Ultrasonography Assessment of Ankle/Foot Pain: A Biopsychosocial Model

THESIS

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By

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Abstract

Approximately 20 percent of the general population suffers from musculoskeletal pain, and foot pain is one of the most common reasons people make an appointment to see their physician. With the current medical model, the economic burden of musculoskeletal pain costs US insurance companies nearly $850 billion dollars annually. Furthermore, musculoskeletal pain leads to a loss of physical function and declines in mental health, which may adversely affect gainful employment.

For these reasons a new biopsychosocial model is needed to help address this significant problem. Therefore, this work aims to provide a cost-effective, holistic approach to ankle/foot pain with the utilization of a hand-carried ultrasound unit (HCU). A pre-experimental research design was used to allow for a convenient sample of asymptomatic and symptomatic volunteers to undergo evaluation of the ankle/foot. This innovative mixed-method screening included a questionnaire, an intake history, as well as a bilateral sonographic evaluation of the ankle/feet. Evaluation of tendons in the posteromedial and posterolateral compartments can provide a potential diagnosis of tenosynovitis, tendinopathy, and varied levels of tendon tears. In addition to the typical structures evaluated with ankle/foot MSK sonography, myofascial trigger points (MTrPs), were palpated and scanned, since they are an overlooked, as a common cause of MSK pain. This approach allowed for the exploration of the usefulness of an HCU to contribute to the holistic diagnostic work-up for patients with ankle/foot pain.
In keeping with a person-centered approach, the participant’s pain represented the dependent variable, via self-reported pain and visual analogue scale (VAS). The sonographic findings, both palpated and visualized MTrPs, and questionnaire responses represented the independent variables. The researcher/sonographer scanning the participants was blinded, and a protocol was used to systematically evaluate the tendons and ligaments in the anterior, posterior and lateral compartments. All sonograms were evaluated post examination.

The results of this study found several significant independent variables to help identify patients with ankle/foot pain in this population. An increase in MTrPs and sonographic abnormalities were found to be statistically significant when correlated with painful limbs, while the predictive value of these independent variables to the VAS, while still significant, was lower. Questionnaire components, including the VISA-A and Physical SF-12 surveys also provided statistically significant correlations. The VISA-A, however, was the single best predictor for ankle/foot pain, when compared to the VAS, accounting for nearly 60 percent of the variation. This screening protocol offers salient independent variables (including the VISA-A, SF-12, palpable MTrPs, and a modified sonographic screening) to help holistically identify patients with ankle/foot pain. More rigorous studies, utilizing these variables in combination, are needed to provide support for its use as a good alternative to more expensive diagnostic screenings, such as magnetic resonance imaging (MRI).
"Knowing others is wisdom knowing yourself is Enlightenment"
-Lao-Tzu

This work is dedicated to my son who, has come into, and my grandmother, who has
gone from my life during this process. Both who have provided me with Enlightenment.
Acknowledgments

Without the help, support and patience of my family and friends, this fun adventure would have all come to a premature end. I am grateful for those scholars, I have been lucky to learn from, who have provided me the ability to get to this point. A huge thank you goes to my advisor, Dr. Kevin Evans understanding and guidance have been invaluable. I am appreciative of all his training of diagnostic medical sonography over the years, as well as introducing me to graduate school and research. Furthermore, I look up to his enthusiasm and passion for his work and this profession. I am grateful to have Dr. Evans as a mentor, a teacher and a friend.

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This thesis has been a collaborative effort, and I am grateful to everyone who has been involved and provided his or her support. Namely, without the support of my co-workers, Kevin Volz and Chris Kanner, in the Laboratory for Investigatory Imaging, this thesis would not be in existence.

Thank you again to everyone who has supported me! (Now as a reward you get to read lots of pages on ankle/foot pain, whoo hoo!)
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Major Field:  Allied Medical Professions
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Chapter 1: The Biopsychosocial Model

“The greatest mistake in the treatment of diseases is that there are physicians for the body and physicians for the soul, although the two cannot be separated.”
- Plato

Biomedicine is rapidly evolving, yet its philosophy is revolving. Advances in technology have allowed for growing evidence-based medical practices and even personalized healthcare, which proposes customization of an individual’s care, based on their molecular data. Biomedicine is, undoubtedly, rooted in the objective and measurable - a hermetic dualistic system bound to the physical components of illness and disease. Patients seek care to find a diagnosis, which presumably will lead them to possible cures. However, even diagnoses are not always precise and maybe ‘substantial’, meaning there are straightforward cures and actions (such as strep throat), or ‘nominal’, meaning they cannot be predicted or even fully understood (such as rheumatoid arthritis). (Zigmond, 2012) While substantial diagnoses increase faith in this medical model, at the same time nominal diagnoses, arguably, lead both patients and practitioners to lose faith and perceive a maladroit system.

Underpinning this model is the ontological and epistemological position of positivism, assuming there is one truth and that sensory experience is the sole source of all valid knowledge. It is the culmination of Descartes (1596-1650) dualistic view of mind and body, commonly known as the Cartesian or biomedical model. (Westman,
This was pushed forward with Virchow’s 20th century supposition that all disease is a result of cellular abnormalities. (Wade & Halligan, 2004) Personalized medicine, if viewed from a strict genomics perspective, is an equally flawed model of medicine. Foucault states the most objectionable part about this Cartesian science “…is the unacknowledged implication of the claim to knowledge, that is, the will to power.” (Scheurich, 1996, p. 55) It is no wonder some patients are left feeling stripped of power to control their own health. The patient may report an illness, yet with no disease found by a doctor, their illness falls out of the realm of real and the doctor, not the patient, holds this authoritative knowledge. Unfortunately, it is the patient who is diminished, in this reductionist model. Wade and Halligan (2004) argue there are flaws with this authoritative system and propose medical models of illness that need to be openly debated as modeled in this excerpt: “The biomedical model of illness, which has dominated health care for the past century, cannot fully explain many forms of illness. This failure stems partly from three assumptions: all illness has a single underlying cause, disease (pathology) is always the single cause, and removal or attenuation of the disease will result in a return to health. Evidence exists that all three assumptions are wrong.” (p. 1398)

Furthermore, they propose a more complex medical model (Figure 1.1) to account for physical and social environments on health dysfunction.
This model is particularly focused on improving health care systems by focusing on the person, yet it also focuses on the health care professional and their interaction with the person. There are many models of illness, born out of different specialties and professions. For example the social model (Figure 1.2), shows how disability among children is brought on by society, but it does not address illness as a whole. It does bring up this social aspect of labeling again, however, and acknowledges that society evolves and relationships are important to foster.
While the Wade and Halligan model and social model are a few examples, the most popular alternative model, included in over 400 Medline titles (Wade & Halligan, 2004), is the biopsychosocial model. This model proposes illness is caused not only by biophysical factors, but psychological and social ones as well. This concept was originated by George Engel, who was a physician and, although first a skeptic of psychosomatic medicine, became a pioneer of this field. His famous 1977, Science, article entitled, “The Need for a New Medical Model: A Challenge for Biomedicine,” outlines the beginning of the biopsychosocial model, although does so only in words. Engel argued this new model was based on history and how illness exists, despite a physical disease. He wrote, “In all societies, ancient and modern, preliterate and literate, the major criteria for identification of disease have always been behavioral,
psychological, and social in nature.” (Engel, 1977, p.196) This clearly opens up our perspective on illness, from a reductionist model to multi-factorial phenomena.

Engel’s model, while depicted and described in many ways for many different uses, is an alternate position compared to the linear biomedical model, which still persists today. Yet, in recent years, due to healthcare reform around the globe and here in the United States, his holistic approach to illness is gathering attention. One health care specialty, which has been particularly interested is this model, has been those dealing with the issue of chronic musculoskeletal pain.

The International Association for the Study of Pain (2009) issued a review on evidence-based treatments focused on the biopsychosocial model. This document summarizes that, “Biological, psychological, and social factors must all be simultaneously addressed.” (p.1) They support, via many studies, that comprehensive biopsychosocial-based treatment is best when it is interdisciplinary, such as incorporating a physician-nurse team, physical or occupational therapists, psychologists and/or physiatrists. One review found greater improvements in a variety of areas, directly comparing an interdisciplinary group versus a unimodal treatment or no treatment group. These areas included returning to work (68% for the interdisciplinary group vs. 32% unimodal or no treatment), pain reduction (37% vs. 4%), medication reduction (63% vs. 21%) and increases in activity (53% vs. 13%). (Gatchel & Okifuji, 2006)

The biopsychosocial model is usually shown as a Venn diagram, showing the intersection of all of these factors. However, there are more complex variations (Figure
1.3), where we can see how each element can interact and affect the others and gives more description, in particular for pain.

![Biopsychosocial Model](image)

**Figure 1.3 The biopsychosocial Model (Specialist Osteopaths, 2013)**

Pain is one of the most common symptoms patients seek out for medical help, yet is it perhaps the least understood. (Westman, 2010) While many other models were explored, such as the Karasek’s job strain model (Karasek, 1979), the biopsychosocial model seems to fit best with the overall aim of this thesis (as well as seem to best reflect reality), which is to explore ankle/foot pain, in a holistic manner, situated in a post-positivist theory of knowledge.
Furthermore, this model blends well with a holistic Eastern medicine philosophy, often taught in the traditional martial arts, which provided a personal basis for the evaluation of lower extremity trigger points in this study. This philosophy contends that the self can only be made strong or healthy though balance. In the biophysical sense, this is the ever-important homeostatic balance. Yet, balance in the holistic sense, is a combination of the mind, body and soul. It is like a tripod and if one piece is missing, the whole may topple down. Arguably, of the biopsychosocial model, the biophysical is the obvious physical, and the mental, psychological and the soul is the social piece.

While this model is seemingly beneficial for improving health outcomes, the biopsychosocial model has been accused of bordering on anarchy, since one can choose to emphasize the bio, the psycho or the social. This alleged arbitrariness is the chief criticism and it has been proposed that in order to counter this complaint, “scientifically proven concepts” should be used to see which relationship(s) of this model are supported. Clearly, if these are biological facts, which is both implied and stated, then the model reverts right back to “biologism.” (Stier, 2014, p.1) This conundrum of proven knowledge must be totally overhauled to get out of this rut. Psychiatry, in particular, is hotly debated as being either scientific, rooted in biologism or regarded as arbitrary at best and not scientific at worse. Ways of ‘knowing’ must meet the current diaspora of information and historical context from which it came. There is no such thing as proof, only contexts from which to draw conclusions, which may need to be re-drawn soon-thereafter upon new context. While this inquiry appears muddled, it is no different than what we already do, only with the acknowledgement and transparency of calling humans what they are –
bewildering (or higgledy-piggledy if you prefer). While biomedical quantitative research does not address these outlying concepts, qualitative research may be helpful, as an opposite and equal partner to explore the biopsychosocial model.

This thesis specifically proposes to blend the biophysical with the psychosocial in a cohort of people with and without ankle/foot pain through mixed-methods. This will be achieved by evaluating biophysical structures, including myofascial trigger points (MTrPs), with a physical exam and a hand-held ultrasound machine. Patients will also be evaluated according to their perceived mental and physical overall health, as well as their specific ankle/foot pain. Furthermore, this will be done in a screening fashion to see what can be captured with these methods in a limited amount of time. This is done to keep with a clinically useful and applicable manner. While it is impossible to understand the whole person, particularly in a short amount of time, the goal is to stop reducing our vision of our patients to one lens, and become multifocal.
Chapter 2: Review of the Literature

This research project is aimed at averting the hegemonic “medical gaze” or dehumanizing separation of the patient’s mind and body from their identity, by establishing a holistic post-positivist medical model. We, as clinicians and clinical researchers, have an obligation to our patients to end “mindless phenomenologies” (Foucault, 1973, p. pxiii-xiv) and the default scientism, which pervades most anatomical assessments. As most diagnostic medical sonographers are aware, clinical reality reaches far beyond a simplistic, stethoscopic look into the body to diagnose disease. Rather, “disease is being done,” (Mol, 2002, p. 32) and the investigation of disease are never isolated. Yet, “valid” western medical science has been dominated by Cartesian dualism or positivism. This Cartesian dualism, “asserts an ontological premise in which there is radical separation between subject and object and between people and the external world.” (Pascale, 2011, p. 31) In this narrow view of science, empirical claims can be verified by sensory inspection within a localized context. Consider, however, how this subject/object dichotomy breaks down in sonography – we the subjects, are in fact, measuring other subjects, err humans. Certainly, a participant of a research project may be studied as an object; yet, medicine is the science of humans. In response to this “reductionist, dualistic biomedical model” George Engle proposed the biopsychosocial model which shows us how disease is a result of, not only
physical/biological reasons, but psychological and psychosocial reasons as well. (Engle, 1977) So, are we not unethical then in studying humans overwhelmingly in one dimension, dismissing and/or minimizing the social and psychological? Yet, the somatic, dualistic approach in medical research persists and this leaves our patients disjointed - separating body, from mind, from soul. This project aims to create a new discourse to return the human to the body. How can we tout individualized medicine, and forget the individual?

While this holistic model was presented nearly 35 years ago, medicine still submits to political pressures, as ontologies of multiple-realities do not bode well for the scientific dream of wielding authoritarian power. Yet, as Engle points out:

“The boundaries between health and disease, between well and sick, are far from clear and never will be clear, for they are diffused by cultural, social, and psychological considerations. The traditional biomedical view, that biological indices are the ultimate criteria defining disease, leads to the present paradox that some people with positive laboratory findings are told that they are in need of treatment when in fact they are feeling quite well, while others feeling sick are assured that they have no “disease.” A biopsychosocial model which includes the patient as well as the illness would encompass both circumstances.” (1977, p. 132-133)

Therefore, it is imperative to evaluate disease with many factors in mind. So in an attempt to provide a holistic medical approach, the biopsychosocial model of pain was chosen for this research. The mixed-methods approach utilized with this research
attempts to provide a place where one work would not exclude the other, or take ultimate authority, but in which they cross-check one another and view any differences found between them to be a place of rich information, rather as a messy entity, which must be tidied up or reconciled. (Howe, 2004)

While this model covers many different facets of disease, a review of the literature pertaining to the physical/biological ankle/foot pain in regards to sonography is performed. This includes the evaluation with ultrasound on both traditional structures of the ankle/foot (muscle, bone, tendons, ligaments) and myofascial trigger points (MTrPs).

**Self-reported Pain as the Independent Variable**

To date there is no universal standard measurement of pain, since it is unique to each individual; as it is his or her own perception. Many attempts at quantifying and qualifying ankle/foot pain have been undertaken using many different questionnaires. In a recent systematic review of patient reported outcome measures used in ankle/foot research, there was considerable variety, with a small portion of it used consistently. Furthermore, although the review calls for a more consistent use in research, it concedes that it is not clear which of the outcome measures will emerge as the most clinically useful. In this same systematic review a total of 878 clinical foot/ ankle articles, which utilized at least one patient reported outcome measure were included, and from these there were 139 unique outcome scales used. The top five utilized scales included the American Orthopaedic Foot & Ankle Society (AOFAS) scales, the visual analog scale (VAS) for pain, the Short Form-36 (SF-36) Health Survey, the Foot Function Index
(FFI), and the American Academy of Orthopaedic Surgeons (AAOS) outcomes instruments. (Hunt & Hurwit, 2013) Furthermore, a helpful review of ankle/foot pain, entitled, “Understanding the nature and mechanism of foot pain,” by Hawke & Burns (2009) states, “Since pain is a subjective sensory and emotional experience, the participant's own reporting of pain is widely regarded as the most valid representation of their pain.” And, “Despite these limitations, foot pain as an outcome measure has much to offer clinical practice and research.” (p. 6)

**Ultrasound Assessment of the Physical**

While the physical/biological aspects of ankle/foot pain would seem to be the most straightforward in this biopsychosocial model, they are in fact quite complex. The biological reasons for ankle/foot pain are innumerable and therefore, are oftentimes segregated by studies of a particular effected area or specialty based on etiology, though this will sometimes remain unknown. This portion of the review will be mostly focused on ultrasound assessment, however it is important to understand that mechanistic physiological foot pain is only a segment of pathological pain, pertaining to nociceptive pathology, which may include the pathophysiology of the central or peripheral nervous system. In addition to physiologic foot pain, where there is an action/reaction response, one must not forget about neuropathic, inflammatory and chronic pain. (Hawke & Burns, 2009)

A review of the literature pertaining to ankle/foot pain and sonographic evaluation was performed using PubMed, Google Scholar and CINAHL database searches. While a
systematic approach was attempted, this proved to be difficult owing to the wide variety of material within the search terms, “ankle OR foot pain musculoskeletal sonography evaluation,” or “ultrasound musculoskeletal evaluation ankle foot pain.” Over 75 like searches were performed among these different databases and it resulted in two systematic reviews (one on ultrasonography in osteoarthritis and another on diagnostic imaging for chronic plantar heel pain), 14 reviews, 19 cohort studies and one case study about tibialis posterior tendon evaluation with ultrasonography. All evaluated articles had the following inclusion criteria: peer-reviewed within the past five years (systematic reviews were open to the past 10 years), adult population, musculoskeletal and human subject. A few were excluded due to being inaccessible and a majority were excluded because they pertained to injections of the ankle/foot, were about juvenile idiopathic arthritis, therapeutic ultrasound, neuropathy, vasculopathy or not did not pertain to the ankle/foot at all.

