THE EFFECTS OF SENSORY FLOW ON THE AUTONOMIC NERVOUS SYSTEM: A DISSERTATION OF CLINICAL PRACTICE IMPROVEMENT

A Dissertation

Presented in Partial Fulfillment of the Requirements for the

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Major in Athletic Training

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by

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Authorization to Submit Dissertation

This dissertation of Jessica Rae Keller, submitted for the degree of Doctor of Athletic Training with a Major in Athletic Training and titled "THE EFFECTS OF SENSORY FLOW ON THE AUTONOMIC NERVOUS SYSTEM: A DISSERTATION OF CLINICAL PRACTICE IMPROVEMENT" has been reviewed in final form. Permission, as indicated by the signatures and dates given below, is now granted to submit final copies to the College of Graduate Studies for approval.

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Abstract

The capstone project of the Doctor of Athletic Training (DAT) program is a Dissertation of Clinical Practice Improvement (DoCPI). The DoCPI is a document designed to show the progress of DAT candidates in their pursuit of advanced scholarly practice. As clinicians reflect upon local problems in need of solutions or upon their own clinical practice and identify weaknesses, they are directed to use action research to identify solutions. The growth of the clinicians and the changes produced by the research are included in the DoCPI. The culmination of the DoCPI is shown in an applied clinical research project. The *a priori* research project was designed to begin to understand the role of sensory flow on the autonomic nervous system and to demonstrate progress towards an advanced clinical practice.

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Dedication

I dedicate this research to several individuals. First, I dedicate this research to my Lord and Savior, Jesus Christ. This process has taught me more about what it looks like to completely surrender a process and its timing to you and to believe that you will never leave me or forsake me.

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Chapter 1

Narrative Summary

Doctoral education in Athletic Training (AT) is a new and exciting step with the continued evolution and advancement of the profession. The Doctor of Athletic Training (DAT) degree at the University of Idaho is a post-professional degree designed to improve the clinical practice of healthcare providers. The construct of the DAT program is based on the most robust aspects of professional practice doctorates, clinical practice doctorates, and traditional PhDs. Traditional PhD programs are focused strongly on research (Loomis, Willard, & Cohen, 2007), while professional practice doctorates and clinical practice doctorates seek to improve the effectiveness of the student in the profession (Loomis et al., 2007; Siler & Randolph, 2006). Gleaning the strongest components of each degree and following the mission of the DAT, students contribute to the field of AT in many ways, including the betterment of athletic training education, patient care, and scholarship via applied research.

Evidence of clinical, professional, and personal growth is presented in a Dissertation of Clinical Practice Improvement (DoCPI), which shares characteristics similar to a professional practice dissertation (PPD). With a focus on disseminating real-world solutions to local problems, the DoCPI is constructed of practices that are applicable to the local clinical setting. Such solutions demonstrate professional knowledge, not theoretical knowledge (Willis, Inman, & Valenti, 2010). In its completed form, a DoCPI outlines the strong academic basis of the DAT and allows graduates to communicate a thorough knowledge of educational, research, and clinical growth.

Because the focus of the DoCPI is on real-world problems, most often the research does not follow the traditional laboratory research (Willis et al., 2010). In the DAT, I had to learn to think like a researcher performing "bench" research that is also practicing as a clinician at the "bedside" of my patients, and translate both paradigms. David Satcher M.D., formerly the U.S. Surgeon General, said, "The gap between what we know and what we do in public health is lethal to Americans, if not the world" (Drolet & Lorenzi, 2011). Bridging the gap from "bench" research to "bedside" patient care is called translational research and has been discussed in medicine for over 40 years (Wolf, 1974). However, in the early 2000s, it became the focus of many leading medical institutions such as the Institute of Medicine (IOM) (Committee on Quality of Healthcare in America IOM, 2001), the American Medical Association (AMA) (Fontanarosa & DeAngelis, 2001), and the National Institutes of Health (NIH) (Zerhouni, 2003). These institutions and others sought to encourage medical practitioners to use evidence drawn from their own clinical practice to substantiate the decisions they were making in patient care. Medical practitioners were encouraged to use practice-based evidence (PBE) to inform evidence-based practice (EBP) (Swisher, 2010).

In order to incorporate PBE, clinicians must collect data on the results of their clinical practice. The data include information that is important to the clinician, known as clinician-oriented outcomes (e.g., range of motion), along with information that is important to the patient, known as patient-oriented outcomes (e.g., change in pain) (Hankemeier et al., 2013; Snyder Valier, Jennings, Parsons, & Vela, 2014). Once the outcomes (e.g., data) have been collected, the clinicians can reflect on the quality of their results by comparing them to the best available literature and identifying ways to improve future care. Through the process of honest, critical reflection, strengths and weaknesses in clinical practice are identified, best practice is discovered, and clinical expertise is developed.

The primary framework for collection of and reflection on outcomes followed by creating a plan to improve patient care is known as action research. Action research is defined as follows:

> "An approach commonly used for improving conditions and practices in a range of healthcare environments…which involves healthcare practitioners conducting systematic enquiries in order to help them improve their own practices, which in turn can enhance their working environment and the working environment of those who are a part of it" (Koshy, Koshy, & Waterman, 2011, p. 1).

Action research is unique because the researcher can make adjustments to the research methods when and if challenges are met or improvements are indicated, while continuing to collect data.

Ultimately, my goal in the use of action research was to advance my clinical skills and practice. Advanced practitioners are defined as athletic trainers with a minimum of five years of experience who demonstrate depth of knowledge within the athletic training practice domains. The clinician must also blend current research, evidence drawn from their own practice, and reflection to best treat their patients (Nasypany, Seegmiller, & Baker, 2013). As I was exposed to the above ideas through the DAT, I became determined to use the model of action research to pursue clinical practice improvement.

I had an open mind regarding learning new interventions that would enhance my success as a clinician. I believe my open mind was due primarily to reflecting on my clinical practice and recognizing my weaknesses. Open-mindedness allowed me to discover flaws in my clinical practice and inspired me to lay aside pride to seek solutions. As I integrated new techniques such as the Mulligan Concept, instrument-assisted soft tissue mobilization (IASTM), Positional Release Therapy (PRT), MyoKinesthetics (MYK), and Associative Awareness Technique (AAT) into my clinical practice, I immediately noticed changes in my patient outcomes. Collecting and assessing the outcomes provided a way to objectively measure the effectiveness of my patient care (Hostetter & Klein, 2012). This new approach to outcome measures, in addition to my personal reflection on patient treatments, has been the catalyst for growth in my practice.

As I reflected on my own clinical practice, I became aware of patients who responded differently to my intervention choices, e.g., the Mulligan Concept or PRT. I found that a history of stress, anxiety, and depression was more common than anticipated in the lives of my patient population. As such, I began to look for intervention strategies designed to address stress, trauma, and anxiety, which led me to Sensory Flow, a component of AAT. Sensory Flow helps restore allostasis to the body through activation of key components of the Autonomic Nervous System (ANS). As this population of patients presented a challenge to me in daily practice, I decided to take this on as my primary applied research project.

The chapters that follow are a detailed outline of my journey towards an advanced practice. Each chapter addresses a “local problem” that needed a solution. As you read, I hope you are able to see evidence of my personal growth as a clinician but also as an academic. I am excited to share my journey towards advanced practice with you through the rest of my DoCPI.

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Chapter 2

The use of the MyoKinesthetic™ System to treat Medial Tibial Stress Syndrome in Collegiate Track and Field Athletes: A Case Series

(This article was submitted to the *Journal of Sport Physical Therapy*)

Abstract:

Background and Purpose: Treating shin pain in athletes is difficult for most healthcare professionals. Many of the techniques in the literature do not provide "treatment outcomes that are superior to natural history" and often require complete rest, which is unrealistic for an in-season athlete. Thus, the purpose of this study was to evaluate the effectiveness of the MyoKinesthetic (MYK) System on treating Medial Tibial Stress Syndrome (MTSS).

Case Descriptions: Seven track-and-field athletes were diagnosed with MTSS and included in this case series. The patients' duration of shin-pain symptoms was two weeks to one year. They were evaluated and treated using the MYK™ System.

