A NOVEL APPROACH TO TREATMENT UTILIZING BREATHING AND A TOTAL MOTION RELEASE® EXERCISE PROGRAM IN A HIGH SCHOOL CHEERLEADER WITH A DIAGNOSIS OF FROZEN SHOULDER: A CASE REPORT

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ABSTRACT

Background and Purpose: Frozen shoulder (FS) is a condition of the shoulder that is characterized by gradual loss of passive and active range of motion of the glenohumeral joint. Current treatment recommendations remain unclear due to the elusive etiology of FS and absence of nomenclature in the literature. The purpose of this case report is to describe the effects of treatment guided by the assessment and treatment of a breathing pattern disorder (BPD) coupled with Total Motion Release® on a 17-year high school cheerleader with a diagnosis of frozen shoulder.

Case Description: A 17-year-old female cheerleader reported left anterolateral chest pain after running during cheer practice. The subject continued to experience additional episodes of chest pain and sought out medical care at an emergency department where she was diagnosed with a FS. Clinical findings upon examination included soft tissue muscular irritability, glenohumeral internal and external rotation active range of motion (AROM) loss, and a dysfunctional breathing pattern. Intervention consisted of two types of breathing interventions and a Total Motion Release® (TMR) exercise program. The Numeric Rating Scale (NRS), inclinometer measurements to measure AROM, and breathing assessment outcomes were used to identify patient-reported outcomes and determine treatment effects.

Outcomes: The use of the coupled treatment resulted in a resolution of the patient's primary complaint, an increase in AROM, and an improvement in breathing assessment outcomes. After the first treatment, internal rotation (IR) improved by 27° exceeding a minimal detectable change (MDC) of 8°, and after the second treatment, external rotation (ER) improved by 21° exceeding a MDC of 9°. Equally important, there were improvements in flexion (11°) and abduction (45°) exceeding the MDC of 8° and 4° respectively over the course of treatment. The minimal clinically important difference (MCID) on the NRS was exceeded when the patient returned to activity.

Discussion: In this case report, breathing treatments, coupled with a TMR® exercise program, were beneficial treatments for this patient and provided a clinically meaningful resolution of her condition. Clinicians treating patients who display a similar presentation of frozen shoulder can consider this a possible treatment option.

Levels of Evidence: Level 4; single case report

Key Words: Adhesive capsulitis, breathing pattern disorder, manual therapy

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The authors do not have any conflict of interest, financial or otherwise, to report pertaining to this study.

BACKGROUND AND PURPOSE

Frozen shoulder (FS), or adhesive capsulitis, is a common shoulder condition characterized by an insidious onset of pain and loss of active and passive range of motion (ROM) of the glenohumeral (GH) joint. Classification of FS encompasses a primary condition, characterized by idiopathic, progressive painful loss of active and passive ROM of the shoulder; and a secondary condition that has a similar clinical presentation, but results from a known extrinsic or intrinsic source.¹⁻² The characteristics of FS is described by four stages with varying time presentations. (Table 1).³⁻⁴ A gradual onset of pain and cascade of inflammation and fibrosis causes the individual to limit the use of the affected arm.³⁻⁵ While specific inflammatory cells have yet to be identified,⁶⁻⁷ pain at end range of motion and muscular inhibition results in compensatory movement patterns in order to minimize pain.²

Clinicians typically diagnose FS based on patient history and physical examination. Patients report sleep-disturbances at night due to pain, with female patients between the ages of 40 and 65 years of age commonly at risk to develop primary FS.⁴ Patients reporting trauma, diabetes, prolonged immobilization, thyroid disease, stroke, heart attack, and the presence of an autoimmune disease are commonly at risk to develop secondary FS.⁴⁻⁵ The

typical pathological capsular pattern of limitation that occurs with FS is decreasing motions of external shoulder, followed by abduction or shoulder flexion and internal rotation (IR).³⁻⁴ Classification based on physical examination occurs when there is a greater than 50% reduction as compared to the contralateral shoulder in passive external rotation or less than 30° of external rotation in the affected shoulder.^{4,7}

Many interventions have been examined in the treatment of FS however, the definitive treatment remains unclear.⁷⁻¹² This is partly due to the unknown etiology and absence of a standardized nomenclature for FS, which causes confusion in the literature. Additionally, if FS is classified as secondary FS, systemic, extrinsic, or intrinsic factors must be addressed first.⁴ Treatment for FS has traditionally been directed to eliminate pain, decrease inflammation, and stretch surrounding tissue to increase shoulder ROM via the use of NSAIDS, therapeutic modalities, corticosteroid injections, exercise, joint mobilization, manipulation (i.e. under anesthesia forcefully abducting the shoulder by stabilizing the scapula against the thorax, elevating the humerus to release the inferior capsule), and surgery.⁴ Yet, little evidence exists to support the use of modalities and when comparing exercise versus manipulation, researchers found no difference in patient outcomes at various follow-ups.⁸ A common intervention used

