An Epidemiological Observation: Non-Contact Anterior Cruciate Ligament Injury Risk Prediction Using Functional Movement Screen™ and Knee Abduction Moment: A Dissertation of Clinical Practice Improvement

A Dissertation

Presented in Partial Fulfillment of the Requirements for the

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by

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AUTHORIZATION TO SUBMIT DISSERTATION

This dissertation of Scott Landis, submitted for the degree of Doctor of Athletic Training with a Major in Athletic Training and titled "An Epidemiological Observation: Non-Contact Anterior Cruciate Ligament Injury Risk Prediction Using Functional Movement Screen™ and Knee Abduction Moment: A Dissertation of Clinical Practice Improvement," has been reviewed in final form. Permission, as indicated by the signatures and dates below, is now granted to submit final copies to the College of Graduate Studies for approval.

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ABSTRACT

The Dissertation of Clinical Practice Improvement (DoCPI) is a comprehensive document that is completed in the Doctor of Athletic Training (DAT) Program. The DoCPI serves to support the clinician's achievement towards an Advanced Practice (AP) in athletic training. The clinician's achievement of AP is evidenced by a Plan of Advanced Practice (PoAP), which includes an in-depth analysis of the clinician's clinical competence (strengths and weaknesses), professional goals, and a plan for the achievement of those goals. The DoCPI also includes a critical and reflective analysis of patient outcomes data that were collected during the clinician's residency. This analysis provides the clinician with the justification necessary to make changes in his or her clinical practice that result in improved patient care. Such improvement is demonstrated through reflective journaling, improved patient outcomes, and intelligence gleaned from an original applied clinical research investigation. This dissertation contains such an investigation; in particular, an epidemiological observation of non-contact lower extremity injury risk prediction using the Functional Movement Screen™ and knee abduction moment. A thorough review of the literature on this topic (in particular, on anterior cruciate ligament injury risk) and a consideration of movement quality to identify at-risk individuals both provide rationale for the investigation and are further evidence of the clinician's path toward AP.

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DEDICATION

I would like to dedicate my dissertation work to my parents and friends, all of whom dealt with my absence while I devoted my attention to successfully completing this dissertation of clinical practice improvement. I look forward to investing more time with you.

TABLE OF CONTENTS

CHAPTER 1

NARRATIVE SUMMARY

Post-professional Education (PPE) and the Doctor of Athletic Training (DAT) Program

In 2003, the National Athletic Trainers' Association (NATA) adopted guidelines that required individuals to complete an accredited athletic training (AT) education program for Board of Certification exam eligibility (National Athletic Trainers' Association, 2003). Once the NATA established the guidelines for professional AT education programs (formerly known as entry-level AT programs), post-professional education (PPE) programs in AT became the advanced degree available to athletic trainers. These programs provided athletic trainers with a clinical degree beyond the entry-level (bachelors) AT degree and introduced students to a level of education that emphasized critical thinking and a theory-based understanding of AT principles. Current PPE programs in AT continue to challenge students to further their scholarship (Willis, Inman, & Valenti, 2010), develop their critical thought processes—including their ability to scrutinize any and all clinical decisions—and gain a deeper understanding of clinical practices. The AT degree level requirements for becoming an entry-level athletic trainer, however, have changed from a bachelor's degree to a master's degree.

On May 20, 2015, the Strategic Alliance, which is a committee comprised of stakeholders within athletic training, announced that a master's degree will be the new minimum standard of education required for an individual to become an entry-level certified athletic trainer ("Standard for Athletic Training Degree and Implementation Timeline," 2015). The Commission on Accreditation of Athletic Training Education (CAATE) recently drafted a proposal, scheduled to become effective in the fall of 2022, which states that an athletic trainer can only be eligible for the BOC exam if he or she has completed a CAATE accredited program in AT at the master's degree level. With this change comes the possibility that the 15 masters-level post-professional education programs in AT that currently exist will be eliminated.

The University of Idaho doctor of athletic training (DAT) program is a post-professional education program that promotes scholarship and original research as means by which to advance in one's clinical, professional practice (Nasypany, Seegmiller, & Baker, 2012). Advancement is demonstrated through critical reflection, a clinical residency, the creation of a plan of advanced practice (PoAP), and the completion of a dissertation of clinical practice improvement (DoCPI). Completion of the DAT program indicates progression towards advanced practice in AT.

Elements of the DoCPI

The DoCPI, which is the culminating project in the DAT program, is developed over the course of two years and introduces issues or problems in professional practice that are then addressed through action research as well as the development of a PoAP, the collection and analysis of patient outcomes in residency, and the application of clinical research. Action research takes the "real-world" issue or problem identified by the clinician and attempts to solve it through clinical action, followed by reflection on the action's outcome (Parkin, 2009). Action research is not limited to particular clinical contexts, such as when a clinician attempts to identify an optimal treatment paradigm for a specific patient; rather, it is a holistic view of all facets of one's professional practice that is, ideally, then shared with others. Self-reflection, which leads to self-awareness, is often a part of action research. McNiff (2013) said, "...[I]t is important to remember that there is no such 'thing' as 'action research.' It is a form of words that refers to people becoming aware of and making public their processes of learning with others, and explaining how this informs their practice." Action research also informs each element of the DoCPI through the promotion of change that is useful for specific patient populations. The DoCPI includes a plan for advanced clinical practice, a summary of individual clinical outcomes data and the related reflection on patient care, a review of the literature related to the original clinical research project, and an original applied clinical research manuscript.

Plan of Advanced Practice

Advanced practice in AT involves the selection of focused areas of clinical practice, the evaluation of one's clinical strengths and weaknesses through critical reflection (Nasypany, Seegmiller, & Baker, 2012). All doctoral candidates in the DAT program create and frequently update a Plan of Advanced Practice (PoAP) that addresses and outlines goals for each of the aforementioned tasks. The PoAP goals are intended to confront the student's weaknesses and advance the student toward his or her selected area of advanced practice. Each PoAP is unique, because each student's strengths and weaknesses in knowledge, treatment, evaluation, diagnosis, and research, vary. My PoAP includes a specific and measureable representation of how I have, and plan to continue accomplishing my goals towards an advanced practice in AT. My PoAP is provided in Chapter 2 of this dissertation.

After two years in the DAT program, I have come to fully embrace the changes in my professional development that were necessary for me to advance my practice in AT. When I consider the professional settings in which I may find myself in the future, I am uncertain if I will continue to pursue a long-term career in academia. As I have progressed in the DAT program toward advancement in AT, my interest in returning to a clinic-focused position has been renewed. I have become particularly interested in lower extremity (LE) injury risk prediction and have chosen this subject, particularly non-contact ACL injury risk in active female populations, as my area of advanced practice. My PoAP (Chapter 2) provides detail regarding how I have achieved and will continue to develop advancement in this area.

Summary of Clinical Residency

The DAT's two-year residency in patient care allows each student the opportunity to be mentored by an attending clinician (AC) and program faculty while he or she applies recently learned treatment methods, collects patient outcomes, and reflects on patient care. In keeping with the principles of action research, the dialogue that ensures between the DAT student and the AC is reflective in nature. The residency is an essential component of the DAT program because it provides each student with a patient population that is unique to his or her practice.

Development of scholarship and implementation of new treatment methods.

Although scholarship is promoted and developed in most doctoral programs, the DAT program also emphasizes the dissemination of newly acquired knowledge. The base of literature in AT grows as knowledge is shared through scholarly avenues (publications and professional presentations). Once a clinician has been exposed to new evidence and information, that clinician may then consider integrating what he or she has learned into his or her own practice. As the clinical practices are implemented into a clinician's patient care, he or she tests the new evidence using outcomes measures. Unless current evidence exists to support the continued use of a particular intervention, clinicians risk creating habitual patterns when they overuse that treatment intervention. Clinicians should use evidence in the form of scholarly research and patient outcomes data to provide rationale for the decisions they make.

Evidence-based practice (EBP) demands the practical incorporation of data that has been acquired through various forms of research. Continued evaluation, analysis, and acceptance of potential changes in patient care challenge EBP in a positive way. As clinicians collect their own evidence, they strengthen or disprove previous findings (results). Clinical and patient-oriented outcomes help produce practice-based evidence (PBE) that, in turn, may lead to EBP.

Collection of patient outcomes.

The collection of patient outcomes data occurs during the clinician's two-year residency. The outcomes data serves as evidence that helps guide clinical decision-making. Oates, Weston, and Jordan (2000) observed that clinical outcomes are impacted by the implementation of patient-centered care (PCC), or care that places emphasis on the needs of the patient (Robinson, Callister, Berry, & Dearing, 2008). Oates, Weston, and Jordan (2000) also learned that patients recovered faster and felt emotionally better when they knew their care was patient-centered. When a patient embraces PCC, he or she becomes part of the rehabilitative process, which leads to higher adherence to a treatment plan (Robinson et al., 2008). When a treatment plan is followed, the resulting patient-oriented outcomes serve as meaningful data that can be used to inform future patient treatment plans.

Before entering the DAT program, I worked as an athletic trainer for 11 years without properly collecting patient outcomes; therefore, changing my methods to incorporate outcomes collection did not happen overnight. However, from halfway into the Fall 2013 semester and through Spring and Fall 2014, I collected patient outcomes for interventions I provided and tracked these outcomes using scales (discussed in Chapter 2) that supplied me with data. My collection of patient outcomes data afforded me with an opportunity to progress towards advanced clinical practice, in that it allowed me to make comparisons between particular dysfunctions and treatments, which, in turn, facilitated the implementation of a plan (an *a priori* design) to address treatments that I had identified as “unsuccessful.” The outcomes data presented in Chapter 3 represent my first attempt to improve as a clinician through EBP.

Critical self-reflection on patient care.

Critical self-reflection is a process that involves analyzing the presuppositions on which ones beliefs were built (Mezirow, 1990). Brookfield (1990) describes the process of critical self-reflection in three phases: 1) identifying the assumptions, 2) assessing the validity of the assumptions, and 3) transforming the assumptions to become more integrative and using the newly formed knowledge to better inform future practices. The “assumptions” Brookfield mentioned are considered to be any clinical practice that is not supported by literature (i.e. not considered EBP). Health care professions found to benefit from reflective practice include nursing (Paget, 2001), physiotherapy (Ladyshewsky & Gardner, 2008), occupational therapy (Schell & Cervero, 1993), and athletic training (J. Parker & Pitney, 2003; Radtke, 2008). Clinical reflective practice can take different forms and may be defined differently, depending on the profession or context of the reflection (Eva & Regehr, 2005). Epstein (1999) illustrates the intention of the reflective process as follows:

> …[C]ritical self-reflection enables practitioners to listen attentively to patients' distress, recognize their own errors, refine their technical skills, make evidence-based decisions, and clarify their values so that they can act with compassion, technical competence, presence, and insight. (Epstein, 1999, p. 839)

Epstein further emphasizes that practitioners should be mindful in their practice, and that reflective practice allows explicit knowledge to be gained, quantified, and easily translated to evidence-based guidelines (Epstein, 1999).

Prior to the DAT program, I had not utilized reflection in my practice beyond observing the short-term effects of the treatments I provided (e.g., improvements in muscle function, range of motion, and patient-specific functional ability; and reduction in inflammation: pain, redness, swelling, heat, and/or loss of function). Because I focused my treatments on my patients' inflammatory symptoms, I potentially limited their bodies' own tissue healing responses. For example, by applying a cold modality to the inflamed tissue, I reduced blood flow to the injured area, thereby limiting the necessary delivery of white blood cells to repair the damaged tissues.

As I began to incorporate Epstein's view on reflective practice into my own patient care philosophy and started to record my decisions through online journaling, I became more aware of the positive and negative changes that my patients were experiencing. These changes included shortened length of daily treatments, increased patient satisfaction, and faster recovery times. My DAT cohorts and I shared our journal entries among ourselves and with the program faculty, and the resulting dialogue helped to guide me toward an advanced path of professional practice. In keeping with Brooksfield's (1990) steps for performing critical self-reflection, the DAT faculty reminded me to challenge the presuppositions I had made regarding the effectiveness of my chosen treatments. As meaningful self-reflection took place, I began to question why I chose one treatment method over another. I realized that my perspective on patient care was, in essence, one-sided. I had only considered *my* perspective on the patient's dysfunction. My awareness led me to take a more holistic and patient-centered approach to patient care. The transformation that I made in my approach was the hallmark benefit of my critical reflective writing experience.

Overview of Literature Review

While in my clinical residency, I noticed that my active female athletic patient population had an uncommonly high incidence of non-contact lower extremity injuries, in particular, anterior cruciate ligament (ACL) injuries. The identification of this problem led me to choose lower extremity injury risk assessment and prediction as my area of advanced practice. Chapter 4 of this dissertation contains a review of literature that deals with this topic.

Athletic female populations possess a four to six times greater likelihood of ACL injuries than males (Hewett et al., 2005; Lohmander, Englund, Dahl, & Roos, 2007). The future risk of osteoarthritis after an ACL injury is 50-100%, regardless of whether surgical intervention takes place (Lohmander et al., 2007; Meunier, Odensten, & Good, 2006). It was my purpose, in selecting lower extremity injury risk assessment and prediction as my area of advanced practice, to determine athletic females' risk for sustaining a non-contact ACL injury through practical and clinician-friendly movement screens.

Before attempts were made to address the problem I had identified, I first needed to review evidence that related to and potentially influenced the problem. Most investigators have agreed that the risks associated with non-contact ACL injuries are multi-faceted (Ali & Rouhi, 2010; Dragoo, Braun, Durham, Chen, & Harris, 2012; Evans et al., 2011). The degree of influence that each potential risk factor holds remains a subject of debate (Evans et al., 2011; Kobayashi et al., 2010). The researchers whose work was featured in the literature that I reviewed investigated the risk factors that are considered modifiable: fatigue (general and muscular), hormonal influence, muscular (strength ratio and muscular stiffness), lower extremity joint biomechanics, neuromuscular control, and proprioception (balance). After I gained a better understanding of the associated modifiable risk factors, I was able to more accurately evaluate and review the ACL injury prevention interventions that were available.

Preventative ACL injury programs, such as “FIFA 11+,” knee ligament injury prevention (KLIP), and prevent injury and enhance performance (PEP), were created in an attempt to address those risk factors associated with ACL injuries that are seemingly more influential, such as muscular dysfunction, balance deficiency, and reduced flexibility of the lower extremities (Irmischer et al., 2004; Mandelbaum et al., 2005; Pfeiffer, 2006; Soligard et al., 2008; Steffen et al., 2013; Steffen, Myklebust, Olsen, Holme, & Bahr, 2008). A number of investigators have observed a decreased incidence of non-contact ACL injuries using the preventative programs (Mandelbaum et al., 2005; Steffen et al., 2013; Steffen et al., 2008); however, other researchers has demonstrated that some ACL injury-prevention programs do *not* reduce the risk of injury (Pfeiffer, 2006). While the programs were designed to attempt to address potential neuromuscular, musculoskeletal, and biomechanical deficits in individuals that contribute to an increased risk of ACL injury, strict adherence (commitment) to the intervention is necessary (Gilchrist et al., 2008; Irmischer et al., 2004; Longo et al., 2012; Mandelbaum et al., 2005; Pfeiffer, 2006; Steffen et al., 2013; Steffen et al., 2008).

In the attempt to identify individuals at a higher risk of sustaining a non-contact ACL injury, investigators have also created predictive tools, such as the landing error scoring system (LESS) and knee abduction moment (KAM) value (Myer, Ford, Khoury, Succop, & Hewett, 2010; Padua et al., 2009). The few studies available has not demonstrated that the LESS (Smith et al., 2012) or the KAM value (Goetschius et al., 2012) identify individuals at a higher risk. However, the functional movement screen (FMS), which is another prediction tool, has been successfully used to identify participants' lower extremity injury risk (Chorba, Chorba, Bouillon, Overmyer, & Landis, 2010; Lehr et al., 2013; Peate, Bates, Lunda, Francis, & Bellamy, 2007; White, 2013). The FMS ranks movement patterns in healthy individuals (Cook, 2010). The FMS and KAM tools both help to identify poor movement quality in stationary (FMS) and dynamic (KAM) actions.

After I reviewed the pertinent literature, I determined to identify the validity and reliability of the FMS and KAM value in predicting non-contact ACL and non-contact LE injury risk in an active female sample population. The review of literature (Chapter 4) provides information that is intended to establish the theoretical framework necessary to support my research investigation. It also serves to support my original research investigation (Chapter 5).

Summary of Original Applied Clinical Research

The purpose of my original research investigation was to understand the reasons behind the high incidence of non-contact ACL injuries in the athletic female population in my clinical setting. I wanted to investigate whether or not poor movement quality scores, measured by the FMS and/or KAM, were observed in participants who sustained a non-contact ACL and/or lower extremity (LE) injury while active in their respective athletic season. I intentionally used an action research philosophy to identify my clinical problem. I then designed a clinical study that would lead to an improvement in my clinical practice.

The results of my investigation, found in Chapter 5, demonstrate the benefits of preemptively identifying active female individuals at a higher risk for non-contact ACL and/or LE injuries. The data that I compiled also led me to develop a research manuscript, the dissemination of which will offer clinicians insight into movement screens and injury risk assessment for active females. My research manuscript is just one of the projects I completed while in the DAT program; yet it contributes evidence of progression along my path to advancement as a clinician in athletic training.

Closing Reflection

I believe that health care professionals who collect patient outcomes to assist in clinical decision-making processes will lead in EBP research scholarship and will challenge those health care professionals who do not collect and utilize patient outcomes. The incorporation of action research in clinical practice, supported by EBP principles, will further improve patient outcomes. Expectations in quality, effectiveness, and the pursuit of positive effects in patient care will continue to increase as collected outcomes are published (Ferlie & Shortell, 2001).

Clinicians should avoid the habit of utilizing treatments in patient care that lack evidence to support their use. Instead, clinicians should investigate current literature to determine what interventions demonstrate the best results. These practices may improve overall clinical effectiveness when incorporated into a systematic, evidence-based approach.

Critical self-reflection challenges athletic trainers to evaluate their beliefs and knowledge, the result of which may inspire significant changes in a clinician's practice. The results of the changes I made in my own clinical practice led me to higher scholarship and advanced professional practice in AT. My PoAP served as the foundation for my growth as a clinician. After I identified my clinical strengths and addressed my clinical weaknesses, I was able to change my approach so it was patient care-centered and observe improvement in patient outcomes. My area of advanced practice focuses on addressing a "real-world" problem that I observed in my local patient population: a high incidence of non-contact ACL injuries in female collegiate-level athletes. The result of my investigation provided evidence of the usefulness of a movement screen (FMS) for identifying female collegiate-level athletes at a high risk for sustaining a non-contact ACL injury. The DoCPI represents my unique path toward a scholarly level of advanced clinical practice in AT.