Starting with the highest level of evidence, the two systematic reviews showed positive outcomes for utilizing ultrasound in their respective areas. The first entitled, “A systematic review of ultrasonography in osteoarthritis,” identified 47 studies in which ultrasound was used to assess osteoarthritis. Most of these studies examined pathological changes and only 10 of them did any Doppler assessment. Keen et al (2009) concluded that while there is an increase in evidence pointing to validating sonography for this use, it was still not any standardized criteria and more work needs to be done. (Keen, Wakefield, & Conaghan, 2009) Another systematic review conducted by McMillian et al (2009) examined all relevant imaging modalities to assess the plantar heel, in particular
the plantar fascia. A total of 23 studies were included, 13 of them utilized ultrasound. It was determined a thickened plantar fascia measuring greater than 4.0 mm and an associated subcalcaneal spur were most strongly related to pain beneath the heel. (McMillan, Landorf, Barrett, Menz, & Bird, 2009)

The next highest level of evidence included were the prospective cohort studies. There were eight large cohorts (over N=50) and nine smaller ones. There was a wide variety amongst all of these cohorts, within the larger ones there included a successful longitudinal evaluation with ultrasound to follow the extensor hallucis longus tendon injury in 50 (plus 50 case-controls) taekwondo athletes (Lee, Choi, Lee, Young, & Park, 2009) and a comparison of 51 patients using CT arthrography and sonography in the diagnosis of anterolateral ankle impingement, which concluded CT arthrography was still superior, however adding Doppler could help confirm a diagnosis with ultrasound. (Cochet, Pelé, Amoretti, Brunot, Lafenêtre, & Hauger, 2010) Yet, another study found a 12-joint power Doppler ultrasound (PDUS) assessment of RA joint inflammation may be a valid, feasible method in comparison to the existing comprehensive 44-joint assessment in 160 patients with active rheumatoid arthritis.(Naredo et al., 2008) Next, a study showed ultrasound detecting 40 talocrural joint effusions, same as MRI, in 110 emergency room patients presenting with an ankle sprain, in 39/40 MRI visualized damage to the anterior talofibular ligament, as well as 5 cases showing damage to the calcaneofibular ligament, and 14 cases had cartilage damage or bony contusion. This study promoted ultrasound as a screening tool, but did not use it to evaluate the actual talofibular ligament in the study.(Guillodu, Riban, Guennoc, Dubrana, & Saraux, 2007)
Also, a study found ultrasound to be useful in detecting joint and/or tendon abnormalities in the fingers and toes of 36 of 52 patients with psoriasis who had suspicious changes. (Caldarola et al., 2011)

A more relevant and smaller cohort found ultrasound to be highly sensitive in detecting fractures of the ankle/foot within an emergency room setting. In 131 patients included in the study, in comparison to 20 positive radiographs, ultrasound detected all of the fractures, with the most occurring at the lateral mallalous and at the base of the fifth metatarsal. Furthermore in one patient the radiograph was read as normal, whereas the ultrasound detected an ankle fracture. (Ekinci, Polat, Günap, Demirkan, & Koca, 2013)

In a very similar study of 110 patients, 11 had radiographic fractures and ultrasound detected 10 of them. (Canagasabey, Callaghan, & Carley, 2011)

In a study by Jamadar et al. examination of a focused ultrasound versus a more comprehensive one was undertaken on 602 patients over a period of six months. They concluded, “although focused sonography examination of the distal extremities at the site of symptoms corresponded to an abnormality in most cases, a protocol-based approach identified 98% of symptomatic abnormalities. We advocate a protocol-based approach to musculoskeletal sonography supplemented with a focused evaluation at the site of patient symptoms to ensure a thorough and complete evaluation.” While this study had many areas of the body to focus, the ankle/foot area showed that the foot, with a focused exam, could detect 73% of abnormalities. (Jamadar et al., 2008)

In the smaller cohort studies, again, there was an array of evaluations from rheumatology based ultrasound assessments (Bowen et al., 2008) (Filer et al., 2011) (Micu, Serra,
Fodor, Crespo, & Naredo, 2011) to ultrasound versus MRI for detecting spring ligament abnormalities (10/10 correlation) (Harish, Kumbhare, O’Neill, & Popowich, 2008) to detection of Morton neuromas, where ultrasound detected 79% and MRI 76% compared to surgery. (Lee et al., 2007) In a study of 30 ankle sprains, ultrasound was found to be a good and reliable method for diagnosing Grade I and II ankle sprain, but in the case of a Grade III sprain an MRI was recommended. (Margetic, Salaj, & Lubina, 2009)

As the above literature search shows, in all but one example, research on the assessment of ankle/foot pain with ultrasound is almost always very focused, either by disease (such as rheumatoid arthritis), by cohort, (i.e. martial artists) or by clinical use (assessing for broken bones in the emergency department). For purposes of clarity on at least one anatomical assessment with ultrasound another more focused review of the literature was performed, choosing a particular aspect of the ankle/foot for ultrasound – the Achilles tendon and tendinopathy specifically.

Achilles tendinopathy is a common musculoskeletal disorder, which often arises from chronic overuse of the calcaneus tendon. Tendinopathies of the tendo calcaneus may range from tendinitis (inflammation of the tendon), to tendinosis (partial tears or micro-tears) and tendon rupture (complete tear). Tendinosis often results in chronic pain, whereas complete rupture of the tendon is an acute problem. Tendinitis, without other disorders on its own, often resolves within the acute time-frame, however it often accompanies tendinosis, causing chronic pain. (Bleakney & White, 2005) It is well-documented both magnetic resonance imaging (MRI) and ultrasonography (US) are the imaging modalities of choice to diagnose Achilles tendinopathies. It is also well known MRI is the current radiological
gold standard in the United States with studies supporting a sensitivity > 90%. While there is consensus over MRI’s accuracy to diagnose Achilles tendinopathy within the United States, the accuracy and efficacy of utilizing US remains unclear.

This more focused review was performed by using a MEDLINE (via PubMed) and WorldCat search. Search terms used for each database are listed in the summary search diagram shown in the figure below. The inclusion criteria were based solely on adults with chronic Achilles tendinopathy. Spondyloarthritis of the Achilles tendon was included because it is mostly inflammation causing chronic pain. Children, acute complications, or other tendons were not included. Also, the study must have compared ultrasound or power or color Doppler to a gold standard, either MRI or histological samples. Histological samples are the gold standard, whereas MRI is the radiologic gold standard. While, the newest US innovation, elastography, was used in some studies found in the search, this was not included for this guideline. Furthermore, the study must have produced quality results with quantitative measures. Only studies with a level of evidence of two or higher were included. The summary search diagram and summarized studies included in this review are shown below.
Figure 2.1 Summary Search Diagram
<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>Author, Year</th>
<th>Overview</th>
<th>Results</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-randomized comparison study (Medium - 3)</td>
<td>Aström et al., 1996</td>
<td>27 patients with chronic Achilles tendinopathy Compared conventional (T1 &amp; T2) MRI to conventional (greyscale) Ultrasound (US) to surgical findings Used 5-7 MHz transducer</td>
<td>2 normal, 4 partial ruptures, 21 degenerative lesions AP – P&lt;0.01 (10-15mm – severely abnormal) US 21/27 MRI 26/27</td>
<td>MRI is more sensitive than US at detecting tumors, but both give similar information, and this information can be used to facilitate surgical management.</td>
</tr>
<tr>
<td>Non-randomized comparison study (Medium – 3)</td>
<td>Paavola, Paakkala, Kannus, &amp; Järvinen, 1998</td>
<td>79 patients with Achilles tendinopathy Compared US to surgical findings Used 5-10 MHz, mainly 7.5 MHz transducer</td>
<td>US found 76/79 abnormal tendons No false-positive cases</td>
<td>Conclude US is reliable for locating tendon abnormalities and estimating the severity. Can determine most cases requiring surgical intervention However, US not completely reliable to differentiate between tendon ruptures from focal degenerative lesions</td>
</tr>
<tr>
<td>Study Type</td>
<td>Authors</td>
<td>Participants</td>
<td>Ultrasound Findings</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Non-randomized comparison study</td>
<td>Hartgerink, Fessell, Jacobson, &amp; Van Holsbeeck, 2001</td>
<td>26 patients with Achilles tendinopathy ranging from partial to full tears and tendinosis</td>
<td>Sensitivity - 100% Specificity - 83% Accuracy - 92%; NPV - 100% PPV - 88%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Compared US to surgical findings Used 7.5-12 MHz Transducer</td>
<td>Ultrasound can differentiate between all of these tendinopathies with 92% accuracy and can be recommended as an alternative to MRI</td>
<td></td>
</tr>
<tr>
<td>Non-randomized comparison study</td>
<td>Hodgson, et al., 2011</td>
<td>25 patients with Spondyloarthritis (SpA) 10 healthy volunteers</td>
<td>AP Healthy controls – 5 mm AP patients with SpA – 6.6 mm (over 6 considered abnormal)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Compared MRI ultrashort echo with and without contrast to MRI and greyscale &amp; US power Doppler Used 14 MHz transducer</td>
<td>2D US 19/25 (76%) PD US 14/25 (56%) MRI Enhaned (TE=2 ms) 23/25 (92%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Best method was with contrast MRI, US PD gave the same information, just did not show the same extent</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The extent of abnormalities seen on greyscale ultrasound was greater than the extent of any vascularisation detected with power Doppler (p=0.0001)</td>
<td></td>
</tr>
<tr>
<td>Non-randomized prospective comparative study</td>
<td>Khan et al., 2003</td>
<td>45 patients with chronic tendinopathy, total of 57 Achilles tendons</td>
<td>Abnormal US 37/57 (65%), MRI 19/34 (56%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Compared MRI to greyscale, power Doppler and color Doppler US to clinically diagnosed tendinopathy</td>
<td>Normal US 19/28 (68%), MRI 15/16 (94%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Used 12 MHz transducer</td>
<td>US sensitivity (.80) and specificity (0.49)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MRI sensitivity (0.95) and</td>
<td></td>
</tr>
</tbody>
</table>

Continued
### Table 2.1 Continued

<table>
<thead>
<tr>
<th>Study Description</th>
<th>Participants/Methods</th>
<th>Imaging &amp; Analysis</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitudinal prospective pilot study (Low – 2)</td>
<td>Richards, McCall, Day, Belcher, &amp; Maffulli, 2009</td>
<td>9 patients with chronic Achilles tendinopathy Compared MRI (with and without contrast) with US (2-D and PD) to clinical assessment with questionnaire</td>
<td>Conclude US has better resolution and thus easier and better inter-rater reliability for measuring AP Vessels both with contrast MRI and PD US related to the abnormal morphology and size of the tendon rather than symptoms</td>
</tr>
<tr>
<td></td>
<td>Used 7-12 MHz transducer</td>
<td>AP measurements more significant with US (correlation of $r=0.835$ compared to MRI (correlation of $r=0.640$ with questionnaire</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>US stat. significant $P=0.038$, 95% CI 0.074, 0.981)</td>
<td></td>
</tr>
</tbody>
</table>
The methods used in all of these studies were, for the most part, rigorous. However, none of these studies were in the higher levels of evidence because they were not randomized. Furthermore there were not many participants in these studies, with the most including 79 subjects. While the inclusion criteria accepted MRI as a comparison in order to boost the number of studies for this review, this resulted in some studies not measured against the gold standard of histological samples. In these cases, while compared to MRI, they were also compared to clinical diagnosis or a questionnaire, which are less than ideal. In addition, while the studies used standards in the field, they did not disclose precise ultrasound settings beyond the transducer frequency. Also, in many of these studies the transducers used are outdated for MSK imaging (ie. lower frequency < 10-12 MHz).

Finally, the power and color Doppler studies did not include precise settings, such as PRF, to indicate blood flow sensitivity. This is a very important factor when looking for low blood flow, such as inflammation. Since ultrasound is a very operator dependent modality, it was important all operators were disclosed and qualified. All of the studies utilized a person well qualified to perform the evaluation of the Achilles tendon. Many of these studies were performed outside the United States, which appears to be an advantage in MSK imaging, since it is done more and therefore the operators would have more experience from these countries. The study by Paavola et al. seemed to be the most rigorous one, since it included the most subjects, compared to histological samples and disclosed the most in terms of ultrasound settings. Interestingly, this study, which used a low frequency transducer and performed in 1998, strongly recommended ultrasound to find
abnormalities within the Achilles tendon, US found 76/79 abnormalities or 96% compared to the gold standard. This was consistent where US was shown to be the most accurate within the literature when compared to surgical gold standard specimens versus comparison to MRI, clinical diagnosis, or questionnaire. Finally, the older studies stated US was not as accurate at detecting partial tears, whereas the newer literature states it is effective at this exact thing. This may be due to the improvement in equipment and higher frequency transducers. Overall, even with slight differences, these studies all came to the same conclusions: grayscale ultrasound is effective and produces high sensitivity and specificity at diagnosing Achilles tendinopathy. Also, both of the color/power Doppler studies included agreed this US function did not add to the clinical diagnosis and may or may not be added to the grayscale image to look for Achilles tendinopathy.

Next, in addition to the more traditional aspects of pathology investigated by ultrasound, the use of this technology to detect myofascial trigger points (MTrP) is briefly discussed here. Problems from any part of the musculoskeletal system, including the Achilles tendon, can produce an associated muscle response. A person may also exhibit a muscle twitch response upon palpating an active myofascial trigger point, which is a taut nodule within a muscular band, related to the area of pain. This is called the trigger point syndrome. Scientific method research, via the study of electromyography and biopsy material, has shown that trigger point syndrome makes predictable changes in areas of muscle where trigger points clinically lie. (Travell & Simons, 1992)

Since trigger points can play a large role in musculoskeletal pain, they are also investigated. Currently, there is very little literature on utilizing ultrasound to detect
MTrPs. More specifically only two studies were found that have characterized them with 2D and externally applied vibration elastography ultrasound and both evaluated the susceptible and superficial trapezius muscle. The first study evaluated 29 participants, with 15 asymptomatic (no pain or palpable nodule) and 14 symptomatic MTrPs within the trapezius. Those obtaining the ultrasound images were blinded to symptomology of the participants. This study concluded that areas with active MTrPs have significantly lower entropy (p<0.05), and have more homogenous texture, than asymptomatic MTrPs with both appearing hypoechoic on 2D ultrasound. (Turo et al., 2012) A second study evaluated nine participants, where four sites were assessed to see if the MTrP was active or not. The results also showed local changes in tissue echogenicity, where active MTrPs appeared as focal, hypoechoic regions on 2D ultrasound. (Sikdar et al., 2009)
Chapter 3: Beyond the Biophysical: A mixed-method holistic approach to evaluating
Ankle/foot pain utilizing a hand-held ultrasound machine

Introduction

People in the U.S. report musculoskeletal disease more than any other health condition. In 2004, the cost of treatment and lost wages associated with these diseases was $849 billion (roughly 8% of the gross domestic product or GDP) (American Academy of Orthopaedic Surgeons, 2008) Musculoskeletal pain leads to a loss of physical function and declines in mental health, which may adversely affect gainful employment. (Dall, Gallo, Koenig, Gu, & Ruiz, 2013) According to a large cross-sectional survey of the general population, musculoskeletal pain has a prevalence of 20 percent. (Tough, White, Richards, & Campbell, 2007) The idea of myofascial trigger points (MTrPs) as a source of musculoskeletal pain is no longer the controversial idea it once was when it was originally proposed by Travell in 1942 (Simons, Travell, & Simons, 1999). Since this time there has been more acceptance and understanding of myofascial pain, and even though the full pathophysiology of MTrPs remains contested,

2 The latest best competing hypotheses, Integrated Trigger Point Hypothesis and Cinderella hypotheses, both conclude that local inflammatory mediators, namely increased release of acetylcholine, creates a vasodilatory effect along, which works with a promotion of increased sensitivity to pain, in response to local “ischemia”, or capillary constriction. (Thomas & Shankar, 2013) Unaccustomed eccentric exercise of a muscle or maximal or submaximal concentric exercise, leading to muscle fiber damage and segmental hypercontraction of this muscle causes the ischemia, adding to the tissue injury. This results in poor motor function, muscle weakness
it is now widely utilized within the therapeutic massage community, with dedicated certification of myofascial trigger point therapists. In fact, many clinicians believe they are the source of most chronic musculoskeletal pain (Simons, Travell, & Simons 1999, Baldry, 1993), which affects about 23 million people or about 10 percent of the U.S. population. (Alvarez & Rockwell, 2002) Yet, according to many experts in this area, like clinician and author P.E. Baldry, doctors fail to search for myofascial trigger points when investigating pain. If no abnormality is found on diagnostic imaging, such as radiographs or an MRI, the pain a person is feeling is often looked upon as being inconsequential. Furthermore, Baldry states, “in spite of reassurance that nothing serious has been found, the patient should have the temerity to continue to complain about the pain, there is always the risk that it will be assumed to be of psychogenic origin, without the possibility of its persistence being due to the activation of trigger points in the muscles even being considered.” (Baldry, 1993, p. 83) Despite their importance in musculoskeletal pain, MTrPs are not commonly taught in medical schools and are lacking in current medical school curriculum (Baldry, 1993).

MTrPs are considered hyperirritable spots within taut bands of skeletal muscle fibers, often producing a palpable nodule. Biopsies of MTrPs have shown contraction knots and giant round muscle fibers (Hong, 2002) Yet, currently in clinical practice, physical examination is the sole way to make a definite diagnosis of an MTrP, which is most often defined as palpation of a tender point in a taut band. (Simons, Travell, &

and stiffness, along with restricted range of motion. (Gerwin, Shannon, Hong, Hubbard, Gevirtz, 1997)
Simons 1999) Complicating matters, the authoritative experts, namely Travell and Simon’s have understandably changed their criteria in attempts to improve diagnostic sensitivity. For example, the local twitch response, which has shown to be the least reliable of the original criteria, is not considered essential for a diagnosis and the predicted pain referral, according to these experts (Simons, Travell, & Simons 1999) is now considered nonspecific. A 2007 review of 93 research articles found the diagnostic criteria unreliable and inconsistent for an MTrP diagnosis (Tough, White, Richards, & Campbell, 2007). Furthermore, in order to palpate an MTrP a high level of skill is required (Hong, 2002) and research has revealed poor inter-rater reliability based on the current diagnostic criteria. (Thomas & Shankar, 2013) Likely, it is due to these reasons MTrPs are left out of the current medical evaluation. It is obvious a more reliable and objective diagnostic test is needed to help clinicians identify MTrPs.

Until recently, a limited amount of research has been published in regards to evaluating MTrPs with medical imaging. Fifteen years ago, the first study to evaluate MTrPs with sonography found no correlation between clinically identified A-MTrPs and the US findings. Out of 11 subjects with MTrPs of the upper trapezius, only one hyperechoic area of 5 mm in diameter was observed and it related to the superficial fascia of the superficial erector spinae (longissimus/ iliocosalis). The pilot study does not mention how many MTrPs were observed in total. (Lewis & Tehan, 1999) The most recent studies utilize sonoelastogaphy in conjunction with 2-D or B-mode imaging. Two studies, (Sikdar, Shah, Gilliams, & Gerber, 2008, Sikdar et al., 2009) both headed by the same author, evaluated the upper limb (upper trapezius). Unlike the 1999
study, the 2009 study by Sikdar, et al., described the MTrPs identified with 2-D sonography as inhomogeneous hypoechoic areas, leading one to determine the one hyperechoic nodule from this study 10 years earlier was not a trigger point. Also, it is unclear from the Sikdar studies how identifiable the MTrPs are without the use of elastography, which has limited use in current clinical practice.

Most of the imaging research literature deals with MTrPs in the upper extremity or back. While it is most common in the upper extremity, (i.e. postural strain from modern life) little has been done to investigate the lower extremity through diagnostic imaging. Therefore, this project aims to uncover sonography’s potential for imaging ankle/foot MTrPs. Sonography (US) is a non-ionizing imaging technique, which is affordable and increasing in use within the United States and around the world for musculoskeletal disorders. Sonography may be performed portably with a hand-carried machine, increasing its accessibility, and has the added ability to provide dynamic real-time evaluation.

Furthermore, an innovative approach to this research project utilizes qualitative techniques in addition to the quantitative analysis of sonographic imaging. This was very important considering a biopsychosocial model was utilized as a platform to include all aspects of a patient’s pain. A holistic understanding of pain is not limited to the biophysical; therefore every aspect of this biopsychosocial model must be explored. It is important to keep in mind the biophysical may account for only a portion of musculoskeletal pain.
Methods/ Materials

This IRB approved study recruited 25 patients via a flyer (See Appendix A: Study flyer) on a large college campus. All recruited patients were consented (See Appendix B: Consent form) and received a $25 grocery gift card for participation. A single sonographer, with five years of clinical scanning experience evaluated every participant. This same sonographer did all of the sonographic analysis, and was blinded to the participants status of being symptomatic or asymptomatic until all analyses were complete. The sonographer also has over 12 years of traditional martial arts experience where she gained intimate understanding of MTrP palpation. Additionally, a licensed massage therapist, who is also a massage educator, was consulted for MTrP palpation methods and study feedback. The study accepted any patient ages 18-65 with the exclusion criteria of diabetes, past ankle surgery or current pregnancy, in order to try and control these confounding factors. The study finished with 17 symptomatic and 8 asymptomatic patients of varying ages and gender. With a total of 11 males and 14 females, ages 18 to 63 years old with a mean age of 33.58 years and median age of 28 years. There were a total of 14 painful self-reported right limbs and nine painful left limbs, with six individuals reporting bilateral pain.

