was scaled back to 30-35 miles/week, in comparison to the rest of the team, which typically completed around 60 miles. As a high school runner, she was very successful at regional and state track and field championships. When she initially arrived at the university, she presented with a significantly smaller frame than when she was first recruited, thus leading the coaching staff to believe she was suffering from some form of disordered eating or possible overtraining. She was referred to mental health counseling the following week and continued to work with counselors until her junior year of college.

Environmental and Personal Factors

The patient comes from an affluent, supportive family who encouraged and modeled being

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physically active. He had goals to serve in a special-forces unit since he was a child. The student-athlete has a history of seeking treatment for anxiety that was relatively successful.

INTERVENTIONS

After diagnosis confirmation with continuous laryngoscopy during exercise, the patient performed three sessions of therapeutic laryngoscopy during exercise (TLE), described below. During the sessions, the patient learned one version of the EILOBI (EILO biphasic inspiratory) breathing techniques as well as a framework for managing some of the cognitive behavioral contributors to EILO.

OUTCOMES

Although intermittent results were noticed with traditional respiratory therapy interventions, the patient noticed significant improvements after the series of therapeutic laryngoscopy during exercise sessions and with the EILOBI techniques. He routinely uses them during all of his runs. He's no longer a collegiate athlete but still averages 50 miles per week. The patient still has symptoms albeit they're less frequent and severe from a respiratory perspective if his GERD is controlled but has periods of respiratory distress. He does note, however, that if he misses a day of GERD medication his breathing while running is difficult for reasons related to pain.

DISCUSSION

We present a case of an elite male athlete with EILO who struggled with delays in diagnosis and poor responsiveness to conventional and invasive therapies for EILO including traditional respiratory retraining with trigger suppression and Botulinum toxin injections to the larynx.

This is an important case because it highlights that the EILOBI breathing techniques can result in successful treatment of EILO in elite athletes previously unresponsive to therapy. Secondarily, although previous literature seems to suggest a very high success with botulinum toxin injections, this report underscores a concern for treatment failures.[17]

This patient made major improvements with the use of the TLE procedure. In this procedure, patients are able to visualize their upper airway during intense exercise, with the ability to use the images as biofeedback during respiratory retraining teaching sessions (**Figure 1**). Additionally, the procedure enables thoughtful discussion about cognitive behavioral features which may be suspected in the event that EILO episodes trigger at somewhat unusual times. The procedure naturally enables complex teaching necessary to learn the EILOBI breathing techniques.[8]

Figrure 1: Therapuetic Laryngoscopy During Exercise.

The EILOBI breathing techniques feature a high resistance and low resistance phase of inspiration that can be performed rapidly.[15] The techniques were discovered fortuitously during the endoscopic evaluation of patients who had previously not responded to conventionally used breathing techniques. Many of the conventional respiratory retraining strategies focus on slow breathing in the use of the diaphragm- concepts not compatible with the high respiratory rates and engagement of abdominal muscles that accompany intense exercise with athletes.[15] The techniques are challenging yet important to learn and require a thoughtful teaching strategy. Nonetheless, in appropriately selected patients, like ours, that demonstrated a high degree of

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motor coordination, the techniques can minimize or eliminate symptoms.

CLINICAL BOTTOM LINE

It is common to diagnose and treat exercise-induced respiratory problems based on patients-described symptoms alone which may lead to misdiagnosis as asthma with subsequent inappropriate management, and ineffective interventions. Athletic trainers have a very unique perspective because they may be present during events with the opportunity to visually distinguish inspiratory stridor from other respiratory phenomena. Observation of characteristic field events or videos of characteristic episodes can be helpful in terms of raising suspicion of EILO. Continuous laryngoscopy during exercise can provide definitive diagnosis of EILO. Traditional breathing techniques learned from speech therapists often do not provide relief from exertional dyspnea and are difficult to perform during high-intensity exercise. The EILOBI breathing techniques were designed specifically to address these concerns. After this case presentation, athletic trainers should be able to recognize their very unique perspective on events that can occur in the field, clinically suspect EILO cases based on inspiratory stridor, and feel comfortable contacting and collaborating with expert providers on appropriate treatment.

PATIENT PERSPECTIVE

My breathing problems began during my sophomore year of high school. I had been a tennis player who occasionally ran until I took up running full time during my freshman year of high school where I was able to make it to the state regional meet. I had been a diagnosed asthmatic since I was 8 years old and occasionally used an inhaler during wheezing episodes. Despite wheezing at times, I was still a competitive tennis player who was ranked in the top 5 in the state.

At the conclusion of my freshman season we wanted more answers so I saw an immunologist. I tested positive for multiple allergens. We were excited for this news as we thought we had found the reason for my breathing issues that were starting to develop. Initially I had thought my issues were from pre-race anxiety but the confirmation of having multiple allergies seemed like a more likely cause. I started getting routine allergy shots which led to a sophomore track season where I had very few breathing issues.

My junior and senior year of high school were drastically different. I routinely had significant breathing issues during multi-race days, some of which would reduce my pace to a jog with bad wheezing. There was no consistency to causes to these issues; high- and low-pressure races, time of year, nothing was consistent. During this time my race anxiety seemed to escalate and I would sometimes puke before or after races. By this time, I had been to the doctor multiple times and had been told I was anemic, had asthma, and was over training.

