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CASE SERIES

A CLINICAL GUIDE TO THE ASSESSMENT AND TREATMENT OF BREATHING PATTERN DISORDERS IN THE PHYSICALLY ACTIVE: PART 2, A CASE SERIES

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ABSTRACT

Introduction: Breathing pattern disorders (BPDs) are characterized by persistent, suboptimal breathing strategies that may result in additional musculoskeletal pain and/or dysfunction. The purpose of this case series was to examine the effects of Primal Reflex Release Technique (PRRT) and breathing exercise interventions in physically active individuals that presented with a primary complaint of musculoskeletal pain, a BPD, and startle reflexes.

Subjects: The assessment techniques described in Part 1 of this series were used to identify three student athletes (aged 16-22) who presented with musculoskeletal pain of the low back, mid back, and knee, BPDs, and startle reflexes. The subjects were unable to identify an apparent source of their pain.

Intervention: The clinician's classification of the subject's breathing patterns guided intervention(s). Each subject was treated once with PRRT and/or a breathing reflex triggering exercise.

Results: Each of the three subjects demonstrated clinically important improvements on the numerical pain rating scale specific to their tender areas and/or with their primary musculoskeletal complaint.

Discussion: These findings suggest that it may be useful to assess for a BPD and startle reflexes along with a standard orthopedic evaluation in the physically active athlete. Treatment of BPD's may positively impact musculoskeletal pain and/or dysfunction. Further research is needed to understand the effects of treatment of BPD's and how these effects relate to musculoskeletal dysfunction.

Summary: The prevalence of BPD with startle reflexes is unknown and implications regarding the assessment for and treatment of BPD has limited research; however, positive results were demonstrated for the three subjects after normalizing breathing patterns.

Level of Evidence: 4

Key Words: Primal Reflex Release Technique, musculoskeletal pain, startle reflex

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INTRODUCTION

Musculoskeletal injury incidence is high among the physically active population; Hootman et al[1] reported an average rate of injury of 13.79 per 1000 athlete-exposures in collegiate athletics during games. Physical activity increases the respiratory, cardiovascular, and musculoskeletal demands on the body and simultaneously the body adapts to chemical, psychological, and biomechanical changes through the breath. Respiration and breathing patterns play a vital role in maintaining allostasis[2] and biomechanical stability and mobility of trunk and spine.[3] Therefore, breathing pattern disorders (BPDs) may cause or contribute to a variety of general health[4] and musculoskeletal conditions (e.g. inappropriate motor control patterns and/or compromised trunk stability).[5-7] An optimal breathing pattern is typically defined as a three-dimensional abdominal breath resulting in expansion of the lower ribs[2,6,8,9] and has been suggested as an essential component for maintenance of allostasis, posture, and spinal stability.[9]

The autonomic nervous system (ANS) plays an essential role in maintaining allostasis and balancing several involuntary systems in the body (e.g., endocrine, respiratory, circulatory, lymphatic, and muscular) by altering breathing, blood pressure, heart rate, muscle tone, and hormones.[10-14] The sympathetic nervous system (SNS) and parasympathetic nervous system (PNS), branches of the ANS, respond to experiences (e.g., emotions, pain, fear, or stressors) and adjust breathing, blood pressure, and heart rate.[10-14] A change or dysfunction in the ANS, operating mainly (i.e., biased) through the SNS is also considered "up-regulation,"[15] a continuous period of heightened arousal of the nervous system.[16] "Up-regulation" could alter breathing patterns in order to attempt to maintain allostasis, and change the recruitment of respiratory muscles and alter motor control patterns,[15,17-19] potentially causing acute or chronic musculoskeletal pain.