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CHAPTER 2

PLAN OF ADVANCED PRACTICE: FINALIZED NOVEMBER 20, 2015

Reflection on Professional Experience and Development

My first exposure to the athletic training (AT) profession occurred at the end of my freshman year of undergraduate study at San Diego's Point Loma Nazarene University (PLNU). While investigating academic majors, I became drawn to AT because of the opportunities that are afforded to clinicians in this field to serve a physically active patient population. Having suffered from musculoskeletal injuries myself while in youth sports, I desired to gain the skills necessary to effectively treat individuals. After declaring my major in AT, I began observing and assisting athletic trainers in a variety of clinical settings. Over the next three years, my internship opportunities were in secondary school athletics, collegiate athletics, physical therapy, and orthopedic surgery. As a result of my experiences, I learned that the patients I was most interested in working with were secondary school students. The knowledge that, as a certified athletic trainer, I would be responsible for the healthcare and well-being of my patients led me to the decision to further my AT education.

Immediately after the completion of my bachelor's degree, I chose to enroll at San Jose State University (SJSU). I knew that their post-professional master's degree program in AT would help me to improve my critical thinking skills, and that I would gain practical experience through the graduate assistant (GA) position that I received at a local secondary school. This position would also allow me to provide patient care without any supervision.

While in the SJSU AT program, I had the opportunity to share experiences that I had had at the secondary school with fellow athletic trainers who were also in the SJSU AT program. These discussions enabled me to critically think about and reflect on the decisions

I'd been making while providing care to my patients. Our topics of discussion often revolved around rehabilitation and treatment choices, patient evaluation and assessment, and ethical decisions presented in AT. By the time I had completed my master's program, I felt as though my patient care was at a sufficient level to safely manage the healthcare and well-being of my patients.

After graduating from SJSU, I was offered the position of head athletic trainer at a private school that I had previously provided AT coverage for. All of the stakeholders (administrators, parents, teachers, and coaches) at the school were appreciative of the care that I provided and the attention I gave to the student-athletes. The encouragement and positive reinforcement that I received from my patients and the stakeholders in regards to my patient care led to an increase in my confidence. I soon began to regard myself as a "successful clinician." Looking back, I realize that I did not have a proper understanding of what it meant to be successful. I further discuss what I believe makes a clinician successful in the subsequent chapter (Chapter 3: Outcomes Summary).

After having spent seven years in AT, practicing within the secondary school setting, I lost my job due to the economic crisis. However, this change in my employment afforded me the opportunity to work with a different patient population: I began to work in the collegiate athletics setting at Bryan College as their head athletic trainer. I was also offered an adjunct teaching position, housed within the exercise and health science department at the college.

As the head athletic trainer, I was assigned to "provide AT services and coverage during athletic events," including men's soccer, men's basketball, and cross-country running. Unfortunately, I did not know that the coaches, the director of athletics, the administrators, my AT staff, and I all would all have different definitions of what "AT services," "coverage," and “athletic events” mean. Along with my team assignments were new athletics related coverage and travel responsibilities, both of which I was unaccustomed to. When I asked my supervisor what was expected of me schedule-wise, he said, “Do whatever you need to do to get the job done.” At the time, I did not realize that this was not sufficient guidance. I did note, however, that I frequently had to ask for clarification regarding when and how often I was expected to work. The responses I was given to these questions were often supportive and seemingly absolute—certainly meant to encourage a fair workload for my AT staff and I. Many times, however, there were exceptions to my supervisor’s responses, of which I had not been made aware.

After working for one year as the head athletic trainer, I found that I was unhappy with my position. I attributed my discontent to the long work days, limited weekends off, and low salary I received. In an effort to alleviate my frustration, I expressed my concern regarding the average hours I worked per week with the administration at Bryan College. Once I had supplied my supervisor with a breakdown of my in-season coverage, the administration chose to open a new part-time AT position.

Unfortunately, despite the hiring of an additional athletic trainer during my second year at Bryan College, the work schedule of my full-time AT staff and I did not improve. Once again, I assumed that the primary reason for my unhappiness was due to the work hours required of me. At the end of my second year, I visited once again with my supervisor and expressed my concerns about the hours my staff and I were still working. In an effort to at least partially alleviate the time commitment burden, my supervisor informed the athletic department that the AT staff would no longer travel with non-contact sports, except during conference tournaments. I was grateful that the decision to no longer travel with baseball, softball, and volleyball during the regular season had been made; however, since I still covered soccer and basketball, which are contact sports, my work schedule remained unchanged. As a result, during my third and final year as Bryan College's head athletic trainer (my ninth year working as an AT), I began to entertain the idea of taking another AT position elsewhere.

While I still assumed that the majority of the unhappiness I experienced in my employment was the direct result of long hours, I knew that a degree of self-doubt, regarding whether or not I was an effective head athletic trainer, also contributed to my discontent. The definition of workplace effectiveness often varies among professions and sites of employment (Dose & Klimoski, 1995), but there are certain specific standards that a state licensed and certified AT is expected to maintain. In my case, these standards were set forth by the Tennessee Department of Health Board and the Board of Certification, Inc. (BOC). Aside from expecting me to uphold these standards, my supervisor did not offer me any other guidance in how to be most effective in my work. However, I now know that at the time, I did not understand what it meant to be "effective," nor did I know that my effectiveness as an AT clinician could be at least partially defined by my patient outcomes. How could I have expected my supervisor to assess my role as the head athletic trainer if I could not identify traits of a successful head AT, myself? I had been contributing to my own discontent, but I found that it was easier to put the cause of my unhappiness on an external factor rather than on my own failings.

In retrospect, I realize that not only had I not developed a personal definition of what it meant to be a successful AT, I had also unwittingly attempted to meet the demands of everyone around me—particularly those of my supervisor, the coaches, the AT staff, and the patients with whom I interacted—even at my own expense. When I consider the employment I held prior to Bryan College, at the private secondary school, I realize that I had tried to please both my patients and their parents there, too. My mindset had not been focused on providing successful treatment or reasonable patient care coverage; instead, my job satisfaction was determined by whether or not I pleased the people around me.

Halfway through my final year as Bryan College's head athletic trainer, I applied for a full-time faculty position within the exercise and health science department at Bryan College. Not only had I enjoyed the classes that I had taught as an adjunct instructor, the idea of a consistent, structured schedule appealed to me. I was very pleased when the department offered me the full-time teaching position in the fall of 2012.

In direct contrast with earlier experiences, when I began teaching full-time, my new supervisor made her expectations of me as a professor in the exercise and health science department very clear: She expected me to integrate my Christian worldview into the classes that I taught; she also requested that I provide my students with a real-world understanding of the content being taught in such a way that would allow them to be proficient in various exercise and health science settings. This has allowed me to better understand my roles as a faculty member. My work schedule consists of teaching classes equivalent to 12 credits each semester and being available 8 hours per week in my office.

As a professor, I have become less focused on pleasing the students I teach and more interested in allowing my passion for the subjects within health science to be effectively expressed in class. This has led to a tremendous increase in my job satisfaction, as have the positive evaluations I have received. These evaluations, which are conducted by a fellow faculty member on an annual basis and by a class of students biannually, are not intended to show whether or not I meet a minimum standard of practice for teaching; rather, they rate classroom content, structure, organization, and quality of teaching. In doing so, they offer me insight into my teaching strengths and weaknesses and provide me with evidence of my effectiveness as a professor. The administrators at Bryan College review my evaluations annually. I am also required to respond to the feedback I receive from my peer evaluations. In doing so, I indicate how I plan to change my teaching practice for the better. I have found this type of external accountability more effective at changing my practice than internal accountability (such as that which I had when I was the head athletic trainer at Bryan College), because it requires me to consider a different perspective than my own.

Rationale for Pursuing a Doctorate in Athletic Training

When I was offered my faculty position at Bryan College, it was on the condition that I begin a doctoral program by the fall of 2014. I was unsure if a doctor of athletic training (DAT) program or a doctor of education (Ed.D) program would be of greater benefit to me. The Ed.D degree focuses on education as well as on learning and leadership. The DAT degree provides a one-of-a-kind post-professional athletic training program that emphasizes improving patient outcomes, acquiring clinical skills, and conducting scholarly research specific to athletic training. Although I felt both programs would benefit me, I chose the DAT because of the opportunity it afforded me to grow as a clinician. I knew that once I improved my practice in AT, I could teach more effectively within academics.

After beginning the DAT program, I quickly came to understand and accept how clinically incompetent I had become. Within the first week of the program, professors asked the DAT students who taught full time (collegiately) if we had transitioned into teaching because we had become ineffective clinical practitioners. As mentioned earlier, the excuse I had given myself for leaving my previous clinical position had been “feeling over-worked” and “burnout”; however, the professors’ suggestion that I may have become an ineffective practitioner caused me to reflect. I did not possess any clinical evidence to prove my competency. I began to wonder if I had felt overworked because I had been working harder than was necessary to treat patients. If I had been providing poor treatment that resulted in undesired patient outcomes, then the burnout I felt might not have been from the clinical position I held, but because I was an ineffective practitioner.

Since starting in the DAT program at the University of Idaho, I have learned new treatment interventions, observed improvement in my patient outcomes, and matured professionally within the field of AT. In this chapter, I will focus on providing critical reflection on those competencies that I have come to value in my own practice and will give evidence of my current state of understanding/ownership of the competency as well as my expectations of competency advancement. I will also provide my plan to achieve these expectations. Competencies that I will review include clinical knowledge (with sub categories), basic science, and evidence-based practice. Strengths and weaknesses within each competency will be examined as well. Table 2.1 provides specific goals that I have created to facilitate my plan for achieving a professional, advanced practice.

Along with clinical competencies, I will discuss professional development—the continuation of which allows a practitioner to maintain clinical competence. Professional development is a crucial aspect of my practice as an athletic trainer. Previously-learned clinical skills can become difficult habits to break, even when more recent, sound evidence demonstrates the existence of more reliable and effective skills. The importance of possessing a detailed plan for professional development (or plan of advanced practice—PoAP), in order to reduce the risk of forming poor, outdated clinical habits, is therefore amplified. Areas within professional development that I will discuss include the following: acquiring advanced practice of AT, seeking out pertinent continuing education units (CEUs), broadening treatment specialization, completing a post-professional clinical degree, and improving patient outcomes. The purpose of my PoAP is two-fold: to present a current critical self-analysis of my clinical practice as an athletic trainer (AT), and to create a detailed plan of improvement to address weaknesses and issues identified from the self-analysis.

Reflection on Current Clinical Competence

Clinical competence, although sometimes defined differently among professions, is often considered to be a clinician's capacity to integrate what they know, academically, into what they do, clinically (Burg & Lloyd, 1983). A clinician can possess the knowledge required to perform a special test in healthcare, however their competency is what will contribute to how successful the clinician is, performing the special test. The licensing and certification boards of healthcare professions (e.g. nursing, athletic training, and physical therapy) decide how the competency of skills are to be tested of their professionals, and to what degree the competencies of those skills will be measured/tested.

My clinical competency in AT as a whole, was tested through the National Athletic Trainers' Association (NATA) Board of Certification exam in 2002. The test was created to measure my competency in five domains of AT (injury/illness prevention, clinical evaluation and diagnosis, immediate and emergency care, treatment and rehabilitation, and organizational and professional health and will-being). By passing the certification exam, I demonstrated to the Board of Certification, Inc. that I possessed sufficient entry-level knowledge, skill, and competency required to practice AT. It is important to note that although clinicians (myself included) may demonstrate knowledge and skill competency by passing a certification exam, the successful performance, and/or utilization of those skills in practice is up to the clinician. For example, on a test, I may indicate all the correct instances when I should perform ACL special tests on the knee; yet in a real-world clinical setting, I may not apply the ACL special tests when I should. Clinicians and patients should be aware that competency is not necessarily the equivalent of high proficiency.

During my first semester in the DAT program, I realized that because I had learned basic science and what I had believed were the fundamentals of AT more than 11 years earlier, most of my clinical skills were outdated. As a result, I began to rebuild the foundation upon which I had assembled these skills. Doing so helped to strengthen my areas of weakness (the most significant of which will be discussed in further detail in another section of this chapter) by grounding my practices in sound and current theory. The clinical competencies that I focused on improving were my understanding of basic science, my clinical knowledge, and my implementation of evidence-based practice (EBP).

Reflection on Current Clinical Competence: Understanding of Basic Science

Some clinicians accept anecdotal evidence from fellow practitioners as reliable information (Gabbay & May, 2004). As an athletic trainer who is moving toward advancing my clinical practice, I, however, must explain why I choose particular treatment methods. Simply stating, “I know this is a current ‘best treatment’ option because my team doctor told me it was,” is not professionally acceptable. Basic science plays a supportive role in the explanation of treatment decisions. This will be discussed separately, in a subsequent section.

Until I became immersed in the DAT program, I rarely utilized current literature for clinically applicable information on an injury-related topic. However, I now recognize the benefits gained by seeking out the current best practices in AT. Less error in diagnoses can result when practitioners utilize available current best-practice evidence for various diagnostic tools (Rubinstein & van Tulder, 2008). Diagnostic tool sensitivity and specificity values are generally higher in current best-practice literature, as opposed to older and potentially outdated tools (Lord, Irwig, & Simes, 2006).

Reflection on Current Clinical Competence: Clinical Knowledge

Before I entered into the DAT program, a substantial amount of my clinical knowledge was gained through clinical experiences. Unfortunately, relying on a “trial and error” model with my clinical experiences in my own practice has been humbling. Through the DAT program, I have become aware that an athletic trainer’s clinical knowledge encompasses a large breadth of information, including injury assessment, diagnosis, treatment, and prevention. Specialized skills and knowledge may also be required for ATs who desire to work within particular job settings (e.g., military). The NATA provides further detail on the skills and knowledge required for athletic trainers in every category (National Athletic Trainers’ Association, n.d.). In this section, I will discuss areas of clinical diagnoses (including examination and assessment) and treatment (including immediate care, injury rehabilitation, and injury prevention) separately, in order to allow each area the focus and detail they deserve.

Examination and Diagnosis

In an effort to accurately assess patients, I combine current clinical knowledge, a systematic movement quality evaluation (Selective Functional Movement Assessment™, SFMA™), and my own past experience with diagnostic procedures such as injury assessment, observation, and special tests. Previous to my enrollment in the DAT program, the only measure to determine my diagnostic validity was through patients' doctors suggesting the same diagnosis I gave them (assuming doctors diagnose correctly every time). This method seemed unreliable; yet, at the time, it was still desirable over no measure at all. Once I began the DAT program, I realized that accurately diagnosing patients was often less important than identifying the true pathological cause of their complaint. The transition from my prior symptom-to-diagnosis approach to my current movement-quality-to-pathological-assessment approach resulted in an improvement in my patient care. I demonstrate improvements in my patient care through my semester outcomes analyses in Chapter Three.

I use the SFMA in my evaluation of patient movement quality. A key concept of the SFMA is regional interdependence, in which the clinician considers movement dysfunctions throughout the body and determines whether or not these dysfunctions cause and/or contribute to a patient's primary complaint. After I have treated my patient according to the movement dysfunction(s) present, I reevaluate their movement quality using the SFMA to identify whether or not the primary issue has improved. By addressing dysfunction that I was not previously aware of before I enrolled in the DAT program, the SFMA system helped me to branch out from my limited awareness of my patients' actual pathology.

Before the DAT program, my clinical assessments were primarily with acute lower extremity and shoulder injury pathology. This was, in part, due to the high patient exposure I received at previous employment sites. The first 7 years of my athletic training career were in the secondary school setting, where I managed the healthcare and well-being of 800-1100 student athletes. I received more examination and assessment opportunities during these years than I did in the collegiate setting, where I oversaw 275-300 student athletes with 2-3 fellow athletic trainers. Although I was exposed to a lower quantity of acute injuries during my employment in the collegiate setting, working closely with fellow ATs at the college allowed me to communicate and share my clinical findings. I found that doing so encouraged me to provide rationale to support my clinical decisions (assessment, examination, treatment, and rehabilitation). When I explain my rationale for the clinical decisions I make, I am less likely to make guesses in patient care or, for the sake of convenience, simply repeat the same treatments that I've already employed.

Before addressing my pre-DAT competence in concussion assessment, it is important to note where my clinical assessment skills and protocols stemmed from. Some of the foundational knowledge that I learned during my undergraduate program still contributes to current protocol that I follow today, but other facets were not taught at the undergraduate level. The athletic trainers' professional duty to their patients includes maintaining a basic level of knowledge on current trends of practice, regardless of the injury. Prior to the DAT program, my clinical diagnostic weaknesses included the treatment of pelvic girdle dysfunction as well as concussion assessment.

The pelvic girdle is a complex structure influenced by musculature that both directly and indirectly surrounds and neighbors the bones that create it (Lee, 2011). Despite the difficulty of assessing and treating patients who appear to have pelvic girdle injuries, I have remained vigilant in seeking to understand the variety of potential dysfunctions associated with the pelvic girdle through recent CEU activity and discussion with other clinicians that I work with. During the Fall 2014 semester, I created an *a priori* treatment design that allowed me to choose treatment interventions based on my orthopaedic special tests and SFMA findings. In Chapter 3, I discuss how my patient outcomes improved after I implemented *a priori* treatment designs.

Before I began the DAT program, I regularly experienced frustration when assessing patients with pelvic girdle pain. This frustration was due, most likely, to the complexity of the articulations within the lumbopelvic region, which have the potential to contribute to pelvic girdle pain. Until I became well immersed in the DAT program, I did not fully realize the significance of a systematic assessment and diagnosis and of an evidence-based practice. Pengel, Herbert, Maher, and Refshauge (2003) said that 66-84% of patients treated for low back pain had at least one recurrence of low back pain (LBP) within a year. Without a repeatable systematic approach, identification of the true pathological dysfunction that led to pelvic girdle dysfunction may be ineffective, and even counter-productive. The DAT program provided a much-needed semester-long emphasis on the diagnosis and treatment of LBP (often associated with the pelvic girdle). Reading the assigned text, "Medical management of acute and chronic low back pain: an evidence-based approach" (Bogduk and McGuirk, 2002) and dialoguing within the DAT cohort helped me to begin addressing my weakness assessing and treating pelvic girdle dysfunction. Before attending the DAT program, I had not considered the contribution and influence of regional interdependence to LBP. As I stated earlier, before the DAT, I focused my clinical treatment on addressing my patients' symptoms (pain, tightness, inflammation, and loss of function). This led to short-term improvements; however, the ability to return to complete function rarely resulted from the treatment that I provided. Once I began to address my patients' movement dysfunction in areas other than where their symptoms lay, I began to observe an improvement in my patients' recovery time and a decrease in the incidence of LBP reoccurrence.

My treatment of seemingly unrelated movement dysfunction is based on the concept of regional interdependence (RI). Regional interdependence is a concept which demonstrates that apparently unrelated neuromuscular-skeletal dysfunction may contribute to a patient's primary complaint (Wainner, Whitman, Cleland, & Flynn, 2007). In an effort to address my patients' primary complaint, I consider RI to be the true pathological issue. A hallmark moment for me, early in the DAT program, was when I learned and understood the concept of RI, which is profoundly different from what I had been previously taught and how I had treated my patients.