During my freshman year of college in 2013, I had very few breathing attacks early in the season; however, when I did have them they were severe and the severity seemed to be getting worse. As the season progressed the breathing attacks became more frequent, which was a pattern for my entire college career. I can only think of one season where the first real workout of the year didn't go amazing. I chalked this pattern up to being less stressed coming out of the summer but when I thought about my anxiety levels before a fast workout, there didn't seem to be any correlation. It seemed as though the more fit I got through the season, the worse and more frequent my attacks would become.

By the spring season during my freshman year I was able to run workouts in practice very well but struggled during competition. From the outside it appeared as if I was overtraining and couldn't handle the pressure while racing. I don't have any hard feelings for anybody who thought

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that because it seemed pretty obvious but I knew there was something more to it. It has always torn me apart on the inside trying to prove that I knew I was fit. During this time I became very callused emotionally and really struggled with the fact that I couldn't push my body to its physical limits although I knew I had more in me. From this point on was the loneliest and toughest part of my life but it didn't stop me from putting in the work or trying to figure out a solution.

Starting my sophomore year, the pattern continued where I would run well early in the fall semester and trail off as the season progressed. Additionally, early during the fall of 2014 my heartrate was very irregular and high which led to being diagnosed with Supraventricular Tachycardia (SVT) so I ended up having a cardiac ablation procedure. We had hoped this may have been a contributor to my breathing issues but shortly after I started running again I realized it was unrelated. I made it through the season racing slightly better than my freshman year until the outdoor track conference meet where I had such severe breathing attacks that my pace was reduced to a jog and I finished last in two races.

Naturally after years of hearing that I'm overtraining and I'm a "head-case", I started overanalyzing everything I was doing looking for a cause to my running issues. During the summer between my sophomore and junior year of college I came up with a brilliant solution- I would get so fit that I could overpower my breathing problems; unfortunately, that didn't work either.

Early during my junior season in 2015 I started having consistent throat pain, so I returned to the immunologist. She suggested I might have Vocal Cord Dysfunction (VCD) which seemed to fit after looking into it on my own. I had unexplained voice cracks during conversations that didn't align with puberty, I stuttered on and off which developed around the same time as my breathing issues got worse, and I developed a habit cough that would get worse with running at times. I worked with multiple Speech Pathologists and eventually ended up with a pathologist who worked specifically with athletes. Following a speech therapy session there were good and bad days of running still. I ended up being tested for GERD and tested positive. I was super excited for this diagnosis as well since GERD had been linked to causing VCD. Unfortunately, treating the GERD didn't seem to help my breathing attacks much.

During the summer of 2016, I ran 100 miles a week for 10 weeks straight and was feeling okay. I was still having breathing attacks but I felt like I had some control over them as I was still using a POWERbreathe® device most of the time. Like the previous college years, the fall season started out great but went downhill fast. I started seeing a sports psychologist in the fall of 2016 who worked with an NBA team in the area as well but this also didn't seem to have any lasting effect. After the GERD treatment failed to have any real effect, I got a series of three Botox injections. At first, I felt like these injections helped but it was very short-lived and also had no lasting effect. During this time, I also started taking amitriptyline which also seemed to have very little effect on the breathing issues.

In the spring of 2017 I was referred to the National Jewish Hospital (NJH) in Denver, CO. Due to classes, I ended up scheduling a series of appointments over a ten-day period that summer. By this point the self-doubt and the inability to do what I had dreamed of being the best at were taking a toll on me. It was at this time where I started having breathing difficulties in everyday life. Stairs were harder to get up. I would often have to cut off a friend mid-conversation just to catch my breath after climbing just one flight. I couldn't talk on long runs anymore because I would mumble and slur my words. These speech difficulties got worse to where I would have difficulty just having conversation while walking long distances across

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campus. I would often be light-headed and dizzy after long easy runs; I couldn't wait until Denver.

During my ten-day stent in Denver that summer, I saw a myriad of doctors at NJH. Three inlet patches were found in my throat. I ended up having ablation therapy on the patches and it was thought that I would be back to running without issue in 2-3 months. In conjunction with the ablation therapy I was also put on Nexium which didn't help much either. There was one physician at NJH that was doing research on vocal cord disorders but he was on vacation during this trip so I scheduled to see him in December of 2017.

In the Fall of 2017, I started my last cross-country season in college and I was mentally not into it. Before I knew it, I was back at NJH in December. I had one more ablation procedure on a small portion of one inlet patch and saw the physician who was researching vocal cord disorders (Dr. Olin). I went through a series of treatment sessions with Dr. Olin where I was taught how to breathe during exercise. To this day, this has been the single greatest help to my breathing.

The Spring of 2018 was a turning point in my life. I began to put life after college as a priority while continuing to run. Since then, I have only run a few 100-mile weeks while continually averaging 50 miles per week. There is no doubt that the breathing techniques I learned with Dr. Olin have helped. I still have breathing issues although they're not as frequent or severe. I continue to have heartburn, albeit less severe. If I miss a day of taking Nexium then I notice my breathing is worse.

SUPPLEMENTAL VIDEOS

Video 1: Example of Exercise-Induced Shortness of Breath

Video 2: Visualization of Airway Obstruction

Video 3: Continuous Laryngoscopy During Exercise

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