Table 1. Stages of Frozen Shoulder (Adhesive Capsulitis)^{2,4}

Stage 1: Freezing Stage	Stage 2: Freezing/Painful Stage	Stage 3: Frozen/Transitional Stage	Stage 4: Thawing Stage
Duration of symptoms: 0 to 3 months	Duration of symptoms: 3 to 9 months	Duration of symptoms: 9-15 months	Duration of symptom: 15-24 months
Pain with AROM and PROM	Pains worsens and develops with AROM and PROM	Minimal pain except at end-range PROM and AROM	Minimal pain
Limitation of active forward flexion, Abd., IR, and ER.	Significant limitation of active and passive forward flexion, Abd., IR, and ER. Characterized by an acute synovitis at the GH joint	Significant limitation of AROM and PROM into forward flexion, Abd., IR, and ER with "rigid" end feel (muscular disuse due to limited arm movement) Characterized by a fibrotic synovium at the GH joint	Progressive improvement in AROM and PROM
Abd = abduction; IR = internal rotation; ER = external rotation; ROM= range of motion; AROM= active range of motion; PROM= passive range of motion *Note: Stages are in order, but a transition can occur within a stage and thus the next stage begins.			

to address limitations or restrictions of the glenohumeral joint capsule is joint mobilization. However, when treated with joint mobilization and a home exercise program (HEP), outcomes significantly improved at four-week follow-up and were equal to patients treated with corticosteroid injections.⁴⁻⁹ With the potential to exacerbate symptoms (i.e., HEP and/or mobilizations), GH injections have been recommended in the literature in to be performed in the first four to six weeks.^{4,9-10} To formulate a logical approach to treatment of patients with FS and guide rehabilitation, authors have proposed several classification schemas.^{4,11} The latest is a four-component model for evaluation and intervention that begins with medical screening and differential diagnosis. Clinical decisions regarding rehabilitation and intervention (component 4) are then made based on patient's tissue irritability status (component 3).¹¹ Nonetheless, while treatment interventions are geared towards the patient's irritability status, applying the incorrect tensile dose (frequency, duration, and intensity) by way of stretching or joint mobilizations can negatively impact patient outcomes.¹² Therefore, the limited efficacy of local treatments recommended and utilized in studies supports the exploration of more holistic or regional interdependent (RI) approaches. This often includes assessing and treating multiple body systems and/or body's segments that may be contributing to the patients' condition (e.g., frozen shoulder).

Breathing Pattern Disorders (BPD's)

One potential option for treating patients with FS is the assessment and treatment of breathing patterns disorders (BPD's). A breathing pattern disorder occurs when there is a chronic or recurrent change in breathing mechanics.¹³⁻¹⁴ During ideal breathing, a synchronized motion of the upper and lower rib cage along with the abdomen is present. Additionally, the muscles of diaphragm, which provide 70-80% of inhalation force and are responsible for postural control, must perform properly.¹⁵⁻¹⁶ Improper breathing mechanics happen when the primary muscles become restricted due to biomechanical, biochemical, psychological, physiological and/or unknown factors affecting the body.^{13-14,16} As a result of this restriction in the primary muscles, there is an insufficient ability of the respiratory system to meet the

demands of altered breathing patterns and thus the accessory muscles substitute for the primary respiratory muscle, the diaphragm. Over-activity of the accessory muscles can cause musculoskeletal pain by way of insufficient gas exchange and respiratory distress.¹³⁻¹⁶ Additionally, restrictions in the respiratory muscles may result in compensating structural changes due to muscular and fascial influences and connections.¹⁷

Janda theorized in the case of upper crossed syndrome of imbalances, changes include an altered direction of the axis of the glenoid fossa.¹⁸ The pectoralis major, which contributes to shoulder flexion, horizontal adduction, and internal rotation, tightens and shortens. Fibrosis may also develop in these muscles along with myofascial trigger points (TrPs);¹⁶⁻¹⁸ a similar presentation that is supported in the literature as the etiology of primary FS.¹⁻³ This theory is supported by authors who have linked improper breathing patterns to pain and limited movement of the arm.¹⁹ Breathing pattern disorders have also been found to produce respiratory symptoms (asthma) or non-respiratory symptoms such as neck, shoulder, and/or low-back pain.²⁰⁻²² The body's pH can be altered resulting in respiratory alkalosis which can cause breathlessness and mimic angina or chest pain.¹⁵⁻¹⁶ Kinnula and Sovijarvi believe the anxiety inducing breathlessness that is attributed to asthma may be due to excessive inflation and physiological outcome from a BPD.²³ Once a BPD is identified, the appropriate intervention is aimed at restoring proper breathing mechanics at rest such as resetting the diaphragm.²⁴⁻²⁵ As it relates to the shoulder complex, this action is theorized to induce a relaxation of the pectorals, which became tightened and shortened as a result of a dysfunctional pattern of the breathing muscles.²⁰ Identification and treatment of biomechanical changes as well as functional status of structures involved in respiration must also be addressed. Rehabilitation protocols should include interventions aimed at improving and correcting biomechanical changes and structural compensation patterns of key respiratory muscles.¹⁶