All participants were first asked to complete a questionnaire (See Appendix C: Participant questionnaire) consisting of four sections. The first section consisted of the widely utilized SF-12 (modified) to access their overall health, both mentally and physically. The second section was the VISA-A (Victorian Institute of Sports Assessment – Achilles questionnaire) which is a valid and reliable tool for measuring Achilles
tendinopathy and the scores summed give a total of 100, where an asymptomatic person would score a 100. While the VISA-A is an index of severity of Achilles tendinopathy, other conditions that influence the lower limb function, such as an ankle sprain, will reduce a person’s VISA-A score. (Robinson et al., 2001) The third section included a visual analog scale for participants to rate their ankle/foot pain for each limb on a scale of 0 to 10. Finally, a fourth section included demographic questions, along with occupation and sports activity inquiries.

Next, a scanning protocol, based on the American Institute of Ultrasound in Medicine (AIUM) protocol for ankle/foot imaging, was utilized to evaluate the bilateral ankle/foot structures with sonography. A 5-12 MHz linear probe was utilized with a hand-held GE Logic i (Milwaukee, WI) portable sonography machine. Each evaluation was done with a musculoskeletal setting with cross beam technology and harmonics on the highest frequency. This same equipment receives bi-monthly quality control testing with both a 2-D and Doppler flow phantom. A standoff pad was used for the sonography portion, but was not used for evaluating MTrPs, due to better visualization of the muscle without it for this purpose.

Finally, a bilateral manual assessment of 10 MTrPs was performed. The assessment complied with the latest (Simons, Travell, & Simons, 1999) criteria for the identification of an active MTrP (including both a palpable nodule within a taut band of muscle and pain upon palpation) in conjunction with (Travell & Simons, 1999) well-known lower extremity MTrP locations. (See Figure 3.1) These ten areas included the
quadratus plantae, soleus I, tibialis anterior and posterior, extensor digitorum longus and hallicus, as well as the peroneus longus, brevis and tertius I and II.

Figure 3.1 Selected Myofascial Trigger Points for assessment

Both flat and pincer palpation techniques were utilized. The selected 10 MTrPs, which were chosen to correlate with the referred pain to the physical structures evaluated with sonography, complimented the screening sonography. A four-tier scoring system (see Table 3.1 below) was devised to access MTrPs and patient pain. While this scoring system was developed for the purposes of this study, it is still in need of validation, but hopes to be valuable to the trigger point field. A score of 0 was used for no pain or palpation on examination. A score of one was given for when the patient reported pain upon palpation, but no taut nodule was palpated by the examiner. It was determined a
score should be given, although no MTrP was identified, as a way to account for the patient’s pain and not simply dismiss it. No score however was to be given when a possible MTrP was felt by the examiner and was not reported as pain by the participant. In this case, a latent MTrP may have been identified, but does not relate to the independent variable of the participant’s self-reported pain. A score of two was used when both the participant reported pain and the examiner felt a MTrP. Finally a score of three was given when the criteria for a score of two were met and a sonographic nodule could be identified in two planes, both longitudinal and orthogonal to the muscle fiber. An area tracing was obtained from the longitudinal plane.

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Negative, no pain or palpation of a trigger point</td>
</tr>
<tr>
<td>1</td>
<td>Patient felt pain, but no trigger point nodule was palpated</td>
</tr>
<tr>
<td>2</td>
<td>Patient felt pain and palpable nodule palpated</td>
</tr>
<tr>
<td>3</td>
<td>Palpable, painful MTrP seen 2-D ultrasound (visualization with two planes, measured area cm²)</td>
</tr>
</tbody>
</table>

Table 3.1 Trigger Point scoring system

Linear mixed models were used to analyze the relationship between pain scores (VAS or VISA-A) and trigger status (palpated or US). The subject was included as a random effect in the linear mixed model to account for correlation between responses.
(i.e. right limb and left limb). Comparisons of trigger status for each limb were tested as contrasts within the mixed model. Diagnostic measures such as residual plots were used to assess model assumptions. Linear regression was used to model the relationship between SF-12 scores (Physical or Mental) and Combined MTrp Total. Model assumptions were assessed by the plotting of residuals against predicted values. P-values < .05 were considered statistically significant. All analyses were conducted using SAS version 9.2 (SAS Institute, Cary, NC).

Results

Quantitative

Out of 500 total MTrP areas palpated on both symptomatic and asymptomatic participants, Most (441) MTrP areas revealed a score of 0 according to the above devised MTrP scoring system. It is important to point out there was no MTrP area, in which the examiner felt a nodule and no pain was noted. A total of 49 MTrP locations met one of the criteria for the devised scoring system; 16 were scored as one, 15 were scored a two and 18 met the strict criteria to be scored as three. Based on current MTrP diagnostic criteria, meeting the criteria for a score of two or three, (18/33) 55% were identified with 2-D ultrasonography, fitting with a score of three. The area of the visualized MTrP ranged from 0.05 cm$^2$ to 0.21 cm$^2$, with an average of 0.09 cm$^2$. The MTrP appeared as an inhomogeneous hypoechoic area under 2-D ultrasound.
**Limb Statistical Analysis**

Statistical analysis was conducted to evaluate trigger status and reported pain by limb, as taken from the participant history. Interestingly, the right side trigger status for each scoring algorithm (including total MTrPs (Score 1, 2 or 3), palpable MTrPs (Score of 2 or 3), and ultrasound MTrPs (Score of 3 only)) was statistically significant for those with a history of limb pain, while the all left side trigger statuses were not significant (Fisher’s Exact test, p=1.0000 for each status) when comparing to the participant’s reported history of ankle/foot pain. (See Table 2.0-2.2) For example, looking at the palpable MTrPs, 10/14 (71%) of those that reported a history of pain in their right limb also has positive triggers. This is in comparison to only 2/11 (18%) of those that reported having a history of pain with positive MTrPs. The left limb, however, does not demonstrate a significant difference and palpable MTrPs is 33% for pain and 31% for no pain in terms of positive assessment. Yet, it should be noted there were more painful right limbs (total of 14) than left (total of 9).
<table>
<thead>
<tr>
<th>R_Limb(R_Limb)</th>
<th>R_AnyTrigger</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Negative</td>
<td>Positive</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>No pain</td>
<td>8</td>
<td>3</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>72.73</td>
<td>27.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain</td>
<td>3</td>
<td>11</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21.43</td>
<td>78.57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>14</td>
<td>25</td>
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</tr>
</tbody>
</table>

Fisher’s Exact test, p=0.0172

Table 3.2 Right limb history of pain and Right trigger (any)
Table of R_Limb by R_PalpTrigger

<table>
<thead>
<tr>
<th>R_Limb(R_Limb)</th>
<th>R_PalpTrigger</th>
<th></th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Row Pct</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Positive</td>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No pain</td>
<td>9</td>
<td>2</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>81.82</td>
<td>18.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain</td>
<td>4</td>
<td>10</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>28.57</td>
<td>71.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>12</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

Fisher’s Exact test, p=0.0154

Table 3.3 Right limb history of pain and Right trigger (Palpable)
Table 3.4 Right limb history of pain and Right trigger (US)

<table>
<thead>
<tr>
<th>Frequency</th>
<th>R_Limb(R_Limb)</th>
<th>R_USTrigger</th>
</tr>
</thead>
<tbody>
<tr>
<td>No pain</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>90.91</td>
<td>9.09</td>
</tr>
<tr>
<td>Pain</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>50.00</td>
<td>50.00</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>8</td>
</tr>
</tbody>
</table>

Fisher’s Exact test, p=0.0421

Next, the participant’s palpable and ultrasound MTrP statuses to the VISA-A questionnaire results were analyzed. For the right limb a total of 13 negative palpable trigger points yielded an average VISA-A score of 85.38 with a standard deviation of 14.20, in comparison a total of 12 positive palpable MTrPs yielded a mean of 65.83 with a standard deviation of 15.70. The left limb had a total of 17 negative for palpable MTrPs with a mean VISA-A score of 82.00 with a standard deviation of 13.73, compared to a total of eight with positive MTrPs yielding an average score of 73.00 on the VISA-A with a larger standard deviation of 20.86. The ultrasound MTrPs yielded similar results.
with participants with right negative ultrasound MTrPs (N=17) with a mean of 82.00 on the VISA-A and standard deviation of 17.33, versus those with positive ultrasound MTrPs (N= 8) with VISA-A score mean of 63.25 with a standard deviation of 10.69.

Those with negative left limb ultrasound MTrPs (N=20) the average VISA-A score was 81.85 with a standard deviation of 13.13, compared to those with positive ultrasound MTrPs (N=5) with an average score of 68.20 with a standard deviation of 24.90.

The palpatated trigger (overall, not specific to limb\(^3\)) does show there is a statistically significant difference in VISA-A for positive and negative triggers (p< .02). The mean adjusted\(^4\) difference in VISA-A between negative and positive palpable triggers is 10.2311 with a 95% confidence interval of 2.0171 to 18.4451. This corresponds to the negative trigger status having a higher mean VISA-A score than the positive trigger status.

Similarly, while there is not a statistically significant interaction between US MTrPs and limb (p<.98), the US trigger overall, while not statistically significant (since the 95% CI contains zero), does show a difference in VISA-A for positive and negative triggers (p<.07), with the trend showing negative US triggers having higher mean VISA-A scores than US positive triggers.

Next, the palpable and ultrasound MTrPs were analyzed in comparison to the visual analog scale (VAS). The VAS rates pain on a scale from zero to ten, with zero

---

\(^3\) There is not a statistically significant interaction between trigger and limb (p<.64), meaning the effect of the trigger status does not depend on the limb.

\(^4\) In order to avoid skewing the distribution of the data, the adjusted accounts for the fact that the VISA-A scores associated with each trigger status come from a different limb. The raw score difference for the overall VISA-A scores between the negative and positive palpable MTrPs is approximately 15 (83.47-68.70=14.77)
meaning the person experiences no pain at all and 10 representing the worst agonizing pain. On the right limb those with negative palpable MTrPs (N=13) the mean VAS score was 1.38 with a standard deviation of 2.84, compared to those with positive palpable MTrPs (N=12) averaging a VAS score of 4.08 with a standard deviation of 2.50. Participants with negative left limb palpable MTrPs (N=17) had a mean VAS score of 1.71 with a standard deviation of 2.76, while the participants with positive left limb MTrPs (N=8) had an average VAS score of 0.88 with a standard deviation of 1.46. For those with negative ultrasound MTrPs (N=17) the mean VAS score was 1.82 (std dev 2.90), compared with participants with positive ultrasound MTrPs (N=8) with a mean VAS score of 4.50 (std dev 2.33). Finally, those with negative ultrasound MTrPs on the left limb (N=20) showed an average VAS score of 1.65 (std dev 2.64), compared with a positive US MTrPs (N=5) had an average score of 0.60 (std dev 0.89).

There was a statistically significant interaction between palpable MTrP and limb (p<.03), as well as US MTrP and limb (p<0.02) meaning the effect of the trigger status does depend on the limb. For the left limb, the mean adjusted difference between negative and positive palpable triggers is 0.2 (95% CI -1.7, 2.2; p=0.8111) No statistical significance was reported for US MTrPs on the left limb. For the right limb, the mean adjusted difference between negative and positive palpable triggers is -2.6 (95% CI -4.5, -0.78), and for US MTrPs the mean adjusted difference was -2.5 (95% CI -4.5, -0.51). This corresponds to the VAS being lower for negative triggers versus positive palpable and US MTrPs in the right limb.
Overall Statistical Analysis

First, it should be noted the overall SF-12 mental health and physical health scores were above average for these participants in general and no difference was seen between the symptomatic and asymptomatic groups. The national mean, based on a scale of 0 (poorest health) to 100 (highest health), is 50.0. The mean of the SF-12 physical component score of all participants was 50.42 with a standard deviation of 7.08 and a median of 52.30. The mean SF-12 mental component score was 56.34, with a standard deviation of 5.04 and a median of 57.89.

There was evidence (p<.02) of a significant linear relationship between Combined MTrp Total and SF-12 Physical Score (See Chart 1.0). The negative linear relationship shows that as overall MTrp increases, the mean SF-12 Physical Score decreases. When the MTrp total increases by one unit, the mean SF-12 Physical score decreases between 0.15 and 1.4 points (95% CI). In this model, a relatively weak correlation was found and 22% (R^2=.22) of the variation in the physical score can be explained by the combined MTrp total. However, while the correlation is not strong for predictive purposes, this relationship does account for some of the variation and may be helpful in the clinical setting.
There is also evidence (p<.02) of a significant linear relationship between Combined MTrp Total and SF-12 Mental Score (positive linear relationship – as MTrp increases, mean SF-12 Mental Score also increases). When the MTrp total increases by one unit, the mean SF-12 Mental score increases between 0.12 and 1.00 points (95% CI). Again, while relatively week correlation is shown, since this would not be used for predictive purposes, it does tell us clinically that there is 23% (R^2=.23) of the variation in the Mental health score can be explained by the regression line using the Combined MTrp Total. So, it appears as the total trigger score increases, so does the mental health score.
Figure 3.3 SF-12 Mental Component Score vs. Combined MTrP total

Descriptive Analysis

Of the eight total asymptomatic participants, only four (4/49 total) painful MTrP areas were palpated in three people. One (participant 6) with a score of 1 reported pain on the right tibialis anterior MTrP. This same participant had a previous hairline fracture of her right tibia near the ankle. The second (participant 9) scored a 2 bilaterally, with palpation of both extensor digitorum (anterior) MTrPs without visualization with ultrasound. Her history intake form did mention she had pain bilaterally six months ago from bad shoes walking on concrete, but was not experiencing pain currently since wearing new shoes. Finally, in one participant (participant 18) an MTrP was identified with sonography, score of 3, on the left tibialis posterior. While the person did not have
any pain a scar near the tibia mid-way down the lower leg was noted by the researcher on examination. Patient history did not reveal how this scar was obtained and the person stated they had no prior surgery or trauma to either ankle or foot. Sonography revealed highly abnormal left bone erosion at the peroneus longus insertion.

Of the remaining five true asymptomatic participants, participants 12, 13, 23, 24 reported no previous injuries, pain or surgery of either foot. Participant 19 reported no trauma or surgeries, though he had chronic tendinosis⁵ about a year ago on the right until he underwent massage and physical therapy, and due to this was not having any current pain.

Interestingly, of a total five limbs given an MTrP score of two or three in an asymptomatic limb (5/17 or 29%); three were given a score of 2 or 3 on the opposite limb in the same area. One MTrP did not match any other side and another positive MTrP score of 3 (participant 5) of the asymptomatic right limb, had a positive MTrP on the right and left in the same tibialis anterior MTrP area on both limbs.

Of the total 17 symptomatic participants with self-reported ankle/foot pain, 14 had a score of 1, 2 or 3 (14/17 or 82%) with palpation of the MTrP areas. In nine of the participants and 10 limbs, a score of three correlated with pain in the same limb (10/17 or 59%). In six symptomatic limbs (6/17 or 35%), a score of two was given. Only one had a score of one in which a nodule could not be located manually. This male (participant 16) reported painful palpation of the right tertius MTrP (lateral) and complained of twisting

⁵ Tendinosis terminology now replacing tendinitis, as the tendon does not become inflamed, rather micro-trauma to the tendon results in varying degrees of tendinosis, up to a full thickness tear.
his lateral right ankle five years ago. Ultrasound showed bony abnormality of the right
tibiofibular ligament, which sits just superior to this MTrP.

There were three symptomatic participants without any reported pain on MTrP palpation, (Participant 4) 27 y.o physically active male had point tenderness of the left metatarsal and complained mostly of bilateral toe pain, and he was starting to get some relief with new shoes. The second (participant 11) had extensive abnormalities, revealed with sonography, to the left lateral ankle. This participant had rolled their left ankle in the distant past and had re-sprained this same ankle only 12 days prior to examination. Finally, the third participant without active MTrPs (participant 14) was a football player with bilateral pain and swelling. He did have a history of a left sprained ankle about 10 years ago and a stress fracture in the right foot over four years ago. Sonography revealed right and left bony abnormalities with venous clusters on the left, as well as right edema on the anterior sweep.

Of these remaining 13 participants MTrPs with active score of 2 or 3 palpated (13/17 or 76%), there were 17 total symptomatic limbs. Combined a two or three MTrP score was given correctly with the same limb 76 percent of the time (13/17). Of the remaining four which were symptomatic and had no MTrP score was a 24 year old female dancer (participant 7), this patient’s history revealed she had left knee surgery in 2010 for a torn meniscus and her gait changed causing pain in her left great toe. Sonography showed a decrease in echogenicity of the left extensor hallux. Another participant had a negative MTrP on the right symptomatic lateral limb, but had a positive MTrP on the left lateral limb. This 24 year old male participant had been very active prior
to suffering from an injury and sharp pain on the right lateral ankle six years ago and he complained of right lateral ankle instability since; however sonography demonstrated subluxation of his left lateral peroneal tendons. Sonography also showed increased vascularity and decreased echogenicity of the right talofibular tendon. He reported no pain on the left. Furthermore this participant had a negative radiography, an MRI shortly after the injury which showed fluid build-up and a possible chip on the right lateral side, and no lasting relief with cortisone shots, physical or shock therapy. Next, a 38 year old active male participant (participant 22) with bilateral pain had chronic pain on the right for 3-4 years and had just sprained his ankle on the left two weeks ago. An MTrP score of 3 was detected on the right and none on the left. Sonography revealed abnormalities on both sides, right greater than left. The last had a missed MTrP on the bottom of his foot and is discussed below.

The quadratus plantae MTrP on the bottom of the foot could be visualized with ultrasound in 4 out of 5 (participants 15, 17, 20, 21, 22) participants with pain in this area. The one participant (participant 17) in which no MTrP within the quadratus plantae could be palpated had as he described “subtle heel pain.” This same older gentleman gave a description of having general foot pain in both feet as well. Interestingly with sonography there was extensive swelling and venous channels noted bilaterally, as well as bony abnormalities noted in both feet. In the remaining four patients with heel pain, one person had bilateral pain and sonography detected five MTrPs. Furthermore, all of these complaints of heel pain were chronic and three had undergone previous treatments from cortisone injections to massage and physical therapy.
Qualitative Results

“In the middle of chaos lies opportunity.”
-Bruce Lee”

Much of what has been done up to this point in biomedicine, as we know, is highly quantitative. While there has been some push for mixed methods, according to Howe (2004) we still “relegate qualitative methods to an auxiliary role” (p. 42). Howe’s view concerning the importance of bringing qualitative work to the forefront in this uneven balance, proposing a “mixed-methods interpretivism.” A place where one work would not exclude the other, or take ultimate authority, but in which they cross-check one another and view any differences found between them to be a place of rich information, rather than a messy entity, which must be tidied up or reconciled. The main messy entity described in this study focuses on the intersection of man and machine – the cyborg. The cyborg combines the natural and the artificial together, one system, and human cyborg health is only increasing; for example bioengineered microbes to implants. Even vaccinations are a form of cyborgification. (Gray, 2001) Those working in technologically advancing fields, such as sonography, are greatly influenced by this dichotomy. Finally, in quantitative analysis the researcher remains silent; this qualitative analysis however places importance on the role of the researcher and the epistemological views one brings with them to the research they perform. This results section, therefore, will aim to capture a qualitative viewpoint on a quantitative study.
Epistemological Situating (or the importance of boring)

Please note: this is my medical research imaginary. I hope to create a new space, both physically and paradigmatically, in which to create and conduct holistic medical research. Furthermore, this new imaginary hopes to incorporate a physical space utilizing technology. For the purposes of making a respectful nod to the qualitative creativity (but also to distract the reader), an online Prezi is provided.