When the body functions with an "up-regulated" nervous system, there is an increased sensitivity to touch and increased pain perception to various tender areas in the body.[17,20-22] Hallman et al[12] found that patients in chronic pain presented with an "up-regulated" nervous system and suggested that patients with chronic neck-shoulder musculoskeletal pain may benefit from treating the ANS. The "up-regulated" nervous system can also be present in conjunction with a startle or withdrawal reflex.[8,21,23] A startle reflex is an abnormal response to normal palpation/stimulus causing the body to withdraw from an area or move in a pattern to protect itself (e.g., head jolting forward, shoulders flexing, or other reflex reactions of the body).[15,17,24] The presence of startle reflexes may be relevant to the ANS, theoretically explaining the cause and perpetuation of BPDs in patients reporting musculoskeletal pain without a pathoanatomic cause.[25] Further, abnormal sensitivity to pressure (e.g., palpation) and temperature is theorized to be caused by hypersensitivity of the CNS and is thought to contribute to chronic musculoskeletal pain.[26-30]

Palpation bilaterally of the $1^{st}/2^{nd}$, $7^{th}/8^{th}$, and $11^{th}/12^{th}$ ribs may be associated with BPDs and a startle reflex.[6,17] Through palpation of the ribs, as described in Part 1, the clinician can identify if a startle reflex is present during the breathing pattern assessment. While the Numerical Pain Rating Scale (NPRS) may be variable between subjects (e.g. minimal to very painful), but most importantly the patient reacts abnormally to normal palpation.[25] It should be noted that following the initial trigger that initiated the SNS response, the dysfunctional movement patterns and BPDs may continue even after the stimulus has been eliminated. The inclusion of the one-minute nociceptive exam™ assists the clinician to establish whether the ANS plays a role in changes in breathing patterns and consequently in global movement patterns.

Many factors influence breathing patterns, therefore it is essential to have a multifaceted assessment. Part 1 of this series presented techniques for observation, palpation for the presence of startle reflexes, and orthopedic tests to assess local and global motor control patterns. The causes of BPDs are typically compensatory for biochemical, biomechanical, psychosocial, and/or psychological factors, varying widely between individuals. Therefore, the assessment and intervention strategies presented in this case series could be helpful in improving primary musculoskeletal complaints and/or overall health of patients.[4] The purpose of this case series was to examine the effects of Primal Reflex Release Technique (PRRT) and breathing exercises in physically active individuals that presented with a primary complaint of musculoskeletal pain, a BPD, and startle reflexes.

SUBJECT DESCRIPTIONS

Initial Examination

The evaluating clinician performed a breathing pattern assessment prior to determining the source of a potential subject's primary complaint of musculoskeletal pain. Two different clinicians at their respective work locations examined patients in order to identify subjects appropriate for the case series. The clinicians had over four years of professional experience, with one year of focused experience evaluating and treating BPDs in the physically active population. Inclusion criteria included patients that presented with musculoskeletal pain and a startle reflex to palpation at the $1^{st}/2^{nd}$, $7^{th}/8^{th}$, and/or $11^{th}/12^{th}$ ribs; if the patient presented with a startle reflex at any of the tender points they were then evaluated for a BPD via the physical assessment described in Part 1 of this series. Eight individuals who were examined presented with a BPD without a startle reflex, and were therefore excluded. All included subjects provided written informed consent for participation in the case series.

The observation of the subjects breathing pattern began prior to the formal assessment, thus allowing the clinician to observe unaltered breathing patterns. Mentioning to a patient that their breathing is being observed has been noted to significantly alter their natural pattern.[8] Bilateral palpations assessed startle reflexes at $1^{st}/2^{nd}$, $7^{th}/8^{th}$, and $11^{th}/12^{th}$ ribs tender areas using the NPRS scale. The assessment of breathing patterns occurred in two positions: seated and supine. In a seated position, the clinician performed a modified version of the Manual Assessment Respiratory Movement (MARM)[2,31] and a Hi Lo assessment in a supine position,[2,5,8,31] both as described in Part 1. For the purposes of this case series, the MARM was recorded only as positive (apical) or negative (abdominal) perceived motions rather than the calculations. The results were utilized in addition to the Hi Lo assessment in order to classify respiratory motion. The examiner observed and noted where the respiratory movement initiated in each of the patients' (e.g., paradoxical, apical, or abdominal) as described in Part 1. The clinician then determined the subjects breathing patterns, normal or dysfunctional, from the outcomes of the modified MARM and Hi Lo assessment. The outcomes from the assessments above might provide varying degrees to further classify each subject's breathing pattern.

HISTORY AND EXAMINATION

A summary of each subject's history is provided in Table 1. Each subject denied any history of a traumatic event or spinal pathology. Orthopedic special tests, specific to each subjects musculoskeletal injury were negative, manual muscle testing of the involved muscles were completed, and no weakness or pain was noted, therefore the authors performed the Selective Functional Movement Assessment[32] to identify muscle imbalances and motor control dysfunctions.