Similar to my prior frustration with pelvic girdle assessment and treatment, before my transition to the collegiate level, I had not considered investigating recent literature on evidence-based practices for concussion diagnosis and treatment options. When I transitioned to the collegiate level, I was positioned as the head athletic trainer with two newly hired assistant athletic trainers who had recently completed their entry-level master's graduate AT education programs. For the first time in seven years, I was working directly with fellow athletic trainers in a clinic. Before the pre-participation exams at my institution of employment took place, I distinctly remember both assistant athletic trainers asking me if we would incorporate the SAC (standardized assessment of concussion) and/or BESS (balance error scoring system) into our concussion protocol. To my embarrassment, I had to ask them for an explanation of both.

I began to improve in my ability to assess concussions during the summer of 2013, when I conducted a search for recent literature reviews on concussion assessment and protocol (return-to-play, and return-to-academics). Communication with fellow DAT students who were conducting research related to concussions also provided me a valuable avenue to learn current best practices of concussion assessment and treatment options. Although my ability to use best practices regarding concussion assessment and treatment has improved, I remain mindful that all diagnostic tests and tools should be evaluated regularly (McCrory et al., 2009). Similar to my experience at Bryan College of providing fellow AT clinicians with my rationale for clinical decisions, I discussed my protocol for concussion assessment and treatment with my fellow athletic trainers, knowing that doing so would remind and encourage me to use current best practices in concussion management.

Treatment and Rehabilitation

Prior to the DAT, I relied primarily on treatment and rehabilitation methods that I learned while in my undergraduate and graduate AT programs. I chose treatment and rehabilitation interventions for my patients based on how well I believed those interventions would improve their symptoms. Simply stated, I believed that by addressing the symptoms that my patients presented with, the pathological problem (be it an injury or musculoskeletal dysfunction) would be corrected and heal properly. The primary symptom that I sought to address was pain. I believed that pain negatively contributed to my patients' issue. I also believed that for an injury to properly heal, pain associated with the injury must first be reduced. What I had not considered was that my patients' pain was associated with the inflammatory process.

Local vasodialation (increased blood flow) allows the transport of cells that promote wound/tissue healing (Koh & DiPietro, 2011) and is a part of the inflammatory process. My goal—to reduce the pain my patients suffered from, through the treatment and rehabilitation that I provided—compromised the inflammatory (healing) process. Although the reduction of pain experienced by my patients currently remains a goal that I strive to address, I consider pain to be a valuable messenger or signal that, after proper treatment and rehabilitation, will reduce as a result of my actions.

In regards to treatment, as I previously mentioned, the clinical knowledge I gained throughout my AT career was largely based on a "trial and error" method of practice. I do not consider this method of practice an appropriate process for selecting treatment interventions, if *a priori* assessment and treatment designs have not been established. Most clinicians would agree that treatment that works well for one patient may not provide the same positive results for another patient, even if he or she has a similar injury or dysfunction. To identify the treatment interventions that result in successful outcomes from *a priori* treatment designs, clinicians should administer patient outcomes measures (POMs) (referred to as patient oriented evidence, or POE, after administration) that, preferably, have been well established as reliable and valid. The POMs that are chosen by the clinician are intended to indicate whether changes in a patient's condition have occurred. The POMs that I chose to use while in my DAT residency are discussed in Chapter Three. Further discussion of clinical treatment, with emphasis on immediate care, injury rehabilitation, and injury prevention, follows.

Immediate care

Best practice methods exist for particular immediate, injury-care scenarios. During the first semester of the DAT program, I remember being asked, "What is the best liquid solution to use when cleaning a superficial wound?" I could only respond with an educated guess that was based on what a team doctor had advised me three years earlier, which was that a 50% povidone-iodine and 50% saline solution should be used. While this was fairly close to what the professors referenced from a recent study, my ratios were incorrect. The study demonstrated that a 10% povidone-iodine and 90% saline solution should be used (Brown, Cipriano, Moric, Sporer, & Della Valle, 2012). This example demonstrates the importance of studying literature in order to provide quality patient treatment.

As I described previously regarding pain and inflammation, the use of outdated treatment methods in immediate-injury care can not only affect patient recovery time, they can also result in lasting tissue impairments. Older treatment methods are not necessarily ill-advised or wrong, as they may remain the preferred treatment option; nevertheless, before entering the DAT program, my problem of not knowing how effective particular treatment methods were remained. I combated this weakness by searching the literature for best practices of specific immediate-care treatments. For example, the treatment that I provided for my patients who sustained an apparent lateral (inversion) ankle sprain changed drastically after I investigated and learned the Mulligan Concept (MC) treatment intervention. Instead of using outdated interventions that I learned during my undergraduate program, I used the MC mobilization with movement to correct a positional fault of the distal fibula bone. After I treated three patients with the MC intervention, I noticed a significant improvement in their functional outcomes and POEs compared to my prior patients who received outdated treatment interventions. My perspective on treatment interventions pertaining to injuries that require immediate care has transformed because of the changes I observed using the MC for apparent lateral ankle sprains.

To remain informed on best practices, I plan to investigate treatment methods for specific acute (immediate) injuries that indicate positive outcomes. After I have compared my patient outcomes with the patient outcomes in recent literature for the intervention I am investigating, I will decide what treatment is best for my patient. My goal is to minimize further damage to tissue and associated structures while providing a preferred healing environment.

Injury rehabilitation

In regards to treatment, injury rehabilitation covers a broad area of clinical practice. Patients respond differently to rehabilitative treatment, which complicates the use of optimal therapeutic exercise and modality prescription to promote healing and reduce pain (Knight, Knight, & Draper, 2012; Sahrmann, 2002). Similar to when I choose a treatment intervention for the immediate care of injuries, I review current literature to remain informed regarding the most popular rehabilitative concepts and protocols. Often, studies demonstrate findings that support one treatment paradigm over another. Conflicts are common among publications, and practitioners should rely on foundational knowledge regarding injury rehabilitation and experience (Yoshida et al., 2014). As I mentioned earlier, much of my career as an AT prior to my enrollment in the DAT program was based in the secondary school setting. Patient rehabilitation was often conducted by physical therapists outside of my clinic. Given the volume of daily initial injury assessments I conducted, I assumed that little opportunity existed for me to provide adequate rehabilitation, and that any rehabilitation I provided would require more time than I could afford to take. Nevertheless, I provided rehabilitation to patients when I could—especially those patients who could not afford clinic co-payments or costs. For years I have desired to better understand why I chose particular exercises and modalities over others. While earning a post-professional master's degree in AT, I began building a stronger foundational knowledge as to why I used specific interventions in rehabilitation.

My current strengths in injury rehabilitation include post-surgical knee and shoulder treatment as well as apparent joint mobility dysfunctions (JMDs). I gained first-hand experience with post-operative shoulder rehabilitation due to sustaining a labral tear, myself, as a result of multiple shoulder dislocations. The surgical and rehabilitative process I endured provided valuable insight into patient rehabilitation. I regularly reflect on how I felt after surgery, and in so doing, I find it easier to communicate with patients who undergo surgery. One particular patient told me, “Knowing that you went through the same injury and surgery I just had takes many of my worries away.” Regardless of the injury sustained, I make an effort to empathize with the patient. Research has demonstrated the positive influence of clinicians who are empathetic toward their patients’ issues (Street, Makoul, Arora, & Epstein, 2009). Furthermore, my efforts to understand my patients’ primary injury complaints allows me to choose the rehabilitative interventions that will best address the causes of their injuries.

Prior to the DAT program and in regards to injury rehabilitation, I found it difficult to utilize available tools to measure outcomes and to provide rationale as to why I chose one rehabilitative intervention over another. Rehabilitative tools I sought to apply more often included positional release therapy (PRT), Mulligan joint mobilization with movement (MWM), total motion release (TMR), primal reflex response technique (PRRT), and trauma release exercise (TRE). Both my PRT and joint MWM techniques were improved by revisiting the Northeast Seminars (NES) videos available to me through the DAT program. Additionally, during the summer of 2013, I attended a weekend workshop, led by Dr. Tim Speicher, that offered exposure to PRT. I also took a weekend Mulligan mobilization course during the summer of 2014. Although Dr. Speicher’s course improved my understanding of the concept and application of PRT, the application of PRT on patients ultimately improved my effectiveness. Regarding Mulligan MWM, regularly reviewing the NES videos available helped me to improve the technique required to apply joint MWMs. The Mulligan course helped me apply what I saw in the videos and books. The attending clinician I worked with during my Fall 2013 residency had taken a course in the Mulligan concept and regularly used natural apophyseal glides (NAGS) and sustained natural apophyseal glides (SNAGS) in his practice. He provided further guidance as I used MWM techniques with patients. My first exposure to TMR was in the summer of 2013. Similar to the Mulligan MWM intervention, I did not initially gain enough exposure to the paradigm to feel comfortable integrating it into patient treatments. During the fall of 2014, however, the DAT program gave me access to the TMR course online. This course was designed in such a way as to afford flexibility in regards to the breadth of content that was covered. As my understanding of TMR increased, I became more comfortable with using this particular rehabilitation tool form patient treatments.

I plan to communicate with fellow DAT clinicians for further guidance in PRRT and TRE treatment paradigms. Although I was briefly exposed to PRRT, TMR, and TRE the first summer semester of the DAT program, I did not practice them consistently enough to feel competent utilizing them in my practice. I also did not understand the paradigms for PRRT, TMR, and TRE, well enough to apply them in rehabilitation at that time. By the end of the Fall 2013 semester, I began to realize that my understanding of the treatment and rehabilitative paradigms was not as important as how effective they were at improving my patients. Some investigators claim that rehabilitative paradigms used to inform decisions made by clinicians in patient care may not be fully understood because the paradigms are not objectively defined, which, therefore, threatens their efficacy (Allman et al., 2001; Whyte & Hart, 2003). At the start of my second semester in residency (Spring 2014), I began to base my clinical decisions on whether or not the treatments and rehabilitative interventions were improving my patients, instead of whether or not I understood the paradigm. While foundational knowledge of the proposed mechanisms that treatment and rehabilitative paradigms have on the human body are important to understand, I consider their effectiveness in patient care to be most valuable.

Injury prevention

Injury prevention was not an area within clinical treatment that I considered with much significance early in my career. As I mentioned previously, the seven years I worked within the secondary school setting provided me with little time to rehabilitate patients; nonetheless, I should have spent more time considering injury prevention, particularly since it became a priority in my patient practice within the collegiate setting. Not only was it necessary for me to advise injured patients regarding their return to activity, but I also needed to be able to advise those who had yet to sustain an injury on how to remain healthy and uninjured. Before entering the DAT program, I could not claim ownership in or strength over any aspect of injury prevention. After completing a literature review on anterior cruciate ligament (ACL) prevention interventions, I felt that what I lacked in injury prevention, other AT clinicians may have lacked as well. Disparity between non-contact ACL injury rates and lack of predictive tools to identify at-risk individuals prompted further interest, which will be discussed in greater detail in the area of advanced practice.

Reflection on Current Clinical Competence: Implementation of Evidence-based Practice

When I began working without supervision as an athletic trainer, an accurate description of my practice and the clinical decisions I made could have been “anecdotal-based.” Much of my clinical practice revolved around what I witnessed professors and supervising athletic trainers doing. Theoretically, this should have been acceptable, if what they were performing were current best practices in AT. However, independent responsibility begins the moment AT certification is awarded. The fourth principle in the National Athletic

Trainers Association (NATA) code of ethics states, “Members shall maintain and promote high standards in their provision of services.” The preferred method to transition from “anecdotal-based” to “evidenced-based” practice is to utilize a 5-step process to address clinical questions: 1) develop an answerable clinical question, 2) search for the best evidence related to the clinical question, 3) appraise the evidence, 4) apply the best evidence, and 5) evaluate the outcomes (Ciliska, Pinelli, DiCenso, & Cullum, 2001). In reflecting on my current state of practice, I see that I still use suggestions received from fellow practitioners. When I use anecdotal evidence to complement literature in order to support what is verbally stated, I am afforded a greater opportunity to support my clinical actions in practice. This has been the essence of my transition into evidence-based practice (EBP).

Evidence-based practice consists of several steps. First, a clinician asks a question that directly impacts his or her patient care; then the clinician conducts a review of literature to help answer his or her questions; then the clinician makes a decision based on evidence he or she finds in the literature; and finally, the clinician evaluates the outcomes of the treatment that is employed for any changes (both positive and negative) that have occurred.

The transition that I made from a primarily anecdotal practice to an EBP began my first semester of residency (fall of 2013). I was challenged by the DAT faculty to better support the clinical decisions I made, collect outcomes based on the treatment that I provided my patients, and establish my clinical effectiveness for those treatments (once I had collected enough outcomes). I desired to be a more informed clinician who could support his actions in patient care with evidence in literature. As I began to investigate the treatments I traditionally chose for my patients, I learned that many of my treatment choices were not supported by literature, and/or they demonstrated insignificant changes in patient outcomes. After I investigated my own treatment effectiveness, I realized that I needed to consider using different treatment interventions that, according to literature, have demonstrated success. In addition to implementing new treatment interventions, I began collecting patient outcomes to help objectively measure the success of my treatments. Once I began collecting and monitoring my patient outcomes, I revisited the literature to compare my patient outcomes measures with what was listed there and to determine whether my patients' improvements were congruent with the results demonstrated in pertinent literature.

Reflection on Strengths

Early in my enrollment in the DAT program, I realized the importance of identifying my strengths and weaknesses as a clinician. Once I understood which components of my clinical practice demonstrated adequate proficiency and which components evidenced weakness, I was able to more accurately establish my plan for improvement and advancement in AT. Since the completion of my residency in the DAT program, I believe that I have 3 significant strengths in my clinical and academic practice: 1) patient assessment and evaluation, 2) patient centered care, and 3) promotion of an effective academic environment. The development of my strengths began once I created my athletic training and treatment philosophy, as well as my low back pain and teaching philosophies (provided in the subsequent section).

My focus on patient assessment and evaluation has changed from symptom-based, to quality-of-movement-and-function-based. Throughout my tenure as a clinician, I have enjoyed improving my patients' pain, injury, and/or ailment. Before I entered into the DAT program, however, I was limited in my assessment and evaluative thought process. I had not previously measured how effective I was in my patient assessments and, therefore, could not form a realistic perspective of my ability to assess and evaluate injuries. After my enrollment in the DAT, I learned the importance of considering my patient's quality of movement and functionality during my patient assessments and evaluations. Through the use of the Selective Functional Movement Assessment (SFMA) and Total Motion Release (TMR) Fab6™, I classify patients according to their quality of movement (SFMA), and I collect patient-rated movement scores (TMR Fab6) to identify movement deficiency and to observe changes after I use treatment interventions. As I compare my documented movement quality scores with those presented in current best practices, I am able to determine whether focusing on movement functionality and quality is an effective method for patient assessment and evaluation.

After my first semester in residency (Fall 2013), I transitioned to providing care that was centered on my patient's needs because I was not providing treatment that resulted in successful outcomes. Additionally, investigators have demonstrated improvements in patient outcomes when patients are included in setting treatment and rehabilitation goals (Holliday, Cano, Freeman, & Playford, 2007; Oates, Weston, & Jordan, 2000; Street et al., 2009). My transition to patient-centered care was my first step toward the advancement of my clinical practice in AT.

After I have listened to what my patient's primary needs are, I consider what correlation, if any, the primary needs have to movement dysfunction that I previously identified through the SFMA and TMR Fab6. My treatment methods are intended to address both the patient's primary needs and his or her movement dysfunction. In addition to changes in movement quality (functionality and score), I utilize patient-reported outcomes measures to track changes in my patient's perception of his or her injury and/or quality of life. Throughout my clinical residency, I observed improvements in my patient's movement functionality and quality, as well as in their reported needs. These improvements occurred quicker and lasted longer than those to which I had become accustomed. Further discussion of my patient outcomes measures and the changes that I identified (according to treatments) can be found in Chapter Three.

Since my recent transition from a clinical position to one that is academic, I have discovered that teaching is one of my strengths. I was apprehensive to accept the first adjunct teaching offer that I received, but I immediately found enjoyment in teaching the various facets of AT (e.g. kinesiology, exercise physiology, and cardiopulmonary resuscitation/first aid). I continued teaching for the department of exercise and health science and later accepted a full time teaching position. While teaching undergraduate students, I have learned that in order to effectively disseminate information and foster student learning, an instructor must fully grasp subjects and concepts taught, including knowledge, comprehension, application, analysis, synthesis, and evaluation (Bloom's taxonomy of educational objectives, 1956). These concepts are important to other areas of my clinical practice, as well. In my clinical and teaching philosophies, I discuss the fluid nature of information pertinent to patient care and teaching.

Throughout my tenure in the DAT program, I was exposed to a number of treatment, evaluation, and diagnostic paradigms. After I had gained a sufficient understanding about a new paradigm, I was eager to apply it in my practice. The eagerness I gained from learning new treatments, evaluations, and/or diagnostic paradigms helped me maintain a passion for my work as a clinician. In order to achieve successful clinical and academic practices, I review each component of my practice and decide if change is warranted through evidence available to me. Since my time in the DAT, my passion for teaching has grown, as has my ability to challenge my students through critical analyses and thoughtful discussions.

Specific Strengths

1. In order to identify the correct pathologies, I establish my patient assessments and evaluations using movement quality (SFMA) and scoring (TMR Fab6).
2. I provide successful treatments to my patients through evidence-based practice and proper pathological identification.
3. I utilize outcomes measures to determine positive changes in my patient's movement dysfunctions, and to decide whether or not those changes are adequate.
4. I support the clinical decisions I make through EBP patient care, including: 1) immediate care, 2) injury rehabilitation, 3) diagnosis, and 4) injury prevention.
5. I value and incorporate my patient's needs into the treatment I provide, through patient-centered care.
6. I promote an effective learning environment in which students feel comfortable asking meaningful questions that result in valued discussion.
7. I possess above-average manual therapy skills, gained through my experience in clinical practice and in massage therapy school.
8. I use research-based movement screens to identify individuals who are at risk for non-contact lower extremity injury.
9. I am committed to continually advancing my clinical skills and teaching abilities so I can provide my patients and students with better service.

Reflection on Weaknesses

While in the DAT program, I have become aware of the clinical and personal weaknesses that I possess. My weaknesses were made manifest through the weekly journal reflections I made on my clinical and professional practice and through dialogue between me, my fellow DAT students, and the DAT faculty. The weaknesses that I felt needed to be addressed the most were: 1) complacency in the workplace, 2) faulty research methods, and 3) poor clinical documentation. The goals that I then set—with the intention of rectifying my weaknesses and turning them into strengths—and the plans for the accomplishment of these goals will be discussed in greater detail in the next section.