This online space will open up the possibilities of utilizing what Voithofer (2005) describes as a datascape, whilst being aware of “hypermediacy”, or aware of how media always causes remediation. In this case, context for work posted should be relevant and situated in an effort to juxtapose the media against “the real,” as not to give a false impression of actually achieving reality. Each footnote made in this text is in the online version, what one would consider a hyperlink. This setup allows the online reader to allow the text to, “become less authoritative and more contingent and situated” (Voithofer, 2005, p. 6). Furthermore, this situating is more appropriate for the research approach methodology of mixed post-positivism.

In keeping with a more open methodological mixing, a blurring of the humanities, social and detached sciences are called upon to depart from orthodoxy (Lather, 2013). It is meant to keep many different perspectives in order to capture a new holistic medical model.

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6 Be careful - what you are about to experience is real.
7 Please visit the following link to obtain the online version of this text: http://prezi.com/ut2dz_ddogkf/?utm_campaign=share&utm_medium=copy
Finally, sweet relief – humor! Oh my, what would a day in the medical world be without this much-needed distraction? I had decided long ago it was either laugh or cry. Of course not all things are laughable, but keeping this quality, within limits, has a way of tempering the “too much” of the emotional work involved with patient care. While this is research, we must view our participants, as patients and I will refer to them as such from now on. Patient is more appropriate – after all, they go through a lot too.

As I hope to provide a post-paradigmatic perspective – a new reconstruction – I am hopeful for medicine’s return to the whole, the being - the soul. I will aim to move beyond the binaries by first describing them and then blurring them in the reconstructed imaginary. Through a reflexive journal I was able to use personal insight to flesh out the ideas surrounding research – including my quantitative experience. This will therefore be autoethnographic. It is important in this new methodology to locate oneself, as Lincoln (1995) says, “enables the researcher to begin to uncover dialectic relationships, array and discuss contradictions within the stories recorded, and move with research participants toward action” (p. 283)

In this new paradigm, I do not choose one qualitative paradigm and envision doing all four aims – predict, understand, emancipate, and deconstruct.

Regardless of our research, we as scientists, be it social

Fun fact: Over 1,800 grams of Gobstoppers will have been consumed by the writer at the end of this research – that’s about 4 pounds.

A real fact: You are lucky if you haven’t experienced foot/ankle pain – as 75% of people do at some point in their life.
or physical, should present our views and be reflexive. In this way I fully agree with Pascale (2011) saying, “the ontological premise of social research should be a conscious choice that is both articulated and justified in the research design” (p. 47). My final emergent research design is outlined below:

**Predict** – This is the quantitative portion of this research. The “Physical/Biological”

**Understand** – while not a pure ethnography, I have had prolonged exposure in the field of sonography, for the past five years since I have been scanning.

**Emancipate** - Critical race/feminist – Questioning how we do research and how we present it. I will also highlight the importance of returning power to our patients. Power/knowledge struggle, not just give them respect, but knowledge as well. It is arguably an ethical duty to go beyond “Do no Harm”

**Deconstruct** – Mostly I will be deconstructing my own study and my unconventional style and presentation will fit this category as well.

On many levels I am an insider to this topic, having had ankle/foot pain, having been the patient, but also having been a clinician. From an article on insider-outsider positions, I feel it is important to carefully consider the “marginal position” and make sure that I clearly know where I am on the spectrum of trust and objectivity within the politics of my research (Brayboy & Deyhle, 2000).
In contrast to a lack of researcher voice used in quantitative research, and in keeping with qualitative literature, the personal pronoun returns, making its debut to bring to life this complex individual interpretivism. So, it is with artistic interpretation, I will refer to it/us as the sonoborg. We rarely realize the degree to which we are asked to be a sonoborg and with increasing sonographer workloads, brought on by healthcare reform and an aging population, the robotic borg increases in us with each passing clinical day. Yet, as stated in his article, *The Interface Between Sonographer and the Sonographic Machine: A Post-Postmodern Perspective*, Evan’s states, “If the sonographer wants to continue to be the important component of conducting the sonographic examination, he or she must avoid automation.” (Evans, 2007, p. 42)

This qualitative results section aims to examine the researcher’s/sonographer’s role, the clinician’s responsibility, and patient satisfaction centered on the idea of this “sonoborg.” Certainly, these concepts are not limited to sonographers, though this is the primary example for this study. This is highly applicable to many other allied medical professions, such as physical, occupational therapies, athletic training, and even health information systems. Each profession certainly has a unique ratio of technology and patient interaction, but overall the allied medical professionals are the gatekeepers of healthcare.

In looking through a holistic lens at the 25 patients (please note a departure from the description of participant) in this study, I hope to shed light on aspects that may otherwise be overlooked. It is important to look at our patients in keeping with a biopsychosocial model (See Figure 1.3), which encompasses the biophysical, but also
social and psychological aspects of the patient. It is therefore imperative to dig deeper into the lives of our patients, including their occupations, lifestyles and overall health. Dr. George Engel first described the biopsychosocial model in his 1977 *Science* article. He proclaimed that the medical model was in crisis, with a reductionist and dualistic view of disease based solely on the biochemical/physical abnormalities. Yet, one patient may have a biophysical defect and not be ill and at the same time another person may have no known biophysical abnormality and be ill, suffering from other elements. The new model he proposes must have a full understanding and frames of reference. Just as history does not stand alone, time is situated. Engel states, “The boundaries between health and disease, between well and sick, are far from clear and never will be clear, for they are diffused by cultural, social, and psychological considerations.” (Engel, 1977, p.196) In light of this situating, a dualistic medical model breaks down and Engel calls for physicians to approach patients with a holistic understanding of the individual, beyond the biophysical. While Engel is writing to physicians, his words should echo with every health care worker and especially those in the medical field, such as sonographers and other allied medical professionals, who often spend a considerable amount of time with a patient, oftentimes more than the actual doctor.

**The Research** (Angst of the researcher/sonoborg)

It was not until I performed this blinded study did I truly appreciate the clinical implications of research, also I never missed the narratives of my patients, as much as when I was devoid of them. Since being a clinician requires a thorough history, this
important missing step during the blinded research position was much harder for me than I had anticipated and upon examining the quantitative results, it appears the participants mental health fared much better than this researcher’s. While there was the simple temptation to “cheat,” the blinding surprisingly only gets at the tip of the ethical iceberg dilemma I faced. Yet, it did force me towards being more acutely aware of my other senses in deciding whether a participant was symptomatic or not.

Since I am a sonoborg, the machine was, therefore, an extension of my human abilities, such as the ultrasound giving my eyes a unique view, yet it could not be a substitute for my humanness, such as my hands providing the important sense of touch. Before revealing to myself the status of my participants’ symptoms, I assigned them myself to put these “blinded” skills to the test. Of the 25 participants, again 17 were symptomatic and 8 were asymptomatic. I called 15 positive, five negative and five inconclusive. Of the 15 patients I placed into the symptomatic category, I was correct except for one.

Similarly, I was correct about all of the five negative diagnoses, with the exception of one. Finally, of the five inconclusive studies, I stated and leaned toward the correct diagnosis in three. Looking back, I should have called those three what I thought they were, but probably wanted to save myself embarrassment just in case I was wrong. However, I was wrong in the case of two patients and really had no idea with another two, leaving my “intuition rate” at (21/25) or 84 percent. While this is high enough to “separate the chaff from the seeds,” it may mean little to the traditional research community about the conjoining of sonography and MTrP palpation in screening patients
with ankle/foot pain. This intuitive rate perhaps reiterates the idea that both sonography and MTrP palpation are both highly operator-dependent, a seemingly negative connotation within an automated world. The angst I mostly experienced stemmed from this unknown, questioning my own skills, chosen protocol and evaluative tools along the way. And while I was the only sonographer performing the screening and analyzing within this study, more should be revealed about the process as a whole and my views I brought to the study, as I think, in general, more should be revealed about a researcher’s trials and tribulations, ethical struggles and general impressions.

While the quantitative portion of this study follows an a-priori approach, the qualitative aspects are in line with the emergent design. This portion of the study evolved from a reflexive journal and laments of my inability to actually be able to interview my participants. My patients’ stories told to me through my co-researchers helped bridge some of the gaps and an auto-ethnography to corroborate their stories attempt to augment the psychosocial aspects inherent to this project. Despite these late reprises, this study, like so many quantitative studies, lost the important humanizing aspect due to blinding, and the ethical handcuffs that come with this type of inquiry. Furthermore, it is important to understand these aspects of the data are entirely lost, and since a temporal situation exists, such cohorts can never be reproduced.

In evaluating these symptomatic patients in this study according to the biopsychosocial model, the aspect of psychological may easily be overlooked based on the quantitative results of the Mental SF-12, which showed they were a relatively happy, healthy group despite ankle/foot pain. However, in reviewing these patients’ histories it is
not hard to imagine these symptomatic participants had chronic pain which was affecting their lives in some way. When asked on the questionnaire if they had sought treatments for their pain, most symptomatic individuals (11/14 or 79%) had, and most of these seeking treatments included more than one; ranging from seven people who had massage, eight who underwent physical therapy, and three who had undergone cortisone injections. Furthermore, a co-researcher described to me the mental anguish described to him by several female dancers in this study who were experiencing ankle/foot pain. It is important to note that these women self-identified as dancers. Their ankle foot pain was causing understandable frustration, since they were not able to do what they loved to the best of their ability or at all. This was giving them a sense of helplessness and a forced detachment from their passion, and in essence, one may presume – ones self. This biopsychosocial model, however, does not limit this pain the dancers are experiencing to the psychological; certainly this model shows how the dancers may also be undergoing a re-organization of their social networks at the same time.  

When evaluating patients from a psychosocial perspective, work and employment is a large factor for many people. This study asked the patients to fill in their occupation on the questionnaire and found that a large number (11/24, one did not respond to this question) were, not surprisingly, students. The questionnaire results also revealed most

8 As a martial artist who has undergone injury and pain, I can easily relate to these dancers. Following a knee injury several years into my martial arts career I was suddenly cut off from not only doing kicks, but also from a lot of the social interaction I had with other members of my group. During a period of four to six months, I dealt not only with physical pain and rehabilitation, but also depression and isolation, as I had to watch my peers be promoted without me. Fortunately, I fully recovered this round and came back stronger, however when the pain continues, often a new identity needs to be established and new social dynamics made.
patients (21/24, same person as above did not respond to this question) were employed full-time or if, they were a student, they were a full-time student and part-time employed or part-time student and part-time employed. Some of the other occupations listed included a manager of retail, data entry, home health care aide, professor, waitress and research coordinator. While the majority of our participants were students, 7/8 of the asymptomatic participants were students, meaning most of the symptomatic cohort were employed in a full-time position. Certainly, there is a lot more stability being employed full-time than being a student or a part-time employee.

In evaluating this group on the other factors perspective of the biopsychosocial model, it is only possible to continue a hypothetical look at the patients. It is hard to escape the main drawback of financial difficulties, as most students face this dilemma. Even with health insurance, medical care is not necessarily affordable. Also, every person in this study spoke English and therefore, no language barrier was encountered. Interestingly, when asked if these patients had undergone any treatments, no one mentioned anything about pain medication. While this group cannot be fully assessed on these other factors, those in the medical field know, such things, as health insurance, language and drug dependencies are all everyday realities of the health care professional.

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9 When I had chronic pain in the arch of my foot for four years, following a freak kickball accident (I do NOT recommend kickball in flip flops), I had gone to several orthopedic specialists in this area, got custom made orthodics, which did not help and had an x-ray and ultrasound. However, I never got the gold-standard MRI because it was just out of my price range (You guessed it, I was a student), even with insurance covering a large amount I could not afford it, so like many other patients I just suffered and ended my relationship, in regards to my foot pain, with the medical community.
Finally, the biophysical health of these patients was assessed, not only by sonography and palpating trigger points, but also by asking about their physical activity and pain measures. In evaluating the questionnaires, this was a relatively young and active group, with only two people not participating in any sports activity. Activity of the participants included walking, running, swimming, dancing, yoga, and playing various sports from lacrosse to volleyball and soccer. These activities were performed at least once a week and most reported doing much more. (See Appendix A) Physical inactivity and advancing age may pre-dispose individuals to developing trigger points, along with physical trauma. Most symptomatic patients in this study fit this last category.

Another important factor with the biophysical is how the patients perceived their own pain. Most patients answered their pain was uncomfortable or less via the visual analogue scale (VAS Figure below). About one third (seven limbs out of the total 22 symptomatic limbs or 32%) were self-rated on the scale as a 5 or higher and only three individuals rated limb pain above an 8. While this was a small study, it would be interesting to see how different levels of pain correspond with the identification of trigger points or sonographic abnormalities.
As this short synopsis reveals, an ideal mixed-methods evaluation of this population might include in-depth interviews with several of the participants. However, due to time restrictions, this was not possible in this screening study. It was this lack of narrative, which was the real ethical dilemma in my study. No real voice was given to the group of patients and here I failed them. Not only do we need to seek out the narratives of our patients to understand how ankle/foot pain may be affected by the psychological elements within their lives, we should also take a moment to reflect on how we affect them with our “usual” order of strict hegemonic research methodologies. I studied patients, and referred to them as numbered participants with so many outlined sonographic or MTrP abnormalities. In essence they became objects and not humans.

**Clinician** (fun clinician responsibility)

As the sonoborg rises, so does our propensity as clinicians to call our patients by their order or harried part, “Mary, did you scan that breast?” or better yet, “Hey John,
there is a scrotum coming at four o’clock.” Some clinicians may cite HIPPA violations as a reason for this turn from human to object, however it has been my experience that this is done to distance oneself from the patient. Just as humor distracts emotion, objectification deflects attachment. Work within the medical field is just as emotional as it is physical and mental, however little outlets exist for workers to express emotional anguish that goes along with caring for patients who pass away or end up severely disabled.10 Most (err, I hope all) of us who go into health care cite a moral high ground in wanting to ‘help people,’ yet often we discover there are many times we cannot do anything to help correct these uncorrectables. Some clinicians burn out completely, others resort to automation and distance, while the best clinicians understand that even the smallest acts of kindness may have a large positive impact on the patients we serve. When you look through the medical textbooks at children with genetic abnormalities, their images come across in strange and cold ways. Often naked, against a table or a wall, with a black bar across their face and private areas, these images do not conjure up any sort of real life. Awestruck by the beauty he saw in a child with albinism, international photographer of the stars, Rick Guidotti, started doing photo-shoots of these children, and then this spread to other genetic abnormalities, as a way to see beauty in these differences. He essentially is re-humanizing medical images. His TedX (2011), “From

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10 Having worked in a Children’s hospital, I was responsible for doing the routine neurosonology exams on premature neonates. Processing the death of these infants was often done internally with little social support from fellow clinicians. I recalled the emotional drain most when I was pregnant and scanning patient’s younger in gestational age than the fetus I was carrying. Imagining that this patient could be my child was in the realm of the emotionally ‘too much.’
Stigma to Supermodel” talk can be viewed here.\textsuperscript{11} He sees this work as a way to pay back society and challenge all of us to take a deeper look at beauty. I borrow his work to this place as an inspiration to what medicine could become, not the same old stale.

Although sonoborgs, we as clinicians are more than machine and striking a delicate balance of technology and human praxis may enhance health care for our patients. As a clinical sonographer I am taught to be responsible for obtaining a good history of any patient I encounter. It would be a huge disservice to reduce my participants to a biophysical specimen. Instead, a full view (no matter how painful at times) of the person is a very important aspect, not only in sonography, but health care in general. The scanning portion of this reflexive journal, however, yielded a view into the lives of the participants and the researcher/participant interaction. While, certainly, this view is limited, much may be gained through talking with one’s patient, as many sonographers are aware. There is much to be said about the act of touch throughout my research. Not only am I using my typical tool of sonography to peer into the human body, but also the act of physical touch\textsuperscript{12}, when palpating MTrPs helped to solidify my impressions.

For the most part I enjoyed my patients throughout the study, as they were funny and engaging. However, there is always that one patient which drives you crazy. In my case, one young male patient kept telling me he was having ankle pain. Even after he had been briefed that I was supposed to be blinded (so yes, you may demote my “intuition

\textsuperscript{11} http://www.ted.com/talks/rick_guidotti_from_stigma_to_supermodel.html
\textsuperscript{12} As a sonographer scanning neonatal hips, the element of touch was very important. My impression of a hip “feeling loose” although the sonographic appearance was borderline normal was important and recorded by the reading radiologists. Without touch, elements of warmth, cool, or any deviation from “normal,” can easily be missed.
rate” to 20/25) and my insistence not to tell me anymore, he continued on about what terrible ankle pain he was having. Meanwhile, I did not find too much in terms of what I was seeing sonographically or palpating any MTrPs. I recalled a passage from the book, The visible woman, by Treichler, Cartwright, & Penley, discussing about patients who suffer from environmental illness are often sent for “psychological distress,” yet they are really being sickened by something physical, they state, “The disbelief and the negative attitudes of the medical profession and the greater society may contribute to sufferers’ feeling of distress and alienation” (1998, p. 370). Just because I could not see the clear reason for this patient’s pain, it does exist for him and I had no place to dismiss it as a clinician. In fact, I have a responsibility to accurately describe what I see, so something may be ruled out to look for the next possible etiology.

Finally a large football player was enrolled in the study and fell asleep during the examination. After the exam, he asked me for the results, which I was not allowed to reveal for obvious reasons. Then after a long pause he asked me how he should go about finding out the problem to his ankle/foot pain. (Cut that “intuition rate” to 19/25 now) I proceeded to tell him a consult with his doctor and a foot radiograph was the first step. He was clearly embarrassed in asking me this question, but I sensed the pain was enough to demand a thorough workup. Also, the bilateral ankle swelling and bony abnormalities on the sonogram left little doubt in my mind there was something systemic at work with this patient. He was never sore at any of the trigger point locations I palpated. The social pressure for this particular patient to understand his own health was high, to the point when he did not know the answer; it was difficult to seek it out.
It should be noted that more women than men are prone to MTrPs, and more likely to seek medical assistance for myofascial pain. (Simons, Travel, & Simons, 1999) This research taken from a feminist epistemology, seeks to make this fact known to the medical community. Women in particular make up the cohort of patients who are having pain and not getting the answers they seek.\textsuperscript{13} This particular study did not support this however. While most of our participants were female (14 vs. 9 males) the symptomatic patients were split with eight males and eight females, one participant did not answer this question, but he was posing as male from what I could tell, and was symptomatic – yes, this was the same non-compliant patient who refused to fill out the entire questionnaire and told me of his ankle pain. Although this study did not confirm this with ankle/foot MTrPs, there are many other areas of the body where this has been shown, in particular in the upper extremity and back. Clinicians therefore, need to be aware of this, and not dismiss female musculoskeletal pain, as there really could be a biophysical component they are not examining.