Subject #1 had been experiencing low back pain for over a year without resolution despite participating in a therapy routine including, interferential current electrical stimulation and a core stabilization program. The subject reported an increase in pain and discomfort following a long travel day (i.e., bus and airplane ride). The subject's NPRS was a 2/10 for her

Table 1.

PATIENT HISTORY

Patient Number	Age	Sex	Onset of Pain	Occupation/Activity
1	**21**	**F**	**1 year**	**Student/Collegiate Softball Participant**
2	**22**	**F**	**5 years**	**Student/Track Participant**
3	**16**	**F**	**2 years**	**Student/High School Softball Participant**

Table 2.

CLINICAL EVALUATION AND INTERVENTIONS			
Patient Number	BPD	Startle Reflex	Intervention
1	**Chest/lateral breath**	**$11^{th}/12^{th}$ rib**	**PRRT/McGill Side Bridge**
2	**Chest breath**	**$1^{st}/2^{nd}$ rib $11^{th}/12^{th}$ rib**	**PRRT/Clam Shell**
3	**Paradoxical**	**$11^{th}/12^{th}$ rib**	**PRRT/Clam Shell**

PRRT- Primal reflex release technique

primary complaint of low back pain during daily and physical activities. Upon entry to the clinic, the subject exhibited excessive chest movement upon inhalation. The Hi Lo assessment revealed the subject's breathing pattern as an apical breathing pattern with limited movement of the abdomen. Startle reflexes were elicited upon palpation bilaterally at the $11^{th}/12^{th}$ ribs (Left-3/10 NPRS, Right-2/10 NPRS). A positive modified MARM confirmed the apical breathing pattern with minimal lateral and no back breath at rest (Table 2).

Subject #2 had been experiencing a sharp pain in the middle back for a period of five years without resolution. During initial examination, the 5^{th} rib ring was determined to be laterally positioned to the right at rest, as assessed by the Thoracic Ring Approach™ developed by Linda Joy Lee.[33] The subject's NPRS was a 6/10 for her primary complaints (i.e., pain during inhalation or physical activity). The Hi Lo assessment revealed the subject's breathing pattern as an apical breathing pattern with limited movement of the abdomen. The subject also presented with a bilateral startle reflex response upon palpation of the $11^{th}/12^{th}$ ribs (Left-3/10 NPRS, Right-4/10 NPRS) and $1^{st}/2^{nd}$ ribs (Left-5/10 NPRS, Right-6/10 NPRS). A positive modified MARM confirmed that the breathing pattern was apical with a rigid abdomen and limited anterior, lateral, and back movement at rest (Table 2).

Subject #3 had been experiencing intermittent, throbbing pain in her left knee for a period of two years. During evaluation, the subject presented with muscle pain and a tender point on her left medial knee proximal to the joint line. The subject's NPRS was a 6/10 for her primary complaint of muscle pain at insertion of gracilis. The Hi Lo assessment revealed a paradoxical breathing pattern with minimal abdominal movement. Upon palpation, the subject also presented with a startle reflex at the left $11/12^{th}$ ribs (8/10 NPRS). A positive modified MARM confirmed that the breathing pattern was paradoxical with minimal abdominal movement (Table 2).

INTERVENTION

The exercises used in this case series have been beneficial in the authors' clinical setting to address various BPDs (e.g., paradoxical, apical, and breathing lacking lateral or back motion).[21] The "clamshell" and/or PRRT were used to address BPDs in all three subjects in order to reset and re-establish motor control dysfunctions. While the concept of resetting a BPD is fairly uncommon, a reflex triggering exercise, the "clamshell" is a modified exercise proposed by the authors from Michael Grant White's "Optimal Reflex Triggering Ankle Raise" exercise.[21] The reflex triggering exercise elicits the subject's need to breathe by altering the intra-abdominal pressure at the end of a natural exhalation.[21] The subject was side-lying and instructed to complete a full natural exhalation, (not a forced exhalation), then hold their breath. While holding their breath, the subject abducted the top knee, keeping their heels together for a count of three for abduction and count of three for adduction movements of the leg (Figure 1). When the limb returns to the resting position, the subject relaxes the body and inhales normally. If the "clamshell" reset is needed, and done correctly, the subject will demonstrate a deep and normal (e.g., a three-dimensional abdominal) breath, or at least significant progress in that direction as compared to a "normal" breathing pattern. A common mistake is to either force the exhalation or to not follow all of the breath out, both would not trigger the need to breathe reflexively. The process can be