After I began teaching full-time at Bryan College, I found it easy to accomplish my job duties. I was responsible for teaching 12 class credits each semester, being available 8 hours each week in my office, and providing students with advising, as needed. I often worked less than 40 hours a week, which my previous position as the head athletic trainer never allowed. As a full-time professor, I contributed very little to the development of the EHS department because I felt that I, being the newest member of the department, was not obligated to do so. My complacent mindset limited my potential to contribute to the department.

While in my final semester of the DAT program—which also was my final teaching semester at Bryan College—I created a "Pre-Physical Therapy" track within the EHS major. During the three years I taught in the department, I had witnessed students neglect to enroll in the appropriate classes that they would need for a graduate physical therapy program. The initiative I took to create the Pre-Physical Therapy track subsequently encouraged my EHS cohort professor to help me to create additional tracks for pre-athletic trainers, pre-physicians' assistants, and pre-chiropractors. My desire to create the tracks was spurred by dialogue that I had with a DAT cohort during our final semester. My cohort reminded me that we may become lazy when we find comfort in a work position. To address any future risk of workplace complacency, I will continue to enroll in workshops and seminars in which I will be able to receive applicable skills sets specific to my profession as an educator and/or clinician.

Prior to my time in the DAT program, I had little exposure and experience with research in AT, both clinical and lab-based. During my master's program at San Jose State University, I conducted a research investigation on injury rates and activity level in female high school student athletes. Although I learned basic research and statistical methods from my master's program, I had little desire to continue conducting research after its completion. I was uninterested in further research endeavors, because I did not consider the value that research held for me or for my profession as a whole. However, once I began learning new clinical paradigms, I began to want to address the problems I identified in my patient population through research endeavors.

The continuance of my interest in research was a matter of focusing on the issues that I observed in my clinical practice. The first issue that held my interest was the predictive ability of movement screens and tools to identify female individuals at risk for non-contact ACL injury. I witnessed a high incidence of non-contact ACL injuries among my female patient population, and I wanted to investigate the accuracy of a movement screen (FMS) and a previously validated prediction tool (KAM) in identifying individuals at a higher risk of ACL injury. The second issue involved gaining a better understanding of the manual therapies that sought to improve tissue dysfunction. After my discussion with fellow DAT students about my frustration when choosing an optimal manual therapy, I decided to investigate and write an article about three common therapies used to improve tissue dysfunction (McMurray et al., 2015). My investigation helped me to better understand the supporting theory and clinical application for myofascial release therapy (MRT), instrument assisted soft tissue mobilization (IASTM), and Active Release Techniques® (ART®).

As I further my career in AT, I will identify issues that I encounter in my practice and setting, review literature that relates to the issues, and decide if any gaps in research exist that warrant further research. Through my research, I intend to improve the real-world clinical issues that I and my patients encounter. When I identify meaningful or significant results in my research endeavors, I will submit a manuscript of my investigation to an appropriate scholarly journal.

I learned the value and need for accurate and consistent clinical documentation during my undergraduate AT program. Throughout my employment in the secondary school setting, however, I did not prioritize my clinical documentation—specifically my patient treatment and progress notes. I often thought that I did not have the time to provide sufficient treatment and complete my paperwork. I relied on my patients to remember how they felt before and after my treatments. Aside from the patient recalling how they felt prior to their last treatment and whether their issue had improved, I had no way to know which of my treatments provided any benefit. My transition to the collegiate athletic setting resulted in minor improvements in my clinical documentation in that I began to document the treatment that I provided on a consistent basis. I did little with the information I collected, however.

Once I entered into the DAT program, I learned the value of proper clinical documentation. My positive patient outcomes were evidence that I was indeed providing treatments that resulted in significant improvements in my patients. I incorporated a number of patient outcomes measures into my clinical practice, including a numeric rating scale, a patient specific functional scale, a disablement in the physically active scale, a foot and ankle disability index, and a McGill pain questionnaire. I also noticed that my patients benefited from witnessing changes in their reported outcomes measures. At times, a patient's improvement was less apparent on a day-to-day basis. Providing that patient with the changes in his or her outcomes scores gave the patient reassurance that he or she was improving.

After collecting patient outcomes for the past two years, I am confident that it is now habitual in my clinical practice. I plan to remain vigilant in my documentation through continued use of outcomes measures and through incorporating other outcomes measures that pertain to my patient population and intended measure (e.g., pain, quality of life, function).

Specific Weaknesses and Areas Needing Improvement

1. Investment in my career and workplace
2. Awareness of my "people-pleasing" nature
3. Participation in professional and public speaking engagements
4. Plan for future research endeavors
5. Optimization of my clinical documentation protocol
6. Investigation of the myokinesthetics treatment intervention

Goals for Professional Practice

Professionals of different disciplines generally agree that goal-setting leads to an improvement in professional practice (Brunstein & Gollwitzer, 1996; Duke, 1990; Playford et al., 2000). Goal-setting examples of various professions that have led to improved professional practice include, but are not limited to: educational teaching (Duke, 1990; Lumpe, Czerniak, Haney, & Beltyukova, 2012), nursing (Hinds et al., 2015), physical therapy (Playford et al., 2000), and athletic training (Courson et al., 2014). Components of professional practice that are improved upon include: educational- academic performance (Chase et al., 2013) and healthcare- patient outcomes (Arnetz, Almin, Bergström, Franzen, & Nilsson, 2004; Ericsson, 2015). Goals may then be established by both individuals and organizations after an assessment has occurred and should address identified personal (individual) and organization-based weaknesses (Eva & Regehr, 2005).

During my final academic semester in the DAT (Spring 2015), I accepted the position of clinical coordinator of AT education at King University in Bristol, Tennessee. The position is my first opportunity to teach in an accredited AT program. I look forward to contributing what I have recently gained from the DAT program at the University of Idaho, especially my application of EBP, action research, and patient outcomes measures. I believe that my direct impact on future athletic trainers will provide me with ample job satisfaction. Because I know that I instill much of my own beliefs and perceptions of AT in the students I teach, I am obligated to maintain my clinical knowledge and practice at the highest level possible.

My exposure to patients on a regular basis allows me to practice and improve my clinical skills. In turn, I can provide better instruction and practice-based evidence to my AT students in the classroom. My current patient population comes to me through referral from my previous patients. Beginning in the fall of 2015, I have the opportunity to treat student-athletes at King University. Although my work contract does not require me to treat individuals at the University, the AT staff have allowed me to treat the student-athlete population. I plan to incorporate *a priori* treatment plans specific to any observed movement dysfunctions. My patient care and low-back pain philosophies serve to remind me of my foundational purpose and intention to improve my patients' well-being as well as I can. Both of the philosophies, which can be found in a subsequent section, have changed throughout the DAT, and I anticipate that they will continue to change as I develop as a clinician.

I thoroughly enjoyed conducting my investigation of whether FMS and/or KAM would identify female student-athletes at risk for sustaining a non-contact ACL injury. In preparation for my research investigation, I learned about the risk factors, incidence, and pathology associated with ACL injuries, as well as ACL injury prevention programs and ACL injury risk prediction methods. The results of my investigation have spurred me to create similar research questions that pertain to ACL injury risk prediction. To validate my research findings, I proposed that the King University institutional review board allow me to conduct the same research investigation. I also plan to review and test other clinical measures that may demonstrate the ability to identify individuals at risk for non-contact lower extremity injuries. My research goals are: 1) to address clinical problems evident in my patient population, 2) to contribute to the body of literature specific to my research questions, and 3) to equip clinicians with tools to identify individuals at risk for non-contact injuries.

As I continue my research endeavors and achieve further understanding in my area of advanced practice, I will present at state, regional, and national conferences to disseminate my knowledge regarding non-contact lower extremity injury risk prediction. My purpose in presenting to fellow clinicians is to inform them of my research findings, to provide them with information that they can immediately incorporate into their practice, and to promote the importance of continual AT scholarship to my students and fellow athletic trainers. This will also help address my need for improvement in professional and public speaking.

Professional Development

Successful professional development requires a detailed plan that is intended to help guide the clinician to a higher level of professionalism within their respective field. I have chosen three areas of professional development upon which I plan to improve: 1) my area of advanced practice, 2) my ability to utilize pertinent CEU opportunities, and 3) my completion of a post-professional graduate program (specifically, the DAT). Each of these areas will be reflected on in detail within this subsection, and each reflection will specifically address my current state of development, my future expectations, and my plan for achieving those expectations. Table 2.1 includes my goals and methods to achieve the goals that serve to promote my professional, advanced practice. The goals are reviewed, updated, and modified as needed to promote continual growth and clinical advancement.

Area of Advanced Practice

When I reflect on the 11 years I served as an athletic trainer, I am frustrated that I did not build upon (or even begin to select) an area of advanced practice. I do have strengths within specific areas of practice; however, I would not consider the level of strengths to be near what could be considered "advanced." The DAT program sparked a desire in me to seek out an area of advanced practice, and composing a literature review during the first semester of the program guided me towards the selection of an area: lower extremity non-contact injury risk screening.

At the time I began composing the literature review, I did not find a significant breadth of literature on practical lower-extremity non-contact injury risk screens. In July 2013, however, I learned of the Functional Movement Screen (FMS) and Selective Functional Movement Assessment (SFMA), which are assessment tools that have the potential to determine and reduce lower extremity injury risk in patients.

I began using the FMS in the fall of 2013 at Bryan College, where I worked with individuals participating in collegiate sports. I screened approximately 100 individuals to develop a pilot study to determine whether a correlation exists among non-contact injury rates and participants' FMS score. In the fall of 2014, I conducted FMS screens on approximately 200 female individuals who participated in soccer, basketball, or volleyball for my research study regarding lower extremity non-contact injury risk assessment. Both studies supported the area of advanced practice I am pursuing. During the spring of 2014, I completed the FMS level 1 course online. I attended a workshop on the SFMA in January of 2014 in Atlanta. This workshop proved extremely beneficial to me, in that it helped me to acquire assessment skills for identifying movement dysfunction.

My area of advanced practice is non-contact ACL and lower extremity injury risk screening. Included in this area are prediction, prevention, movement screen assessment, and manual therapy application. I plan to further strengthen my area of advanced practice in lower extremity non-contact injury risk assessment by researching other assessment tools that measure movement quality. Further enhancement of growth and maturity in my area of advanced practice will also occur by attending lectures that relate to predictive lower extremity injury risk screening.

Continuing Education Units

Continuing education units (CEUs) play an important role in professional development. Principle 3.4 of the NATA code of ethics states, “Members shall recognize the need for continuing education and participate in educational activities that enhance their skills and knowledge” (September 28, 2005, http://www.nata.org/codeofethics). Due to the ever-changing nature of health care, what seemed appropriate 10 years ago may be ill advised in today’s clinical practice. I have not upheld principle 3.4 for the greater span of my career. Although I have purchased online CEUs and have attended massage therapy school for CEUs, I have not participated in what most consider to be educational activities that further my development as an athletic trainer. I attended my first annual national NATA convention in 2009; since then, I have not missed one. Valuable and up-to-date information regarding advanced practice techniques can be learned at national conventions, and I look forward to regularly attending them from now on. I plan to focus my CEU activities around those that broaden my clinical skills, enhance my area of advanced practice, and support an EBP.

Doctor of Athletic Training

Completion of the DAT program is paramount to my professional development. Once I have graduated from the program, I plan to further contribute action research in my area of advanced practice to the field of AT. When I enrolled in the DAT program, I did not anticipate my past lack of academic drive to be a problem; however, because procrastination was a constant battle in both of my previous educational programs, I was fully aware that it could emerge as the program progressed. Students in the DAT program begin writing their dissertations during their first semester. This motivated me to remain ahead of the expected readings, reflections, and projects.

Table 2.1
Goals to Achieve Plan of Advanced Practice

Area of Focus - Goal	Methods to Accomplish Goal - Measures of successful completion of goal	Completion Status - Date
Professional Development - Clinical Skills Improvement	Review patient outcomes and compare results in literature specific to the dysfunction and treatment provided - Achieve minimal clinically important difference (MCID) in 80% of outcomes measures - Total number treatment sessions provided to patients with specific dysfunction are less than or comparable with the total number of treatment sessions demonstrated in literature	Ongoing (current and future) - Achieved in Spring 2014, Fall 2014, and Spring 2015 - Achieved in Fall 2014 and Spring 2015

- Broaden Clinical Treatment Options	Attend workshops and seminars on treatment interventions that demonstrate successful outcomes in literature and that are, to me, 1) not well understood, 2) address movement dysfunction, 3) new or unknown, and/or 4) related to my area of advanced practice - Complete a myokinesthetics course - Complete PRRT online program - Complete a Mulligan Concept workshop - Complete TMR through level 3	Ongoing - PRRT course April 2014 (completed) - MWM course June 2014 (completed) - TMR level 1 - Jan. 2015 - (completed) - TMR level 2 and 3 date TBD - Myokinesthetics course date TBD
- Continuing Education Units-	Utilize CEUs that promote my professional development, broaden my treatment options, focus on my area of advanced practice, and address my areas of needed further improvement - Attend national NATA convention - Attend lectures to enhance my area of advanced practice (movement screen, injury prevention and prediction, and manual therapy application)	Ongoing - NATA convention 2009 - present - SFMA- Jan. 2014 (completed) - FMS level 1 - Feb. 2014 (completed) - Webinar by JOSPT: Treatment after ACL surgery, return to sports Nov. 2014 (completed) - Concussion seminar by Robert Cantu: Diagnosis, treatment and management of concussion- July 2015 (completed)
- Evidence Based Practice	Integrate anecdotal statements with scientific evidence and patient input to seek out and provide current best practices - Complete NATA EPB in AT, modules 1 and 2, and pass the associated quizzes	Ongoing - EBP in AT level 1 and 2, NATA online - Dec. 2014 (passed)

- Teaching Improvement	Identify teaching skills and strategies that will enhance my teaching style, and improve my methods of instruction - Review teaching strategies with my department head biannually - Review teaching strategies with the dean of academics annually - Reflection of student and cohort classroom feedback bi-annually; consider revising method of instruction when overall evaluation is "adequate" or 3/5	Ongoing - Review with department head, 2013 - current - Review with dean of academics, 2014-current - Overall student feedback score: Fall 2014 - 4.2/5; Spring 2015 - 4.6/5
Area of Advanced Practice - Movement Screening	Advanced development and understanding of current movement screens, methods of lower extremity injury risk prediction and prevention, and manual therapy applications - Achieve FMS levels 1 and 2 - Attend SFMA workshop - Complete SFMA certification	- SFMA - Jan. 2014 (completed) - FMS level 1 - Feb. 2014 (completed) - FMS level 2 - Dec. 2016 - SFMA certification - April 2015 (completed)
- Lower Extremity Injury Risk Prediction	- Review literature on Y-balance test and STAR excursion test, KAM, and landing error scoring system - Identify appropriate parameters for collegiate female population	- Literature review – Jan. 2015 (completed) - Fall 2016 (in progress)
- Lower Extremity Injury Prevention	- Conduct an investigation with lower extremity injury prevention programs (KLIP, FIFA 11+, and PEP)	- Date TBD
- Manual Therapy Application	- Review common methods of manual therapy (indirect MFR, IASTM, and ART)	- Comparison of manual therapies manuscript- Jan. 2015 (completed)
Professional and Academic Scholarship - DAT program	My continual effort to gain knowledge (clinical and academic), apply what I learn, analyze the results of my applications, critically reflect on those results, and share my results with students and clinicians - Proposal of dissertation, defense of dissertation, and completion of degree	- Proposal - Summer 2014 (completed) - Defense- date TBD

- Conference Presentations	- Present on lower extremity injury prevention options at a professional conference (annual NATA convention, regional SEATA annual convention, and/or state TATA annual conference)	Ongoing - Regional interdependence: Assistant presenter NATA national symposium, June 2014 (completed) - Submission - April 2016 (ACL risk prediction)
- Article Publications	Manuscript submissions to scholarly journals - Review and comparison of common methods of manual therapy, IJATT (published Sept. 2015)	 - Submission: Jan. 2014 (completed and accepted)

Athletic Training Philosophies

The initial purpose of my philosophies was to establish a foundation from my beliefs that, based on sound principles of practice, would allow me to ask the "right questions" (academic and clinical). For example, in my Patient Care Philosophy, I state that I "…expect the patient to become part of the rehabilitative process…." During patient care, I then ask myself, "Have I included in my treatment plan interventions that require my patient to contribute towards their recovery?" My purpose in asking questions such as this one was to promote my development towards becoming an advanced practitioner. The philosophies that I created inform and remind me of my purpose, specific to the subject (patient care, low back pain, and teaching).

My philosophy regarding patient care in my clinical practice has also changed since my time in the DAT program. Prior to the program, I chose treatment interventions that I believed would address the symptoms that I considered to be of significance in my patients. I judged the success of my treatments based on whether or not my patient's symptoms improved or not. My treatments were typically intended to directly address inflammatory symptoms (pain, redness, swelling, heat, and loss of function). This approach was a "Band-Aid" to my patient's true problem, and my treatments were suppressing the body's natural response to the pathological problem. When I reflect back on the times when I treated my patients with this mindset, I am not surprised that their symptoms quickly returned.

Patient Care Philosophy – Scott Landis (July 15, 2015)

I believe that patient-centered care is vital to the rehabilitative process. Along with my focused care of the patient, I strive to critically reflect on the results of my treatments in order to foster meaningful changes in my patients' health. I carry out the treatment changes through action research, which requires me to make continual changes and modifications to my original plan.

I also expect the patient to become part of the rehabilitative process, as higher adherence to my treatment plans often results in a quicker recovery. Emphasis is also placed on patient education. Patients who understand the principles behind their treatments respond to those treatments with more diligence. I encourage my patients to continue their treatment outside the clinic in order to promote recovery. I consider treatment to be any process that intends to improve a patient's current state of disease and/or dysfunction.

Low-back Pain Philosophy – Scott Landis (February 20, 2015)

Rehabilitation of LBP should improve patient's symptoms and identify and correct the pathology which led to LBP. I consider regional interdependence in my patients with LBP; as there may be structurally compromised tissue away from the site of pain in the lower back. Conducting a thorough evaluation and movement quality assessment (both global and segmental) helps to identify problems affecting the apparent pathology. I use the SFMA to identify dysfunction throughout the body and to establish a movement quality baseline. After treatment is provided, the SFMA assessment is conducted again, and any changes in movement quality and range of motion are noted. Total motion release (TMR) is also incorporated, in order to monitor changes in the patient's movement quality.

Low-back pain can be caused by outlying issues of the body that are seemingly unrelated to the lower back, entirely. My primary goal is to rule out genuine lower-back pathology at or near the site of pain, determine and treat dysfunction thought to be unrelated, and provide lasting improvement for the patient. Further investigation of the treatment protocols found in "Physical Therapy Management of Low Back Pain" (Chevan & Clapis, 2013) may alter the treatment philosophy. Biannual re-assessment of my LBP treatment philosophy will allow improvement in my approach to patients with LBP.