\textbf{Patient} (Cyborgs don’t satisfy)

Clearly, sonographers, already act in a capacity beyond the machine. As advances are made sonographers should embrace technology, as they always have, but must continue with the highest patient care. Quite possibly the most important job of the sonographer is the interaction between sonographer and patient. The automation of

\textsuperscript{13} Looking back at my arch foot pain, I was shuffled around clinician to clinician until I left the western medical community entirely and sought out acupuncture. This ancient medical technique healed my foot pain after the first session. It was during this time, I realized I most likely was suffering from an active MTrP.
sonographers simply can’t happen. This is especially important as workloads increase, and new Medicare and Medicaid reimbursements will be linked to patient satisfaction. As much as we want to ignore the incompliant or annoying patient (note above), we have to continue serving each individual as a whole and realize there is a lot at work we may not observe. However, our field, as one senior sonographer shared, “is not really about the quantitative-we are a touchy, feely bunch.” It is this touchy, feely coupled with quantitative, I would argue, however, is what will allow the sonographer to become the ultimate sonoborg. Never will we be able to detach ourselves from the machine, we are inexplicably tied to it; however, the human sonographer can integrate holistic perceptions of individual patients to drive a better health care system. The health system of the future will not pay for cyborgs.

It should be noted, that sometimes patients might receive therapeutic benefits from negative radiographs. (Olysav, 2011) In the same way, a negative sonographic examination can help ease anxiety. The biopsychosocial model allows us to understand our perceptions of pain. Again, the situational and temporal come into play. If a person stubs their toe on after getting a promotion at work, pain may not be perceived as severe, compared to the person who stubs their toe after getting fired. A quick secondary screening may add to a patient’s re-assurance that something grossly physically abnormal is not to blame.
Quantitative Discussion

Quantitative Diagnostic Discussion

Returning to the quantitative portion, this blinded study is the first of its kind to compare trigger point palpation in the lower extremity, in conjunction with sonography, with self-reported patient ankle/foot pain. While only 55 percent of the MTrPs palpated could be confirmed with sonography, this is a vast improvement from the last study which utilized 2-D US alone in 1999 which did not identify a single MTrP with sonography. Furthermore, this study used a portable machine whereas the study by Lewis & Tehan (1999) used a large, now outdated, ATL UltraMark 9 machine. This increase in visualized MTrPs is most likely attributed to the advances of ultrasound machines and increased transducer frequencies, which greatly increases spatial resolution. The older study used a transducer frequency of only 5 MHz, whereas this one had a 12 MHz transducer. Similar to other studies (Sikdar et al., 2009, Thomas & Shankar, 2013) evaluating MTrPs with 2-D sonography, they appeared as an inhomogeneous elliptical hypoechogenic areas.

While this study demonstrates 2D sonography has improved in its detection of MTrPs, there are certainly better ultrasound technologies which may bolster the ability to visualize them. However, it should be noted that while the technology in this study is limited compared to the most cutting edge sonography available on the market, it does capture nearly all ultrasound technology used in the field today, meaning this is widely accessible. While 17-18 MHz transducers are becoming more dispersed in the field, there are now newly FDA approved portable ultrasound machines with transducer frequencies
up to 20 MHz. It is highly likely these newer higher frequencies would be more sensitive at detecting MTrPs with 2-D US. Yet, while 2-D sonography has greatly improved there have been many other ultrasound technological advances, which were unavailable for this study. The use of color and spectral Doppler to evaluate blood flow in and around the MTrP were available, yet unfortunately, this investigation was removed from the screening protocol, due to the expense of time. The evaluation of the blood flow with Doppler, however, in several studies has yielded differing results. However, the newer 2009 Sikdar et al. and other studies (Thomas & Shankar, 2013) showed, elastography can evaluate tissue density and allow for better visualization of MTrPs in general. Sikdar et al. (2009) detected MTrPs at all 33 sites in the upper trapezius in 9 participants. While stating they were able to identify all MTrPs with both 2-D and 3-D sonography in B-mode, it is unclear how much elastography helped in identifying the focal areas. From the images, elastography surely may have helped visualize the nodule, as it can delineate tissue density much better than traditional 2-D echoes. Sikdar did mention that quantification of the density of MTrPs was not possible with elastography, although it certainly showed them more clearly. Clinically, elastography is in its infancy, often limited by its lack of reproducibility, due to the use of freehand pressure and operator-dependent variations. (Park & Kwon, 2011) Future studies would likely benefit from utilizing acoustic radiation force impulse (ARFI) elastography imaging which can actually quantify tissue stiffness by sending a vertical pulse signal into the tissue and record density in m/sec, unlike elastography which can only record the received horizontal reflected signal, expressed in Pascal corresponding to a color code. By
quantifying the actual stiffness of these MTrPs, it may help in determining more about their pathophysiology. Recent FDA approval of ARFI will likely propel this technology within the sonography market and its clinical utility will increase. Already, large ultrasound manufacturers are equipping their machines with this new technology. (Nightingale, 2011)

Another limitation of this study was the inability to distinguish latent from active MTrPs since the researcher was blinded to the participant’s symptoms. It is important to discuss here these two types of MTrPs. Active MTrPs (A-MTrPs) are described as always causing a persistent pain response, usually in a referred pain pattern, whereas latent (L-MTrPs) ones do not produce this same constant pain. However, L-MTrPs, when detected and pressed may produce a similar focal tenderness. Often latent MTrPs are associated with older age, stiffness and restricted motion. However, it is important to note, healthy muscle tissue does not contain active or latent MTrPs and both may cause dysfunction. (Simons, Travell, & Simons, 1999) Clearly, a thorough patient history and evaluation of pain symptoms is critical to differentiate active from latent MTrPs and this would be an advantage of clinicians.

Sikdar et al. (2009) looked at both active and latent MTrPs and found no significant difference in their size, with an average size of 0.16± 0.11cm² for all MTrPs, and this was relatively close to the size of the MTrPs found in this study with an average size of 0.09 cm² with a range from 0.05 cm² to 0.21 cm². Furthermore Sikdar et al. often found MTrPs to exist with multiple nodules in close proximity. Difference in the muscles
being examined may account for the smaller sizes and the fact most all of the MTrPs in this study were found alone.

A disadvantage of this study was that there was only one researcher to do the evaluation and analysis. However, due to known poor inter-rater reliability in detecting MTrPs, it was decided to proceed in this fashion, in keeping with a screening scenario, and may be a strength given the rest of the study. Another limitation of this study may also be the experience of the researcher at detecting MTrPs in the ankle/foot, while a massage therapist with a focus on MTrPs was consulted and both found both active and latent MTrPs in the same locations on an outside participant, the researcher had much more experience in detecting MTrPs in the typically evaluated upper extremity.

When evaluating the statistical analysis by limb, most statistically significance was reported or driven (in the case when the two were combined together) by the right limb. The participant’s reported history of ankle/foot pain may be due to more painful right limbs (total of 14) than left (total of 9). Although a matched-controlled study was originally planned for this study, it was not possible, and certainly future research should employ a match-controlled study for this reason. Also, the examination was done in conjunction with standard general sonography positioning with the patient on the examiner’s right side. It is hypothetically possible, MTrP palpation was limited on the left due to this reason and future studies with sonography may evaluate MTrPs on both sides prior to scanning. Finally, since the sample size and power analysis is limited in this pilot study, more participants would be needed to see if this same right versus left lower limb discrepancy changes.
Yet, based on this preliminary data it may be worthy to have patients fill out the VISA-A form prior to evaluating for MTrPs. The VAS may not be as sensitive for MTrPs, however. In this study the VAS data is a bit skewed as seen by the standard deviations being larger than the means reported. Therefore, as a sensitivity analysis, this was looked at using a square root transformation on VAS to help improve the normality, but it did not greatly help. The linear mixed model for the VAS square root transformation also had similar conclusions (significant interaction as well as the same trends for right and left limbs).

Furthermore, the SF-12 physical score may be helpful in evaluating patients with suspected lower limb MTrPs. While the negative linear relationship shows that about 22% ($R^2=.22$) of the variation in the physical score can be explained by the combined MTrP total, this low $R^2$ is not necessarily a bad thing. Since it is not used for predictive purposes, there are still clinically meaningful realtionships.

Also, the positive linear relationship observed between relationship between combined MTrp Total and SF-12 Mental Score is a bit counter-intuitive, since a higher score of the SF-12 equates to better mental health. Obviously, in this population, participants were happy regardless of a higher combined MTrP score. Again, the limitation of not being able to ascertain the differences in active versus latent MTrPs in this study may have been influential.

Looking at the individual participants and their MTrP status according to the descriptive results section, it would be highly recommended to evaluate a cohort of patients, and their lower limb MTrP status longitudinally with sonography. This is based
on the four asymptomatic participants with positive MTrPs, who all had prior injuries related to the MTrPs palpated, versus the 4/5 asymptomatic participants with no prior pain who had no palpable MTrPs. It would be interesting to see what separates those who go on to have presumably L-MTrPs versus those who have presumed A-MTrPs post injury – demarcating injury type, length, etc. Furthermore, evaluation of the sonographic musculoskeletal structures may aid in better understanding the poorly understood pathophysiology of MTrPs in general. While the focus of this study was on muscular trigger points (MTrPs), trigger points may also exist in the skin, fascia, or tendon. Musculoskeletal sonography offers the added benefit of evaluating these often overlooked structures as well.

Also, since several asymptomatic limbs were given an MTrP score, opposite of a painful limb or injury in the same area, more thought should be given to development of MTrPs in opposing limbs, since antagonist muscles may play a role.

Finally, future similar studies using 2-D ultrasound to detect MTrPs of the lower extremity may yield more results by evaluating those participants with heel pain, as the quadratus plantae MTrP was readily visualized in 4/5 such participants.

**Quantitative Therapeutic Discussion**

Currently, there are many different ways to deactivate trigger points ranging from the more traditional manual therapy to electrotherapy, thermotherapy, laser therapy, even exercise programs and yoga. MTrP injection and dry needling, which is increasing, is another method. (Hong, 2002) While most of these traditional manual therapies are
touted as being clinically effective, the scientific basis for some techniques, such as trigger point pressure release or acupressure and others is still inadequate. Also, electrotherapy while providing immediate pain relief the effect may only be temporary. The application of heat, or thermotherapy can help improve circulation and provide a certain degree of pain relief, it often is not effective to relieve pain from an MTrP. It is often clinically used in conjunction with other therapies, such as manual or electrotherapy. It would be interesting to be able to see how MTrPs morphologically change, evaluated by sonography, in response to these different therapies.

Furthermore, localization of MTrPs for injection or dry needling is certainly an area in which the use of sonography would be helpful. Currently, there is general debate in the field over which of these two treatments is more effective in treating musculoskeletal disorders. There are clear advantages and disadvantages to both techniques discussed here, specific to MTrPs. Local steroid injections of trigger points can cause a lot of post injection pain for up to 24 hours and injection into the achilles tendon, for example, may cause irreparable rupture, not to mention possible atrophy of sub-dermal fat and discoloration of the skin if given over a short period of time (Baldry, 1993) According to The Atlas of Pain Management Injection Techniques book by Dr. Steven Waldman, a series of 2-5 treatments are necessary in treating most myofascial pain syndrome, MPS, which is the chronic musculoskeletal pain due to active MTrPs. (Waldman, 2012) This book discusses injecting MTrPs in only seven conditions; trapezius myofascial pain syndrome, cervical strain, sternocleidomastoid myofascial pain syndrome, scapulocostal syndrome, sternalis syndrome, lumbar myofascial pain
syndrome, and fascia lata fasciitis syndrome. It is interesting there is no mention of trigger point injections for the entire ankle/foot. However, Dr. Waldman states in his newest 2012 edition, “the field of pain management is entering a new and exciting era, now that ultrasound guidance has become increasingly utilized…my clinical impression is that ultrasound guidance represents an important advance in regional anesthesia and pain management that I think will stand the test of time.” (2012, forward) He even has provided a how-to section presenting the fundamentals of sonography guidance and provides new figures with images throughout the book.

Oftentimes, however, injection is considered unnecessary and dry needling will achieve the same results. A 2010 article by Bubnov, used sonography guided dry needling for the treatment of myofascial pain in a group of 91 patients and found 93.3% reported pain relief. (Bubnov, 2010) The exception to this would be if there is active inflammation, as the steroid can exert a strong anti-inflammatory effect. With sonographic visualization inflammation may more readily be detected, showing increasing echogenicity of the sub-dural fat along with power Doppler detection. Complications from dry needling, while relatively safe, do exist. These complications include damage to viscera which may easily be avoided if the practitioner may visualize any surrounding viscera such as an enlarged spleen or liver, or more commonly punctured, lung. (Baldry, 1993)

Increasing documentation that dry needling is effective in treating including MTrPs, also includes acupuncture. (Hong, 2002) However, when it comes to MTrP, they may not even actually hit directly during acupuncture, since the needle is only inserted 5-
10mm at most. This may result in many follow-up visits (average of 5) needed before pain is relieved. Baldry maintains, that “The failure of trigger point pain to respond to acupuncture is often because one or more trigger points have been overlooked.” (Baldry, 1993, p. 100) This may include L-MTrPs, as well as A-MTrPs.

Through diagnostic imaging an area tracing can be obtained to more precisely measure the size of the MTrP. This size is important and may inform possible future treatments of a particular MTrP, since the size of an MTrP plays an important role in treating them. Essentially, the size of an MTrP is used to inscribe the tissue just surrounding the MTrP, which through the correct ischemic compression techniques, can provide a larger reserve pool of blood flood the MTrP and relieve muscle ischemia. (Link to online diagram\textsuperscript{14}) Also, in support of this vasodilation to help treat MTrPs it is interesting that it is recommended to perform acupuncture when it is warm, not on cold days (Baldry, 1993) According to a systematic review on the effectiveness of laser acupuncture, laser needling, highlight the importance of a minimum mW intensity and joule (J) dosage, promoting irradiation which could promote tissue healing and alleviate pain. Finally, one of the bioeffects of ultrasound is tissue heating. In fact, comparison of the effects of laser and ultrasound treatments on rats (Demir, Menku, Kirnap, Calis, & Ikizceli, 2004, Ng & Fung, 2007) has shown therapeutic ultrasound and laser have similar results in the promotion of tendon healing. Ultrasound has become known, not only for its diagnostic purposes, but increases in use for therapy, ranging from the more well-known physical therapy applications to the newest advances in high intensity focused

\textsuperscript{14} See video: https://www.scienceofmassage.com/dnn/som/journal/0907/medical.aspx (Turchaninov & Prilutsky)
ultrasound or HIFU, which amps up the Hz to produce bioeffects to damage tissue, such as destroying breast cancers and treating uterine fibroids (only FDA approved use). (Ren et al., 2007) It is not hard to imagine ultrasound, which behaves much like a laser, could be used to not only diagnose MTrPs, but is a good candidate to treat them as well. However, as with the laser acupuncture, intensities and length of time of the treated MTrP will need to be established through research to set minimum threshold, along with upper limits.

Qualitative Discussion

“Divine is the task to relieve pain.”
– Hippocrates

My martial arts master lived by the idea that the world would be better if everyone was a black belt. He reasoned that a strong body, mind and spirit are necessary to not only help oneself, but to help others. How can we help others, if we cannot help ourselves? This perspective can also reveal more about the softer side of sonography, beyond the sterile white walls where most of it takes place. Qualitative perspectives should not be placed on the back burner, but brought to the forefront and where Eastern medicine is not dismissed as alternative, but integrated with modern medicine, so a balance can be carefully achieved. As a clinician, good patient care is about being in the moment and mindfulness may help us to avoid automation. In her 2011 TedX Columbus presentation, Dr. Maryanna Klatt discusses how mindfulness can allow us to relieve pain.

15 http://www.youtube.com/watch?v=YaYt-ASuc0g
stress, slow down and be in the moment. A good clinician must focus on the here and now, especially with increased demands on the job. Over 90 percent of sonographers will experience some sort of work-related musculoskeletal disorder. (Evans, 2009) We as a profession are mostly made up of women and are more prone to MTrPs\(^\text{16}\), with work repetition in the shoulder and wrist. Interestingly, mindfulness, according to a review on medical therapies in the management of myofascial pain disorders (Harris, et al.) states that relaxation can help reduce the development of MTrPs.

In addition to relaxation to help suffering from MTrPs, stretching, yoga, massage, acupuncture, and biofeedback (oh yes, and ultrasound) are all very helpful. So first, we must utilize and try these solutions for ourselves, the clinician, and then have a duty to pass these skills along to our patients. There is mounting evidence that visualization can be used to help identify with and relax patients. Biofeedback is an important step in the human interaction and should be integrated in the clinical examination. (Harris & Clauw, 2002)

The more I read on this topic, the more confused I became and less sure I was about what I was seeing and doing. For example, the massage therapist said I was possibly activating latent MTrPs. I was left with a new fear – I was actually inciting pain and not relieving it. There is also a lot of overlap between comparing tender points of fibromyalgia to MTrPs in myofascial pain disorders. However, although the evidence is at times conflicting on the topic of MTrPs, it is nonetheless progressing. Sonography certainly has a place to help propel MTrP research and much more is needed. One of the

\(^\text{16}\) I have experienced these in my sonography career personally, and as a martial artist, I have been acutely aware of these, especially when my patient load increases.
first steps to relieve pain is to first diagnose it. Myofascial pain is only one part of this project, as interplay between mind and body, that is situated, is important of the holistic biopsychosocial

We are the face of medicine, the ones patients spend the most time with, so we have a high responsibility to understand what is relevant and synthesis what we learn to share with the physicians we assist. Like a yin yang we must be balanced as clinicians, bringing qualitative to the forefront and bridging the gap of east and west, the organic and man-made - the sonoborg. Sonography has the potential to close this space, as it is non-invasive, non-ionizing radiation, increasing in use and portable.