Figure 1. *The clamshell exercise is completed in a side lying position (as seen in picture). Following the completion of an exhale the patient was instructed to hold their breath. While holding their breath, the participant abducted the top knee, keeping their heels together for a count of three abduction and three adduction movements of the leg.*

repeated until normal breathing is established, but the subject should monitor a few breaths between each "clamshell" repetition in order to create awareness of the changes in their breathing pattern.

The PRRT developed by John Iams, utilizes the one-minute nociceptive exam™ as a global assessment to identify startle reflexes and quick movements with specific body positioning for treatment.[16,17] The PRRT treatment technique utilizes coughing in certain positions in order to eliminate startle reflexes and decrease pain upon palpation of the 1st/2nd and 11th/12th ribs. The PRRT technique for the 7th/8th ribs utilizes applying pressure with two fingers just below the costochondral cartilage angle during the pause between the exhalation and inhalation.[34]

RESULTS

Subject #1: PRRT was used to correct the startle reflex and BPD. PRRT performed (2x) bilaterally to the 11th/12th ribs as a means to reduce the tender areas that elicited a startle reflex upon palpation. Following the intervention, the clinician reassessed the subject's breathing pattern using the MARM and Hi Lo assessment and identified a normal abdominal breath (abdominal, lateral and back breath). The startle reflexes were re-evaluated using the one-minute nociceptive exam™. The startle reflexes dissipated to a NPRS of 0/10 bilaterally. The "clamshell" was not included as part of this subject's intervention as the PRRT intervention re-established an abdominal breathing pattern. The subject's primary musculoskeletal complaint of low back pain was 1/10 NPRS following a single treatment session.

Subject #2: PRRT was used to correct the startle reflex and BPD. The PRRT was performed (1x) bilaterally to the 1st/2nd and 11th/12th ribs. Re-evaluation using the one-minute nociceptive exam™ determined that the startle reflexes dissipated and tender areas all had an NPRS of 0/10 bilaterally; however following re-assessment using the MARM and Hi Lo, the BPD was still present. The BPD was therefore treated using the "clamshell" exercise (5x) and following the exercise the subject was able to establish an abdominal breath with anterior and lateral movement, but still lacked back movement. The subject's primary musculoskeletal complaint of sharp pain in the middle of the back was 0/10 NPRS following a single treatment session.

Subject #3: PRRT was used to correct the startle reflex and BPD. The PRRT was performed (1x) to the left 11th/12th ribs. Re-evaluation using the one-minute nociceptive exam™ determined that the startle reflex dissipated, but the subject was still tender (NPRS score of 7/10) upon palpation at the left 11th/12th ribs. The MARM and Hi Lo assessment indicated that the BPD was still present. The BPD was then treated with the "clamshell" exercise (5x) and following the exercise the subject had established an abdominal breath with anterior movement, but still had limited lateral and back movement. The subject's primary musculoskeletal complaint of left knee pain was 4/10 NPRS following a single treatment session.

The outcomes of this case series demonstrate that subjects #1 and #2 presented a change on the NPRS[35] achieving the minimal clinically important difference (MCID) in the affected areas after treatment of the startle reflex using PRRT (Table 3). All three subjects reported a change on the NPRS related to their primary complaint of musculoskeletal pain (consistent with the MCID) after the breathing pattern interventions (Table 4). Subject #1 was the only participant to exhibit a normalized breathing pattern following the PRRT treatment of the 11th/12th startle reflex. Whereas subjects #2 and #3 needed the addition of the clamshell exercise to initiate the ideal abdominal breath.

Table 3.

STARTLE REFLEX PRE/POST NPRS			
Patient Number	Startle Reflex Palpation Location	Pre NPRS	Post NPRS
1	11/12th Left	3/10	0*
	11/12th Right	2/10	0*
2	1/2nd Left	5/10	0*
	1/2nd Right	6/10	0*
	11/12th Left	3/10	0*
	11/12th Right	4/10	0*
3	11/12th Left	8/10	7/10

*= achieved MCID, NPRS= numerical pain rating scale

Table 4.