Total Motion Release®

As investigators develop interventions from an RI approach, Total Motion Release® (TMR®) may be

an option to improve biomechanical and functional status of structures involved in respiration. Founded and developed by Tom Dalonzo-Baker, TMR® is an evaluative and treatment tool used to correct asymmetries of the body. A proposed TMR® theory describes the body as an integrated system striving to maintain balance and stability.²⁶⁻²⁷ As such, an individual reporting restriction due to tissue tightness or pain over a long period of time develops a shift in their center of balance. Additionally, due to a natural tendency to place stress on other areas of the body when a body part becomes injured, a person's center of balance is pulled secondarily toward the compensatory dysfunction. This leads to changes in joint alignment, joint integrity, tissue tension, and/or pain. Within the concept of TMR®, movement forces pull the affected joints and/or soft tissue from the contralateral side to correct and re-align the tissue and/or joint into a more normal position;²⁶ a technique supported by the theory of cross education and neural coupling. Utilization of TMR® has demonstrated a high degree of success in treating mobility deficits (external rotation) in the shoulder as seen in patients with FS.²⁷

Given the underlying factors,¹⁻³ various classification systems within the literature to guide treatment,^{4,11} transient effectiveness of recommended treatments,⁷⁻¹² and a potential RI manner influencing FS,^{18,25-26} a broader perspective should be practiced in the evaluation and treatment of patient classified with FS. Successful treatment of FS is not solely based on the restoration of full ROM, but rather, overall patient satisfaction and decrease in symptom(s).⁴ Therefore, the purpose of this case report is to describe the effects of treatment guided by the assessment and treatment of a breathing pattern disorder (BPD) coupled with Total Motion Release ® on a 17-year high school cheerleader with a diagnosis of frozen shoulder.

CASE DESCRIPTION

Subject Characteristics

The subject, a 17-year-old female cheerleader, reported an acute onset of left anterolateral chest pains following running during cheer practice. The subject removed herself from practice and reported directly to her athletic trainer (AT). She had

participated in high school cheer for two years and had a history of asthma. The subject did not report having any chest pain prior to the first episode.

CLINICAL IMPRESSION 1

When the subject initially reported to her AT, she stated that her chest pain was a 10 out of 10 on the Numeric Rating Scale (NRS).²⁸ The subject reported taking her asthma medication prior to activity as prescribed. The subject denied any serious cardio-pulmonary conditions or direct trauma to the upper extremity, chest, neck, or upper back. Physical observation (gross deformity, ecchymosis, edema) revealed a well-appearing, otherwise healthy female in distress. Vital signs (blood pressure, pulse rate, and blood oxygen) were within normal range and a life-threatening-emergency was ruled out. Based on the subject's initial history, evaluation, and current condition, the AT concluded that the subject's condition was systemic in nature and was primarily due to the patient's asthma. The subject's treatment plan included rest, hydration, and her prescribed asthma medication. The subject continued to participate in activity as tolerated and was advised to follow-up with her immunologist. Within 48 hours, the subject reported to her AT again complaining of an acute onset of anterolateral chest pains after running. Follow-up re-examination findings were consistent from initial evaluation across pain and observation; however, vital signs revealed a sustained elevated heart rate (155 bpm). The subject was immediately treated with her asthma medication, rest, and hydration and was referred for further lung function testing. Approximately six to eight hours later, the subject had another occurrence of anterolateral chest pain that lasted an hour and was taken to the Emergency Department (ED) to be evaluated by a physician. The radiograph performed at the ED was negative for an enlarged heart or lung fluid build-up, and the electrocardiogram was normal. The treating physician diagnosed the subject with FS, for which he prescribed cryotherapy and NSAIDS. The physician recommended the subject follow-up with her orthopedic physician for further care of her FS and a cardiologist to rule-out a possible cardiac condition. Differential diagnoses included bursitis, shoulder impingement, and juvenile rheumatoid arthritis.