Outcomes: All seven patients were pain-free following two MYK™ System treatments.

Discussion: Using the MYK™ System, return-to-play (RTP) times were exceeded in all seven patients compared to treatments outlined in current literature. Participants in this study were also allowed to continue training as usual, while patients in the current literature were required to modify training during treatment.

Level of Evidence: 4

Key Words: Medial Tibial Stress Syndrome, MyoKinesthetic™ System

Introduction

Medial Tibial Stress Syndrome (MTSS), formerly included in the diagnosis of "shin splints"[1], is one of the most common causes of exercised-induced lower-leg pain. A frequent complaint among runners, MTSS accounts for between 13.2% and 17.3% of all running injuries.[1–4] As MTSS is a common problem for those who regularly exercise, it is also a common injury treated by healthcare providers.

The most promising treatment for MTSS was studied by Moen et al. in 2012 and Rompe in 2008. Both found a significant reduction in the severity of pain and a reduced time of return to play when using extracorporeal shockwave therapy (ESWT).[5–7] Patients in the Moen (2012) study were treated with ESWT while they completed a six-phase graduated running program.[5] Patients in the Rompe (2008) study were treated with ESWT and a home exercise program while resting completely from aggravating activities.[6]

Moen (2012) included patients who were referred to an outpatient clinic for persistent shin pain and who had pain along the posteromedial border of the tibia that was at least 5 cm in length.[5] Patients were instructed in a six-phase running program and were treated with ESWT during weeks 1, 2, 3, 5, and 9 along the painful portion of the tibia. A new phase of the running program could be started once patients reported a four or less on the visual analog scale (VAS). No restrictions were placed on the patients other than that they stay within the parameters of the running program. Forty-two patients began the study and three quit due to continued or increasing pain. Patients took an average of 59.7 days to complete the program, finishing with a four or less on the VAS while running.[5] In this study, patients were required to use a prescribed running program that required a change in their training program. They were also considered fully recovered if they reported a four or less on the VAS.[5]

Currently, icing the painful area, maintaining complete rest from activity, or modifying training to include non-impact cardiovascular exercise and using compression across the shins are considered the most common interventions to manage MTSS.[8,9] The

American College of Sports Medicine recommends at least 7 to 10 days of rest from all painful activities.[9] While none of these techniques has been shown to provide meaningful patient improvements beneficial to the long-term success of the patient-athlete, they are the current best standard of care.[8]

Treating MTSS can be a challenging task for healthcare providers and a frustrating process for affected patients, due partially to restricted training. Identifying an effective approach to treat patients classified with MTSS without significant restriction to training would benefit patients and healthcare providers alike. The purpose of this study was to 1) assess the effects of the MyoKinesthetic™ (MYK) System assessment and intervention to treat college track-and-field patient-athletes classified with MTSS and 2) attempt to successfully return patients to play without having to modify training regimens.

Methods

Subjects

Seven consecutive participants with shin pain were chosen as a convenience sample of patients. They reported to the athletic training clinic complaining of shin pain and were members of the track-and-field team at a private NAIA Division I institution. The patients ranged in age from 19-24 ($\bar{x}$ = 20.86, SD = 1.57) (Table 1). Patients were included in the study if they met the criteria developed by Yates and White (2004) for the diagnosis of MTSS: a patient must 1) have pain along the posteromedial border of the tibia that occurs during exercise and 2) the painful area must be at least 5 cm in length. Patients were excluded if a stress fracture or compartment syndrome was suspected or if there was numbness or tingling associated with their shin pain.

Table 2.1

	Age	Sex	Duration of MTSS	Number of treatments until discharge	MyoKinesthetics Level
Patient 1	24	M	3 weeks	3	L4
Patient 2	19	F	1 year	6	L4
Patient 3	21	M	8 weeks	3	S1
Patient 4	21	F	2 weeks	6	C6
Patient 5	20	F	5 weeks	6	C5
Patient 6	21	F	6 weeks	6	L4
Patient 7	20	M	4 weeks	6	S1

Patient Demographic Information

Pre-Intervention Measurements

Patients were assessed using a MYK™ System posture screen as part of the initial evaluation. Patients then filled out a Disablement in the Physically Active Scale (DPAS), a Patient Specific Functional Scale (PSFS), and a Lower Extremity Functional Scale (LEFS). The Minimal Clinically Important Difference (MCID) for the DPAS is six[10], for the PSFS the MCID is three[11], and for the LEFS the MCID is nine.[12] Patients were also asked to rate their pain on a Numeric Pain Rating Scale (NPRS) from 0-10 during activity. The MCID for the NPRS scale is two points or a 30% change.[13] The NPRS and PSFS were collected with every treatment. The DPAS and LEFS were retaken weekly on Monday, and a seven-point Global Rate of Change (GRC) scale was collected at discharge. The GRC is used to assess a perceived change in pain and can be positive or negative. An MCID of +4 or -4 has been used in previous studies to indicate significant change.[10,14] Additional pertinent information on these scales can be found in Table 2.

Palpation and Treatment Parameters

After consenting to this study and the completion of physical examinations and intake forms, the patients were assessed with the MYK™ System postural screen and the results were used to determine patient treatment levels. Six structures were also palpated for tenderness. The palpated structures included the tibial shaft, the extensor digitorum longus, the extensor hallucis longus, the tibialis anterior, the tibialis posterior, and the flexor digitorum longus. The structures were palpated to ensure the patients met the inclusion criteria set forth by Yates and White (2004)[1].

Patients were scheduled to return for two consecutive days of treatment, followed by one day off and then one additional treatment. The treatment pattern was chosen as illustrated by the MYK™ System recommendations[15] and allows the patient to experience a day of training without treatment to accurately assess their improvement. The pattern was continued until the patient reported a one or less on the NPRS during activity. No other forms of treatment, modalities, or medications were used during this study.

Intervention

MyoKinesthetic System

The MYK™ System (Myokin. Inc., Shawnee Mission, Kansas) is a manual-therapy technique that includes an assessment and an associated treatment plan.[16] The posture screen is a unique assessment used to identify postural imbalances that correspond to a specific nerve root(s).[15] Asymmetries are noted for a set number of anatomical landmarks and compared bilaterally. The imbalances are then calculated for each nerve root and a treatment level is identified. Once the nerve root(s) is identified in the assessment, treatment is completed by providing touch stimulation bilaterally to all the muscles primarily innervated by the selected nerve root. Each muscle in the specified treatment level receives two stimulatory messages during treatment. The first when the muscle is passively stretched, and the second when the antagonist is contracted.[15,17] In the passive portion of the treatment, the clinician stretches and applies pressure to the muscle being targeted. In the active portion of the treatment, the patient contracts the muscle being targeted through normal range of motion while tactile stimulation is being applied.[15]

The primary goal of the MYK™ System is to balance posture in the body.[15] Imbalances in posture may set off a cascade of muscle compensation that, in theory, can lead to decreased joint range of motion (ROM), inappropriate submaximal firing of compensatory muscles, and increased pain.[15,18–21] These compensations are thought to be caused by disruption of the transmission of signals traveling between the muscles and the central nervous system (CNS)[15,16] Pain and injury can be one cause of faulty communication between the CNS and muscles. The MYK™ System was developed to clear the dysfunctions by increasing signal transmission through the use of sensory touch and movement of all the muscles primarily innervated by one nerve root. Treating imbalances at their associated nerve root level, bilaterally, may allow the CNS to achieve a more normal allostasis in neuromuscular firing patterns, thus decreasing pain and dysfunction.

Results

Six of seven patients achieved a MICD for change in NPRS during activity after their first visit (Table 3). All seven achieved an MCID for change in DPA score and change in LEFS and PSFS and were discharged after an average of 5.14 visits (SD = 1.46). Patient DPA scale scores changed by an average of 14.28, which exceeds the MCID by seven points. The LEFS improved by an average of 12.33 (SD=5.16) points and the patients were discharged with a mean score of 76.4 (SD = 2.88), which exceeds the LEFS MCID. All patients were discharged within normal healthy ranges for the DPAS and LEFS. The PSFS results at discharge were a mean score of 8.86 (SD = 3.34) (Table 4). Lastly, patients were discharged with an average of +6.28 on the GRC.