Teaching Philosophy – Scott Landis (May 4, 2015)

I believe that education provides students with a strong foundation and a source for gaining wisdom in their chosen field. Teachers at all levels play an integral role, and, in fact, have a duty to promote students' thirst for wisdom and truth. By prompting students with a statement that facilitates their inquiry to respond with 'why' and 'how,' I seek to advance my students towards wisdom and truth.

During my undergraduate education, I experienced first-hand the benefit in learning information through different modalities. Within the study of athletic training, I combine visual, auditory, and kinesthetic modalities for learning, whenever possible. I have found such opportunities to be plentiful in most classes that I have taught. For example, in my Structural Kinesiology class: I discuss the characteristics of the shoulder complex (auditory), I provide images and skeletal models of the shoulder (visual), and I conduct a participatory lab in which students locate key structures and perform each motion of the shoulder with a classmate (kinesthetic).

As an educator, I strive to always conduct myself in a professional, respectful, and non-judgmental manner. It is also my goal to remain open-minded and steadfast in teaching my students from an objective standpoint, and to present accurate information specific to each class. My demeanor—how I react to different situations, both good and bad, both in and out of the classroom—is critical to imparting wisdom to my students. The success of my students, to an extent, determines my success as their educator.

Justification of the Plan of Advanced Practice

Creating a PoAP offers practitioners a logical and critically-thoughtful process through which to achieve one's desired level of practice. Because I desire to advance my level of education and clinical practice in AT, a PoAP was necessary to facilitate my professional growth as both a scholar and a clinician. As stated when I described my pre-DAT clinical years, I did not practice AT beyond an intermediate-level AT clinician before I enrolled in the DAT program. I learned a great deal about myself while writing my plan of advanced practice. More importantly, I made clear what goals and expectations I had for the DAT program, for my own professional development, and for the continuance of my professional and academic scholarship.

The reflection on my personal experiences and development as an athletic trainer led me to consider where my clinical competence stood when it came to basic science knowledge, clinical knowledge, and EBP implementation. Once I understood my clinical competence in these three areas, I could more accurately identify my strengths and weaknesses. My critical reflections on these competencies provided me with a foundation to more effectively choose goals that would best lead me toward an advanced practice in AT. The goals that I chose serve to improve my professional development, area of advanced practice, and professional and academic scholarship. As I continued through the DAT program, I changed my clinical and teaching philosophies to reflect my progression toward advanced practice.

This PoAP serves to remind me of where I was as an athletic trainer, where I currently am, and where I expect to be in the future. My current and prior weaknesses are less likely to inhibit my advancement in AT because of the results I achieved in my patient care while in the DAT program. My desire to advance in the area of injury risk prediction also decreases my risk of repeating old practice habits. I am aware and will remain mindful that barriers and weaknesses not yet anticipated or known do exist. Therefore, I will modify my plan of advanced practice on a semester basis, each year. I plan to remain steadfast in further advancement of my practice, as there is always more to learn.

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CHAPTER 3

CLINICAL OUTCOMES SUMMARY, RESIDENCY FINDINGS, AND STATEMENT OF IMPACT

The purpose of this chapter is to analyze my clinical outcomes and demonstrate the progression I made, as a clinician, during my residency.

First, I will supply a reflective narrative of my patient care while in residency. In this narrative, I will discuss the process by which I achieved proficiency in two particular assessment paradigms that were introduced in the DAT program: Regional Interdependence, and the Selective Functional Movement Assessment (SFMA).

Next, I will provide a progressive and comparative analysis of the clinical outcomes that I gathered each semester. I will recount specific cases of patient care, which will include examples of instances of meaningful *a posteriori* self-reflection, the likes of which improved my patients' outcomes and inspired me to refine my *a priori* treatment methodology. In providing this analysis of each semester's clinical outcomes, I will supply and support the rationale under which I operated when making decisions regarding whether or not to change a patient's treatment.

Finally, I will evaluate my residency's impact on me, as a clinician. I will provide the reader with "before, during, and after" perspectives on my residency, which will ultimately yield evidence of its positive impact on me and my patient care.

Reflective Narrative

Acquisition of Skills

According to S. Dreyfus & H. Dreyfus (1980), individuals who wish to procure a new skill may do so through trial-and-error or by seeking instruction from a person or manual. The authors created a 5-stage skill acquisition rating scale that defines the progressive ownership of a skill: 1) novice, 2) competence, 3) proficiency, 4) expertise, and 5) mastery. The Dreyfus model has been used to identify and define skill ownership in various healthcare professions that rely heavily on learned skills (Benner, 2004; Carraccio, Benson, Nixon, & Derstine, 2008; Peña, 2010). While in the DAT, I improved my skills in using different treatment interventions primarily through an individual's instruction. This instruction usually occurred at a seminar, workshop, or class where I could learn and practice the skill with someone who had acquired "expertise" or "mastery" in the skill that was being taught. I found this kind of teaching to be more effective, for me, than instruction I received from a book and/or through trial and error.

Utilization of Assessment Paradigms

Early in the DAT program, the faculty introduced assessment paradigms to allow the DAT cohort the opportunity, through clinical reasoning, to improve their ability to identify instances of true pathological dysfunction. Although many assessment paradigms currently exist in some degree, most evolved from dysfunctional movement theories that Janda, Sahrmann, and Cyriax created (Petty, 2011). I found Cyriax's concept of regional interdependence to be the most useful in my patient assessments.

Regional Interdependence

Regional interdependence is a concept that demonstrates how neuromuscular-skeletal dysfunction in an area that is seemingly unrelated to a patient's injury may, in fact, contribute to that patient's primary complaint (Wainner, Whitman, Cleland, & Flynn, 2007). Once I began to consider regional interdependence as a contributor to my patients' dysfunctions, I found that I could more easily identify the true causes of their initial dysfunctions and choose appropriate treatments for my patients. My improved treatment selections led to a reduction in my patient's overall treatment and injury recovery times.

Selective Functional Movement Assessment (SFMA)

Cook (2010) suggests that treating movement dysfunction away from pain may reduce a patient's pain overall. He promotes a movement assessment tool called the *Selective Functional Movement Assessment* (SFMA). The SFMA was designed to assess seven fundamental movement patterns in individuals with symptomatic pain. The use of the SFMA as a tool affords clinicians with an approach to patient assessment that allows for systematic classification of dysfunction (Cook, 2010). I was introduced to the SFMA in the summer of 2013 (Summer-1). Although I came to understand this assessment tool, I found utilizing it to be time consuming whenever movement breakouts were indicated. I remained hopeful, however, that with practice, I would improve my ability to conduct the SFMA with efficiency. The SFMA was also useful to me as a baseline measure for the effectiveness of my treatment. When treatments that I used on patients eliminated a previously identified movement dysfunction, I could begin to classify successful and unsuccessful treatments based on the specific dysfunction identified.

Progressive and Comparative Analysis of Clinical Outcomes

During the summer of 2013, shortly after I began my journey through the DAT program, the DAT faculty challenged me to objectively determine where I stood in my clinical competency in regards to patient treatment. In order to identify my clinical competency, I needed proof of whether or not my treatments were working. Therefore, I created a plan of advanced practice in which I would begin to collect appropriate global and patient-specific outcomes on a consistent basis. I decided that all of the patients whom I evaluated would receive a daily and weekly outcomes measure, regardless of their injury or complaint. The weekly global outcomes measure that I used was the Disablement in the Physically Active (DPA) scale, which covers four domains of an individual's well-being: impairments, functional limitations, disability, and quality of life (Vela & Denegar, 2010). I also chose to use the 11-point Numeric Rating Scale (NRS) to measure pain intensity before and after treatment interventions. The NRS is easily administered and is scored from 0-10, with 0 being no pain at all and 10 being the worst pain imaginable (Farrar, Young, LaMoreaux, Werth, & Poole, 2001). My intention in collecting the outcomes measures was, for the first time, to objectively evaluate and assess the results of treatment I provided.

Fall-1

Summary

Although my goals going into the Fall 2013 (Fall-1) semester were straightforward and simple to perceive, I did not anticipate how difficult it would be to change old clinical habits. My Fall-1 goals were: to begin collecting patient outcomes, investigate the theoretical basis for my clinical decisions, and develop my research questions. I was made aware of my old habits early on, through my weekly reflective journaling and through discussions with other members of the DAT cohort. The consistent administration and collection of patient outcomes using the DPA scale and NRS was my primary struggle early in the semester. The DAT cohort advised me to consider collecting patient outcomes on a specific patient population.

Once I began to identify similarities in dysfunction and responses to treatment, I realized that I could begin to classify patients into groups. I began to do so according to my patients' dysfunctions, which I revealed using the SFMA. I also grouped my patients based on their type of injury (acute or chronic), treatment provided, and location of injury. Using these groups to classify my patients helped me to see the benefit of collecting patient outcomes. I was better able to identify which of my treatments were the most or the least successful, which movement dysfunctions I consistently improved or did not improve, and whether or not my outcomes indicated adequate results based on the types and/or location of injuries (e.g. acute ankle sprains).

While in residency, my patient population consisted primarily of collegiate-level athletes and general college students, with the occasional faculty or staff member, all of whom were associated with Bryan College. I also received patients through referrals. These patients, whom I treated outside of the athletic training clinic, included general students, faculty, and staff members, also from Bryan College. Due to constraints on my time, during the Fall-1 semester, I was unable to commit to more than one treatment session per week with my patients who were non-student-athletes. I treated 20 patients in the Fall-1 semester, 6 of whom were non-student-athletes. Considering the number of treatments per week, my patient outcomes measures demonstrated that no statistically significant difference existed between my patients treated weekly and those treated two or more times per week (DPA, $p = 0.31$; NRS, $p = 0.45$). At the end of the Fall-1 semester, I believed there were two reasons why my patients who were treated more often did not evidence improved outcomes: I did not have any patient outcomes from previous years to compare with my Fall-1 semester outcomes, and I was not adequately proficient with the SFMA to identify dysfunction associated with regional interdependence. My plan to address these issues can be found in the “Resulting Semester Goals and Changes in Practice” section for this semester.

During the Fall-1 semester, the treatments interventions that I utilized most often were Positional Release Therapy (PRT), instrument-assisted soft tissue mobilization (IASTM), and Mulligan Mobilization with Movement (MWM). The goal of PRT is to reduce the irritability of tender points (TPs) that result from somatic dysfunction in the body, through the identification of optimal movements and positions of comfort (D'Ambrogio, Roth, Robertson, Halperin, & Wiley, 1997). I found myself using PRT often, because of its simplicity of application and its immediate results. I used the NRS outcome measure before and after I applied PRT.

In order to identify which of my treatment interventions resulted in successful or unsuccessful patient outcomes, I classified my patients according to the type of injury they presented with: acute (n = 9) or chronic (n = 11). My patients who had sustained a chronic injury were also classified according to their SFMA (top tier) movement dysfunction (e.g. cervical rotation DN). I collected NRS scores from my Fall-1 patients before and after treatment interventions to identify immediate changes in pain. I also measured my patients' well-being on a weekly basis using the DPA scale, which is a global outcome measure. The treatment interventions that I collected NRS scores on were PRT (n = 13), IASTM (n = 3), and Mulligan MWM (n = 4). Based on my analysis of the treatment interventions I used, I was able to provide the acute injury patient group with the greatest immediate and overall reduction in pain (NRS immediate m = -3.2, NRS overall m = -6.5) and overall improvement in disability (DPA m = -25.3). My chronic injury group results demonstrated adequate changes in their outcomes measures (NRS m = -2.2, DPA m = -14.8). I credited my less successful chronic injury group outcomes to my "proficient" skill acquisition level in using the SFMA. Chart 3.1 represents the changes in my chronic injury patients' DPA values. Chart

3.2 displays the outcomes (DPA) of the treatments I administered to my acute patients. When both figures are observed, one can easily see the greater immediate and overall improvement in my acute patients' DPA scores.

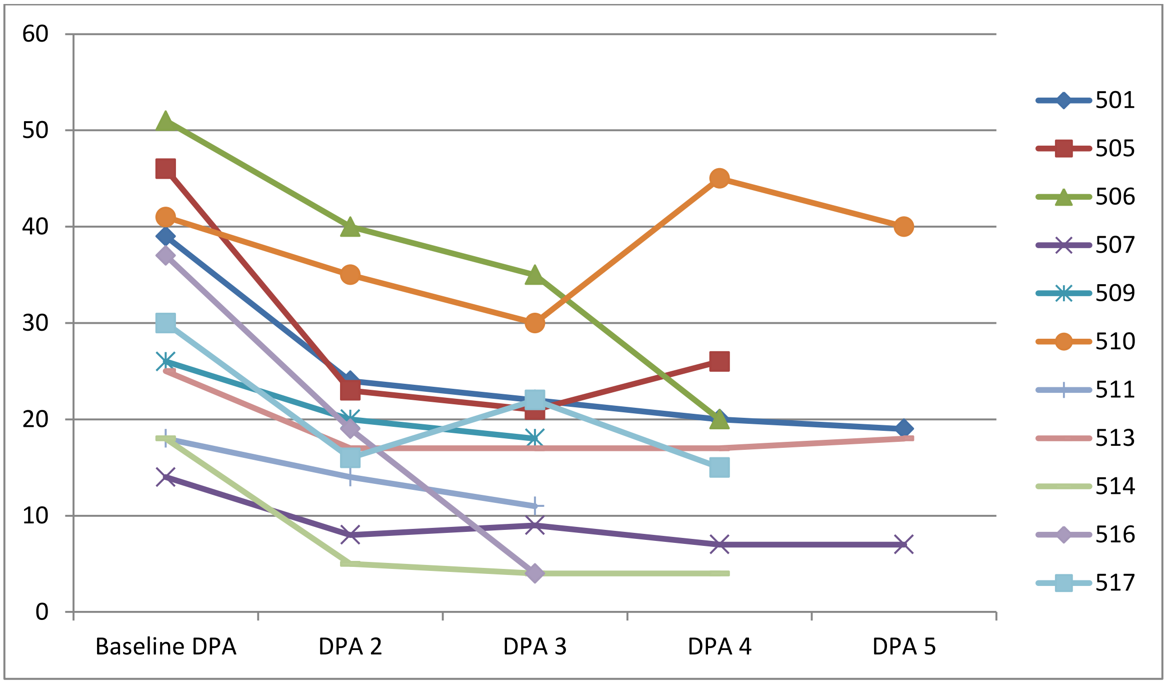

Chart 3.1. Fall-1 DPA scores in chronic patients.

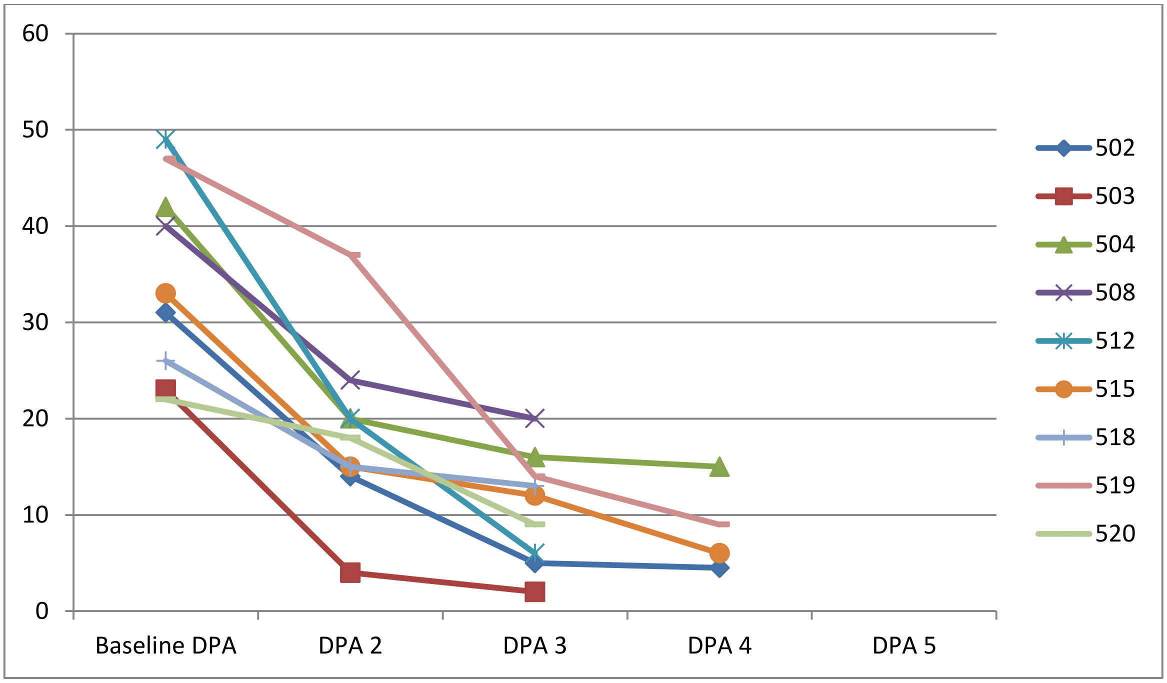

Chart 3.2. Fall-1 DPA scores in acute patients.

I analyzed the NRS score changes of my treatment interventions (PRT, IASTM, and Mulligan MWM) (Table 3.1). When I applied more than one treatment using the same intervention, I collected NRS scores using the same process (before and after the treatment). As previously mentioned, the NRS score total range is 0-10 (11-point scale). Upon consideration of each treatment intervention and its associated NRS scores, it is evident that I achieved the greatest immediate reduction in pain with both injury groups using Mulligan MWMs (Table 3.1).

Considering all treatment interventions (PRT, IASTM, and Mulligan MWM), the average change in my patients' NRS scores was -4.11. The mean overall change in my patients' DPA score was -18.8. Having completed my first semester in residency, I decided that an average overall decrease of -18.8 in my patient's DPA scores was an adequate starting point to begin measuring my clinical effectiveness.

Table 3.1
Treatment Intervention and NRS Pain Score (Immediately Pre- and Post-treatment)

	Acute Injury			Chronic Injury		
	Initial NRS	Post-treatment NRS	Change	Initial NRS	Post-treatment NRS	Change
Mulligan MWM	7.2	3.7	-4.5*	6.3	2.8	-3.5*
IASTM	6.3	4.1	-2.2*	6.4	5.6	-0.8
PRT	6.8	3.9	-2.9*	5.1	2.8	-2.3*

Note. * Denotes MCID was met (NRS MCID = decrease of 2 points or 30%)

Over the course of the Fall 2013 semester, I learned the value of providing greater detail when reporting on my patient cases in my blog posts. When I wrote with more detail, the DAT faculty and cohort were able to gain a clearer picture of the patient cases that I shared and were able to provide me with specific feedback that I was able to use immediately in order to improve my patient care. The following patient cases are examples of my progression towards improved patient care through my dialogue with the DAT faculty and cohort, and my utilization of regional interdependence.

Patient Data

Patient-1.