Prior to ED diagnosis, the subject did not report any shoulder pain or restriction. The subject was actively participating in cheerleading and FS was not a consideration as the subject was in distress during evaluation(s) and a history was not disclosed. Additionally, the typical demographics of FS include females age 40 to 65 years old and with a higher incidence affecting those with diabetes or thyroid disease.¹⁻⁴ The subject's first diagnosis of frozen shoulder happened four years' prior while participating in softball. The subject was treated with traditional conservative care for four weeks at a physical therapy clinic. The subject's most recent experience with frozen shoulder happened two years prior. The subject did not receive treatment from a healthcare provider and continued with activities of daily living and softball as tolerated. Follow-up physician referrals after the FS diagnosis revealed no cardiac condition or respiratory pathology. The subject decided to deny treatment with a physical therapist as prescribed by her orthopedic physician and sought care of her athletic trainer (AT) for re-evaluation until the end of cheer season (i.e., end of football).

EXAMINATION

The subject was re-evaluated by her athletic trainer four days after her ED visit. The subject reported that she had to work over the weekend and had difficulty using her involved shoulder while driving or performing overhead activities. The subject also

reported sleep disturbing night pain in her shoulder. Observation and palpation of the bony structures and soft tissues of the shoulder were found to be abnormal. Irritability status reported by Kelley et al. was used to evaluate the subject's tender areas.⁴ Inclinator measurements were recorded for active range of motion (AROM) in 90° for the GH joint and deficits were noted.²⁸⁻²⁹ Observable signs during internal rotation (IR) revealed extension of the thoracic spine as a compensation.²¹ Considering the subject's history of asthma and physical findings, breathing patterns were further identified with the use of an optimal breath assessment (Table 2). The Hi-Lo assessment was then used to determine respiratory motion (Figure 1).^{16, 24} The AT then determined the patient's breathing patterns, normal or dysfunctional, from the outcome measures and respiratory motion from the Hi-Lo assessment. A summary of the subject's clinical exam can be found in Table 3.

CLINICAL IMPRESSION 2

Based on the subject's history, physical examination, inclinometer measurements, and outcomes on the breathing assessment, the AT hypothesized that the subject's condition (glenohumeral joint ROM loss) was associated with a breathing pattern disorder. Breathing treatments and TMR® were deemed ideal treatment paradigms for this subject, addressing the BPD that may have contributed to the subject's

Table 2. *Optimal Breathing Assessment*²⁴

Breath Assessment	Description	Ranges
Volume Oxygen Uptake (VOU)	Seated or standing, the patient is to inhale fully. Then, while exhaling fully, quietly, but out loud, count fast speaking clear counting as high as possible. Note: The patient is cued to be sure to squeeze out the last bit of air while counting. The patient is not allowed to inhale while counting, hold their breath, skip numbers, or whisper. ²⁴	150+ =Excellent, 110-149 = Very Good, 90-109 = Good, 60-89 = Fair, 2-59 = Poor
Breathing Rate (bpm)	Standing or seated, the patient breathes in their normal pattern and rate and the practitioner counts complete breaths for one minute. ²⁴	5-6 Excellent, 7-9= Good, 10-13 = Fair, 14-16= Fair (Normal), 17+= Poor
Breathing Pause Extension (BPE)	At the end of an exhalation or natural exhalation, the patient pauses and counts as long as they can before their next inhalation. Note: The patient is to count until there is even moderate discomfort, but DO NOT to go so long that the patient passes out, and do not allow patient to exhale more while counting. ²⁴	60+ = Excellent, 45-59 = Good, 30-44 = Fair, 15-29 = Poor, 0-14 = Very Poor

Figure 1. *The Hi-Lo Test. The patient is directed to place one hand on their chest and the other hand on their stomach in a supine position. An apical (chest) breather will demonstrate first movement occurring at the chest.*

primary complaint and the biomechanical and structural changes surrounding the GH joint that may have resulted from a BPD. Total Motion Release® is an important concept when restoring range of motion (ROM), because it is an indirect treatment that avoids increasing irritability, thereby fostering

patient satisfaction. The Institutional Review Board committee approved this case report and the subject gave assent and written consent prior to care and data collection acknowledging possible publication of their outcomes. The subject's confidentiality was protected according to the United States' Health Insurance Portability and Accountability Act (HIPAA).

INTERVENTION

Outcome Scales

The outcome scales that were used in this case study included the following: (a) the Numeric Rating Scale (NRS), which is a patient-reported outcome measure that is used to assess the subject's pain intensity level (0 = no pain to 10 = worst pain imaginable). The NRS has been found to be both valid and reliable with the minimal clinically important difference (MCID) value reported as a two point change or 33%;²⁸ (b) GH inclinometer measurements for IR, ER, flexion, extension and abduction AROM (collected at intake and post-treatment), which is a valid and reliable tool used to assess the subject's active ROM of the GH joint.²⁹ The minimal detectable change (MDC) is regularly reported as an increase of 4° in IR, 5° in

Table 3. *Summary of Physical Exam Findings*

Subjective: 17-year-old female cheerleader reports an acute onset of left anterolateral chest pain, which began after running during cheer practice. Pain experienced approximately 3 times prior to physician consultation. Medical hx of asthma. Physician diagnoses was frozen shoulder. Follow-up physician referral revealed no cardiac condition or respiratory pathology.