PATIENT PRIMARY COMPLAINT PRE/POST NPRS		
Patient Number	Primary Complaint Pre NPRS	Primary Complaint Post NPRS
1	2	1
2	6	0*
3	6	4*

*= MCID, NPRS= numerical pain rating scale

DISCUSSION

The assessment and treatment of BPDs in three physically active subjects presented in this case series was beneficial in decreasing pain and improving breathing patterns prior to a clinical orthopedic evaluation and subsequent interventions. Breathing pattern disorders can produce inappropriate motor control patterns and compromised trunk stability resulting in musculoskeletal pain.[5-7] Janda's approach to pain and dysfunction focuses on finding the cause of signs and symptoms, which is typically away from the site of the patient's primary complaint.[36] The Central Nervous System (CNS) and musculoskeletal system work together to create movement; pathology to one system may be reflected by adaptation of another.[36] The diaphragm is crucial to structural posture and core stabilization.[37] Elevation of the lower rib cage (caudally) during inspiration may be a result of a weak diaphragm or poor recruitment of deep spinal stabilizers that can contribute to musculoskeletal pain or dysfunction of the cervical, thoracic, or lumbar segments.[36,38] The diaphragm is responsible for initiating core stability by regulating intra-abdominal pressure[37] and works collaboratively with the transversus abdominis, multifidus, and pelvic floor to provide support.[2,38] If breathing is dysfunctional this may predispose the patient to muscular adaptations and/or musculoskeletal pain in various other regions. For example, the most extreme BPD, a paradoxical pattern, is often accompanied with cervical spine pain, muscle imbalances, and/or dysfunction.[2,8] Alterations or weakness of the pelvic floor muscles have been associated with low back pain, groin strains, iliotibial band syndrome, anterior knee pain, anterior cruciate ligament tears, and lateral ankle sprains.[36,38-41] In this case series, the focus was on treating the diaphragm, often overlooked as a contributing factor to core stability, in order to decrease the subject's musculoskeletal pain through reflexive exercises targeting the CNS and ANS. The variety of musculoskeletal pain complaints in this case series may be related to global muscle imbalances, motor control adaptations, and trigger points within the kinetic chain.

The decrease in pain may have been due to improvement in diaphragmatic function, and/or the ability to initiate core stabilization, restore movement patterns, and diminish tender areas associated with BPDs. The exact mechanism for positive effects in these three subjects is unknown. Lucas et al[42] determined that altered muscle patterns within the kinetic chain had trigger points that may be associated with changes to breathing patterns or posture. Mehling et al[43] compared the effects of physical therapy (e.g., soft-tissue mobilization; joint mobilization; and exercises for postural righting, flexibility, pain relief, stabilization, strengthening, functional task performance, and back-related education) and breathing therapy (e.g., verbal intervention and tactile cueing for proper breathing mechanics) on patients presenting with chronic low back pain and found that patients undergoing breathing therapy had similar improvements in pain, function, and physical and emotional role as the physical therapy group even though breathing therapy or exercises are typically not viewed as effective as physical therapy. The results of this case series determined that early inclusion of breathing exercises were beneficial in decreasing musculoskeletal pain in three physically active individuals.

Breathing is influenced by emotional and psychological input, yet it is difficult to identify if these sources contribute to BPDs.[44] McNulty et al[45] reported that EMG activity increased over trigger points when a patient was placed in a stressful situation. Untreated trigger points could result in continuous disruption of motor patterns that can be "reset" and re-established through appropriate interventions, such as muscle re-education. If trigger points increase during stressful circumstances, it may explain the startle reflex response and decreased tolerance to palpation, as seen in this case series. The PRRT used in this study are proposed to address the startle reflexes associated with BPD by addressing the nervous system through "resetting" primal reflexes.[15,16,46] Theoretically, by stimulating the reflexes through a cough or quick palpation, neural input being sent to the spinal cord and brain and is temporarily overloaded and/or "reset," which restores normal neural input to the muscles being treated.[16,34] The inclusion of evaluating startle reflexes in primary and accessory respiratory muscles could assist in directing treatment intervention and explain how BPDs have an intimate connection to stress, emotions, and musculoskeletal pain.