**Conclusion**

This mixed-methods adventure has led me to believe that a holistic assessment is necessary and we should consider the biopsychosocial model and the multi-factorial nature of ankle/foot pain. Furthermore, rather than defining this study as alternative, it is hoped the term integrative will better explain it, especially as the medical community struggles with the clinical options and efficacy of diagnosing and treating MTrPs. While producing some statistical significance within a limited cohort of a convenience sample, this study has also provided many unexplained results, demonstrating clear pitfalls with current MTrP imaging with sonography and prompts future endeavors with MTrPs, to be carried out in a more dedicated manner with the latest ARFI elastography technology. Certainly, by utilizing advances in sonography, more objective MTrP criteria may be made and this would allow their identification and classification to be more reliable,
sensitive and specific. The advantages of having a low-cost reliable way to visualize trigger points are many, including their treatment and evaluation over time. Furthermore, the qualitative must be brought to the forefront in addition to adhering to quantitative results in regards to ankle/foot pain. A holistic approach should guide, not only research in this area, but in our clinical realm as well.
Chapter 4: Screening Sonography of the Ankle/Foot to Link Pain with Pathology

Introduction

The ankle is the most injured joint in the body and a common source of musculoskeletal (MSK) pain. Lateral ligament injury is the most common site of ankle injury seen in outpatient primary care. Posterior ankle pain is another common complaint. (Daniels & Shinavier, 2010) Clinicians are in need of a quick, portable diagnostic tool to screen for abnormalities. Musculoskeletal sonography allows the identification of common injuries or musculoskeletal disorders of the ankle, such as ligament sprains, tendon rupture, joint effusions, soft-tissue masses and peritendinous swelling. Additionally, sonography provides a dynamic real-time evaluation of the structures. (Hatzenbuehler, 2013) Therefore, the focus of this research is to determine whether a hand-carried ultrasound unit (HCU) unit contributes to the holistic diagnostic work-up for patients with ankle/foot pain.

Interestingly, foot and ankle pain is one of the most common reasons people make an appointment to see their physician. (Belatti & Phisitkul, 2014) A 2011 systematic review indicates that as many as 20 percent of the population may suffer from frequent ankle and foot pain (Thomas et al., 2011) and each year over seven million Americans are hospitalized for problems related to the feet. As a consequence of these statistics, the economic burden of ankle/foot pain costs U.S. insurance companies billions of dollars.
annually. (Belatti & Phisitkul, 2014) This is a significant problem that needs to be addressed in order to assure severe patient cases are being treated and work to reduce unnecessary interventions.

A review of the most recent guidelines from national and international organizations supports the use of MSK sonography for many conditions, yet discrepancies regarding its use exist. According to the World Health Organization (WHO) Manual of Diagnostic Ultrasound (WHO, 2013) the top indications for evaluating the musculoskeletal system with sonography includes musculoskeletal pain and trauma. This manual supports and recommends the use of ultrasound for specific diseases and diagnostics. It is a joint effort of the Diagnostic Imaging and Medical devices unit of the Department of Essential Medicines and Health products of WHO’s Health Systems and Innovation cluster, along with WHO’s Public Health and Environment cluster. Additionally, the World Federation for Ultrasound in Medicine and Biology (WFUMB) has been working with WHO for 10 years in the publishing and editing of these ultrasound manuals.

In his article, Insights into Imaging, (2010) Martinoli gives a review of the European Society of Musculoskeletal Radiology (ESSR) guidelines for ankle MSK sonography, which provides a systematic scanning technique of 14 scanning sites. Yet, it is noted this scanning is only theoretical due to the fact that the examination of the ankle joint with sonography is often only focused to one or a few areas based on clinical findings. However, according to Martinoli, these ESSR Musculoskeletal ultrasound technical guidelines are what the ESSR considers, “essential scanning protocols for a
complete high-quality ultrasound examination in each joint.” Furthermore, “Musculoskeletal radiologists who perform ultrasound are expected to follow these guidelines while recognizing that variations will be required in some cases, depending on patients’ needs and available equipment.” Yet, despite the aim to improve education and provide a uniform practice among MSK ultrasound practitioners, these guidelines, according to Martinolli, are not proposed to establish a legal standard of care.

The latest Delphi-based consensus of the ESSR (Klauser et al., 2012) ankle/foot MSK sonography graded the levels of evidence for the following clinical indications, and came to a consensus, summarized in the table below:

<table>
<thead>
<tr>
<th>ESSR Ankle/foot Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Indicated</td>
</tr>
<tr>
<td>If other imaging techniques are not appropriate</td>
</tr>
<tr>
<td>Equivalent to other imaging techniques</td>
</tr>
<tr>
<td>First choice level technique</td>
</tr>
<tr>
<td>PTF ligament</td>
</tr>
<tr>
<td>Intraarticular disease</td>
</tr>
<tr>
<td>Cartilage lesions</td>
</tr>
<tr>
<td>Distal tibia</td>
</tr>
<tr>
<td>Talus Coalitions</td>
</tr>
<tr>
<td>Deltoid ligament</td>
</tr>
<tr>
<td>Spring ligament</td>
</tr>
<tr>
<td>Loose bodies</td>
</tr>
<tr>
<td>Bony avulsion</td>
</tr>
<tr>
<td>Haglund disease</td>
</tr>
<tr>
<td>Morton neuroma</td>
</tr>
<tr>
<td>Tendinopathy</td>
</tr>
<tr>
<td>Tears</td>
</tr>
<tr>
<td>Sheath effusions</td>
</tr>
<tr>
<td>Peroneal dislocation</td>
</tr>
<tr>
<td>Calcific tendinitis</td>
</tr>
<tr>
<td>Retrocalcaneal bursitis</td>
</tr>
<tr>
<td>Postoperative tendon tear</td>
</tr>
<tr>
<td>ATF ligament</td>
</tr>
<tr>
<td>CF ligament</td>
</tr>
<tr>
<td>Joint effusions</td>
</tr>
<tr>
<td>Synovitis</td>
</tr>
<tr>
<td>Plantar fasciitis</td>
</tr>
<tr>
<td>Retinacula</td>
</tr>
<tr>
<td>Ganglion cysts</td>
</tr>
<tr>
<td>Nerve entrapment</td>
</tr>
</tbody>
</table>

Table 4.1 2012 ESSR Delphi-consensus indications for Ankle MSK Sonography
Next, a review of the latest AIUM Guidelines for MSK ultrasound (2012) reflects a similar position in regards to establishing minimum criteria for a complete MSK ankle examination in that AIUM-accredited labs are expected to generally follow these standards, but deviations will exist. However, the AIUM adds, “Practices are encouraged to go beyond the guidelines to provide additional service and information as needed.”

The indications for an MSK sonographic examination, according to this organization, include, but are not limited to the following indications and should only be performed when there is a valid medical reason.

- Pain or dysfunction
- Soft tissue or bone injury
- Tendon or ligament pathology
- Arthritis, synovitis, or crystal deposition disease
- Intra-articular bodies
- Joint effusion
- Nerve entrapment, injury, neuropathy, masses, or subluxation
- Evaluation of soft tissue masses, swelling, or fluid collections
- Detection of foreign bodies in the superficial soft tissues.
- Planning and guiding an invasive procedure
- Congenital or developmental anomalies
- Postoperative or post-procedural evaluation

The technical guidelines for the ankle ultrasound exam, in particular, is divided into four quadrants (anterior, posterior, medial and lateral) and, depending on the clinical presentation, may include a complete evaluation of one of the four quadrants or may be focused. Furthermore, the foot MSK ultrasound examination is usually focused to a particular structure, again relating to the clinical question (i.e. Morton’s neuroma, plantar fasciitis or ganglion cyst). These ankle/foot guidelines state color or power Doppler may be helpful in detecting hyperemia within these structures. It should be noted, these AIUM
guidelines are collaboration between the AIUM, American College of Radiology (ACR), Society for Pediatric Radiology (SPR) and the Society of Radiologists in Ultrasound (SRU).

Finally, podiatry has loosely suggested guidelines for ankle/foot MSK sonography, and according to Nathan Schwartz DPM (2010), there are many indications for this examination. Indications, however, are usually specific to pathologies. Posted on the popular Podiatry Today website, entitled, “Sounding off on ultrasound,” Allen Jacobs DPM, FACFAS (2013), provides insight for the wide potential of misuse and abuse of MSK ultrasound and this is reflected in the recent denial, by insurance carriers, of billings by podiatrists or their requirement for certification in diagnostic ultrasound by those who wish to use and charge for its use. The following alleged malpractice case illustrates the problem. A high-level, competitive and scholarship athlete received multiple ankle injections by a podiatrist after evaluating it with sonography, was only later referred to an orthopedic surgeon and had to undergo surgery for tendon rupture and ligamentous disruption. In addition to pointing out this problem, Jacobs, states, “It also, in my opinion, calls for our profession to establish podiatry profession guidelines for the use of ultrasound and for podiatric certification.”

Guidelines for MSK sonography of the ankle/foot provide a general consensus in regards to clinical pathologies indicated, but discrepancies do still exist. Both the WHO and AIUM explicitly state pain as an indication for this examination, while both Martinoli’s technical guidelines and the ESSR Delphi paper, along with known podiatric
indications do not explicitly indicate pain for the evaluation of the ankle/foot with sonography.

In light of these current ankle/foot sonography practices, it would seem that guidelines are widely available, but the use of sonography to detect foot/ankle pain is not complete without using this powerful diagnostic tool as part of a holistic evaluation of the patient. Our research question was how can a HCU be utilized in conjunction with self-reported information to correctly identify patients with ankle/foot pain?

**Methods and Materials**

Study design- Symptomatic and asymptomatic patients were recruited purposively such that a one-shot blinded case study design could be used for feasibility. Selection of participants- Participants were recruited with a university flyer to enter the IRB approved study to explore ankle/foot pain. Volunteers were also recruited to make up a cohort of asymptomatic participants. N=25 [17= symptomatic; 8 = asymptomatic] Any person ages 18-65 years old were admitted, with the exclusion criteria of diabetes, past ankle surgery or current pregnancy.

Study protocol- All participants were first consented and provided a questionnaire to complete. The survey included four sections. The first portion was a modified SF-12 survey to assess both the participant’s overall physical and mental health. The second portion was the VISA-A, (Victorian Institute of Sports Assessment – Achilles) which is a reliable tool for measuring Achilles tendinopathy.(Robinson et al., 2001) The third section included a visual analogue scale (VAS) for pain and the fourth section gathered
sports participation and demographic information. Following the survey, an investigator, not blinded to participant symptoms, took an extensive history from each patient. Next, the second examiner, who was blinded to the type of participant recruited, used a modified scanning protocol to screen the ankle and foot bilaterally. This protocol, based on AIUM (2012) and ESSR (2010) technical guidelines, included 15 ankle/foot structures, including transverse sweeps of the medial, lateral, posterior and anterior compartments. A 12-5 MHz linear probe was utilized with a hand-held GE Logiq i (Milwaukee, WI) portable ultrasound machine. Each evaluation was done on a musculoskeletal setting with cross beam technology and harmonics. This same equipment receives bi-monthly quality control testing with both a 2-D and Doppler flow phantom. A standoff pad was utilized.

This same examiner, still blinded, made sonographic image evaluations, based on the D’Agostino (D’Agostino et al., 2009) scoring system to evaluate tendon thickness/echogenicity, calcification, bone erosion, and vascularization. These same elements were also rated with excellent agreement (>80%) via an initial Delphi exercise to evaluate spondyloarthritis (Terslev et al., 2013). Additionally, a modified evaluation score was added for the detection of fluid, abnormal muscle fiber patterns and subluxation of the peroneal tendons. The details of the devised scoring system are shown below.
<table>
<thead>
<tr>
<th>Tendon thickness/echogenicity</th>
<th>Calcification</th>
<th>Bone Erosion</th>
<th>Vascularization</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score 0 if normal and 1 if hypoechogenic and/or increased thickness present at the bone insertion compared to a contralateral site and/or using personal experience</td>
<td>Score 0 if normal and 1 if a hyperechoic spot (with or without acoustic shadow) in the area of the enthesis insertion is seen</td>
<td>Score 0 if normal and 1 if a cortical break with a step down defect of bone contour in the longitudinal and transversal axis is detected</td>
<td>Scored 0 if absent, 1 if minimal (only 1 color spot detected), 2 if moderate (2 spots), or 3 if severe (3 spots or more shown with power Doppler)</td>
<td>Score 1 if fluid present</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Score 1 if abnormal muscle fiber pattern seen</td>
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<td></td>
<td></td>
<td></td>
<td>Score 1 if subluxation detected</td>
</tr>
</tbody>
</table>

Table 4.2 ‘Agostino and modified (including other category) scoring of ankle/foot sonograms
In addition to the evaluation of this screening sonography, myofascial trigger points (MTrP) were also evaluated and scanned. (See Chapter 3 – “Beyond the Biophysical: A mixed-method holistic approach to evaluating Ankle/foot pain utilizing a hand-held ultrasound machine”) The MTrP scoring system is shown below:

<table>
<thead>
<tr>
<th>Score</th>
<th>MTrP Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Negative, no pain or palpation of a trigger point</td>
</tr>
<tr>
<td>1</td>
<td>Patient felt pain, but no trigger point nodule was palpated</td>
</tr>
<tr>
<td>2</td>
<td>Patient felt pain and palpable nodule palpatated</td>
</tr>
<tr>
<td>3</td>
<td>Palpable, painful MTrP seen with 2-D ultrasound (visualization with two planes, area (cm²) measured in longitudinal plane)</td>
</tr>
</tbody>
</table>

Table 4.3 Scoring of Trigger Points

Data analysis- SAS v.9.2 software (SAS Institute Inc. Cary, NC) and MATLAB v.R2014a (MathWorks, Inc. Natick, MA) were used to analyze the data collected, comparing the dependent variable, which was self-reported pain to the independent variables of holistic diagnosis. The levels of the dependent variable were the VAS and self-reported pain, as noted in the patient history. The levels of the independent variable were the SF-12, VISA-A, D ’Agostino and MTrPs. P< .05 was selected a priori as the measure of statistical significance. Correlations and linear regressions were established as the statistical tools depending on the type of variable measured.
Results

A total of 25 participants were evaluated by both the intake coordinator and the sonographer to collect the data used for analysis.

Descriptive data

A total of 17 symptomatic and 8 asymptomatic participants were enrolled. There were no age or gender between the two groups. There was a total of 11 males and 14 females, ages 18 to 63 years old with a mean age of 33.6 years and median age of 28 years. There were a total of 14 painful self-reported right limbs and nine painful left limbs, with six individuals reporting bilateral pain. A large number of the total participants were students (11/24, with one non-respondent). Some of the other occupations listed included a retail manager, data entry clerk, home health care aide, professor, waitress, and research coordinator. Differences in occupation did exist between the two groups, since most of the asymptomatic participants were students (7/8) versus only a few students (4/24) in the symptomatic category. Both groups were very active, with the average participant participating in physical activity 10.5 hours each week. Only one person reported no activity and three participants did not answer this question, yet these same people listed activities. Physical activities included walking, running, swimming, dancing, yoga, and playing various sports from lacrosse to volleyball, soccer, football, and rowing.

The following table summarizes the descriptive data, including the mean and standard deviation, of the symptomatic and asymptomatic participants for the
questionnaire responses of the other dependent variable of the VAS as well as the following independent variables, SF-12 (physical and mental), VISA-A, included also is the D’Agostino scores (modified and unmodified), and MTrP scores (palpable and ultrasound).

| Combined Mean Scores (StDev) between Symptomic and Asymptomatic |
|---------------|-----------------|-----------------|
|               | Sympt Total Mean | Asympt Total Mean |
| VAS           | 3 (2.9)          | 0.1 (0.4)       |
| SF-12 Physical | 48.3 (7.3)       | 54.9 (4.0)      |
| SF-12 Mental  | 56.6 (5.6)       | 55.8 (3.7)      |
| VISA-A        | 69.9 (14.8)      | 93.9 (6.1)      |
| D'Agostino    | 3.5 (2.8)        | 1.8 (2.5)       |
| D'Agostino (modified) | 4.6 (3.6)        | 2.2 (2.9)       |
| MTrP (palpable) | 2.3 (2.9)        | 1.8 (2.5)       |
| MTrP (ultrasound) | 4.6 (3.6)        | 2.2 (2.9)       |

Table 4.4 Descriptive combined data between symptomatic and asymptomatic participants

<table>
<thead>
<tr>
<th>Mean (StDev) Scores between Symptomic and Asymptomatic by limb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>VAS</td>
</tr>
<tr>
<td>VISA-A</td>
</tr>
<tr>
<td>D'Agostino</td>
</tr>
<tr>
<td>D'Agostino (modified)</td>
</tr>
<tr>
<td>MTrP (palpable)</td>
</tr>
<tr>
<td>MTrP (ultrasound)</td>
</tr>
</tbody>
</table>

Table 4.5 Descriptive data per limb between symptomatic and asymptomatic participants
As a quick reference, the questionnaire scores are described here. The VAS rates pain on a scale from zero to ten, with zero meaning the person experiences no pain at all and 10 representing the worst agonizing pain. (See Figure 3.4)

Next, the physical and mental SF-12 both provide participants with a score from 0 to 100, with 50 representing the national average. The VISA-A also provides a score from 0 to 100, where 100 represents a perfect score for Achilles tendon ability.

**Statistical Data**

The statistical evaluation demonstrates the degree of association and prediction of the independent variables to the dependent variables (P< .05) The self-reported pain, as noted in the history taken from the examiner, was a dependent variable in determining if a patient was symptomatic or not in each limb. Since this was reported as a dichotomous variable, the Wilcoxon Rank-Sum test for non-normally distributed data was used to evaluate differences between those with and without a history of limb pain and the independent variables, including the physical and mental SF-12, VISA-A, as well as the D’Agostino (modified and unmodified). A summary of the P values are reported in the table below, with those reaching significance bolded.
As the table shows, the dependent variable of pain history was significantly associated with many of the independent variables. The physical SF-12 demonstrates, however this association was more prevalent in the right limb and the combined limb outputs, with a P-value of .007 on the right and only .26 on the left, with a combined .006 P-value, indicating the SF-12 physical score was lower overall for anyone reporting pain, and in those who reported right limb pain. The mental SF-12, however, only showed significance for those with right limb pain, reporting that these participants had higher mental SF-12 scores than those without right limb pain. Next, the VISA-A showed the highest significance in differences between the two groups of those who did and did not report limb pain. Those with reported limb pain had significantly lower VISA-A scores compared to those participants who did not report pain on the right (P=3E-5), the left (P=.002) and combined limbs (P=5E-4).

Next, in evaluating the D’Agostino scores by limb the statistical test indicated that those who had a history of pain in their right limb had higher right D’Agostino scores (Wilcoxon Rank-Sum test: p=.02) than those who did not indicate a history of pain. Of
the 11 participants without pain in the right limb, the mean total D’Agostino score was 1.00 (lower quartile = 0.00 to upper quartile 4.00), while for those 14 participants with pain the median D’Agostino score was 4.5 (lower quartile = 2.00 to upper quartile = 7.00). Similarly, those indicating a history of pain in the left limb had higher left D’Agostino scores (Wilcoxon Rank-Sum test: \(p=0.04\)) than those who did not indicate a history of pain. Those without pain in the left limb (\(N=16\)) had a median score of 1.00 (lower quartile = 0.00 to upper quartile = 2.00), versus those who had pain in the left limb (\(N=9\)) had a median score of 3.00 (lower quartile = 2.00 to upper quartile = 5.00).