Observation: No observable signs of inflammation. Depressed left shoulder, excessive movement of the sternum and shoulder girdles toward the head during inhalation (chest breather), compensation during UE ROM assessment by extension of thoracic spine, respiration=22 bpm (poor), VOU= 38 (poor), and BPE= 24 (fair)

Palpation: TTP teres major, posterior deltoid, levator scapulae, pectoralis major, and pectoralis minor, suggesting high irritability status (≥ 7)⁴

Active ROM: Inclinometer measurements in supine: ER uninvolved 61° involved 38°, IR uninvolved 62° involved 27°, shoulder flexion uninvolved 183° involved 133°, shoulder extension uninvolved 65° involved 48°, shoulder abduction uninvolved 170° involved 106°

Hx= history; UE= upper extremity; ROM= range of motion; VOU= volume oxygen uptake; bpm= respiratory rate; BPE= Breathing Pause Extension; TTP= tender to palpation; GH= glenohumeral; ER= external rotation; IR= internal rotation
Note: Shoulder extension, flexion, and abduction measurements were collected on different days. Basic strength testing was not assessed due to patient's tissue irritability status and significant ROM limitation. Rib mobility was not assessed.

Figure 2. The “Clamshell” Diaphragm Reset. *a.* The “clamshell diaphragm reset” is performed with the patient side lying with knees flexed. The patient inhales and then at the end of exhale, the patient holds their breath. *b.* The patient externally rotates their top leg keeping feet together (opening the clam), while counting to 3. The patient then lowers their leg (closing the clam), while counting to 3. A large immediate inhale indicates successful treatment.²⁴⁻²⁵

ER, 8° in flexion, and 4° in abduction;³⁰⁻³¹ (c) optimal breathing assessment (collected at intake and upon the subject returning to activity), which included volume oxygen uptake (VOU), breathing rate (bpm), and breathing pause extension (BPE) (Table 2).²⁴ The MCID or MDC for the optimal breath assessment outcomes are not available in the literature.

Treatment Procedure

The subject was treated with two breathing treatments and TMR® intervention exercises by a certified athletic trainer. Treatment selection was based on clinician’s clinical experience and treatment indications. At the time of the study, the clinician had over 48 online hours of continuing education in TMR® and had completed up to TMR® Adult – Level 3. To address BPD, the clinician instructed the subject to perform the Clamshell Diaphragm Reset (Figure 2a and 2b) and the Optimal Reflex

Figure 3. The Optimal Reflex® Triggering Twist and Stretch (ORTTS) Starting Position. *a.* Starting position: the patient inhales and exhales naturally and completely. *b.* Ending position: the patient then performs a trunk twist to end range to either the right or left side.

® Triggering Twist and Stretch (ORTTS) (Figure 3a and 3b).²⁴⁻²⁵ The “clamshell” is a modified exercise proposed by the authors from Michael Grant White’s “Optimal Reflex Triggering Ankle Raise”.²⁴ The exercise elicits the patient’s need to breathe by altering the intra-abdominal pressure at the end of exhalation. The “clamshell” was performed twice. The Optimal Reflex ® Triggering Twist and Stretch (ORTTS) enhances the breathing reflex by way of gentle breathing-wave with full pelvic torso/neck and head integration.²⁴ The technique was repeated up to 10 times per side. The subject performed this technique for 1x10 each side. To address biomechanical and structural changes, the clinician utilized a TMR® exercise program based on the foundation principles of the TMR® Fab 6; a series of exercises developed by Tom Dalonzo-Baker that allow patients to treat themselves.²⁶ After a TMR® assessment, the Arm Raise (AR) (Figure 4) and Trunk Twist (TT) were indicated (Figure 5). The clinician instructed the subject to perform an arm raise (AR) raise on the uninvolved side to end range for three sets of ten. For the TT, the clinician instructed the subject

Figure 4. Arm Raise (AR). The AR involves forward shoulder flexion of the contralateral shoulder to end range. When resistance during movement was felt, the patient was asked to go further into end range releasing any restriction of body parts that were preventing further motion (i.e. cervical, thoracic, or lumbar extension).²⁶

to perform a seated trunk twist to end range on the “good” side for three sets of ten. The clinician continued with this treatment plan until shoulder ROM normalized overtime (as compared to uninvolved shoulder) and the BPD normalized. Additional exercises within the TMR® system were progressively added and performed to the contralateral shoulder utilizing the foundation principles of TMR® (Table 4, Figures 6 - 11). Exercises were selected based on motion restrictions found in the involved shoulder and neck extensors. During the course of treatment, the subject did not participate in cheerleading activities but continued with activities of daily living. The subject was prescribed a home exercise program (HEP), but she did not follow it consistently.