Table 2.2

	Numeric Pain Rating Scale Scores					
	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Patient 1	4	0^	0^	D/C	D/C	D/C
Patient 2	5	4	4	2^	0	0
Patient 3	8	1^	0^	D/C	D/C	D/C
Patient 4	7	4^	2^	2^	1^	0
Patient 5	6	3^	3^	2^	0^	0
Patient 6	8	6^	4^	2^	0^	0
Patient 7	8	3^	3^	0^	0^	0^
MCID for NRS is 2 points or 30% and is denoted with ^ D/C used to denote patients who were discharged.						

Table 2. 3

	Initial DPA	Week 1	Week 2	Discharge	Change DPA	Initial LEFs	Week 1 LEFS	Week 2 LEFS	Discharge	Change LEFS	PSFS Item 1	PSFS Item 1	PSFS Item 1	PSFS Item 2	PSFS Item 2	PSFS Item 2	PSFS
Patient 6	9	4	D/C	4	5	73	76	D/C	76	3	7	8	1	8	10	2	3
Patient 7	17	10*	8	8	9	61	72^	72	72	11	5	9	4#	7	10	3#	7
Patient 8	21	1*	D/C	1	20	54	75^	D/C	75	21	2	8	6#	7	10	3#	9
Patient 9	25	8*	2*	2	23	62	71^	76	76	14	6	10	4#	6	10	4#	8
Patient 10	15	9*	5	5	10	69	71	76^	76	7	4	9	5#	2	10	8#	13
Patient 11	16	9*	1*	1	15	67	75	79^	79	12	7	10	3#	3	10	7#	10
Patient 12	20	10*	2*	2	18	61	72^	79	79	18	3	10	7#	5	10	5#	12
Mean Values	17.57	4.00	6.50	3.29	14.29	63.86	74.00	75.67	76.14	12.29	4.86	9.14	4.29	5.43	10.00	4.57	8.86

DPA = Disablement of the Physically Active, MCID = 6 and is denoted with *
LEFS = Lower Extremity Functional Scale, MCID = 9 and is denoted with ^
PSFS = Patient Specific Functional Scale, MCID = 3 and is denoted with #
D/C = patients who were discharged before week 2

Discussion

In 1986, Smith, Winn, and Parette studied military cadets in basic training to evaluate the effects of ice, iontophoresis, phonophoresis, and ultrasound on MTSS and found that no one treatment was identified to be significantly better than another.[22] Singh et al., in 2003, designed a study to determine if iontophoresis was superior to phonophoresis in decreasing pain in MTSS and found no difference.[23] The military was again the population of choice in a 2010 study by Moen, Tol, and Weir that found no difference between the control group and the group that was assigned pneumatic braces while progressing through a six-phase running program.[24] In 2012, Moen et al. examined an athletic population utilizing the above-mentioned six-phase running program. In this study, the control group completed the six-phase running program, another group completed the six-phase program with calf stretching and strengthening, and a third group completed the six-phase program while wearing compression socks. Again Moen found no appreciable difference between groups.[5] Unfortunately, none of the interventions studied produced long-lasting positive patient outcomes without major modifications to activity.

Three patients received L4 treatments, two received S1 treatments, and two patients were treated for cervical nerve root level imbalances as indicated by the evaluation of their posture screens. All treatments resulted in a complete resolution of symptoms. The L4 and S1 nerve roots are innervated at the tibial nerve, which appears to be directly correlated with the primary symptoms and classification. Treating the patients' primary complaint of MTSS through a cervical nerve root is indirect and best explained by the Regional Interdependence (RI) Model. In an article by Cheatham and Kreiswirth, we see many examples of successful resolution of pain by addressing "causative" issues within the body such as pain in the shoulder being caused by dysfunction in the ribs or low back pain being caused by osteoarthritis of the knee.[25] Posture imbalances and asymmetries may cause the body to seek resolution of pain by adjusting the tone of muscles and the bony position.[26] Seeking out the level at which the largest imbalance occurs and correcting the imbalance may result in resolution of the faulty posture and resolution of the associated pain. Assessing with an RI model gives the clinician the ability to assess the painful area but also the entire body for more remote factors that may be contributing to compensatory patterns, pain, and dysfunction.[25]

Patients were pain-free with an average of 5.14 (SD = 1.46) treatments without any restrictions on daily activities, practice, or competition, which is encouraging when compared to other best-intervention strategies presented in the literature.[22] The best results provided in the literature used ESWT and a graduated running program, which returned patients to participation in an average of 59.7 days. Full recovery in the Moen (2012) study was running for 18 minutes at mild to moderate intensity without pain.[5] In another study using ESWT, the average return to sport ranged from six weeks to six months. The return-to-participation criteria were not based on pain but on perceived preinjury ability.[6] Not only did return to play happen faster in this case series, but no activity restrictions were imposed on participants. Participants were allowed to continue to train at the same intensity as their peers. Treating the potential source of a patient's pain by identifying the nerve root with the largest imbalances, as discovered using an RI model, may allow the clinician to target the dysfunction causing pain rather than treating the patients' local symptoms in isolation. Because experts disagree on the cause of MTSS, targeting a specific structure to treat is difficult and typically produces outcomes that are considered poor. Assessing and treating with an RI model allows clinicians to look for muscle imbalances and compensatory patterns throughout the body that may be precipitating MTSS.[25,26]

Most literature assessing treatment of MTSS references the use of a standardized protocol to treat each patient in a standardized fashion. Using the MYK™ System allows for standardization of the assessment portion of the protocol but also allows for customization of the treatment. Clinicians are then able to address the most profound imbalances of the patient.[25]

In the first week of treatment, the patients' DPA scale dropped an average of 13.57 points and all but one patient reached an MCID for DPA scale within the first week of treatment. The patient who did not reach an MCID for the DPA scale had an initial score of nine, which is within the range of healthy norms (3-9)[10], and ended up reporting a five-point change. Four of the seven patients achieved an MCID on the LEFS scale in the first week. Only one patient did not achieve an MCID on LEFS. The patient started with a score of 73, which is within the range of healthy norms (72-77) [27,28], and noted a three-point improvement on the scale. Also, all seven patients reported a 10 for their second PSFS item and an average of 9.14 on their first item. According to the scale, a 10 reports that you are able to perform that skill at preinjury levels.[29]

Several limitations were present in this study. First, the small sample size and lack of control group meant that all comparisons were made based on other research studies. Second, the researcher was not blinded when reporting the results of the research, and thus some bias may have been introduced. Although the results of this study show expedited return to play without pain, further research on the MYK™ System is needed to determine effectiveness across multiple patient populations.

Conclusion

MTSS is a prevalent and challenging condition to treat in the athletic population. In this study, all patients reported positive results for all outcomes measures that at least matched and often exceeded the tests' MCID (Table 3) and returned to activity with a 1 or less on the NPRS. All patients were also discharged from treatment with scores on the DPAS and LEFS that were within healthy normal range. These results exceeded the best intervention strategies presented in the literature. Patients also continued training during the study, so there was no time lost and no modification to activity levels. While the preliminary data of this case series is promising, further research is warranted to better assess the use of the MYK™ System on patients classified with MTSS.

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Chapter 3

The Emotional Freedom Technique: Theory and Practice

(This article was submitted to the journal *Explore: The Journal of Science and Healing*.)

Abstract

The Emotional Freedom Technique (EFT) is a unique treatment method in which patients are able to facilitate the cognitive and somatic aspects of healing through exposure, acupressure, and cognitive shift. Recognized by the American Psychological Association (APA) Division 12 Task Force as a validated practice, EFT efficacy has been demonstrated in several randomized controlled trials and case studies. Quick, effective, and easily understood, incorporating the use of EFT into clinical practice may help empower patients in the healing process and provide a more robust treatment.

Key Words: acupressure, evidence-based, cognitive therapy, mind-body connection

Key Points:

- EFT can be used to address and treat a variety of psychosomatic conditions.
- EFT can produce immediate and long-lasting benefits.
- EFT can be self-administered by patients.