The first patient (Patient-1) that I treated using PRT was a baseball outfielder who complained of anterior shoulder pain when throwing a long distance. The patient reported having had the pain for the previous three months. Upon palpation, the patient reported his NRS pain at 7. When he attempted to throw a ball, he reported the pain at 8. After I applied PRT on the most painful site in his anterior shoulder musculature, the patient reported his pain at 1. I then used PRT on a different TP in the lateral shoulder musculature that the patient had said was at 6. After one round of PRT, the patient said the pain was at 2.

The results that I received from using PRT on this particular patient were initially very encouraging. The patient even stated, “I cannot remember the last time when my shoulder felt this good.” I treated the patient for four weeks, two times per week. Because the patient’s shoulder pain had often returned by the following scheduled treatment day, I was aware that my treatments were not providing him with any lasting effects. However, I remained content with knowing that I could reduce his shoulder pain immediately using PRT. What I failed to consider, at the time, was why the TPs existed in the first place. Just as I had done before I started the DAT program, I potentially treated symptoms that were the result of a less-apparent movement dysfunction. Simply stated, I was reducing symptoms that the patient’s brain had initiated for a specific reason. My apparently successful use of PRT was short-lived, after I shared the case among the DAT faculty and cohort. We dialogued about the use of PRT in my particular patient case, and then our discussion transitioned to the importance of creating *a priori* treatment plans.

The concept of pre-determined treatment interventions for specific injuries/dysfunctions was difficult for me to entertain early in the Fall-1 semester. I understood the value behind the concept, yet I felt that creating *a priori* plans for particular injuries and movement impairments would be difficult, due to my inability to demonstrate my current clinical effectiveness. The DAT faculty warned the student cohort of the clinical dangers when approaching new patients without a pre-determined systematic process of evaluation and treatment. The faculty’s concern regarding my “shotgun approach” to patient care resonated deep within me. The shotgun approach, also referred to as the *random* *approach* involves the evaluation and/or treatment of patients with little to no procedural thought (McGuire, 1963). I feared that I would not have the opportunity to improve my clinical effectiveness if I continued using a random approach in my patient treatment decisions. My transition from the random approach to a systematic approach quickly became the paramount change I expected to make in the Fall-1 semester.

Patient-2.

One of my patients during the Fall-1 semester was a 21-year-old male (Patient-2) who played club volleyball. During a practice session, the individual attempted to block a ball hit over the net by an opposing player. Upon landing from the block, his right foot landed on a teammate’s foot. The patient reported feeling a distinct pop and felt an immediate sharp pain in his right ankle. In his words, “I felt my foot go in too far.”

Before I began the DAT, I would have stated that the acute mechanism of injury that he described resembled what I believed was a lateral ankle sprain. But because I had, during the Fall 2013 semester, learned about positional faults occurring in joint articulations, I was able to consider how much ligamentous tissue damage had occurred. Upon observation, I noticed that the patient had moderate edema around his lateral ankle. My evaluation consisted of ruling out the possibility of a fracture using the Ottawa ankle rules (Stiell et al., 1993), a squeeze test, and a bump test. All of the tests were negative, which led me to believe that the patient had not sustained a fracture. Therefore, I concluded that the patient suffered from an apparent lateral ankle sprain. Due to the unpredictable nature of acute injuries, I knew that some treatment opportunities, such as the Mulligan Concept lateral ankle MWM, would rarely be used by other ATs. However, I chose to begin that treatment, based on the close resemblance of my patient's case to other patient cases of apparent lateral ankle sprains that were discussed in the DAT.

The Mulligan lateral ankle MWM attempts to correct a positional fault between the distal tibia and fibula articulation (Mulligan, 2004). Once the risk of a fracture has been ruled out, the mobilization should be applied as soon as possible to an acute inversion ankle sprain. For the technique to be successful, Brian Mulligan recommends that clinicians use the "PILL" response to determine whether the Mulligan MWM treatment intervention is appropriate (Mulligan, 2004). The PILL acronym stands for 1) Applications are *pain*-free, 2) *Immediate* results are observed, and 3) Improvements are *long-lasting*.

Before beginning treatment on Patient-2, I asked him to rate his pain (0-10, NRS score) while standing, balancing on the injured leg, and walking. He reported the pain while standing at 4, while balancing at 5, and while walking at 7. During the application of the Mulligan lateral ankle MWM, I confirmed with the patient that the technique was pain-free. I performed the Mulligan lateral ankle MWM in 3 sets of 10 repetitions. After each set, I re-assessed the patient using the baseline NRS scores for standing, balancing, and walking. The results of the treatment intervention are provided in Table 4. The overall changes that the Mulligan lateral ankle MWM demonstrated using the NRS measure exceeded the MCID: a score improvement of 2 or more for standing, balancing, and walking (Table 4). Patient-2 provided me with a vivid reminder to collect the appropriate patient outcomes before and after treatment interventions.

Resulting Semester Goals and Changes in Practice

I was determined to continue to collect outcomes during the semesters following Fall-1 using the same measures that I had used in Fall-1 (DPA and NRS), along with the additional

PSFS measure. I also improved my skill using the SFMA to identify movement dysfunction. I compared subsequent semester outcomes (Spring-1 and Fall-2) in Fall-2 and found similar results in the number of treatment sessions and improvements in my patient outcomes. To understand why providing my patients with more treatments did not result in improved outcomes (compared to patients treated one day per week), I considered other factors in my patient care, including patient education, home exercise prescription, and dysfunction classification.

At the conclusion of the Fall-1 semester, I felt confident that I was beginning to properly treat my patients and their pain. I based my confidence on the overall average change in my patients' DPA score (-18.8) and NRS score (-4.11). I remained aware that the patient outcomes I had collected did not provide me with sufficient evidence to claim that I achieved adequate proficiency in the treatment interventions I utilized. Through continually evaluating my patient outcomes, I expected myself to improve each semester.

Spring-1

Summary

The Spring-1 semester was humbling and difficult at times, yet motivational and inspiring at others. Throughout, I remained mindful of the goals I had made the previous fall, in that I started to collect patient outcomes on a more consistent basis and from the initial injury date to the date of clearance. I also incorporated the PSFS as part of my outcomes measures.

I included 17 patients in my outcomes for the Spring-1 semester. Of the 17 patients, 1 patient was not a student athlete. As before, I classified my patients according to type of injury (acute or chronic), location of injury, and number of treatments provided in a week. I also added the PSFS as a functional outcomes measure, to provide further evidence of how my treatments were impacting my patients.

The PSFS score is an average score of three patient-chosen activities that were hindered due to an injury. Each activity is rated 0-10 on difficulty or performance (0 = unable to perform activity, 10 = able to perform activity at pre-injury level). I collected my patients' PSFS scores before each treatment session began. Charts 3.3 (chronic injury group) and 3.4 (acute injury group) represent my PSFS outcomes for my injury groups. The chronic and acute injury groups' mean change in PSFS scores were + 5.4 and + 4.5, respectively. Investigators in studies have indicated that the MCID in PSFS scores vary depending on the disability (Chatman et al., 1997; McMillan & Binhammer, 2009; Westaway, Stratford, & Binkley, 1998). The MCID for disabilities related to upper and lower extremity dysfunctions falls between + 1.1 and + 3.0 (Chatman et al., 1997; Horn et al., 2012; Nicholas, Hefford, & Tumilty, 2012). Investigators have determined the MCID in patients with chronic low back pain to be + 2.0 (Maughan & Lewis, 2010). The PSFS appears to be more responsive when clinicians use the outcomes measure for specific conditions such as low back pain, neck pain, and lower extremity dysfunction (Stewart, Maher, Refshauge, Bogduk, & Nicholas, 2007). In order to optimally utilize the PSFS, I used the following MCID values for my PSFS scores: lower extremity dysfunction (not including knee dysfunction) + 1.5 points, knee dysfunction + 3.0 points, upper extremity dysfunction + 3.0 points, chronic low back pain + 2.0 points, and neck dysfunction + 2.0 points.

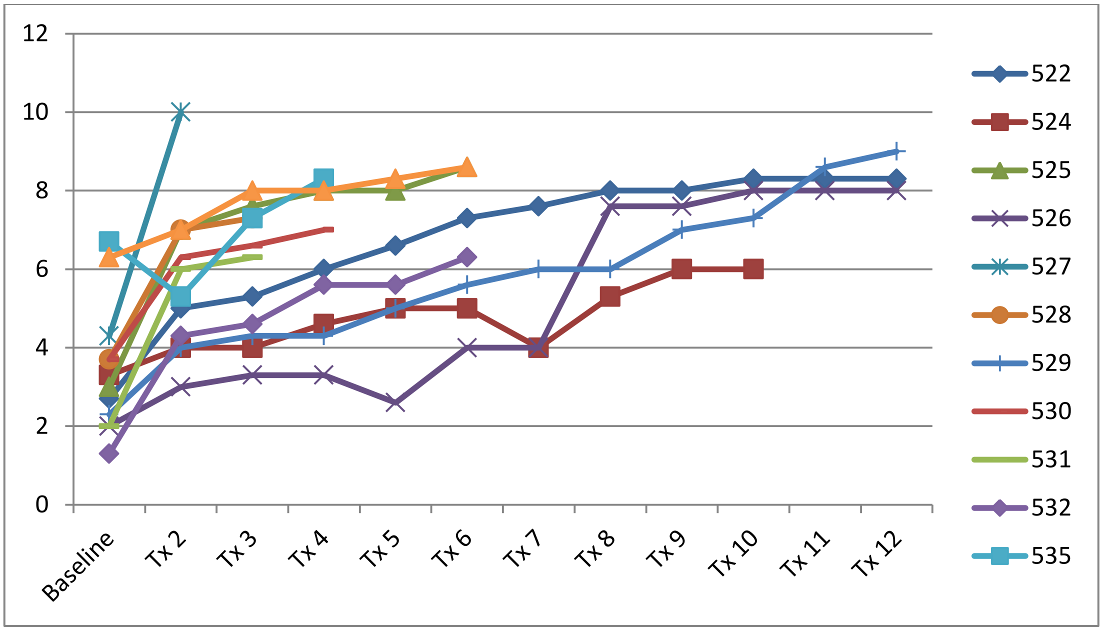

Chart 3.3: Spring-1 PSFS scores in chronic patients.

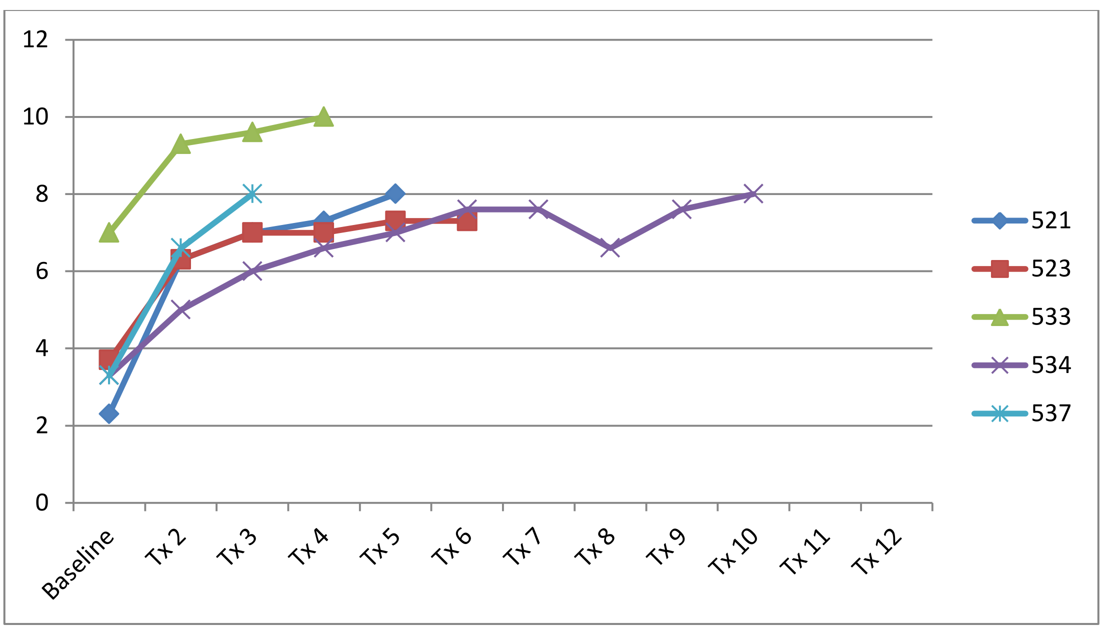

Chart 3.4: Spring-1 PSFS scores in acute patients.

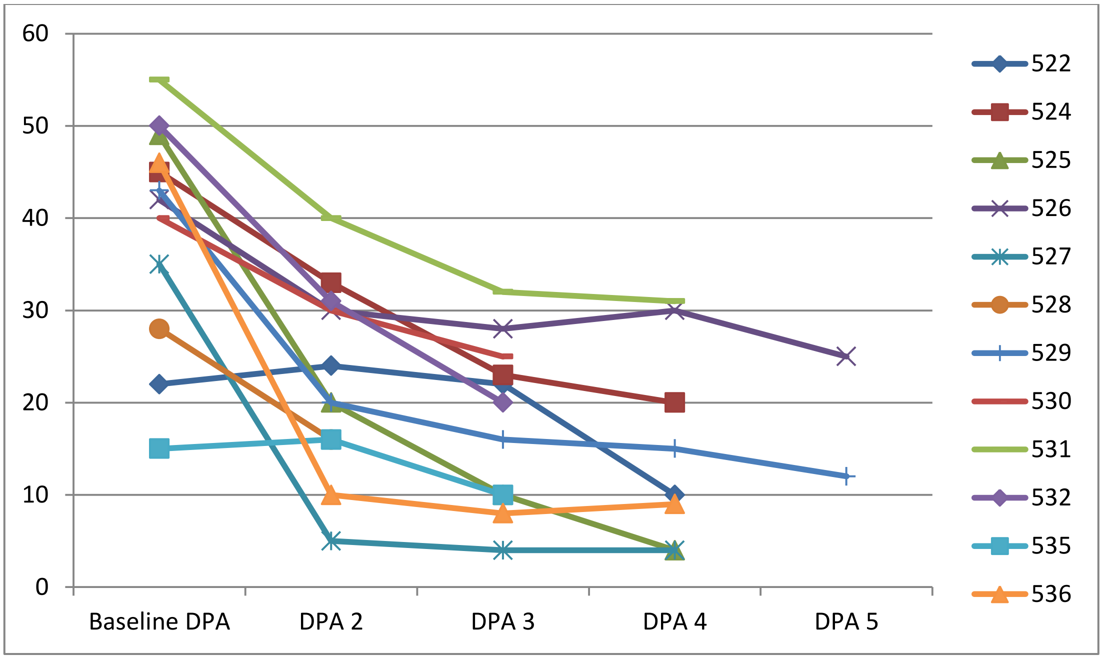

Chart 3.5: Spring-1 DPA scores in chronic patients.

My chronic injury group results demonstrated an improvement in their outcomes measures (NRS *m* = -4.4, DPA *m* = -21.7). The mean chronic outcomes score was a 2.2- (NRS) and 6.9- (DPA) point improvement from my Fall-1 outcomes for my chronic injury group Although I was still not content with my chronic injury patient group outcomes, I decided that the outcomes were adequate for my progression of improved patient care. As evidenced in Chart 3.5, much of the improvement in my patient outcomes occurred between the initial treatment (Baseline) and Treatment 2. During the Spring-1 semester, my treatments often resulted in lasting effects, yet my subsequent treatments did not result in further improvements. I provided 90 treatment sessions (17 initial and 73 subsequent treatments) during the Spring-1 semester. Chart 3.6 provides a comparison of my patient outcomes between the initial treatment, and subsequent treatments. I noticed that a substantial amount of my patients' improvement occurred particularly from my initial treatment. The initial and subsequent treatment groups' PSFS scores resulted in + 2.6- and + 0.4-point mean improvements, respectively. The MCID for PSFS outcomes was achieved in 13 of 17 initial treatments (76%), and 5 of 62 subsequent treatments (or 8%). The DPA mean score improvements were -15.9 ± 10.5 with a 95% confidence interval between 10.5 and 21.3 (initial treatment, MCID achieved in 12 of 17), and -4.2 ± 3.9 with a 95% confidence interval between 2.7 and 5.7 (subsequent treatment, MCID achieved in 4 of 27). I also compared my patients' NRS scores in a similar manner: I evaluated their change in pain before and after my initial treatment (mean = -3.3 ± 1.7, $p < 0.01$), and changes in pain before and after each subsequent treatment (mean = -0.32 ± 1.3, $p = 0.06$). My findings confirmed my earlier suspicion that I needed to change how I approached my follow-up treatments.

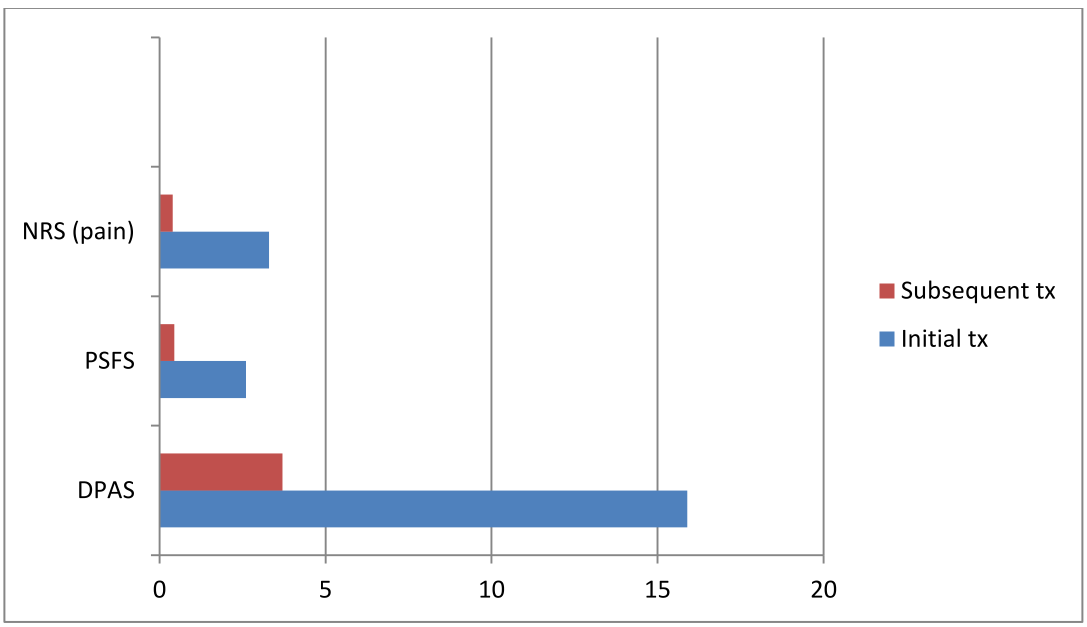

Chart 3.6: Spring-1 comparison of initial and subsequent treatment outcomes.