Similarly, the pain history for the comparison of each limb to the modified D’Agostino scores was also significant. Those indicating they had a history of pain in their right limb had higher D’Agostino (modified) scores (Wilcoxon Rank-Sum test: \(p=0.01\)) than those who did not indicate a history of pain. Of the 11 participants without pain in the right limb, the median modified D’Agostino score was 1.00 (lower quartile = 0.00 to upper quartile 4.00), while for those 14 participants with pain the median modified D’Agostino score was 5.5 (lower quartile = 3.00 to upper quartile = 10.00). Again, those indicating they had a history of pain in the left limb had higher D’Agostino (modified) scores (Wilcoxon Rank-Sum test: \(p=0.03\)) than those who did not indicate a history of pain. Those without pain in the left limb (\(N=16\)) had a median score of 2.00 (lower quartile = 1.00 to upper quartile = 3.00), versus those who had pain in the left limb (\(N=9\)) had a median score of 4.00 (lower quartile = 3.00 to upper quartile = 5.00).

Not surprisingly, both the unmodified and modified D’Agostino scores showed the highest significance for combined limbs, reporting significance of \(P=7.4\) and \(P=5.4\) respectively.
Statistical analysis was conducted to evaluate trigger status and reported pain by limb, as taken from the participant history. As with the independent variable of the physical SF-12, the right side trigger status for palpable MTrPs and MTrPs visualized with sonography were statistically significant for those with a history of limb pain, while left side trigger statuses were not significant (Fisher’s Exact test, p=1.0000 for each status) when comparing to the participant’s reported history of ankle/foot pain. For example, looking at the palpable MTrPs, 10/14 (71%) of those who reported a history of pain in the right limb also had positive triggers. This is in comparison to only 2/11 (18%) positive MTrPs in those who did not report having a history of pain in the right limb. The left limb, however, does not really show any difference and palpable MTrPs were 33% for pain and 31% for no pain in terms of positive assessment. Yet, it should be noted there were more painful right limbs (total of 14) than left (total of 9).

<table>
<thead>
<tr>
<th>Table of R_Limb by R_PalpTrigger</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_Limb(R_Limb)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>No pain</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Pain</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Fisher’s Exact test, p=0.0154

Table 4.7 Right limb history of pain and Right trigger (Palpable)
Next, the VAS dependent variable of pain was compared to the independent variables. Linear regressions were chosen to show how this dependent variable predicts, or does not predict the independent variables, moving beyond association. Analysis of the physical and mental SF-12, as well as the VISA-A results ($R^2$ and $p$-values) are summed up in the following table, again significant values ($p<.05$) are bolded. $R^2$ values provide the proportion of variance of one variable that is predictable from the other variable, in this case the VAS as the dependent variable. General rules for the strength of the correlation coefficient ($R^2$) according to Dancey & Reidy’s (2004) categorization, are as follows:

Table 4.8 Right limb history of pain and Right trigger (Ultrasound)

<table>
<thead>
<tr>
<th>R_Limb(R_Limb)</th>
<th>R_USTrigger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Negative</td>
</tr>
<tr>
<td>Row Pct</td>
<td></td>
</tr>
<tr>
<td>No pain</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>90.91</td>
</tr>
<tr>
<td>Pain</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
</tr>
</tbody>
</table>

Fisher’s Exact test, $p=0.0421$
<table>
<thead>
<tr>
<th>Correlation Coefficient</th>
<th>Strength of Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Perfect</td>
</tr>
<tr>
<td>0.7 - 0.9</td>
<td>Strong</td>
</tr>
<tr>
<td>0.4 - 0.6</td>
<td>Moderate</td>
</tr>
<tr>
<td>0.1 - 0.3</td>
<td>Weak</td>
</tr>
<tr>
<td>0</td>
<td>Zero</td>
</tr>
</tbody>
</table>

Table 4.9 General rules for strength of correlation coefficients

<table>
<thead>
<tr>
<th>Linear Regression results (R² and p value)</th>
<th>compared to Right, Left &amp; Combined VAS scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right R²</td>
</tr>
<tr>
<td>SF-12 Physical</td>
<td>0.2</td>
</tr>
<tr>
<td>SF-12 Mental</td>
<td>0.02</td>
</tr>
<tr>
<td>VISA-A</td>
<td>0.58</td>
</tr>
</tbody>
</table>

Table 4.10 Comparing VAS scores to questionnaire independent variables

The results of the questionnaire independent variables were very reflective of their associations with the pain history; however provide the predictive values, as well as the accounted variation. The physical SF-12 significantly predicted the right VAS scores where p=.03, with R²=.2. The left VAS scores were not significant (p=.48, R²=.02) and the combined total VAS scores were significantly predicted by the physical SF-12, where p=.03 and R²=.09.
The mental SF-12 reached no significance in accounting for any change in VAS scores, either by limb (Right p=.5, \( R^2=.02 \), Left p=.55, \( R^2=.02 \)) or combined (p=.88, \( R^2=.0005 \)).

Again, the most significant results were those of the VISA-A questionnaire. Linear regressions demonstrate significance for both limbs, compared to their respective VISA-A score, as well as the combined VAS and VISA-A scores. Goodness of fit is depicted for each in the graphs below.

Figure 4.1 VAS (right) to VISA-A (right)

The VISA-A scores for the right limb provided a predictive significance of \( p<.001 \) and \( R^2=.58 \).
The VISA-A scores for the left limb provided a predictive significance of $p=.0003$ and $R^2=.45$.

Figure 4.2 VAS (left) to VISA-A (left)

Figure 4.3 VAS (combined) to VISA-A (combined)
The Combined VISA-A scores for both limbs provided a predictive significance of $p<.001$ and $R^2=.54$.

Next, the dependent VAS variable was compared with the D’Agostino scoring. There was not a statistically significant interaction between the D’Agostino score and limb ($p=0.59$). The D’Agostino score does, however, show an overall trend (not specific to the limb), whereas the score increases, so does the VAS ($p=0.01$). Each point increase on the D’Agostino score accounts for, on average, an additional 0.42 VAS points (95% CI 0.13, 0.72).

Similarly, there was not a statistically significant interaction between the D’Agostino (modified) score and limb ($p=.43$). The modified score, however, does show an overall trend (not specific to the limb), whereas the score increases, so does the VAS ($p=.03$). Each point increase on the modified score accounts for, on average, an additional 0.34 VAS points (95% CI 0.11, 0.56).

Finally, linear mixed models were used to analyze the relationship between VAS pain scores and trigger status (both palpated and those visualized with ultrasound). The subject was included as a random effect in the linear mixed model to account for correlation between responses (i.e. right limb and left limb). Comparisons of trigger status for each limb were tested as contrasts within the mixed model. Diagnostic measures such as residual plots were used to assess model assumptions. On the right limb those with negative palpable MTrPs ($N=13$) the mean VAS score was 1.38 with a standard deviation of 2.84, compared to those with positive palpable MTrPs ($N=12$) averaging a VAS score of 4.08 with a standard deviation of 2.50. Participants
with negative left limb palpable MTrPs (N=17) had a mean VAS score of 1.71 with a standard deviation of 2.76, while the participants with positive left limb MTrPs (N=8) had an average VAS score of 0.88 with a standard deviation of 1.46. Boxplots of these results are depicted below.

Figure 4.4 Boxplot comparing VAS to positive and negative right limb MTrPs
For those with negative ultrasound MTrPs (N=17) the mean VAS score was 1.82 (std dev 2.90), compared with participants with positive ultrasound MTrPs (N=8) with a mean VAS score of 4.50 (std dev 2.33). Finally, those with negative ultrasound MTrPs on the left limb (N=20) showed an average VAS score of 1.65 (std dev 2.64), compared with a positive US MTrPs (N=5) had an average score of 0.60 (std dev 0.89).

There was a statistically significant interaction between palpable MTrP and limb (p<.03), as well as US MTrP and limb (p<0.02) meaning the effect of the trigger status does depend on the limb. For the left limb, the mean adjusted difference between negative and positive palpable triggers is 0.2 (95% CI -1.7, 2.2; p=0.8111) No statistical significance was reported for US MTrPs on the left limb. For the right limb, the mean adjusted difference between negative and positive palpable triggers is -2.6 (95% CI -4.5, -0.78),
and for US MTrPs the mean adjusted difference was -2.5 (95% CI -4.5, -0.51). This corresponds to the VAS being lower for negative triggers versus positive palpable and US MTrPs in the right limb.

There was no statistical significance (p<.09) in the overall palpated MTrPs and combined VAS scores. Nor was there a statistical significance (p<.33) in the overall ultrasound MTrPs and combined VAS scores.

**Discussion**

This study, while small, does provide some significant associations and predictions of a participant’s self-reported pain (pain history and VAS score). The descriptive data shows the average scores for every variable accessed, with the exception of the mental SF-12 were either higher or lower (depending on the variable) pointing towards increased pathology or pain for the symptomatic participants in comparison to those who were asymptomatic. Building onto the descriptive data, the associative significance testing and linear regressions teased out the most salient variables, described below.

Not all of the variables were significant in the predicted fashion. Notably the mental SF-12 scores, yielded surprising results with the symptomatic participants having a significantly higher score (56.6, st dev. 5.6) than the asymptomatic participants (55.8 st dev. 3.7). Both groups scored above the national average however. Differences among the mental health in these two groups may be attributed to the differences in occupation, as most of the asymptomatic cohort consisted of students (7/8), and this group is notoriously known for high stress and low stability. Furthermore, psychological...
significance is often harder to come by than physical attributes, given the multi-factorial aspects that come into play. Hypothetically, this asymptomatic group may have come in on gloomy winter days, while most of the symptomatic group was evaluated on sunny spring days. Another possible explanation of this increase in mental health scores among the symptomatic group may be attributed to a placebo-like effect (Hawke & Burns, 2009) where patients are feeling as if they are getting their concerns and pain finally addressed.

Next, the symptomatic participants overall had lower physical SF-12 scores (48.3, st dev. 7.3) than the national average, while the asymptomatic participants had higher physical SF-12 scores (54.9, st dev. 4.0) than the national average. The right painful limbs were significantly associated with both the pain history and the VAS scale, whereas the left limb was not significant for either dependent variable. The combined limb output from both the pain history and VAS, however, was significant. The combined score significance was likely driven by the right limb in this study. It is unknown whether this is due to a larger sample size (N=14 on the right vs. N=9 on the left) between the painful limbs or if the significance is related to a higher pain reported in the right limb. Likely, both factors contribute, but further studies would need to be conducted to positively identify this hypothesis.

Differences in VISA-A scores were the most notable between these two groups of participants (symptomatic average of 69.9 and asymptomatic average of 93.9). While this questionnaire has been validated as a clinical index of Achilles tendinopathy, it can detect other conditions that influence lower limb function, such as an ankle sprain, which is a condition some of our participants reported in their history. Interestingly, the VISA-A provides a range of severity of those with Achilles tendinopathy, with pre-surgical
patients scoring an average of 44 (28-60), non-surgical patients averaging 64 (59-69), and normal controls exceeding 96 (94-99). (Robinson et al., 2001) Within our cohort, six participants scored a 60 or below on the right VISA-A and only two scored a 60 or below on the left VISA-A limb evaluation. This information shows how the severity of the painful right limbs was higher than the painful left limbs.

Corroborating the conclusions drawn from the VISA-A, the VAS scores were much higher on the painful right limbs, than the left painful limbs. In fact only 5/9 painful left limbs on the VAS scale were scored above a four (uncomfortable pain). In comparison, 11/14 painful right limbs reported a score of four or above on the VAS. Some prior studies on clinically diagnosed Achilles tendinopathy, have actually excluded those participants whose pain on the VAS scale was below a four. However, VAS is very subjective and may have to do with how the patient wants the clinician to perceive their pain. For example, only one participant recorded a bilateral VAS score of 10. This same person fell asleep during the examination, and the manipulative techniques did not bring a wince to this person’s face. Not surprisingly this participant was a visual outlier. Was this an example of a man just being tough? Or perhaps he had recently took pain medication? On the other end, a participant who clearly winced during the physical exam was revealed to have only placed her pain via VAS as a three.

The D’Agostino and D’Agostino modified scores were significantly correlated to both the pain history by limb and combined. However, only the combined scores for each of these were predictive of the dependent VAS scores. The D’Agostino modified was slightly more significant for each statistical evaluation and this is likely due to the D’Agostino scoring being specific to enthesitis in spondylarthritis (D’Agostino, 2009),
whereas the modified scoring attempts to capture more general ankle/foot abnormalities, such as trauma. Currently, this scoring system would only be useful for evaluating the patient as a whole and refining of this evaluation would be needed to access a patient per symptomatic limb.

While the ultrasound evaluation provided holistic predictive information, the commonly seen holistic trigger point evaluation provided predictive information per each limb via palpable triggers although not combined. Furthermore, the sonography triggers only provided predictive information in the right limb. Again, the pain status of the right limb and number of right vs. left painful limbs likely attributes to this phenomenon. While this was an overall sample, the consistency with which the MTrPs align (and/or outperform) statistically with other predictive tests, notably the physical SF-12, warrants a closer look at the importance of these often overlooked sources of pain, specifically in the ankle and foot.

Clearly, from the linear regressions, the VISA-A provided the most predictive correlation with the VAS; accounting for nearly 60 percent of the difference in the right limb, 45 percent in the left and almost 55 percent overall. While the physical SF-12 accounted for only 20 percent of the VAS variation, with an $R^2$ of .2 in the right limb and nearly 10 percent overall, there are still statistically significant predictors, so regardless of the low correlation coefficient the mean change shows a response in the predictor and this information could be very valuable from a clinical standpoint.

While this study hopes to be a springboard for a holistic evaluation within a clinical setting, it would be the combination of these salient variables, which could provide the most valuable information. In a recent review on foot pain, Hawke and
Burnes (2009), state, “it is important to recognise that foot pain is not the noxious-stimuli-induced activity in the nociceptive pathways, but rather the perception of these processes and the consequent effects on suffering and pain-related behavior.” (p. 2) This reminds us that the perceived patient pain comes first and therefore, the self-reported pain, via history and VAS are critical and should remain the center of the clinician’s exam. If this study were to be repeated the independent variables, which would be most helpful, include the VISA-A, palpable MTrPs, modified D’Agostino scoring, and physical SF-12.

As earlier stated most of the guidelines are based on research studies and are specific to pathology, it is not surprising then that most of the previous studies regarding ankle/foot sonography focus on specific pathologies. One small cohort of 17 athletes and two controls evaluated synovitic lesions concluding that abnormal antero-lateral soft tissue does not necessarily mean a person is symptomatic. Only synovitic lesions greater than 10 mm were associated with symptoms. (McCarthy, Wilson, & Coltman, 2007) Our cohort is similar in that we had a subset of professional dancers, however, we were able to use the combination of diagnostic techniques to better classify our participants.

Next, another study by Kainberger et al. (1990) evaluated a cohort of 73 symptomatic and 24 asymptomatic participants reporting Achilles tendon pain, finding abnormal sonographic features in 53 patients (sensitivity, 0.72; specificity, 0.83), with the extent of structural disorders of the tendon properly assessed; finding, “tendon swelling (45%), abnormal tendon structure (42%), rupture (15%), and peritendinous lesions (47%).” However, “No changes were detected in low-grade disease of short duration, which suggests symptoms caused by functional disorders.” (pg. 1031) Although this
study did not detect acute injuries, this could be due to the age of the equipment and lack of using a combination of techniques that are now available at this time. The use of trigger points, sonographic image analysis, and self-reported history has the ability to triangulate the data and potentially increase the overall sensitivity of the individual diagnostic examination.

Limitations of this study included convenient sample and a single examiner for both scanning and sonogram evaluation. Future studies would fare better to do a match-controlled design and have multiple raters, including a radiologist, with strong inter-rater reliability. It would be interesting for future studies to include a longitudinal component to compare self-reported pain to the significant independent variables before and after interventions from inter-disciplinary teams to evaluate how these independent variables, such as trigger status and sonographic features, change with the hoped improved ankle/foot pain.

**Conclusion**

This study was an innovative approach to ankle/foot pain with the use of a hand-carried ultrasound unit (HCU) and provided a clearer picture for future holistic screening with this modality. Results of this study indicate an HCU can contribute to the holistic diagnostic work-up for patients with ankle/foot pain. However more rigorous and focused studies, utilizing the salient variables found here, would be highly suggested.
Chapter 5: Proposing a movement toward a Homeostatic (Yin Yang) Biopsychosocial Model

The Tao is the One.
From the One come yin and yang;
From these two, creative energy (chi);
From energy, ten thousand things,
The forms of all creation.
All life embodies yin And embraces yang,
Through their union Achieving harmony.

- Tao Te Ching (Dreher translation), Chapter 42

Ankle/foot pain is a complex multi-factorial problem. Yet, the results of this study do not necessarily support a psychological or mental component, as the biopsychosocial model would suggest. Likewise, a study done on department store saleswomen in Thailand, found no significant relationship between psychosocial factors and lower extremity symptoms (Pensri, Janwantanakul, & Chaikumarn, 2010). The authors discussed, however, that psychosocial discrepancies were found in other studies, may point to differences between Asian and western cultures, with more societal pressure and stress being prevalent in the western world. While these are just a few examples where the psychosocial element is not evident, it does not belie the whole biopsychosocial model. In fact, it strengthens the idea that context and culture are vitally important and must be taken into consideration in patient care.
This set of results, from a cohort of participants, appears to only provide support for pain being more attributed to the physical/biological tenant of the biopsychosocial model. Sifting further through the data, there was a tendency to try and make connections with pain being attributed to one leg. In a quantitative sense this may have been a valid analysis however a patient is more than one extremity. A patient in pain is more than the sum of their parts. As was stated in Chapter 1, the biopsychosocial model can be viewed as a tripod and all of the “legs” must support the model. Likewise patients’ pain does not emanate from standing on one leg. The independent variables chosen had limited predictive power however these were somewhat subjectively chosen. Choosing a theoretical model requires testing a variety of representative variables and having a convincing statistical power analysis. This set of studies can only be seen as an initial attempt to better understand what supports/contributes to ankle/foot pain. The qualitative portions of this thesis trouble the notion that patients can be analyzed in an anonymous fashion. Many of our participants were professional dancers who have had to make significant adjustments to their performance and pursuit of excellence. Dancing requires the use of BOTH legs and a creative spirit that is enacted through their bodies. The biopsychosocial model would cast these participants as having to balance their persistent pain, when dancing, against the psychological and psychosocial domains. Data collected in this study would depict this subgroup of participants as having physical and mental health scores that are comparable to most US participants. This leaves a rather incomplete picture of the contributions of their modified career in dance and would also suggest that they are psychologically rather “average”. Although this set of studies does support the contribution of hand-carried sonography, as a means to predict whether a
participant is symptomatic of ankle/foot pain, more research is needed. To further explore
the power of the “tripod” of the biopsychosocial model, a randomized control trial of
participants that has the statistical power could provide higher level supportive evidence.

One suggestion for a future targeted biopsychosocial study on ankle/foot pain may
include the use of the long form SF-36, as the short form SF-12 may not have captured
elements specific to our population’s psychosocial health. Also, a larger cohort would be
ideal. Furthermore, a more complete history including medications, health insurance,
language barriers, and income or social status may be helpful to better identify these
psychosocial elements which were not a part of this study.

As with any proposed model, improvements can always be suggested and the idea
of balance that allows for a continual adjustment within in the current model such that
persistent pain is mediated by a rebalancing of influence of psychological, psychosocial,
and other factors. The idea that a tripod can be upright although one leg is longer or
shorter is not tenable. The use of achieving balance or rebalancing the factors that are
contributing to persistent pain is a worthwhile endeavor.