When a person is experiencing pain, the sensation can persist longer than the suggested healing timeframes.[1] Dr. John Sarno[2] hypothesized that up to 90% of pain is psychosomatic; while this may or may not be an overestimate, it can be agreed that the perception of pain is influenced by psychological factors. Psychosomatic disorders are part of a larger classification, psychogenic disorders, which are defined as “physical disorders induced or modified by the brain for physiological reasons” and are classified into two categories: direct and multifactorial.[2,3] When these are present, it is likely necessary for the psychological aspects of the disorder to be addressed to allow the physical components to resolve. If the physical and psychological drivers of the condition are not resolved, it is possible for those experiencing pain to be left in a state of nervous system hyperactivity.[2]

A major contributor to prolonged pain is hyperactivity, or up-regulation, of the Autonomic Nervous System (ANS). The ANS is composed of the Sympathetic Nervous System (SNS) and the Parasympathetic Nervous System (PNS) and allows many bodily functions to occur independently. Primarily, the SNS is responsible for preparing the body to handle arousal and events that utilize stored energy.[4] During activation of the SNS, the heart rate increases, the blood pressure increases, the pupils dilate, sweating occurs, and the blood flow is focused to the muscles.[4,5] The body's response to the SNS being activated plays a critical role in behavioral response to noxious stimuli as it prepares for a perceived threat.[5,6] The PSNS prepares the body to restore energy, rest, digest, and heal through the stimulation of saliva and the digestive tract, as well as the regulation of heart rate, respiration, and the pupils.[4,5]

Up-regulation of the ANS occurs when the SNS experiences a disruption of communication with the PNS. Effective and smooth communication between endocrine, nervous, and immune systems is imperative to allow for healing to occur. Stress is one of the most common causes of up-regulation of the ANS.[7] Prolonged stress may cause the body to completely misinterpret the intensity and duration of pain, which allows the body to maintain a continuous pain cycle.[8] When the body experiences stress, from life events, memories, or trauma, the SNS is activated, which is referred to as the "fight or flight" response.[4,9] Lasting effects of ongoing perceived stress can lead to conditions such as chronic inflammation, blood-flow changes in the injured area, temperature changes in the affected limb, sweating and trophic abnormalities, and the development of Complex Regional Pain Syndrome (CRPS),[8] as well as psychological changes such as anxiety and depression.[8,10] Short-term activation of the SNS in healthy subjects, however, results in a suppression of pain.[8,11] If the SNS continues to be activated or up-regulated, causing the pain to become chronic, neuroplasticity (i.e., the brain's ability to adapt to change) will alter the physiological reaction of the body to pain, prompting the cycle to persist.[8]

Because there are so many factors influencing the perception of pain, it is often difficult to determine the driver of chronic pain. As the body's source of negative emotions and long-term memories, the amygdala acts as the body's alarm system responsible for initiating the fight or flight response.[12–15] Located in the brain next to the hippocampus, when a person experiences trauma, fear, or memories of a stressful event, the amygdala is activated.[12] The amygdala will continue to seek resolution until the perceived threat has passed. If resolution is not achieved, a state of chronic up-regulation ensues.[9]

Resolution of a threat and dissipation of stress due to trauma occurs when the SNS has been activated and successfully completes the fight-or-flight cycle.[9,16,17] Unsuccessful resolution of a threat causes the body to enter into a state of "freeze" in which the body becomes immobile.[18–20] The state of freeze mirrors that of a stationary prey avoiding the predator.[9,16] The lack of movement by the prey results in the predator losing interest and allowing for escape.[9,16] The body prepares to discharge trauma when a successful evasion of a threat occurs.[18–20] The cycle becomes incomplete if the body fails to experience discharge of the trauma, subsequently storing the stress in the body as a procedural memory.[18–20] The stored memories elicit the body's responses when comparable sensory input or memory arises.[9,16–20] Every detail, such as scents, lighting, noises, sensations, and objects, about an event is stored. The stored details then become sensitizing stimuli in the future. When these stimuli occur in everyday life, the body prepares for an attack by activating the SNS for fight or flight [19,21]

Because every detail of a traumatic event is stored and used to help determine dangerous situations in the future, any aspect of a past trauma can set off a cascade of events in the body leading to activation of the SNS.[22] To break the previously described cycle, an intervention technique is needed to end the up-regulated cycle and allow the PNS and SNS to return to a more ideal allostatic state through modulation of the limbic system, in particular the amygdala. The Emotional Freedom Technique, also referred to as tapping, is a self-administered method that utilizes the mind-body connection by combining cognitive and somatic aspects.[23,24]

The Emotional Freedom Technique was developed by Gary Craig, who created EFT through the Thought Field Therapy (TFT) technique developed by Roger Callahan, and incorporates cognitive and somatic elements.[24] The cognitive aspect requires the patient to perform a self-assessment of the amount of distress related to a trigger such as an event, injury, or memory. The physical action of the clinician or patient tapping on one of the eight tapping points (acupressure points) on the head and upper torso incorporates the somatic aspect.[25] While remembering the trigger of distress throughout the tapping sequence, the stimulation of the acupressure points facilitates regulation of the limbic system through calming the perceived threat from emotionally charged memories.[23,24] Therefore, the SNS is calmed and no longer needs to protect the body from this threat.[23,24] The tapping of somatic acupressure points stimulates all major meridian endpoints of the body.[23,24]

Meridians are a principle component of the ancient Chinese technique known as acupuncture and act as energy channels in the body that carry and distribute energy throughout the body. Each meridian, often described as a channel, is associated with different organs and functions in the body, and, by tapping on an endpoint, the energy channel is accessed.[26] In acupuncture, the energy channels are manipulated with needles but have been found to have the same affect when touched or tapped.[27] Stimulation of these energy channels is done to balance or unblock the flow of energy.[27,28] Tapping or stimulation of specific meridian endpoints, through use of functional magnetic resonance imaging studies, has demonstrated the ability to halt the fight-or-flight response and calm the body.[29,30] Although the mechanism for this effect is unclear, tapping is thought to cause the amygdala to down-regulate and associate the feeling of safety with similar future events by reprogramming the brain and body to act differently to the stimulus and prevent miscommunication of the SNS and PNS in the future.[31]

Incorporating the use of EFT, in conjunction with therapeutic exercises and pain-relieving modalities, may help to provide comprehensive care to patients by addressing the physical and mental aspects of healing.[23,24,32] Aside from the benefits of addressing the cognitive and somatic elements of healing, EFT also provides patients with a method that, once learned, can be self-administered. Additionally, treatment sessions can be as brief as 30 to 60 seconds.[23,24,32] The quick, efficient self-administration procedures of EFT allow patients to perform self-treatments throughout the day or before, after, or during practices and games for active individuals.

Prior to implementation, an introduction to EFT discussing how to perform the tapping procedure, as well as presenting the physical and mental benefits of its use, is encouraged.[23] During the introductory session, it is helpful to administer the "tapping tree" (Figure 3.1).

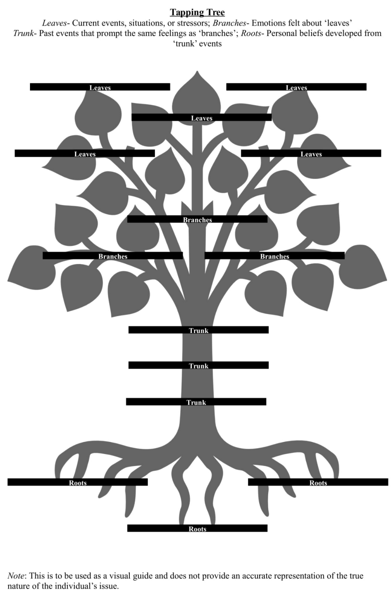

Figure 3.1
Tapping tree. Organizational method for an individual's stressors, thoughts, feelings, emotions, and beliefs. Adapted from *The Tapping Solution: A Revolutionary System for Stress-Free Living* (p.28-30), by N. Ortner, 2013, New York, NY: Hay House. Copyright 2013 by Nick Ortner. Adapted by permission.