Stress has been identified as a risk factor and contributor to musculoskeletal injuries and chronic pain.[47] Hallman et al[12] monitored participants with chronic neck and shoulder pain and found that during rest there was a decrease in PNS activation and increased SNS activation suggesting a mild ANS imbalance, when compared to the healthy control group.[48] Mehling et al[43] suggested that the breath therapy might teach coping skills and provide insight regarding the effect of stress on the body and chronic low back pain. It has been theorized that the presence of startle reflexes provides information regarding the state of the ANS, specifically an ANS imbalance, or "up-regulated" nervous system, however this supposition has not been studied. If restoration of an ideal breathing pattern and treatment using breathing exercises and PRRT created changes in the ANS, specifically an increase in PNS activation, such a change could provide an explanation for the decrease in musculoskeletal pain seen in these subjects. The authors hypothesize that the ANS, specifically an "up-regulated" nervous system contributes to the presence and perpetuation of BPDs in patients that present with a startle reflex.

Breathing pattern disorders in the general population are theorized to be more common than reported[2] and if prevalence is similar in the physically active population, the effects of BPDs could be multiplied due to the increased physiological and biomechanical demands during exercise. If the body is not able to appropriately recruit muscles then compensatory motor patterns may ensue. Therefore, it is the opinion of the authors that breathing should be assessed in all patients due to the bidirectional influence of the psychological, chemical, and biomechanical systems.

The limitations of the present case series include the small number of subjects treated, the absence of a control group, and the clinicians only present the initial assessment and treatment of BPDs outcomes, which do not allow for the generalization of the results. Additionally, the clinician's reliability of assessing BPDs was not tested and only used two treatment techniques to improve breathing patterns out of several simple techniques that have been suggested in the literature. Research on the long-term effects of assessing and treating BPDs is necessary to see if patients maintain improvements in diaphragm function and musculoskeletal pain. Further research using a larger sample with a control group is needed to recognize if changes in breathing patterns actually occur and are due to interventions, and whether the changes alter motor control patterns sustain long-term improvements in pain and function throughout the body. Analyzing the connection between the

ANS, startle reflex, breathing patterns and motor control is essential to understanding how these treatments impact a patient's well-being.

SUMMARY

In this case series, following the PRRT and/or "clamshell" exercise, each subject presented with a clinically important change in NPRS scores in regards to their primary musculoskeletal complaint. In addition, all subjects displayed a change in their breathing pattern as well as a diminished or eliminated presence of a startle reflex. The current findings suggest that the occurrence of a startle reflex upon palpation may be a contributing factor associated with a BPD and musculoskeletal pain. Using PRRT and/or the "clamshell" exercise facilitated re-establishment of an optimal breathing pattern and theoretically, global motor control, contributing to the why the participants primary complaint of pain decreased. No previous research has indicated that the presence of a startle reflex is a common occurrence in an athletic population with disordered breathing. Therefore, the assessment and treatment of BPDs and startle reflexes might be an essential component to determine a potential cause or contributors to musculoskeletal pain.