Where the biopsychosocial model seems to fall short is in its clinical application,
especially among allied medical health care professions. Since these professionals are
relegated to an axillary role in the medical system, they do not have the luxury of
directing and coordinating care – this is left up to the physician. So I would propose a
balanced Homeostatic Model of Health, based on the commonly used holistic model of
knowledge – the yin yang. The focus is on health and not illness, it is looking at the entire
individual you are providing care to and realizing what you are providing is an important
piece of the puzzle. But it also means recognizing the ‘other’ the opposing unknown
about an individual and keeping judgment aside. The focus is balance, recognizing your
counterpoint in the patient. It is about connecting.

The yin yang was chosen because it immediately brings to mind a holistic
approach. Furthermore, it is a representation for how the universe works. The yin yang
can be applied across many natural states from day and night, to seasons and even social
interactions. The yin yang’s circular shape represents the universe and all that is within it.
The yang is the white side with a black dot and the yin is the black side with a white dot.
The curves of the yin yang symbol imply a kaleidoscope-like movement. So this is not a
fixed placement, but fluid and allows for blurring of the paradigm lines. The major
associations of yang are white, male, positive, active, sun, logical, hot, and hard. On the
other hand, yin’s associations are opposite: black, female, passive, intuitive, moon, cold,
and soft. Often in our western perception of things, we associate wrongly yang with good
and yin with bad. But this is a misguided notion, as the yin yang parts are mutually
arising and interdependent; one could not exist without the other, for each contains the
essence of the other.

If we place the two positivist and post-positivist paradigms, generally in two
categories, we see the positivist landing in the camp of yang and the post-positivists
(including constructivism, critical theory and post-structuralism) in the area of yin. The
post-positivist push is a natural reaction to the overly positivist dominance in research – it
seeks to stabilize the knowing and understanding of information. However, it is important
to keep in mind this is a fluid continuum with constant change.
While placed, for symbolic purposes, the positivists in the yang category and the post-
positivists in the yin category, from a strictly elemental level it is quite the opposite. As
stated the whole circle represents the universe - now apply modern physics. Material (yin) is created out of gravitational force (yang). Material is solid, fact, measurable – it could be argued as a positivist notion, born out of yang, the unseen gravitational force at work; or in the sciences we may say it is the human connections, the subtle underpinnings, through which we can see through our ontological and epistemological positions.

Merging the yin/yang with the biopsychosocial model would allow for a true mixed model assessment of patients dealing with persistent ankle/foot pain on a daily basis. The proposed modification would look something like the diagram below. Placing the yin/yang symbol at the center of the model speaks to the continuous balancing and rebalancing the factors that are causing persistent pain. Further research into selecting salient variables that supports or refutes the base model will only be further enhanced by viewing this as a “rebalancing act”.
Figure 5.1 Homeostatic (Yin Yang) Biopsychosocial Model

Considering our participants who were professional dancers, this modification makes better sense of their rebalancing the psychological and psychosocial pressures that stem from ankle foot injuries that have altered their careers. Further testing of this modified model is highly encouraged. Future studies may benefit participants most by evaluating specific cohorts, such as dancers, allowing a more focused and situated view of their ankle/foot pain. A systematic review entitled, “Musculoskeletal Injury and Pain in Dancers,” (Hincapié, Morton, & Cassidy, 2008) concludes that MSK pain is an important health issue for all dancers, yet the resulting disability and health related quality of life is still unclear. Furthermore, the studies on the diagnosis and prognosis of this cohort are lacking current scientific standards.

The proposed modification to the biopsychosocial model for pain has ramifications for health care workers. In the near future, health care workers will be
dealing with personalized medicine. In this new model, however, personalized medicine moves beyond the biomedical research of genes, into the realm of environment, this is the other player in the cause of gene dysfunction/disruption and ultimately illness. The environment (arguably the psychosocial) is the yang to the genetic yin. Systems biology is attempting to answer how to embrace human complexity and variability in personalized medicine. Naylor & Chen (2011) in an NIH article on systems biology, state, “We all believe that the current practice of healthcare is broken.” (p. 13) Furthermore, a more “patient-centric” model is necessary.

Adopting this perspective goes beyond the detached observer and requires allied health professionals to become more engaged, and having a relationship centered approach. Power and emotion in the clinical relationship goes beyond getting the correct diagnosis, it is about allowing the patient to articulate their concerns and expectations, as well as exhorting a human face from the person providing their care. This egalitarian relationship makes the clinician more aware and careful of their power. (Borrell-Carrió, Suchman, & Epstein, 2004) Ultimately, this genuineness is also cultivating patient-provider trust.

Adoption of the proposed modification of the model to include a balancing of influential factors (yin & yang) could also suggest that the process of diagnostic work-up be reimagined. To capture the multifaceted influences contributing to persistent pain would mean relooking at the roles of patient and provider. A health care provider may consider themselves the white yang, while the patient represents the black or yin. The known self, versus the other. The relationship is equal, though we may not completely know the opposite side, as it is hidden from us, we can use what we know about
ourselves to know the other. “Know thyself” may not be all about self-knowledge. Perhaps the more we know about ourselves, ultimately, the more we know about others.
References


comparison of ultrasound and conventional, short and ultrashort echo time MRI with and without intravenous contrast. *European radiology*, 21(6), 1144-1152.


Turchaninov, R. & Prilutsky, B. Science of Medical Massage: Science of Trigger Point Therapy. Part III. Retrieved from


Appendix A: Study Flyer
Volunteers Needed for a Study on Ankle/Foot Pain

**Who:** Adults between the ages of 18-65 may be eligible to participate in this study. Symptomatic and asymptomatic participants are needed.

**What:** You will participate in an evaluation where you will:
1. Complete a questionnaire on your general health and ankle pain.
2. Have an ultrasound of both ankles/feet.
3. Have an assessment of pressure points on both lower extremities. This involves simple palpation of certain areas on the calf, ankle and foot.

*Total testing time should be less than 1 ½ hours*

*You will be compensated for participating*

**Where:** Laboratory for Investigatory Imaging (243D Atwell Hall)

**Why:** This information will help us assess the usefulness of a hand-carried ultrasound unit in evaluating ankle/foot pain.

**For more details, or to apply for this study please contact:**

Dr. Kevin Evans  
evans.36@osu.edu  
614-688-4535
Appendix B: Consent Form
The Ohio State University Consent to Participate in Research

Study Title: Screening Sonography of the Ankle/Foot to Link Pain with Pathology

Principal Investigator: Kevin Evans, PhD

Sponsor:

- **This is a consent form for research participation.** It contains important information about this study and what to expect if you decide to participate. Please consider the information carefully. Feel free to discuss the study with your friends and family and to ask questions before making your decision whether or not to participate.

- **Your participation is voluntary.** You may refuse to participate in this study. If you decide to take part in the study, you may leave the study at any time. No matter what decision you make, there will be no penalty to you and you will not lose any of your usual benefits. Your decision will not affect your future relationship with The Ohio State University. If you are a student or employee at Ohio State, your decision will not affect your grades or employment status.

- **You may or may not benefit as a result of participating in this study.** Also, as explained below, your participation may result in unintended or harmful effects for you that may be minor or may be serious depending on the nature of the research.

- **You will be provided with any new information that develops during the study that may affect your decision whether or not to continue to participate.** If you decide to participate, you will be asked to sign this form and will receive a copy of the form. You are being asked to consider participating in this study for the reasons explained below.

1. Why is this study being done?

   This is a pilot research study that will evaluate the usefulness of a hand-carried ultrasound unit to screen for ankle/foot pain.

2. How many people will take part in this study?

   50 total participants will be taking part in this study.

3. What will happen if I take part in this study?
You will be requested to complete a questionnaire on their general health and ankle/foot pain. Afterwards the researcher will perform a bilateral exam of the ankle/foot with sonography. Finally, pressure points of this region will be simply palpated and you will be asked if it elicits any pain or not.

4. **How long will I be in the study?**

   This is a one-time session, which will last up to one and a half hours total.

5. **Can I stop being in the study?**

   You may leave the study at any time. If you decide to stop participating in the study, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled. Your decision will not affect your future relationship with The Ohio State University.

6. **What risks, side effects or discomforts can I expect from being in the study?**

   Ultrasound has no known bioeffects, i.e. any known human risks or side effects. You may only feel slight discomfort if the researcher palpates an active trigger point. There may also be a little discomfort in positioning of your foot/ankle in the case you are currently experiencing foot pain. The researcher, however, will try to make you as comfortable as possible and will ask you if you need to reposition your body.

7. **What benefits can I expect from being in the study?**

   In addition to adding to scientific knowledge on the use of musculoskeletal ultrasound, you will be compensated upon completion of the study with a $25 Kroger gift card.

8. **What other choices do I have if I do not take part in the study?**

   You may choose not to participate without penalty or loss of benefits to which you are otherwise entitled.

9. **Will my study-related information be kept confidential?**

   Efforts will be made to keep your study-related information confidential. However, there may be circumstances where this information must be released. For example, personal information regarding your participation in this study may be disclosed if required by state law.
Also, your records may be reviewed by the following groups (as applicable to the research):

- Office for Human Research Protections or other federal, state, or international regulatory agencies;
- U.S. Food and Drug Administration;
- The Ohio State University Institutional Review Board or Office of Responsible Research Practices;
- The sponsor supporting the study, their agents or study monitors; and
- Your insurance company (if charges are billed to insurance).

If this study is related to your medical care, your study-related information may be placed in your permanent hospital, clinic, or physician's office records. Authorized Ohio State University staff not involved in the study may be aware that you are participating in a research study and have access to your information.

A description of this clinical trial will be available on http://www.ClinicalTrials.gov, as required by U.S. law. This website will not include information that can identify you. At most, the website will include a summary of the results. You can search the website at any time.

You may also be asked to sign a separate Health Insurance Portability and Accountability Act (HIPAA) research authorization form if the study involves the use of your protected health information.

10. What are the costs of taking part in this study?

There are no costs to participants for taking part in this study.

11. Will I be paid for taking part in this study?

By law, payments to subjects are considered taxable income. You will not be paid money for this study, instead you will be compensated upon completion of the study with a $25 Kroger gift card.

12. What happens if I am injured because I took part in this study?

If you suffer an injury from participating in this study, you should notify the researcher or study doctor immediately, who will determine if you should obtain medical treatment at The Ohio State University Medical Center.

The cost for this treatment will be billed to you or your medical or hospital insurance. The Ohio State University has no funds set aside for the payment of health care expenses for this study.
13. What are my rights if I take part in this study?

If you choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights you may have as a participant in this study.

You will be provided with any new information that develops during the course of the research that may affect your decision whether or not to continue participation in the study.

You may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled.

An Institutional Review Board responsible for human subjects research at The Ohio State University reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

14. Who can answer my questions about the study?

For questions, concerns, or complaints about the study you may contact Kevin Evans, PhD, evans.36@osu.edu, 340 Atwell Hall 453 West 10th Avenue, Columbus, OH 43210, (614) 688-4535.

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.

If you are injured as a result of participating in this study or for questions about a study-related injury, you may contact Kevin Evans, PhD, evans.36@osu.edu, 340 Atwell Hall 453 West 10th Avenue, Columbus, OH 43210, (614) 688-4535.
164 Signing the consent form
165
166 I have read (or someone has read to me) this form and I am aware that I am being asked to
167 participate in a research study. I have had the opportunity to ask questions and have had them
168 answered to my satisfaction. I voluntarily agree to participate in this study.
169
170 I am not giving up any legal rights by signing this form. I will be given a copy of this form.
171

Printed name of subject

Signature of subject

Date and time

AM/PM

Printed name of person authorized to consent for subject
(when applicable)

Signature of person authorized to consent for subject
(when applicable)

Date and time

AM/PM

Relationship to the subject


Investigator/Research Staff

176 I have explained the research to the participant or his/her representative before requesting the
177 signature(s) above. There are no blanks in this document. A copy of this form has been
to the participant or his/her representative.
180

Printed name of person obtaining consent

Signature of person obtaining consent

Date and time

AM/PM

Witness(es) - May be left blank if not required by the IRB

182 Printed name of witness

Signature of witness

Date and time

AM/PM

Printed name of witness

Signature of witness

Date and time

AM/PM
Appendix C: Participant questionnaire
Screening Sonography of the Ankle/Foot to Link Pain with Pathology

QUESTIONNAIRE

As a participant in this study, your answers to this questionnaire are important. All answers will be kept confidential and secure.

This questionnaire is divided into three sections. We ask you complete each section fully and answer every question. Please do not skip any questions. The questions pertain only to your current status, and pain levels. Furthermore, we ask for your honesty and first intuitive response. Do not spend time deliberating over these questions.

If you are unsure of how to answer a question, please give the best answer and make a written comment beside your answer. Thank you.
Section 1: Answer the following questions by placing a check mark on the line in front of the appropriate answer. This section is not specific to ankle or foot pain.

1. In general, would you say your health is:
   - Excellent (1)
   - Very Good (2)
   - Good (3)
   - Fair (4)
   - Poor (5)

The following two questions are about activities you might do during a typical day. Does YOUR HEALTH NOW LIMIT YOU in these activities? If so, how much?

2. MODERATE ACTIVITIES, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf:
   - Yes, Limited A Lot (1)
   - Yes, Limited A Little (2)
   - No, Not Limited At All (3)

3. Climbing SEVERAL flights of stairs:
   - Yes, Limited A Lot (1)
   - Yes, Limited A Little (2)
   - No, Not Limited At All (3)

During the PAST 4 WEEKS have you had any of the following problems with your work or other regular activities AS A RESULT OF YOUR PHYSICAL HEALTH?

4. ACCOMPLISHED LESS than you would like:
   - Yes (1)
   - No (2)

5. Were limited in the KIND of work or other activities:
   - Yes (1)
   - No (2)

During the PAST 4 WEEKS, were you limited in the kind of work you do or other regular activities AS A RESULT OF ANY EMOTIONAL PROBLEMS (such as feeling depressed or anxious)?

6. ACCOMPLISHED LESS than you would like:
   - Yes (1)
   - No (2)

7. Didn’t do work or other activities as CAREFULLY as usual:
   - Yes (1)
   - No (2)
8. During the PAST 4 WEEKS, how much did PAIN interfere with your normal work (including both work outside the home and housework)?
   ___ Not At All (1)
   ___ A Little Bit (2)
   ___ Moderately (3)
   ___ Quite A Bit (4)
   ___ Extremely (5)

The next three questions are about how you feel and how things have been DURING THE PAST 4 WEEKS. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the PAST 4 WEEKS –

9. Have you felt calm and peaceful?
   ___ All of the Time (1)
   ___ Most of the Time (2)
   ___ A Good Bit of the Time (3)
   ___ Some of the Time (4)
   ___ A Little of the Time (5)
   ___ None of the Time (6)

10. Did you have a lot of energy?
    ___ All of the Time (1)
    ___ Most of the Time (2)
    ___ A Good Bit of the Time (3)
    ___ Some of the Time (4)
    ___ A Little of the Time (5)
    ___ None of the Time (6)

11. Have you felt downhearted and blue?
    ___ All of the Time (1)
    ___ Most of the Time (2)
    ___ A Good Bit of the Time (3)
    ___ Some of the Time (4)
    ___ A Little of the Time (5)
    ___ None of the Time (6)

12. During the PAST 4 WEEKS, how much of the time has your PHYSICAL HEALTH OR EMOTIONAL PROBLEMS interfered with your social activities (like visiting with friends, relatives, etc.)?
    ___ All of the Time (1)
    ___ Most of the Time (2)
    ___ A Good Bit of the Time (3)
    ___ Some of the Time (4)
    ___ A Little of the Time (5)
    ___ None of the Time (6)
Section 2: For this portion of the questionnaire, please mark your answers within the corresponding box, using a capital R to indicate the right foot and a capital L to indicate the left foot. You may have R/L in one box if appropriate to the pain in both feet.

13. For how many minutes do you have stiffness in the Achilles region on first getting up?

100 Min. [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] 0 Min.

0 1 2 3 4 5 6 7 8 9 10

14. Once you are warmed up for the day, do you have pain when stretching the Achilles tendon fully over the edge of a step? (keeping knee straight)

strong pain [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] no pain

0 1 2 3 4 5 6 7 8 9 10

15. After walking on flat ground for 30 minutes, do you have pain within the next 2 hours? (If unable to walk on flat ground for 30 minutes because of pain, score 0 for this question).

strong pain [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] no pain

0 1 2 3 4 5 6 7 8 9 10

16. Do you have pain walking downstairs with a normal gait cycle?

strong pain [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] no pain

0 1 2 3 4 5 6 7 8 9 10
17. Do you have pain during or immediately after doing 10 single leg heel raises from a flat surface?

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18. How many single leg hops can you do without pain?

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19. Are you currently undertaking sport or other physical activity?
   _____ Not at all
   _____ Modified training or modified competition
   _____ Full training or competition but not at same level as when symptoms began
   _____ Competing at the same or higher level as when symptoms began

20. Please complete EITHER A, B or C in this question. (For the purpose of this study, sport is widely defined. It may include sports such as volleyball, running, Pilates, kickball, Jazzercise, tennis, soccer, yoga etc.)

   • If you have no pain while undertaking Achilles tendon loading sports please complete Q20a only.
   • If you have pain while undertaking Achilles tendon loading sports but it does not stop you from completing the activity, please complete Q20b only.
   • If you have pain that stops you from completing Achilles tendon loading sports, please complete Q20c only.

A. If you have no pain while undertaking Achilles tendon loading sports, for how long can you train/practice?
   _____ 0 min   _____ 1-10 mins   _____ 11-20 mins   _____ 21-30 mins   _____ >30 mins   _____ N/A

   OR
B. If you have some pain while undertaking Achilles tendon loading sport, but it does not stop you from completing your training/practice for how long can you train/practice?
   ____ 0 min ____ 1-10 mins ____ 11-20 mins ____ 21-30 mins ____ >30 mins ____ N/A

OR

C. If you have pain that stops you from completing your training/practice in Achilles tendon loading sport, for how long can you train/practice?
   ____ 0 min ____ 1-10 mins ____ 11-20 mins ____ 21-30 mins ____ >30 mins ____ N/A

Section 3: Please answer the following questions:

21. Overall, how would you rate your RIGHT ankle/foot pain? Please mark or circle the corresponding number on the scale below.

   ![Rating Scale]

   10 9 8 7 6 5 4 3 2 1 0

   Unbearable Distress    No Distress

22. Overall, how would you rate your LEFT ankle/foot pain? Please mark or circle the corresponding number on the scale below.

   ![Rating Scale]

   10 9 8 7 6 5 4 3 2 1 0

   Unbearable Distress    No Distress
23. What sports do you currently participate in?

24. How many times/hours per week? 

25. What sports did you participate in the past?

26. How many times/hours per week? 

27. If you are experiencing any foot/ankle pain currently, please describe.

28. Have you had any surgeries on either your ankle or foot? Yes No

If yes, please describe

29. Have you gone through any treatments for your current ankle/foot pain?

Yes No N/A

If yes, please describe (reflexology, injections, acupuncture, massage)

30. What is your age? 

31. What is your gender? 

32. What is your current occupation? 

33. Is your position full-time or part-time? 

Thank you!