The tapping tree is an organizational method to assist in determining the initial trigger of stress causing the SNS to remain up-regulated and the amygdala to stay in a state of "freeze" until a resolution can be obtained, resulting in current complaints (e.g., pain, performance phobias, injury, etc.).[23,24] Incorporating the use of a journal is also recommended to organize and track the emotions and events over time.[23,24,32]

If one uses a "tree" organizational technique, it is recommended to start with the "leaves," where the patient identifies current events, situations, or stressors. This may include a recent injury, chronic complaints of pain in a specific body part, or inability to perform athletically after injury. The next step, "branches," considers emotions felt about the current events, situations, or stressors (e.g., fear, disappointment, anger, frustration, resentment). Initially, moving beyond the “branches” may be difficult and require more personal time and reflection to determine deeper emotions. If discussion and notation of past events prompts similar feelings, this falls under the category of “trunk.” Examples of events listed under the “trunk” organizational category would be parental issues, abuse, bullying, and other past traumas. Under the “roots” section are beliefs developed based on the events listed under “trunk” (e.g., “I cannot do anything right”; “I am not loved”; “I am not worthy”; “I am not good enough”). The reflection of events and feelings, current and past, help to determine the intrinsic causes of stress.[23,24] As noted previously, reflection on stressors and emotions may require additional time to process than what is allowed during the introduction. Asking patients to further contemplate and process their emotions and events at home allows for more profound consideration of all factors.[23,24]

Prior to beginning the initial EFT session, a particular event or emotion should be identified as the focus. The level of emotion or event focused on determines the level of resolution of the stress during the session. It is theorized that focusing on emotions and events from the “trunk” or “roots” will provide a more robust result; however, it is often easier to address the superficial issues initially and to allow the patient to gain confidence in the treatment prior to addressing more substantive issues. Once the focus is determined, it is rated on the Subjective Unit of Distress Scale (SUDS) from 0 (i.e., the least amount of stress) to 10 (i.e., the most amount of stress).[33] The score is recorded for reference after the cycle is complete. After the SUDS score is noted, a truth-focused statement is constructed. The statement, also known as the setup statement, is a sentence that acknowledges the problem followed by an unconditional affirmation that is believed by the patient.[23,24] An example of a setup statement is “even though I have this pain in my knee, I deeply and completely love and accept myself.”

During the first session, it is suggested to have the patient mimic the clinician until becoming comfortable with the sequence.[23,24] Treatment begins by having the patient tap the lateral edge of the hand, along the fifth metacarpal, commonly referenced as the karate chop point, using the fingertips of the opposite hand. The setup statement is repeated three times aloud, while simultaneously tapping the karate chop point using a firm but gentle pressure, “as if drumming on the side of a desk or testing a melon for ripeness.”[24]

When moving on to the other tapping points, the patient should be reminded to tap with their fingertips, not their fingernails. The sound will be round, mellow, and the area may be tender.[24] The patient can use all four fingers or just the first two. The following points should be tapped five to seven times in sequence: the inside corner of the eyebrow, the outer edge of the eye socket, underneath the eye socket, the middle of the upper lip underneath the nose, the middle of the chin underneath the bottom lip, the inside corner of the collarbone where it meets the sternum, under the arm on the lower portion of the ribs, and on top of the head.[30,34–38] As the patient moves through each point, repeat a simple reminder phrase, such as “my anxiety” or “my pain.” Once the sequence has been completed, the patient is asked to focus on the problem and to again rate how intense the issue feels in comparison to a few minutes ago, using the same SUDS of 0 to 10. If the patient chooses a number higher than two, another round of tapping is suggested.[23,24]

The setup statement may change throughout the session to take into account efforts to address the current complaint.[23,24] Once the immediate focus has dissipated, the patients should reevaluate their current situation and determine whether their issue has been resolved or if further examination into the cause of the stress needs to be addressed. If the patients have a SUDS score of <2 and feel as though their issue has been resolved, the final cycle of tapping focuses on another issue or changing the focus towards instilling a positive mindset (e.g., “I am okay”; “I am safe”; “I can do this”; “I am in control”). If the patient chooses to address another issue, the EFT cycle starts over. The patients should assess the new target issue on the SUDS and proceed with their next round of EFT.[23,24]

If possible, tapping should be performed in a quiet, private environment, which will allow the patients to relax and focus on the issues being addressed. Privacy will also allow the patients to accurately evaluate the level of distress they are currently experiencing. While it is preferred to perform the treatment in a private location, EFT can be an effective way to cope during an active stressful event. Addressing specific emotions or events afterwards, however, allows for a more refined focus of the cause of the distress experienced.

While research on EFT is still in an early phase, the use of EFT has been accepted by the APA’s Division 12 Task Force on Empirically Validated Therapies for an “evidence-based” practice.[39,40] Researchers have found EFT to be effective in treating several psychological and physical ailments, including pain, phobias, anxiety, PTSD, depression, traumas, fibromyalgia, weight-loss issues, money issues, relationship problems, and personal limiting beliefs, among many other conditions.[23,24,32,41] Regarding athletic performance, several clinical reports and the results of a few studies on the effect of EFT have demonstrated positive results.[41–43] In each of the studies, the athletes who incorporated EFT into their training improved their confidence and abilities to perform; however, a more robust examination with a larger group of participants and repetitive treatments is still needed.

The integration of EFT into clinical practice could help provide patients with a practical self-administered coping method. By addressing the cognitive and somatic elements of healing, patients are enabled to manage their pain, fears, and performance after injury or traumatic event. Techniques that treat the whole patient and not just their perceived injury encourage wellness beyond tissue healing and returning to normal activities.

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Chapter 4

The Effects of Sensory Flow on the Autonomic Nervous System

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Abstract

Treating patients with chronic pain often proves difficult for medical professionals. One potential contribution to chronic pain is that up-regulation of the autonomic nervous system (ANS) may cause the body to enter faulty pain cycles. Interrupting ANS up-regulation may break these faulty pain cycles. Sensory Flow is a manual therapy technique thought to interrupt ANS up-regulation. Twenty patients volunteered and were randomly assigned to a group receiving Sensory Flow or a control group. Results indicate Sensory Flow significantly improved pain ($p < .004$, partial $\eta^2 = .439$) and stress perception ($p =. 020$, partial $\eta^2 = .169$) following the second treatment. Therefore, Sensory Flow may be useful in breaking faulty pain cycles in patients who are up-regulated.

BACKGROUND

Treating patients who have chronic pain is often challenging for healthcare professionals. Typically, patients with chronic pain present with a variety of comorbidities, including but not limited to decreased range of motion, muscle spasms, and recurring muscle tenderness (Lang et al. 1990). Many of these protective patterns have also been observed as components of the fight, flight, or freeze response. An overactive fight, flight, or freeze response, a product of the Autonomic Nervous System (ANS), has been shown to be a major contributor to chronic pain response patterns and persistent pain (Lang et al. 1990; Scaer, 2011, 2001).

One fight, flight, or freeze theory that is starting to gain momentum is explained well in Bessel van der Kolk's book *The Body Keeps the Score: Brain, Mind and Body in the Healing of Trauma* (2014). Van der Kolk explains that if the person having a stressful experience successfully completes the fight-or-flight cycle, the body, recognizing that the threat has passed, will allow the stress of the trauma to dissipate. If the brain chooses fight or flight but the body is unsuccessful, it enters a freeze cycle. During the freeze cycle, the body becomes immobile. Often, predators become less interested in prey that is not moving, which allows the prey to escape. Successful evasion of a threat prepares the body to discharge trauma. If a body never experiences a discharge, the cycle is incomplete and the stress is stored in the brain as a procedural memory (van der Kolk 2014). The stored input tells the brain how to react every time a similar sensory input or memory arises (van der Kolk, 2014 1994).

An important thing to note is every detail about the event is stored (Scaer 2001; van der Kolk 1994). Stimuli like scents, lighting, noises, sensations, and objects become part of the sensitizing factors. These stored stimuli are called kindling (van der Kolk 1994). While kindling often strengthens the original traumatic memory, it can also branch out into new pathways. When kindling recurs in everyday life, the amygdala prepares the body by activating the Sympathetic Nervous System (SNS) for fight or flight (Deyoung 2010; Scaer 2011; van der Kolk 2014). When the fight, flight, or freeze cycle completes properly, the threat to the body is extinguished, sensory information is stored, and the body returns to its normal set point. When it does not complete the cycle properly, the amygdala continues to seek resolution. The incomplete cycle results in chronic up-regulation of the ANS (Bracha 2004; Hamilton 1989; Scaer 2011; Vaiva et al. 2003; van der Kolk,1994).