OUTCOMES

Following the first treatment session, active ROM in IR improved from 27° to 54°. After second treatment

Figure 5. Trunk Twist (TT). The TT involves lumbar rotation to the uninvolved side (least restricted) to end range. When resistance during movement was felt, the patient was cued to go further into end range.²⁶

session, ER improved from 32° to 59°. Active ER (61°) normalized after the third treatment session compared to the uninvolved side. Considering the improvements that were gained prior in both ER and IR, the clinician then measured and recorded active flexion and extension ROM measurements to further determine efficacy of treatment. After two treatments utilizing the same treatment plan, flexion improved from 133° to 144°. To further improve joint motion, the clinician integrated more complex exercises within the TMR® system (Table 4, Figures 6 - 11). At that point, abduction ROM measurements were recorded. After one treatment session with additional TMR® exercises, abduction improved from 106° to 151°. Upon returning to activity, the subject's active ER had improved to 90°, IR 58°, flexion 153°, extension 52°, and abduction 150°.

To assess the subject's primary complaint of chest pain, the clinician incorporated monitored running into the subject's therapeutic and rehabilitation protocol (Table 4; post-treatment 11). The subject

Table 4. Therapeutic Interventions and Associated Timeline

Week	Tx number	Intervention(s)	Settings/Parameters
Week 1:	1-3	Breathing Treatment TMR ® Exercises Modality	1) Breathing Treatment - Clamshell Diaphragm Reset (2x) (Figure 2) - Optimal Reflex ® Triggering Twist and Stretch (Figure 3) -10x per side 2) TMR Exercise - Arm Raise (AR) - 3x10 (Figure 4) - Trunk Twist (TT) - 3x10 (Figure 5) 3) IFC 80 – 150 Hz (deltoid) -15 min
Week 2:	4,5	Breathing Treatment TMR ® Exercises Modality	1) Breathing Treatment - Clamshell Diaphragm Reset (2x) - Optimal Reflex ® Triggering Twist and Stretch -10x per side 2) TMR Exercise - Arm Raise (AR) - 3x10 - Trunk Twist (TT) - 3x10 3) IFC 80 – 150 Hz (deltoid)- 15 min
Week 3:	6-8	Breathing Treatment TMR ® Exercises Modality	1) Breathing Treatment - Clamshell Diaphragm Reset (2x) - Optimal Reflex ® Triggering Twist and Stretch -10x per side 2) TMR Exercise - Arm Raise (AR) - 3x10 - Trunk Twist (TT) - 2x10 - Back 2 D Side Out Bent Rotate In AR – -3x10 (Figure 6) - Shoulder IR (supine) - Back 2 D Side Out Rotate Out AR - 3x10 (Figure 7) - Shoulder ER (supine) 3) IFC 80 – 150 Hz (deltoid) - 15 min
Week 4:	9,10	Breathing Treatment TMR ® Exercises Modality	1) Breathing Treatment - Clamshell Diaphragm Reset (2x) - Optimal Reflex ® Triggering Twist and Stretch -10x per side 2) TMR Exercise - Arm Raise (AR) - 3x10 - Trunk Twist (TT) - 2x10 - Back 2 D Side Out Bent Rotate In AR – -3x10 - Shoulder IR (supine) - Back 2 D Side Out Bent Rotate Out AR -3x10 - Shoulder ER (supine) - Cervical Ext - 3x10 (Day 16) (Figure 8) - Right Cervical Rotation - 3x10 (Figure 9) 3) IFC 80 – 150 Hz (deltoid) - 15 min
Week 5:	11-14	Breathing Treatment TMR ® Exercises Running	1) Breathing Treatment - Clamshell Diaphragm Reset (2x) - Optimal Reflex ® Triggering Twist and Stretch -10x per side 2) TMR Exercise - Arm Raise (AR) - 3x10 - Trunk Twist (TT) - 2x10 - Back 2 D Side Out Bent Rotate In AR – -3x10 - Shoulder IR (supine) - Back 2 D Side Out Bent Rotate Out AR- -3x10 - Shoulder ER (supine) - Sitting 2 D Straight Side Out Rotate In AR - 3x10 (Figure 10) - Shoulder Abd. - Right Cervical Rotation -3x10 3) Elliptical - 20 min

Table 4. Therapeutic Interventions and Associated Timeline (continued)