REFERENCES

1. Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: summary and recommendations for injury prevention initiatives. *J Athl Train.* 2007;42(2):311-319.
2. Chaitow L, Gilbert C, Bradley D. *Recognizing and Treating Breathing Disorders.* Elsevier Health Sciences; 2013.
3. Kolar P. *Clinical Rehabilitation.* Alena Kobesová; 2014.
4. CliftonSmith T, Rowley J. Breathing pattern disorders and physiotherapy: inspiration for our profession. *Phys Ther Rev.* 2011;16(1):75-86.
5. Bradley H, Esformes JD. Breathing pattern disorders and functional movement. *Int J Sports Phys Ther.* 2014;9(1):28-39.
6. Chaitow L. Breathing pattern disorders, motor control, and low back pain. *J Osteo Med.* 2004;7(1):33-40.
7. Hodges PW. Changes in motor planning of feedforward postural responses of the trunk muscles in low back pain. *Exp Brain Res.* 2001;141(2):261-266.
8. Perri M. Rehabilitation of breathing pattern disorders. In: Liebenson C, ed. *Rehabilitation of the Spine: A Practitioner's Manual. 2nd ed.* Philadelphia: Lippincott Williams and Wilkins; 2007:93-109.
9. Perri MA, Halford E. Pain and faulty breathing: a pilot study. *J Bodyw Mov Ther.* 2004;8(4):297-306.
10. Check J, Cohen R, Katsoff B, Check D. Hypofunction of the sympathetic nervous system is an etiologic factor for a wide variety of chronic treatment-refractory pathologic disorders which all respond to therapy with sympathomimetic amines. *Med Hypotheses.* 2011;77(5):717-725.
11. Cohen H, Neumann L, Shore M, Amir M, Cassuto Y, Buskila D. Autonomic dysfunction in patients with fibromyalgia: Application of power spectral analysis of heart rate variability. *Semin Arthritis Rheum.* 2000;29(4):217-227.
12. Hallman DM, Lyskov E. Autonomic regulation, physical activity and perceived stress in subjects with musculoskeletal pain: 24-hour ambulatory monitoring. *Int J Psychophysiol.* 2012;86(3):276-282.
13. Passatore M, Roatta S. Modulation operated by the sympathetic nervous system on jaw reflexes and masticatory movement. *Arch Oral Biol.* 2007;52(4):343-346.
14. Fonseca DS, Beda A, de Sá AMM, Simpson DM. Gain and coherence estimates between respiration and heart-rate: Differences between inspiration and expiration. *Auton Neurosc.* 2013;178(1):89-95.
15. Kasprowicz D. Understanding the autonomic nervous system–A missing piece in the treatment of chronic pain. ND. Retrieved from http://www/boernepti.com/media/file/340330/Understanding the ANS.pdf. Accessed January 14, 2014.
16. Iams J. Primal Reflex Release Technique. *What is the primal reflex release technique for pain relief?* 2012; Available at http://www.theprrt.com/what-is-the-primal-reflex-release-technique-for-pain-relief.php. Accessed August 1, 2013.
17. Iams J. When reflexes rule: A new paradigm in understanding why some patients don't get well. *Adv Phys Ther Rehab Med.* 2005;16(3):41.
18. Ley R. The Modification of Breathing Behavior Pavlovian and Operant Control in Emotion and Cognition. *Behav Modif.* 1999;23(3):441-479.
19. Fantazzi F, Snyder A, Snyder M. CyberPT. *Primal reflex release technique: Welcome to a paradigm shift.* 7 May 2008; Available at http://www.cyberpt.com/prrt.asp. Accessed August 1, 2014.
20. Hansberger BL, Baker RT, May J, Nasypany A. A novel approach to treating plantar fasciitis–effects of primal reflex release technique: A case series. *Int J Sports Phys Ther.* 2015;10(5):690-699.
21. White GM. Optimal Breathing Kit. Charlotte, NC2014.