The purpose of the ANS is to balance internal functions in the body. The ANS is composed of two opposing divisions: the Sympathetic and Parasympathetic Nervous Systems (PSNS). When the ANS is functioning properly, the body will transition smoothly between sympathetically and parasympathetically mediated states (Haker et al. 2000; Tiller et al. 1996). When the ANS is up-regulated, however, the cycling becomes rapid and asynchronous (Kolb and Whishaw 2011; Malliani et al. 1991). This creates confusion in even the most basic bodily functions, including breathing and heart rate (Berntson 1997; Eppinger et al. 1917; Julius 1991).

Up-regulation of the ANS can also cause activation of faulty pain cycles (Schlereth and Birklein 2008). Stress and a perceived immediate threat to the body can cause the body to feel less pain, but prolonged stress can make the body more susceptible to feeling pain (Chapman et al. 2008). Memories, anxiety, or re-experiencing stressful events are also capable of eliciting a stress response from the body (Melzack 1999). The re-experiencing, if it happens often, can drive the ANS into a chronically up-regulated state (Bracha 2004; Melzack 2001; Porges 1992).

Sensory Flow is a manual therapy technique designed to stimulate the ANS; however, because there is no threat to the body, the fight, flight, or freeze response is not activated. The practice of Sensory Flow is an “intense repetitive and focused proprioceptive tactile input sufficient to induce a trance-like state, which may serve the purpose of producing extinction of procedural memory patterns and reflex postural motor patterns” (Musgrave 2011). More simply put, Sensory Flow inundates the ANS with safe sensory input that allows the body to complete the fight, flight, or freeze cycle.

In Sensory Flow, ANS stimulation is initiated through a predetermined series of touches, which cause mechanoreceptors in the skin to communicate with the SNS. The sensory information that the mechanoreceptors are receiving is perceived to be safe and thus they communicate that there is no present threat of harm to the body (Nathan 1983). The information allows the balance of power to shift from the SNS to the PSNS (Craig 2003).

Another theory that might explain this shift of power is known as the Polyvagal theory. The Polyvagal theory explains why constant up-regulation prevents the body from down-regulating (Porges 2001). The Vagus nerve is divided into three parts and is responsible for regulation of the ANS. Those divisions are the primitive unmylenated visceral Vagus, which is responsible for digestion and responds to threats by decreasing metabolism, the vagal brake, which inhibits the SNS by slowing down the heart, and the Social Engagement System, which aids in socialization. When one part is heavily recruited, the other two are not easily accessible (Porges 2001). If the body is up-regulated, the vagal brake and social engagement systems would be more difficult to access, thus impeding down-regulation (Porges 2009, 2001).

Autonomic Nervous System up-regulation happens for a variety of reasons, but some of the most common are persistent stress or anxiety states, often caused by an insufficient resolution of a fight, flight, or freeze response (Scaer 2011). Perception of the initial painful experience and kindling associated with that event could cause misinterpretation of the pain response altogether. Identifying potential therapeutic interventions could prove an invaluable resource in treating patients suffering from chronic pain.

The purpose of this study was to explore the effects of Sensory Flow on the ANS as measured by changes in blood pressure (BP), pulse, heart-rate variability (HRV), perceived stress, and muscle tenderness following treatment, which are standard measures used in assessing the ANS (Mercuri et al. 1979; Schwartz 1972; Sztajzel 2004).

METHODS

Design

A randomized, blinded, repeated-measure study comparing a treatment group that received Sensory Flow to a control group that rested quietly on a table for 15 minutes.

Setting

Department of Health and Human Performance, Indiana Wesleyan University

Sample

Twenty participants (16 female, 4 male) were recruited for the study from a small private college.

Inclusion Criteria

All participants 1) were between 18 and 25 years of age, 2) had a score on the Stress Test of greater than 150 (T. Holmes and Rahe, 1967), 3) had a significant score for any of the three components of the Depression, Anxiety, and Stress Scale (Henry and Crawford, 2005) (DAS scale), and 4) had not consumed caffeine three hours prior to the study (Daniels et al. 1998).

Exclusion Criteria

Patients were excluded if they 1) did not sign the consent and HIPAA forms, 2) had a skin infection, 3) had skin hypersensitivity that would prevent them from being touched, or 4) their schedule did not allow the protocol to be followed completely. The protocol for the study was approved by the University of Idaho and Indiana Wesleyan University Institutional Review Boards.

Instrumentation

The Stress test and the DAS Scale were used as inclusion criteria. The STRESS-O-METER, BP, Pulse, HRV, and Sympathetic Activation Pattern (SAP) measurements were taken before and after treatment at both appointments. For a more detailed description of each outcomes measure, see Table 4.1.

Table 4.1

Outcome Measure	Explanation
STRESS-O-METER	Current stress is rated on a 0-10 interval scale, with 0 representing no stress and 10 representing the highest amount of stress the participant can imagine. While there is no published data on the validity or reliability of this particular scale, it is considered an interval scale and can adequately provide data for parametric analysis (Williamson and Hoggart 2005).
Heart-Rate Variability	Assessing HRV, specifically coherence, will allow us to measure the level of activation of the ANS and to know which part, SNS or PSNS, to attribute the activation of the ANS to. We know this because the greater the coherence, the greater the activation of the PSNS. The converse is also true, in that if coherence does not change, the PSNS is not greatly affected (Tarvainen et al. 2014).
Sympathetic Activation Pattern	The SAP is used to evaluate the tension, tenderness, and reactivity of nine predetermined muscular regions associated with the startle reflex and up-regulation of the ANS (Musgrave 2011).
Depression, Anxiety, and Stress Scale	This is a 42-item self-report survey designed to measure depression, anxiety, and stress. In the scale, each item is weighted towards one of three categories: depression, anxiety, or stress (Crawford and Henry 2003; Henry and Crawford 2005). Scores are considered significant when above 9 for depression, 7 for anxiety, and 14 for stress. The DAS scale was designed to measure severity of symptoms and not to detect significant changes in depression, anxiety, or stress (Crawford and Henry 2003). The DAS scale has been shown to possess adequate construct validity. Reliability for this scale was measured at .88 for depression, .82 for anxiety, .90 for stress, and .93 for the total scale (Henry and Crawford 2005).

Stress Test	This comprises a list of stressors compiled by Thomas H. Homes and Richard H Rahe in 1967. The Stress Test was designed to provide a standard measure for the impact of a wide range of common stressors. Interpretation of the scale is difficult because it does not take into account the coping mechanisms of each individual. A total of less than 150 is considered a low level of stress (Holmes and Rahe, 1967).

Procedures

The primary investigator (PI) and research assistants recruited participants from a private NAIA university. Slottr (Slottr.com, Vancouver, British Columbia, Canada), a sign-up website, was used to schedule appointments. Each participant was contacted by email before his or her appointment, reminded of the scheduled time, and asked not to consume caffeine for three hours prior. All participants were asked to wear a tank top and shorts. Female participants were asked to wear a sports bra, and male participants were asked to remove their shirts to ensure adequate access for palpation.

When the participants arrived, the researchers confirmed that the participants had followed the preparation procedures. If the procedures had been followed, the participants completed the Stress Test and the DAS scale. Both scales were scored to ensure that the participants met the inclusion criteria. If participants did not follow the preparation procedures, they were asked to reschedule the appointment. After completing the consent forms and questionnaires, the participants were given a physical examination, were assigned to their treatment group, and experienced their first round of treatment.

Physical Exam

The physical exam was a standard musculoskeletal and orthopedic physical examination. The exam began with blood-pressure assessment using an Omron M6 HEM-

7001-E Upper Arm Blood Pressure Monitor with ComFit Cuff (Omron Healthcare, Lake Forest, Illinois). The Omron M6 blood pressure cuff was deemed in accordance with International Protocol criteria for use by adults, the elderly, and the obese (Altunkan et al. 2007; Veiga et al. 2009). The participants were placed in a supine position with arms resting next to the participants on the plinth. The researcher used the participants' left arm to obtain all blood-pressure measurements.