Week	Tx number	Intervention(s)	Settings/Parameters
Week 6:	15, 16	Breathing Treatment TMR ® Exercises Running	1) Breathing Treatment - Clamshell Diaphragm Reset (2x) - Optimal Reflex ® Triggering Twist and Stretch -10x per side 2) TMR Exercise - Arm Raise (AR) - 3x10 - Trunk Twist (TT) - 2x10 - Back 2 D Side Out Bent Rotate In AR - 3x10 - Shoulder IR (supine) - Back 2 D Side Out Bent Rotate Out AR -3x10 - Shoulder ER (supine) - Sitting 2 D Straight Side Out Rotate In AR -3x10 - Shoulder Abd. - AR Backward - 3x10 (Figure 11) - Shoulder Ext - Right Cervical Rotation - 3x10 3) 1 mile run (4 laps)
Tx= treatment; TMR®= Total Motion Release; IFC=interferential current; IR= internal rotation; ER= external rotation; Abd= abduction Note: The patient was restricted from actively participating in cheer but continued with activities of daily living during the course of treatment. Patient returned to practice after treatment 16. The patient did not transition to sport-specific rehabilitation outside of monitored conditioning.

Figure 6. Back 2 Dimension Side Out Bent Rotate In Arm Raise (Internal Rotation). The patient is instructed to perform shoulder internal rotation in supine on the uninvolved side for three sets of ten. When resistance during movement was felt, the patient was cued to go further into end range.²⁶

Figure 7. Back 2 Dimension Side Out Rotate Out Arm Raise (External Rotation). The patient is instructed to perform external rotation in supine on the uninvolved side for three sets of ten. When resistance during movement was felt, the patient was cued to go further into end range.²⁶

reported a 0/10 on the NRS for chest pain after running (Figure 12).²⁸ Additionally, the subject reported not complying with asthma medication instructions as she felt her asthma had improved. After six days of treatment with monitored conditioning and no reoccurrence of chest pain, the subject returned cheer practice (post-treatment 16). Prior

to returning to cheer practice, the subject did not progress to sport-specific rehabilitation outside of the monitored physical activity. After returning to cheer, the subject did not continue with treatment, but was encouraged to continue with daily breathing exercise interventions and prescribed TMR® exercises. The subject was a senior and wanted to be able

Figure 8. Cervical Extension. The patient is instructed to extend the neck for three sets of ten. When resistance during movement was felt, the patient was cued to go further into end range.²⁶

Figure 9. Right Cervical Rotation. The patient is instructed to rotate the head to the uninvolved side (least restricted) for three sets of ten. When resistance during movement was felt, the patient was cued to go further into end range.²⁶

Figure 10. Sitting 2 Dimension Straight Side Out Rotate In Arm Raise (Shoulder Abduction). The patient is instructed to perform shoulder abduction on the uninvolved side for three sets of ten seated. When resistance during movement was felt, the patient was cued to go further into end range.²⁶

to cheer at her last home game. The subject reported a complete resolution of chest pain on the NRS after cheer practice (day 16 post-treatment) and two days later, the subject cheered a full football game and remained asymptomatic (Figure 12).

The subject was treated a total of 16 times over the course six weeks. The gap in days' treatment was applied was due to subject's schedule and other conflicts. Over the course of treatment, minimal detectable changes (MDC) were reported in AROM for the GH joint; IR, ER, flexion, and abduction (Table 5).³⁰⁻³¹ A minimal clinically important difference was reported in the NRS (Figure 12) and breath assessment outcomes had improved prior to the subject returning to activity (Table 6).

DISCUSSION

Frozen shoulder is a common shoulder condition of unknown etiology that usually occurs in females

Figure 11. *Arm Raise Backward. The arm raise backward involves shoulder extension of the contralateral shoulder to end range. When resistance during movement was felt, the patient was cued to go further into end range releasing any restriction of body parts that were preventing further motion (i.e. cervical, thoracic, or lumbar extension).²⁶*

age 40 to 65 years old.¹⁻⁴ The subject's symptoms were typical FS symptoms such as pain with AROM, sleep disturbing night pain, high irritability status and limited forward flexion, abduction, IR, and ER. However, the subject also presented symptoms that

were atypical of FS suggesting this may not have been a FS, but rather isolated AROM loss(es) due to a breathing pattern disorder. Prior to treatment, the subject had lacked 23 degrees of shoulder ER and 35 degrees of shoulder IR as compared to the uninjured shoulder, which does not follow the defined capsular pattern of FS.³⁴ The subject demonstrated significant limitations of active and passive shoulder motion in more than one plane and high irritability consistent with the characteristics of FS however, anterior, posterior and inferior glenohumeral joint glides were not performed to assess for capsular involvement. A more passive accessory joint mobility assessment may have elucidated a reason for the limitation of GH ROM.