22. Simons DG, Travell JG, Simons LS. *Travell & Simons' Myofascial Pain and Dysfunction: Upper Half of Body.* Vol 1: Lippincott Williams & Wilkins; 1999.
23. Lang PJ, Bradley MM, Cuthbert BN. Emotion, attention, and the startle reflex. *Psychol Rev.* 1990;97(3):377-395.
24. Larsson M, Broman J. Synaptic plasticity and pain: role of ionotropic glutamate receptors. *Neuroscientist.* 2011;17(3):256-273.
25. Javanshir K, Ortega-Santiago R, Mohseni-Bandpei MA, Miangolarra-Page JC, Fernández-de-las-Peñas C. Exploration of somatosensory impairments in subjects with mechanical idiopathic neck pain: a preliminary study. *J Manipulative Physiol Ther.* 2010;33(7):493-499.
26. Fernández-de-las-Peñas C, de la Llave-Rincón AI, Fernández-Carnero J, Cuadrado ML, Arendt-Nielsen L, Pareja JA. Bilateral widespread mechanical pain sensitivity in carpal tunnel syndrome: evidence of central processing in unilateral neuropathy. *Brain.* 2009;132(Pt 6):1472-1479.
27. Fernández-de-Las-Peñas C, Galán-del-Río F, Fernández-Carnero J, Pesquera J, Arendt-Nielsen L, Svensson P. Bilateral widespread mechanical pain sensitivity in women with myofascial temporomandibular disorder: evidence of impairment in central nociceptive processing. *J Pain.* 2009;10(11):1170-1178.
28. Hidalgo-Lozano A, Fernández-de-las-Peñas C, Alonso-Blanco C, Ge H-Y, Arendt-Nielsen L, Arroyo-Morales M. Muscle trigger points and pressure pain hyperalgesia in the shoulder muscles in patients with unilateral shoulder impingement: a blinded, controlled study. *Exp Brain Res.* 2010;202(4):915-925.
29. Hidalgo-Lozano A, Fernández-de-las-Peñas C, Calderón-Soto C, Domingo-Camara A, Madeleine P, Arroyo-Morales M. Elite swimmers with and without unilateral shoulder pain: mechanical hyperalgesia and active/latent muscle trigger points in neck–shoulder muscles. *Scand J Med Sci Sports.* 2013;23(1):66-73.
30. Jull G, Sterling M, Kenardy J, Beller E. Does the presence of sensory hypersensitivity influence outcomes of physical rehabilitation for chronic whiplash?–A preliminary RCT. *Pain.* 2007;129(1):28-34.
31. Courtney R, Van Dixhoorn J, Cohen M. Evaluation of breathing pattern: comparison of a Manual Assessment of Respiratory Motion (MARM) and respiratory induction plethysmography. *Appl Psychophysiol Biofeedback.* 2008;33(2):91-100.
32. Glaws KR, Juneau CM, Becker LC, Di Stasi SL, Hewett TE. Intra-and inter-rater reliability of the selective functional movement assessment (sfma). *Int J Sports Phys Ther.* 2014;9(2):195-207.
33. Lee LJ. Thoracic Ring Approach [Video]. http://ljlee.ca. Accessed November 15 2013.
34. Iams J. Primal Reflex Release Technique [Videos]. http://www.theprrt.com. Accessed August 1 2013.
35. Farrar JT, Young Jr JP, LaMoreaux L, Werth JL, Poole RM. Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. *Pain.* 2001;94(2):149-158.
36. Page P, Frank C, Lardner R. *Assessment and Treatment of Muscle Imbalance: The Janda Approach.* Human Kinetics; 2010.
37. Frank C, Kobesova A, Kolar P. Dynamic neuromuscular stabilization & sports rehabilitation. *Int J Sports Phys Ther.* 2013;8(1):62-73.
38. Kolář P, Šulc J, Kynčl M, et al. Postural function of the diaphragm in persons with and without chronic low back pain. *J Orthop Sports Phys Ther.* 2012;42(4):352-362.
39. Boyle KL, Olinick J, Lewis C. The value of blowing up a balloon. *N Am J Sports Phys Ther.* 2010;5(3):179-188.
40. Lee DG, Lee L, McLaughlin L. Stability, continence and breathing: the role of fascia following pregnancy and delivery. *J Bodyw Mov Ther.* 2008;12(4):333-348.
41. Warren L, Baker R, Nasypany A, Seegmiller JG. Core concepts: understanding the complexity of the spinal stabilizing systems in local and global injury prevention and treatment. *Int J Athl Ther Train.* 2014;19(6):28-33.
42. Lucas KR, Polus BI, Rich PA. Latent myofascial trigger points: their effects on muscle activation and movement efficiency. *J Bodyw Mov Ther.* 2004;8(3):160-166.
43. Mehling WE, Hamel KA, Acree M, Byl N, Hecht FM. Randomized controlled trial of breath therapy for patients with chronic low-back pain. *Altern Ther Health Med.* 2005;11(4):44-52.
44. Gilbert C. Emotional sources of dysfunctional breathing. *J Bodyw Mov Ther.* 1998;2(4):224-230.
45. McNulty WH, Gevirtz RN, Hubbard DR, Berkoff GM. Needle electromyographic evaluation of trigger point response to a psychological stressor. *Psychophysiol.* 1994;31(3):313-316.
46. Slaughter V. Primitive reflexes. *Encyclopedia of Science [serial online]*. Ipswich, MA: Salem Press September 2013.
47. Benarroch E. Pain-autonomic interactions. *Neurol Sci.* 2006;27(2):s130-s133.
48. Vierck CJ. Mechanisms underlying development of spatially distributed chronic pain (fibromyalgia). *Pain.* 2006;124(3):242-263.