Participants then had their pulse taken using a SantaMedical 110 pulse oximeter (Beijing, Choice Electronic Company, Beijing, China). The participants lay supine with a hand resting comfortably on the plinth. The researcher used the participants' right index finger for all pulse measurements.

The SAP muscles were palpated for tenderness. The SAP was used to evaluate the tension, tenderness, and reactivity of nine predetermined muscular regions associated with ANS up-regulation (Table 4.2) (Musgrave 2011; Shahidi et al. 2013; Sonnesen and Svensson 2013). The area of most tenderness of each muscle was marked with an ultraviolet marker to ensure accurate measures were taken post-treatment. The most tender area was tested with predetermined pressure from a dolorimeter (Table 4.2). A dolorimeter is a force gauge with a rubber disc surface of 1 $cm.^2$ The gauge is calibrated in kg/cm^2 (Fischer 1987). When the dolorimeter reading was equal to the standard pressure from that structure, the measurement was recorded and the participant was asked to rate their pain on a 0-10 numeric rating scale (NRS). If a participant believed the pressure to be too great while attempting to reach the predetermined pressure, they were instructed to say stop, and the tolerated pressure was noted. Jump signs or attempts to withdraw from the pressure were also noted. The measurements were taken following a standard protocol that assures validity and reliability (Fischer 1987).

Table 4.2

Sympathetic Activation Pattern Muscles	Dolorimeter Suggestion	Average (If necessary)
Gastrocnemius	6.0kg/cm^2 (Simms et al. 1988)	
Hip Adductors	6.0kg/cm^2 (Simms et al. 1988)	
Rectus Femoris	5.5kg/cm^2 (Simms et al. 1988)	
Quadratus Lumborum	4.5kg/cm^2 (Schenk et al. 2007)	
Thoraco-Lumbar Paraspinals	Females 6.1 males 8.8 (Fischer 1987)	7.5kg/cm^2 **2cm from spine**
Pectoralis Minor	3.5kg/cm^2	
Upper Trapezius	Females 3.7kg males 5.4kg (Fischer 1987)	4.5kg/cm^2
Masseter	2.3 kg/cm^2 (Cunha et al. 2014)	

List of Sympathetic Activation Pattern muscles and the standardized dolorimeter pressure used for each.

After completing the physical exam, participants were randomly assigned in equal number to the treatment group or the control group. The control group did not receive Sensory Flow treatment but completed the same preliminary measurements as the treatment group.

Intervention Procedures

After group assignment, each participant was connected to the HRV monitor. The participants were allowed to lie in a comfortable position for two minutes while the HRV program calibrated. After calibration and recording of HRV, the participants received their assigned intervention. The intervention lasted approximately 15 minutes. At the conclusion of the assigned intervention, the participants rested quietly for two minutes. After two minutes of rest, BP, pulse, and STRESS-O-METER were re-administered. The participants' BP, pulse, and HRV were again measured eight and 14 minutes after treatment (Table 4.3). The increments of BP measurement were chosen based on pilot data conducted by the PI, which indicated that blood pressure taken every two minutes after Sensory Flow treatment fell to the lowest measured point at eight minutes and returned to baseline at an average of 14 minutes. The SAP was then re-palpated, and the participants were again asked to assign a 0-10 tenderness value to the marked point.

Table 4.3

Time Frame	**Measurement**
Before Treatment	Hooked up to HRV monitor, rest for five minutes
Two minutes after treatment	Blood pressure (BP), pulse, Stress-O-Meter, HRV
Eight minutes after treatment	BP, pulse, HRV
Fourteen minutes after treatment	BP, pulse, HRV, SAP

Timeframes for measurements during treatment

On the second day post-intervention, the participants returned to the clinic for re-evaluation. The participants' BP, pulse, and SAP were taken. The participants also completed the STRESS-O-METER. Following the completion of new measurements, participants again received their assigned intervention. At the conclusion of the intervention, the participants completed the same post-treatment measurement procedure completed after the first intervention session.

Statistical Analysis

All data were analyzed using SPSS version 22.0 (SPSS Inc., Chicago, Illinois). G*Power testing using an effect size of $f = 0.5$ and 80% power (Cohen, 1992) indicated a sample size of 19 participants. A repeated-measure analysis of variance (RM-ANOVA) was conducted for each treatment session to assess the impact of the Sensory Flow versus the control on BP, pulse, HRV, SOM, and SAP. Blood-pressure measurements were converted to a value for mean arterial pressure (MAP) as suggested by *The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure* (*The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure* 2004). Significant results were further analyzed using Bonferroni and Tukey post-hoc testing. Prior to data analysis, testing was done to ensure that assumptions of sphericity and normal distribution were met. Effect size was computed with eta squared (η^2).

The percentage change was also calculated on SOM. The percentage change was used to determine if the changes in the SOM scores were clinically meaningful to the patients. The Minimal Clinically Important Difference (MCID) for the SOM was determined by Farrar to be 30% (Farrar et al. 2001). The formula used to calculate the percentage change for each group was mean baseline minus mean final score divided by baseline [((x2 - x1) / x1)*100].

RESULTS

Twenty patients were recruited for the study (Table 4.4). All twenty were full-time undergraduate students (3 freshmen, 5 sophomores, 8 juniors, 4 seniors). The participants had a mean GPA of 3.45 and were enrolled in 13-17 credit hours ($\bar{x}$=15.36, SD = 1.7). All participants met the inclusion criteria on the Stress Test ($\bar{x}$=447.25, SD=230.978). Control scores on the Stress Test were higher (M=1070.90, SD=250.83) than the treatment group (M=850.10, SD=244.210). There was homogeneity of variances, as assessed by Levene's test for equality of variances (p. = .717).

Table 4.4

Table 4 Characteristics of subjects (n=20)		
Characteristics	n (%)	Mean ± SD (min - max)
Gender (females)	16 (80)	
Credit Hours		15.36 ±1.7 (13-17)
GPA		3.45 ± 0.30 (2.8-3.94)
Year at University		
1st	3 (15)	
2nd	5 (25)	
3rd	8 (40)	
4th	4 (20)	
SD - standard deviation		

Characteristics of Subjects

Mean Arterial Pressure

The change in mean arterial pressure was not statistically significant between groups for treatment one [$F (3, 54) = .396$, $p=.686$, partial $\eta^{2} = .022$] or treatment two [$F (3, 54) = 3.612$, $p=.062$, partial $\eta^{2}=.167$]. There was significant change over time during treatment one [$F (3, 54) = 6.947$, $p=.002$, partial $\eta^{2} = .554$] but not for treatment two [$F (3,54) = 1.679$, $p=.211$, partial $\eta^2 = .085$].

Pulse

Changes in pulse were not statistically significant between groups for treatment one [$F (3, 54) = .262$, $p=.726$, partial $\eta^{2} = .014$] or treatment two [$F (3, 54) = .971$, $p=.413$, partial $\eta^{2} = .051$]. Changes were significant across time for treatment one [$F (3, 54) = 5.281$, $p=.015$, partial $\eta^{2} = .227$], and for treatment two [$F (3, 54) =4.335$ $p = .008$, partial $\eta^{2} = .194$].

Heart-Rate Variability

Heart-rate variability was not statistically significant between groups after treatment one [$F (3, 54) = .405$, $p=. 750$, partial $\eta^{2} = .022$] or following treatment two [$F (3, 54) = .839$, $p = .478$, partial $\eta^{2} = .045$]. Changes were also not significant across time for treatments' one

[F (3, 54) = .549, p = .621, partial $\eta^{2 =}$ .032] or two [F (3,54) = .365, p = .779, partial $\eta^{2 =}$ .020].

Stress-O-Meter

The Stress-O-Meter was not statistically significant between groups after treatment one [F (3, 54) = .177, p = .845, partial η^2 = .010] but was significant after treatment two [F (3, 54) = 2.702, p = .020, partial η^2 = .169] with a large effect size. The SOM was also significant across time for treatment one [F (3, 54) = 41.133, p<.000, partial $\eta^{2 =}$ .696] and treatment two [F (3, 54) = 27.675, p<.000, partial $\eta^{2 =}$ .650] with a large effect size.