Traditional non-operative treatment for FS in patients with high irritability would involve low-grade mobilization and short-duration, pain-free, assisted active range of motion stretching.⁴ Alternatively, breathing treatments, coupled with a TMR® exercise program, increased shoulder IR and exceeded the established MDC after the first treatment session. After the 2nd treatment session, shoulder ER increased and exceeded the established MDC. Both of these outcomes exceed those reported with the use of traditional conservative therapy in patients with high irritability.³³⁻³⁴ The use of manual therapy and therapeutic exercise for treating FS typically requires more treatment sessions over a longer period of time (i.e. six weeks to three months).^{8-10, 12, 33-34} The immediate gain after corticosteroid injections is attributed to anesthetic effect of reducing pain and thus limiting muscle guarding.³⁵⁻³⁶ Furthermore, the subject returned to activity within six weeks of

Figure 12. *Patient-reported outcome on the Numeric Rating Scale for chest pain intensity level.*

Table 5. Inclinator Measurements of Active Range of Motion

Joint Motion (L=affected shoulder)	Baseline	Post- Tx 1	Post- Tx 2	Post- Tx 3	Post- Tx 4	Post- Tx 9	Post- Tx 16	R shoulder AROM (unaffected)
ER	38°	32°	***59°	61°	61°	61°	90°	61°
IR	27°	*54°	**58°	49°	54°	81°	58°	62°
Flexion			133°	133°	**144°	138°	153°	183°
Extension			59°	48°	52°	47°	52°	65°
Abduction					106°	**151°	150°	170°

Tx= treatment; ER= external rotation; IR= internal rotation; AROM = active range of motion
 *=MDC exceeded after first treatment
 **= MDC exceeded in comparison to baseline
 ***= MDC exceeded after second treatment in comparison to baseline and post-tx 1
 Note: flexion, extension, and abduction baseline measurements were collected and recorded on corresponding post-treatment days. Patient returned to activity after treatment 16.

Table 6. Breathing Assessment Outcomes²⁴

Outcome Measures	VOU	BPM	BPE
Baseline	38	22	24
Week 6*	44	20	33

VOU= volume oxygen uptake; BPM= breaths per minute;
 BPE= breath pause extension
 *Note: Patient returned to unrestricted activity at the end of week 6.

being diagnosed with FS with symptom reduction and patient satisfaction of improved shoulder function (Table 5). Generally, it is recommended the patient has manipulation under anesthesia if there is unresponsiveness to varying levels of treatment over time between three to six months.⁴ Time-loss from activity in this subject was lower than the time frames presented in the literature for traditional rehabilitation and/or surgery^{4, 9-10} however, this could have been the result of a differential diagnosis. After 16 treatments, the patient completed her cheer season without a recurrence of symptoms (chest pain) or the need of wanting further treatment for her shoulder.

In patients who have FS or a history of chronic FS, breathing treatments and a TMR® focused exercise program may be an effective treatment (when indicated) in lieu of, or adjunct to treatment strategies recommended for patients with high irritability. Even though current literature indicates that corticosteroid injections are favored in patients with high irritability or in patients who do not respond in the first three to six weeks of traditional treatment,⁴ the patient:(a) may only receive a short-term benefit of

decreased pain and immediate gain in motion up to six weeks if not coupled with physical therapy (b) must recover from the effects of an invasive treatment, and (c) can experience a delay in symptom relief.⁴ Furthermore, treatment strategies such as mobilization and short duration stretching exercise have the potential to exacerbate symptoms delaying recovery.¹² Therefore, the consideration of the discussed non-invasive RI focused treatment is essential.

The outcomes in this case report provided evidence that utilizing breathing treatments and a TMR® intervention exercise program may assist in improving shoulder ROM in an athlete with a diagnosis of chronic FS. The combined interventions may produce rapid changes in ROM and shoulder function. Despite the positive outcomes in this case report, this study is not without limitations. Further research with a greater number of typical FS subjects (females age 40 to 65) is needed to determine the treatment effects of the combined use of breathing treatments and TMR® in the treatment of FS. It is important to determine if the treatment will produce positive results over a larger population or only on a subgroup of patients (adolescents with ROM restrictions). More research is needed to determine the long-term effects of the intervention(s) as well as the potential for reducing the need for corticosteroid injections in certain patient cases. Additionally, while increases were observed in AROM, future research that includes passive ROM measurements and an accessory motion examination are needed to fully evaluate and determine true capsular pattern

of the shoulder. Given the limited risks of the novel interventions used in this patient case, clinicians can utilize the outcomes in this case to consider the inclusion of these techniques into their patient care. However, this case report was a single, short-term patient case, without controlled activity, and should not be generalized amongst the public or athletic population.

CONCLUSIONS

The results of the breathing treatments and TMR® focused exercise program used in this case report demonstrate positive immediate results that were maintained or improved over the course of six weeks in a case of a high school cheerleader diagnosed with frozen shoulder. Return to activity was achieved with the interventions. Breathing treatments coupled with a TMR® exercise program could be considered for the short-term treatment of a patient diagnosed with chronic frozen shoulder or glenohumeral ROM limitations, providing the clinician follows the treatment guidelines associated with these interventions.

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