As I prepared for the Fall-2 semester, I desired to 1) decrease the total number of days in which I provided treatment to my chronic injury patients, and 2) achieve final DPA scores closer to zero. I expected my *a priori* treatment designs to help me to accomplish these goals, because the “shotgun” or guessing approach to my clinical reasoning would be eliminated. To help indicate the lasting effects of my treatments post patient discharge, I planned to collect my patients’ DPA scores 1-2 weeks following their final treatment.

Historically, I have emphasized patient education in my practice. However, before I entered into the DAT program, I educated my patients mostly on the injury that I suspected they had sustained, and not on the treatment I provided. While in the DAT, my patient education changed to a focus on my treatment rationale and how the treatment I chose addressed the identified dysfunctions. During my second, third, and final semester in residency, I observed an increase in my patient adherence to their prescribed home exercises—a direct result of my improved patient education. Indeed, investigators have established that patient education (patients’ understanding of their own dysfunctions) facilitates behavior change and leads to improved adherence to home treatment and patient outcomes (Jack, McLean, Moffett, & Gardiner, 2010; Wagner, Austin, & Korff, 1996).

Following my early Spring-1 improvements in patient care (patient education, home exercise prescription, and dysfunction classification), I found that my patients did not need as many treatment sessions before they began to show improvements. This was the case during the remainder of the Spring-1 semester and during the Fall-2 semester. I attribute this decrease in the number of treatment sessions to my previously mentioned improvements in patient care. At first, I found it difficult to believe that my patients could improve with less clinician involvement (less than two clinical treatments per week), and that they improved faster when they were given and when they adhered to their prescribed home exercises. Perhaps I had discredited my patients’ abilities and had believed that only I, the clinician, could improve their dysfunction. The decrease in number of treatments necessary led me to place more value on patient education and the prescription of home exercises than I had in the past. My realization that patients play an integral role in their rehabilitation process has led me to prioritize patient education and home exercise prescription.

Patient Data

Patient-1.

The following account, which summarizes a particular experience that I had treating a patient (Patient-1) during March of the Spring-1 semester, supports my emphasis on patient education, home exercise prescription, and my improved utilization of the SFMA. This experience also led me to reconsider the contribution of seemingly-unrelated movement dysfunction to acute injuries.

The patient was a 21-year-old male basketball player who complained of pain in his left knee. He first experienced the pain at the beginning of a basketball practice, and he described it as “sharp” during all basketball activity (8, NRS). The three PSFS movements that my patient chose, and their scores, were: running (5), jumping (5), and walking down stairs (6). The patient’s initial DPA score was 33. Upon inspection, I observed point tenderness (6, NRS) directly on the patellar tendon (middle ⅓). Also worth noting was the fact that the patient mentioned that he did not feel any pain (0, NRS) while inactive.

The patient displayed symptoms that, prior to the DAT, would have led me to consider patellar tendinosis as his dysfunction. However, I learned in the DAT program that a truly inflamed structure often demonstrates constant symptoms (redness, heat, swelling, pain, and/or loss of function). The symptoms of inflammation are caused by local and systemic biochemical mediators that are released when specific pain receptors are stimulated (Omoigui, 2007). In regards to my patient, I was more interested in discovering the cause of the patellar tendon pain than I was in relieving the pain. Due to the immediate relief the patient experienced when discontinuing activity, I decided that his pain was not elicited because of the inflammatory response. Research has supported the hypothesis that chronic pain in the patellar tendon is not caused by inflammatory cells (prostaglandins and cytokines) (Alfredson, 2005; Pearson & Hussain, 2014). Therefore, I considered the idea that pain receptors in the patellar tendon were responding to dysfunction located elsewhere.

I conducted the SFMA top tier on Patient-1 and identified five dysfunctional movements that were non-painful (DN): trunk flexion, trunk extension, deep squat, right shoulder internal rotation with flexion, and cervical flexion. Trunk flexion and deep squat presented as the most dysfunctional movements. After conducting a breakout for trunk flexion and deep squat, the SFMA suggested that a lower extremity anterior chain tissue extensibility dysfunction (TED), and a fundamental core stability and/or motor control dysfunction (SMCD) were the causes of the dysfunctional movement.

I began the patient's treatment by first addressing the anterior chain TED. My decision to address the TED before the fundamental core SMCD was based on Cook's guidelines to always treat mobility dysfunctions (TED or joint mobility dysfunction—JMD) before SMCDs: "Mobility must precede stability" (Cook, 2010). Cook based his rationale on the premise that if mobility is compromised, appropriate muscle motor control would be unable to perform a fully functional movement pattern, regardless of muscle motor activation. I chose to use IASTM over the patient's proximal vastus lateralis muscle in order to address the SFMA anterior chain TED. This TED presented as distinct fascial (tissue) restriction, which, upon examination, I noted in the patient's upper thigh. His NRS score for palpable pain was 6 at the middle patellar tendon and did not change after treatment using IASTM. Likewise, his initial SFMA top tier DNs also did not change after the IASTM treatment.

I decided to address the patient's fundamental core SMCD using prescribed home exercises, including a "centering" exercise that was designed to activate the transversus abdominis (TA) muscle and a series of functional exercises in a weight-bearing environment. Two days after the application of IASTM and core activation/progression exercises, the patient rated his pain at 3 during my palpation of the patellar tendon. His initial PSFS score (5.33) demonstrated improvement (9) and met the MCID, as did his DPA score of 15 (a reduction of 18 points). I reevaluated him using the SFMA and noticed that his deep squat and trunk extension movement patterns were drastically improved. They were also performed at a nearly functional non-painful (FN) status. Four days after the initial treatment, the patient's PSFS scores demonstrated further improvement (9.33—a 4-point improvement), as did his DPA score of 12 (his previous score was 15).

My second and final treatment session, one week after the first treatment, focused on further improvement of the patient's core musculature. I chose functional exercises with manual resistance in a weight-bearing environment to reinforce the motor activation the patient had already gained. I conducted the SFMA after the exercises and observed the trunk flexion movement as FN. The final, follow-up meeting with the patient (two weeks after the first treatment) allowed me to perform the SFMA. The results demonstrated all of the prior DN movements to be FN, with the exception of right shoulder internal rotation with flexion. I also collected the PSFS score to confirm that the patient's global outcomes had improved (9.66—a 0.33-point improvement). The patient's NRS score during palpation of the patellar tendon was 1, and the final DPA score was 6 (previously 12).

From my initial to final evaluation of the patient, the MCIDs were met for all patient outcomes measures (DPA, PSFS, and NRS score). All observed SFMA dysfunctional movements were improved, as well.

Throughout the reflective journal entries I made while treating this patient, I wrote of my treatment decisions and what changes I should consider. While I was treating Patient-1, the DAT faculty advised that I reconsider always treating mobility dysfunctions (TED and JMD) prior to SMCDs, since both TED and JMD may be the result of an SMCD. After further discussion in class sessions, I began to understand their reasoning. The particular treatment of a fundamental core SMCD can demonstrate immediate improvement in mobility dysfunctions (Tsao & Hodges, 2008). After my discussion with the DAT faculty and cohort, I decided to treat my patients' fundamental core SMCDs prior to mobility dysfunctions. I wanted to test Cook's treatment-order rule, which states that mobility should be treated before stability, to determine if it held true when treating movement dysfunction.

Patient-2.

The following case is of a patient I treated for low back pain, to little initial effect. I have chosen to include this narrative because it illustrates the important role that the DAT cohort had in improving my patient care. The narrative also shows how much I learned from my unsuccessful patient outcomes.

Early in the Spring-1 semester, I began to treat a female soccer student-athlete (Patient-2) who had been suffering from chronic low back pain for the previous three years. She described her back pain as "tolerable," until the point when she sought my help. During athletic activities and extended periods of sitting, she experienced sharp pain in her lower back and in the gluteal region, bilaterally (both sides). She was not able to reduce her pain during activity, and rest was the only response that gave her temporary relief. My initial evaluation involved collecting a detailed history of her pain and symptoms; outlining her primary concerns; and conducting a posture assessment, the SFMA top tier, SFMA breakouts for the DN movement patterns, and active ranges of motion of her ankles, knees, hips, trunk, and spinal column. Notable findings included an extensive history with other clinicians and doctors, all of whom provided only temporary, minor relief of her back pain.

My assessment of the patient's static standing posture found moderate lordosis (excessive lumbar curvature of the spine), bilateral foot pronation, and bilateral valgus knee collapse. I observed movement dysfunction with the SFMA top tier movements in the following areas: cervical flexion (DN), multi-segmental trunk flexion (DP), multi-segmental trunk extension (DN), multi-segmental trunk rotation (DN, bilaterally), single-leg balance (DN, bilaterally), and deep squat (DN). I found her most severe dysfunctional movement patterns to be the SFMA deep squat and the multi-segmental trunk extension. My SFMA breakouts indicated that my patient had active cervical spine flexion SMCD, fundamental extension pattern SMCD, hip JMD with medial rotation, thorax bilateral extension JMD, and tibial internal rotation JMD. Her active range of motion was limited in her ankles (dorsiflexion R = 0 degrees, L = 3 degrees), knees (flexion R = 110 degrees, L = 115 degrees), hips (flexion R = 50 degrees, L = 54 degrees), and thoracic column (flexion: little to no movement in T6-T12 vertebrae; rotation: R = 20 degrees, L = 40 degrees).

I decided to address her SFMA deep squat and multi-segmental trunk extension movement patterns, because they were the most severe DN movements and because I had prior success when I first addressed trunk dysfunction. The SFMA breakouts for these movements indicated that I should treat her fundamental extension pattern SMCD, hip JMD with medial rotation, thorax bilateral extension JMD, and tibial internal rotation JMD. I used the Mulligan Concept MWM to improve her hip JMD, using three sets with ten repetitions. She did not report experiencing pain with the MWMs (using the NRS, her pain was already 0/10), and there were no immediate improvements in her active hip range of motion. I utilized the PILL process, attempting the MWMs with a number of different hand placement positions and directions of traction, but I soon discontinued using it, since the "PILL" effect had not been satisfied.

Instead of continuing to address the patient's hip JMD, I focused my treatment efforts on her fundamental extension pattern SMCD. My belief was that her hip JMD may have been a product, or result, of movement dysfunction in the spinal column. I had decided at the start of the Spring-1 semester that I would use Total Motion Release (TMR) for all trunk SMCDs, because it allows the patient to reestablish motor function without external cueing. Total Motion Release is an educational/treatment system that flows easily with other paradigms. It also allows the clinician to observe global movement and correct imbalance through directionally-facilitated movement (Baker, n.d.).

After I conducted the TMR Fab6 movements, the patient rated her single-leg sit-to-stand at the lowest possible rating (0-100 scale, L = 85, R = 40). I had her perform 30 repetitions in 3 sets on her "good side" (the left leg). She reported no score change after each set (L = 85, R = 40). As suggested with TMR movements, I adjusted her sit-to-stand movement after each set by changing the speed of the movements (slower during the second set and faster during the third set). The patient reported no changes in her other Fab6 movements after each set.

I decided to discontinue using TMR as a treatment intervention for my patient's trunk SMCD and try a different intervention instead. At the time, my decision to move away from TMR was based on my TMR skill-acquisition level during the Spring-1 semester (between "novice" and "competent"). Later in the Spring-1 semester, I realized that I had not utilized TMR correctly, according to the TMR creators. This confirmed that I had not achieved an adequate skill-acquisition level to effectively utilize the intervention. I continued to struggle with treatment and assessment interventions in which I was not yet at a "proficient" level. I considered my attempts with the hip MWMs and TMR Fab6, and my unsuccessful outcomes, to be failures on my part.

My frustration with my inadequate skill-acquisition level for TMR and Mulligan Concept MWMs, and my difficulties in identifying the proper pathological movement dysfunction in my patient with low back pain, drove me to seek improvement in these areas. This mindset was entirely different from my pre-DAT reaction to unsuccessful patient cases that had also resulted in my frustration. Before enrolling in the DAT program, I followed a pattern of experiencing frustration, followed by discouragement, and finally, defeat. Once I reached that low point, I would fall back to using my traditional treatment methods (rest, ice, heat, electrical stimulation, and ultrasound). After starting the DAT, my treatment philosophy (found in Chapter 2) became my foundation for combatting situations with unsuccessful patient outcomes.

I did not resort to my pre-DAT traditional treatment methods with my low back pain patient. Instead, I revisited the results of my initial evaluation and assessment. Discussion with DAT cohorts, in and outside of class, led me to the decision to address the DNs I had not yet treated on Patient-2: bilateral hip medial rotation JMD, and bilateral tibial internal rotation

JMD. During the subsequent treatment session, I noticed that when Patient-2 maintained a neutral ankle position at the subtalar joint, she could produce tibial internal rotation without restriction. I used the muscle energy technique (MET) treatment intervention at her foot and ankle to re-engage her medial foot and ankle stabilizer muscles. My intention was to improve her bilateral foot pronation so her tibias could properly rotate during knee motion. After I performed seated foot/ankle MET (4 sets of 6-10 repetitions), I had her stand with both feet on the ground and shift her weight from side to side. Without any verbal cuing, she maintained adequate neutral ankle position, which resulted in less foot/ankle pronation (bilaterally). I then transitioned her to walking slowly, in a straight line. The patient reported feeling noticeably better (pain NRS pre-treatment = 5, NRS post-treatment = 2). I also noticed that while standing, the patient's lordotic (lumbar) curve, knee position, and pelvic girdle position had all improved.

While discussing the result of my treatment with the patient, I explained how the kinetic chain operates. During my first treatment session with Patient-2, I had forgotten that the kinetic chain is only as strong as its weakest link; therefore, dysfunction can originate both proximally (trunk) and distally (foot/ankle) (Page, Frank, & Lardner, 2010). Improvement in her trunk dysfunction may not have been feasible at first, because her tibial rotation dysfunction was the pathologically weakest component in her kinetic chain.

One week after the patient's initial treatment session, improvements in her DPA and PSFS scores were -14 and + 4.33, respectively (MCID was met for both measures). I continued to work with this patient for three weeks, because I wanted to monitor changes in her low back pain and strive for complete back pain resolution. Her final DPA and PSFS scores improvements were -21 and + 7. The patient explained to me that, for the first time in two-and-a-half years, she often "completely forgot about [her] back pain" during soccer activity. She also described how she could run faster and kick the soccer ball harder than she could before my treatments.

Resulting Semester Goals and Changes in Practice

My Spring-1 semester goals were intended to further advance my practice in three areas: administration of patient outcomes, patient classification, and critical reflection journal quality. In regards to the area of patient outcomes, I added the patient specific functional scale (PSFS) to offer a wider range of global outcomes. I also planned to collect patient outcomes more often and more consistently. The increased number of outcomes measures that I utilized from Spring 2014 on provides supporting data for the effectiveness of my treatment interventions.

The writing in my reflective journal changed early in the Spring-1 semester, in that I began to include narration on patients for whom I was not achieving successful outcomes. This change allowed my DAT cohort and professors to provide me with feedback on my successful and unsuccessful patient outcomes. Often, insight from my fellow athletic trainers offered meaningful, honest, and constructive feedback to issues I faced in my clinical practice. Patient-2's case has served as a reminder to me of what to do when I encounter other unsuccessful patient outcomes. My reflection on this case helps me to remember that my feelings of frustration and discouragement do not help to improve the patient's well-being. I intend for this experience, wherein a dialogue with the DAT cohort led me to consider making new treatment decisions, to serve as a model for future interactions with the clinicians with whom I work.

Before the DAT program, I was comfortable assessing and treating patients without having developed a rationale for my assessment and treatment choices. By the end of the Spring-1 semester, I was thinking critically about how the paradigms (particularly the SFMA) were intended to operate and why they did so. Although I still did not possess the experience with the SFMA associated with the "expert level" of skill acquisition, I had achieved "proficiency level" (Dreyfus & Dreyfus, 1980).

The Spring-1 semester provided me with the opportunity to compare my patient outcomes with those I collected from the previous semester. For the first time in my professional career, I was able to observe improvements in my clinical treatment practice. I collected patient outcomes using the SFMA top-tier movements as well as NRS, DPA, and PSFS scores. The MCID for each patient outcome measure (NPRS, DPA, and PSFS) was identified and subsequently compared with the changes that I observed in the SFMA top-tier movements. The comparison between the patient outcome measures (PSFS, DPA, and NRS) and changes in the SFMA movements helped me to consider whether any changes in my treatment plans were necessary.

Further improvement in my utilization of the SFMA system remained a goal, even after my attendance in a weekend SFMA course in January of 2014. I also desired to review and potentially change my approach to treating cervical and thoracic JMDs. To better interpret my patient outcomes using the SFMA system, I planned to continue tracking the total treatment days required for the correction of each dysfunction, as I had during the Spring-1 semester. My analysis of treatment length for specific movement dysfunctions could then provide greater insight toward which of my treatment interventions were most effective.

At the conclusion of the Spring-1 semester, I determined to deepen my understanding and application skill of PRRT. I had witnessed the treatment intervention through patient cases that the DAT cohort discussed, and I had also seen the impact PRRT had on up-regulated patients who displayed jump signs, marked apprehension, and/or a breathing pattern disorder. I knew that attempting to progress to a more advanced skill acquisition level in more treatment interventions could “water down” or limit interventions I still needed to enhance. The fear that my current treatment abilities were not sufficiently addressing my patients’ needs drove me to a better understanding of the treatment interventions I used less frequently.

While attending my second summer (Summer-2) semester at the University of Idaho, I improved my ability to understand and use PRRT treatment, Mulligan MWM interventions, and myofascial release (MFR) therapy. This helped me to better address particular movement deficiencies such as thoracic mobilization, and pelvic girdle stabilization in my patients. Although improving my proficiency in these treatment interventions was a goal I had made at the end of the Fall-1 semester, I still desired to achieve a higher level of skill mastery. I also wanted to create *a priori* treatment plans for specific patient cases. The Summer-2 semester allowed me the opportunity to create treatment plans for specific dysfunctions and injuries that my patients presented with. The *a priori* treatment plans I created follow.

Fall-2

Summary

The changes within my professional practice (in the educational and clinical settings) have been significant since beginning the DAT program. They include improved patient outcomes, weekly personal reflection on patient cases, and progression toward my advanced practice in lower extremity injury risk prediction. The inclusion of my action research project during the Fall-2 semester proved difficult for me. However, as the semester concluded, I was confident that my clinical boundaries had become less defined. The milestones I had reached helped me to realize how far I had come.

After reviewing various low back pain treatment paradigms throughout the Fall-2 semester, in September, I continued to notice the value in educating my patients regarding their pain and/or dysfunctions. Multiple paradigms support the practice of patient education and even consider it to be vital when treating the whole patient. The treatment paradigms that emphasize patient education include the Maitland concept, the McKenzie approach, the Mulligan concept, the Paris approach, the osteopathic approach, the movement system impairment approach, and the treatment-based classification approach (Chevan & Clapis, 2013). Low back pain is the most commonly reported musculoskeletal problem, and patient education plays a vital role in positive outcomes (Balagué, Mannion, Pellisé, & Cedraschi, 2012). To optimize my improved patient education, I discussed with my patients my *a priori* treatments for their specific dysfunctions or primary complaints.