Participants also reported MCID on the Stress-O-Meter (>30% change) (Farrar et al., 2001) in the Sensory Flow and control groups in session one but only for the Sensory Flow group in session two (Chart 4.1). The Sensory Flow group STRESS-O-METER scores changed by an average of 39.48% during treatment one and by 45.65% during treatment two. The control group changed by 37.25% in session one and only 25.31% in session two.

Sympathetic Activation Pattern

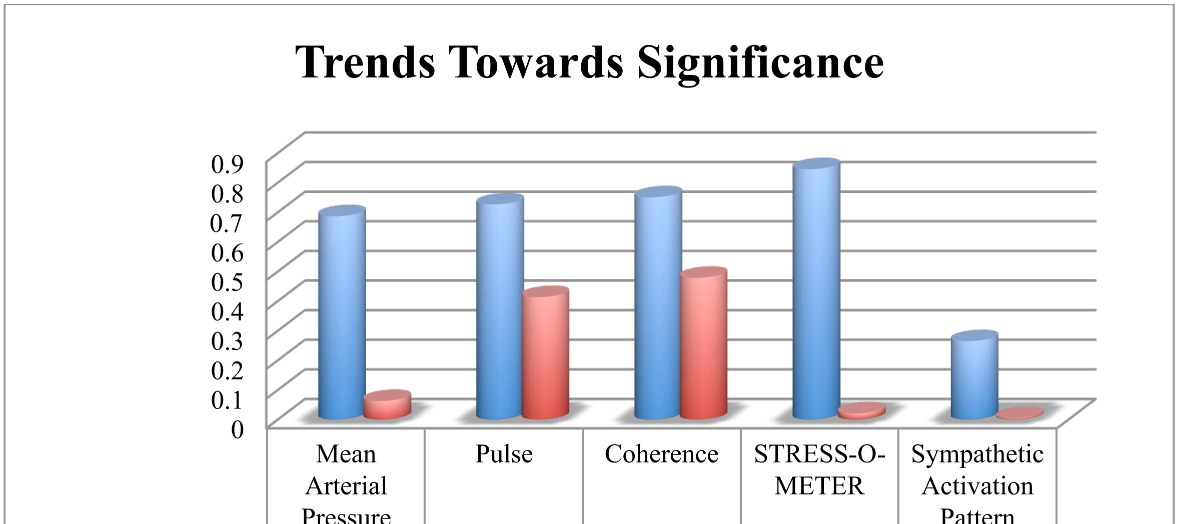
The SAP was not statistically significant between groups for treatment one [F (1, 18) = 1.330, p = .264, partial η^2 = .069] but was a statistically significant over time groups [F (1, 18) = 255.025, p < .002, partial η^2 = .409]. The SAP was statistically significant between the interventions and time in treatment two [F (1, 18) = 17.521, p = .049, partial η^2 = .267]. There was also a statistically significant change between groups [F (1, 18) = 4.042, p < .004, partial η^2 = .493].

Discussion

The biometric measurements (MAP, pulse, HRV) taken in this study do not provide enough information to state conclusively the effects of Sensory Flow on the ANS. While all three show trends towards significance after the second Sensory Flow treatment, none of the three achieves the desired level of significance. While statistical analysis did not reveal significant changes in some of the variables between groups, changes across time were seen in MAP during treatment one [$F (3, 54) = 6.947$, $p=.002$, partial $\eta^{2 =}$ .554] and for pulse during session two [$F (3, 54) =4.335$ $p = .008$, partial $\eta^{2 =}$ .194]. Significance here indicates that the treatment and the control groups produced a reduction in MAP and pulse and therefore these were both effective ways to cause changes to these dependent variables. The effect size in both of these changes is interesting. While the intervention was not statistically significant, both groups showed a large effect size, even with such a small N. The change in MAP and pulse may be related to the effects of lying comfortably in a quiet room for a period of 15 minutes (Bahrke and Morgan 1978; Morgan 1979).

There was also an interesting trend between treatments one and two of Sensory Flow. It appears that treatment two produced improvements in all independent variables (Chart 4.1). Although the effects are not considered significant, treatment two seems to be more effective than treatment one.

Chart 4.1



	Mean Arterial Pressure	Pulse	Coherence	STRESS-O-METER	Sympathetic Activation Pattern
Treatment 1	0.686	0.726	0.75	0.845	0.264
Treatment 2	0.062	0.413	0.478	0.02	0.004

Changes in significance from treatments one to two of the Sensory Flow group

The effect noted could be due to anticipation of the relaxation component of the treatment. Because patients consider the treatment results pleasant, they look forward to their effects and thus prime the body for a better response. A study by Bishop, Mintken, Bialosky, and Cleland (2013) indicated a significant relationship between patient expectations and outcomes. In their study, more than 80% of patients surveyed indicated that they expected that manual therapy would provide relief, and 87% felt that massage would significantly improve their pain (Bishop et al., 2013). Using massage to treat the patient did indeed provide better outcomes, showing that a provider can expect better outcomes when they leverage patient expectations (Benz and Flynn 2013; Bishop et al. 2013).

The trends towards significance could also be explained by the Polyvagal theory. According to the Polyvagal theory the social engagement role of the Vagus nerve determines how the ANS responds and reacts to the person's perceived environment (Porges 2001).

Because the participants were exposed to the environment in the exact same manor in treatment one as in treatment two, the Vagus nerve may have been less engaged in the social engagement aspect of the intervention and thus more free to carry out the role of the Vagal brake (Porges, 2007, 2001).

When evaluating instruments for this study, none were ideal. Up-regulation of the ANS can happen to the SNS and also the PSNS, although this is rarely discussed (Kolb and Whishaw, 2011). Discussion on SNS up-regulation is more common and has been tied to heart disease, high blood pressure, and sleep apnea (Fletcher, 2003; Malpas, 2010). Discussion on PSNS up-regulation is limited, but PSNS up-regulation has been tied to seizures (Wildenauer, 2013) and a rare phenomenon known as voodoo death (June and Zealand, 1942). Presently, there are no instruments designed to determine which division of the ANS is up regulated. Having no way to quantify which division is up-regulated makes measuring exact effect of treatment more difficult.

Being able to accurately capture the nuances of change in a participants stress level from one moment to the next was also difficult. While many studies use NRS for variables such as perceived stress, most self-report data is thought to be less accurate (Short et al., 2010). Having instruments to accurately measure changes in each of the independent variables could have given a more accurate picture of the effects of the treatment.

Limitations of this study include not being able to constantly monitor blood pressure (Parati et al. 1989) and having a small sample size. Also, the results of the study may have been negatively affected by the inclusion criteria for participants. Sensory Flow is most effective for patients who have experienced trauma and who have sought treatment for pain. The patients in this study were screened for up-regulation as characterized by depression, anxiety or stress, but not specifically for trauma and were not screened for a present painful condition. They also volunteered to participate in the study, but were not actively seeking treatment. It does appear that the effects of Sensory Flow may build over time. Used with the other components of the AAT system such as Reflexercise and Congruence, additional benefits are likely to be seen (Musgrave 2011). Further research on the cumulative effects of Sensory Flow and the AAT system as a whole are needed to make any conclusive statements.

The positive results of this study do support the use of Sensory Flow as a mechanism to help decrease perceived stress and to help decrease sensitivity to pain in patients who are up-regulated. Both measures showed MCIDs on the NRS, meaning that tenderness to palpation and stress both improved enough to be considered important to patients. Decreasing perceived stress and sensitivity to pain could interrupt faulty pain cycles, freeing the patient to deal with only the pain that is being caused by a present condition (Chapman et al. 2008; Schlereth and Birklein 2008).

Conclusion

While more research is necessary to confirm the results of this study and to further determine the cumulative effects of Sensory Flow as a stand-alone treatment, Sensory Flow does seem to provide a gateway to decrease stress and perceived pain in participants who were known to be in an up-regulated state. Sensory Flow could then be a helpful component of beginning to treat patients with chronic pain.

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