Incorporating *a priori* treatment designs with specific dysfunctions remained my primary goal for the Fall-2 semester. Successful treatment interventions could be identified more easily when my patient classification systems were in place. I desired to incorporate a patient classification system for movement dysfunction that worked best for me and led to reduced overall treatment time for my patients. I believed the SFMA provided an adequate starting point for the identification of my patients' dysfunctions. The SFMA guidelines are simple and straightforward; yet changes in movement function are nominal in nature. That is, a patient may greatly improve a movement pattern and still be considered DN (i.e. improvement occurred, but change is not evident). As previously mentioned, TMR is easily integrated with other paradigms and provides the clinician with an interval-rated movement score (0-100). This scoring system helps the patient and clinician to identify changes in movement quality, whether subtle or obvious.

Throughout October of 2014, I progressed through TMR grades 1-8. Since TMR was considered both a treatment and a measureable outcome (0-100 percent score), I did not incorporate NRS scores. After learning more about the TMR system late in the Fall-2 semester, I began collecting NRS scores again in the hopes that doing so would provide me with more clarity when I evaluated the effectiveness of various treatments and refined my treatment classification system. Each of my *a priori* treatment designs contained inclusion and exclusion criteria and written procedures, both of which complimented my assessment and treatment flowcharts. The following excerpt and flowchart (Figure 3.1) represent my *a priori* treatment design for patients with shoulder pain. My flowcharts display the potential courses of action, which are dependent on clinical findings.

Inclusion:

- *Pain reported in the shoulder complex (glenohumeral, scapulothoracic, and/or acromioclavicular joint)*
- *Altered and/or limited functional movement in the shoulder complex*

Exclusion:

- *Suspected clavicle fracture*
- *AC joint separation (grade 2 and higher)*
- *Acute glenohumeral joint instability (suspected labral tear)*

Procedures:

The investigator will collect patient history on current and previous shoulder issues. The patient is given an examination for the shoulder injury. The examination includes active and passive range of motion measures, manual muscle testing, and special tests pertinent to the presented shoulder injury. The examination will be conducted on the glenohumeral, scapulothoracic, and acromioclavicular joint. After exclusions are ruled out, the investigator will collect NRS, PSFS, and DPAS values. The NRS score will be measured at tender points identified throughout the shoulder during the examination. Tender points will be marked at time of examination, and re-measured using the NRS after TMR intervention. The SFMA top tier assessment is conducted to determine dysfunctional movement throughout the body. Total motion *release Fab6 movements are conducted and graded by the patient. Guidelines from the creator of TMR will be followed regarding body segment and side treated. The exercise found to be most out of symmetry is treated with TMR first, as well as the side that 'was harder' to perform the movement. Movement of the contralateral side is used in TMR treatment to improve the more dysfunctional side (i.e. move right shoulder to make the more dysfunctional left shoulder improve). Although patients may present with shoulder dysfunction according to the SFMA and/or TMR Fab6, initial TMR treatment will occur in the movement most dysfunctional according to TMR Fab6. After each round of TMR treatment, TMR Fab6 movements will be reassessed and treated according to TMR guidelines. After TMR treatment ends, patient movement will be assessed using the SFMA top tier assessment.*

Changes in SFMA top tier assessment dysfunction and TMR fab6 movement values will be compared. Achieving MCID in patient outcomes measures (NRS, PSFS, and DPAS) will help identify adequate improvement in patient outcomes. Results may help determine clinical effectiveness of TMR as a treatment in patients with shoulder pain.

The following flowchart demonstrates the path of action for patients with shoulder pain.

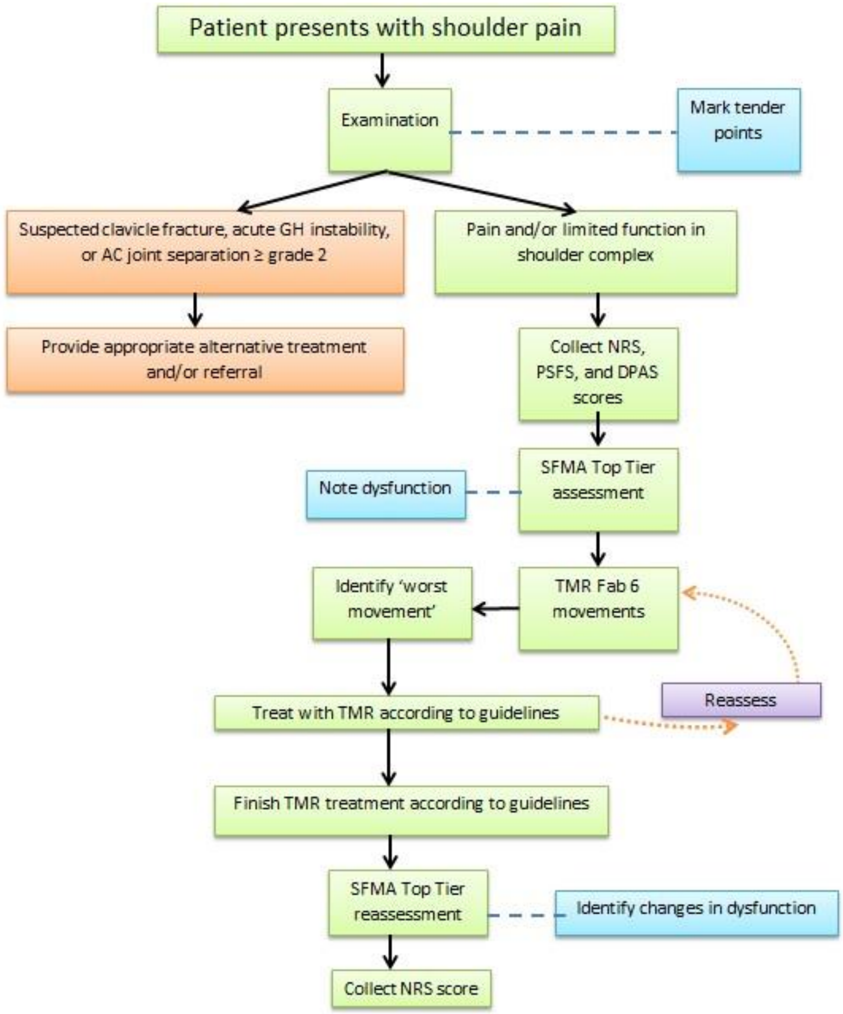

Figure 3.1 Shoulder assessment and treatment flowchart.

By the end of the Fall-2 semester, I had created and utilized *a priori* treatment designs for the head/neck, shoulder complex, elbow/wrist, trunk/pelvic girdle, hip, knee, and ankle/foot. I observed the resulting outcomes measures and organized them into the following categories: 1) exceeded expectations, 2) met expectations, or 3) did not meet expectations. My expectations for patient outcomes are based on my own practice-based evidence and on available literature that defines successful total treatment length for movement dysfunction. Both of these factors are fluid in nature and change as literature indicates and as my practice-based evidence demonstrates through successful and unsuccessful treatment outcomes. I consider treatment outcomes to be successful when the treatment intervention that I used was associated with a patient outcome that I had classified as “exceeded expectations.” When my patient outcome “did not meet expectations,” I considered the associated treatment intervention to be unsuccessful. I monitor my patient outcomes that are classified as “met expectations” to ensure their consistency in meeting my expectations; however I do not consider the treatment interventions that I used in those cases to be either successful or unsuccessful.

During the Fall-2 semester, I treated 18 patients; 7 of which had sustained an acute injury, and 11 of which had a chronic injury. I utilized *a priori* treatment designs on all patients who met the inclusion criteria (n = 15). This included all of the chronic-injury patients and four out of the seven acute-injury patients (the mechanism of injury was clear in the case of the other three patients). I conducted the TMR Fab6 on 14 patients, recorded ratings for all movements, and identified the movement-exercise with the greatest rating difference between the right and left side (‘worst-of-the-worst’). After each treatment intervention, I conducted the SFMA top tier and TMR Fab6 movements again to determine if any changes in movement function (SFMA) or movement rating (TMR) had occurred.

My patient outcome classification expectations (categorized as “exceeded,” “met,” and “did not meet”) were based on changes in SFMA top tier, TMR “worst-of-the-worst” movement rating, number of days between initial assessment to discharge, and changes in global outcomes measures (DPA and PSFS). Positive changes were achieved in SFMA top tier by changing at least 75% of the DNs and DPs to FN. Changes in TMR Fab6 movement rating were classified as having a positive result when the “worst-of-the-worst” movement rating improved at least 75% or when the rating was ≥ 95/100. I classified the total number of days before discharge as a positive result when I discharged my patient at or before the anticipated recovery time-frame had concluded. I based my anticipated recovery time-frames on each patient's injury/dysfunction severity, and, when available, on reasonable recovery time-frames found in literature. I achieved a positive result in my global outcomes when the MCIDs were met in both measures. To achieve "exceeded expectations" categorization, positive results must have occurred in at least three of the four classification categories. I achieved "met expectations" when I had two positive results from my classification groups. When I achieved one or no positive results, I "did not meet expectations." Table 3.2 represents my patients' SFMA findings, TMR Fab6 results, treatment intervention selection, and patient outcome classification.

Table 3.2
Fall-2 Patient Outcome Classification

Pt ID	SFMA dysfunctions	TMR Fab6	Total days	SFMA/ TMR changes	Outcome classification
539	CF (DN) S1-R (DN) S2-R (DN) DS (DN)	Trunk twist (L)- 95 (R)- 65	10	CF (FN) S1-R (FN) DS (FN)** Trunk twist (L)- 100 (R)- 90**	Exceeded expectations (3/4)
540	MSF (DN) MSE (DN) DS (DP)	Sit-to-stand (L)- 70 (R)- 90	12	MSF (FN) MSE (FN) DS (DN)** Sit-to-stand (L)- 95 (R)- 95**	Met expectations (2/4)
541	MSE (DN) Balance-R (DN) DS (DN)	Leg raise (L)- 55 (R)- 80	17	MSE (FN) Balance-R (FN) DS (FN)** Leg raise (L)- 90 (R)- 90**	Exceeded expectations (3/4)
542	S2-R (DN) S1-R (DP) MSR-R (DN)	Arm raise (L)- 100 (R)- 30	49	S2-R (FN) S1-R (DN) MSR-R (FN)** Arm raise (L)- 100 (R)- 85**	Met expectations (2/4)
543	CE (DN) S2-R (DP) S1-R (DP) MSR- R (DN) DS (DN)	Arm raise (L)- 95 (R)- 40	28	CE (FN) S2-R (FN) S1-R (FN)** Arm raise (L)- 100 (R)- 90**	Exceeded expectations (3/4)
544	CE (DN)	Arm raise	6**	CE (FN)	Exceeded

	CR-R and L (DN) S2-R (DP) S1-R (DN) MSF (DN) DS (DN)	(L)- 100 (R)- 55		CR-R and L (FN) S2-R (DN) S1-R (FN)** Arm raise (L)- 100 (R)- 90**	expectations (4/4)
545	CF (DN) MSF (DN) DS (DP)	Toe-reach (L)- 60 (R)- 90	8**	CF (FN) MSF (FN) DS (FN)** Toe-reach (L)- 95 (R)- 100**	Exceeded expectations (4/4)
546	CE (DN) MSF (DP) MSE (DN) MSR- R (DN) DS (DN)	Sit-to-stand (L)- 45 (R)- 20	55	CE (FN) MSF (DN) MSE (FN) MSR-R (FN) Sit-to-stand (L)- 80 (R)- 50	Did not meet expectations (1/4)
547	MSF (DN) Balance-L (DN) DS (DP)	Sit-to-stand (L)- 10 (R)- 80	21	MSF (FN) Balance-L (FN) DS (DN) Sit-to-stand (L)- 65 (R)- 90**	Met expectations (2/4)
548	S2- R (DN) S1- R (DN) MSF (DN) DS (DN)	Arm raise (L)- 100 (R)- 65	14**	S2-R (FN) S1-R (FN) MSF (FN)** Arm raise (L)- 100 (R)- 100**	Exceeded expectations (4/4)
549	S2-L (DN) S1-R and L (DN) MSE (DN) DS (DN)	Arm raise (L)- 65 (R)- 95	12**	S2-L (FN) S1-L (FN) MSE (FN)** Arm raise (L)- 85 (R)- 95	Exceeded expectations (3/4)
552	CF (DN) CR-R and L (DN) MSF (DN) MSR-R and L (DN) MSE (DP) DS (DN)	Twist (L)- 40 (R)- 60	71	CF (FN) CR-R and L (FN) MSF (FN) MSR-R and L (FN) MSE (FN)** Twist (L)- 85 (R)- 90**	Met expectations (2/4)
553	CF (DN) CE (DN) MSE (DN) DS (DN)	Toe-reach (L)- 60 (R)- 80	4**	CF (FN) CE (FN) MSE (FN)** Toe-reach (L)- 95 (R)- 95**	Exceeded expectations (4/4)
554	CF (DN) CE (DP) CR-R and L (DN) MSE (DN) DS (DN)	--	8**	CF (FN) CE (FN) CR-R and L (FN) MSE (FN) DS (FN)**	Exceeded expectations (3/3)
555	CF (DN) CE (DN) S1-L (DN), R (DP) S2-R and L (DN) DS (DN)	Arm raise (L)- 80 (R)- 55	5**	CE (FN) S1-L (FN), R (FN) S2-R and L (FN)** Arm raise (L)- 90 (R)- 95	Exceeded expectations (3/4)

Note. Double asterisks (**) denote that a positive result was achieved.

Patient Data

Patient-1.

The following patient case (Patient-1) from late in the Fall-2 semester illustrated how I utilized an *a priori* treatment design for elbow/wrist pain. The patient was a twenty-year-old female collegiate-level basketball player who had suffered from right wrist pain for the previous two-and-a-half years. The initial mechanism of injury occurred when she fell on her outstretched arm/hand. At my initial evaluation at the beginning of her athletic season, the patient reported pain ranging from 6-7/10 (NRS) during sport-specific activity. She had previously received diagnostic imaging (x-ray and MRI), both of which indicated no substantial abnormalities. The patient had not been provided with a diagnosis and had been told that exploratory surgery or injections were the next treatment options. I used my elbow/wrist *a priori* treatment design for her chronic wrist pain, because she met the inclusion criteria.

Notable findings in my evaluation included range of motion (ROM) and strength differences between the patient's right and left wrists. Her wrist active ROM was limited in flexion (65^0 = R, 80^0 = L), extension (55^0 = R, 70^0 = L), and ulnar deviation (25^0 = R, 40^0 = L). Pain near the lunate and scaphoid was reported in wrist flexion and extension (NRS = 5/10 in all directions). The patient's wrist made an audible "pop" when she flexed and ulnar-deviated her wrist. The pop appeared to initiate near the lunate and radius bone. The patient did not present with any tender points upon palpation. Her resisted ROM in her right wrist was limited in extension (3/5) compared to her left wrist (5/5). All other resisted ROMs were normal in comparison to the uninjured wrist.

I applied the Mulligan wrist MWM laterally (force at pisiform, stabilization at radius) while the patient extended her wrist. My first attempt did not improve the patient's pain (NRS = 5/10) or active ROM. I then applied the Mulligan MWM medially (force at scaphoid, stabilization at ulna) while the patient actively extended the wrist. The patient's pain (NRS = 5/10) and active ROM remained unchanged. On the third attempt, I applied a rotational force with the same previous medial force. The force from my hand was applied on the dorsum of the patient's hand at the hamate (using my thumb), which resulted in significant pain after one repetition (NRS = 9/10), during extension. The rotational force was then switched to the palmar surface directly on the pisiform (using my thumb). The transverse rotational force that I applied resulted in pain free (NRS = 0/10) extension during the Mulligan wrist MWM intervention. The patient achieved full active ROM in extension (70^0) in the first set of 10 repetitions. After the initial 10 repetitions, I completed 2 subsequent sets of 10 repetitions with overpressure applied by the patient at end range (extension), using her left hand. The patient did not experience any pain during either set (NRS = 0/10), and full active ROM remained in her wrist. The patient performed full active ROM without the treatment intervention in extension (70^0) and flexion (80^0), while nearly pain free (NRS = 1/10). The patient's active ROM for ulnar deviation still presented with pain (NRS = 3/10) and limited range (35^0). I decided to apply the same rotational force as before while the patient performed active ulnar deviation (3 sets x 10 repetitions). The patient was pain free throughout the ulnar deviation sets (NRS = 0/10), and full active ROM was achieved (40^0) in the first set and maintained in the subsequent two sets.

Two days after initial treatment, the patient reported improvement during and outside of athletic activity (both NRS = 1/10). The patient's DPA scores were 35 prior to initial treatment, 5 at one week post-treatment, 4 at two weeks post-treatment, and 4 at three weeks post-treatment. With an overall change of 31 points in her DPA score, the MCID was met after the initial treatment. The patient's PSFS activities and initial scores were: shooting a basketball: 3/10, writing: 6/10, and performing a push-up: 4/10. Two days after the initial treatment, her PSFS values were 9, 10, and 10, respectively. The patient's PSFS values remained at 9, 10, and 10, on days 7, 9, and 14. The overall change in the patient's PSFS activity scores were 6, 4, and 6. All two-day post-initial treatment PSFS scores met the MCID value.

I was able to carry out my *a priori* treatment design to address the chronic pain in my patient's wrist. The Mulligan MWM treatment intervention provided me with a manual treatment that required little equipment. Following the guidelines recommended by Brian Mulligan, I achieved the PILL effect for my patient. I classified the patient's outcome as "exceeded expectations" and associated treatment intervention (Mulligan MWM) as "successful" because the elbow/wrist *a priori* treatment design demonstrated reduced total treatment length compared to my findings in literature (Choung, Kwon, Park, Kim, & Cynn, 2013). Based on my classification, I will conduct the same treatment plan on my future patients who suffer from similar chronic wrist pain.

Resulting Semester Goals and Changes in Practice

My primary Fall-2 goal was to further improve my overall patient outcomes by using *a priori* treatment designs. Such designs would inform my treatment decisions in a way that allowed me to identify which treatments resulted in the greatest improvements. Based on a comparison between my previous semesters' patient outcomes (Fall-1 and Spring-1) and my Fall-2 semester outcomes (Chart 3.7-3.9), it is evident that I accomplished this goal.

I conducted paired samples *t*-tests to determine whether the changes in my outcomes measures were statistically significant ($p \leq 0.05$). A statically significant improvement between the baseline DPA scores (38.4 ± 9.9) and DPA scores 1 week after the initial treatment (19.9 ± 11.2, $t(18) = 9.5$, $p < 0.01$) was observed. Changes in PSFS scores were also statistically significant between baseline measures (4.1 ± 1.8) and treatment-2 measures (6.7 ± 1.5, $t(18) = -9.13$, $p < 0.01$). The immediate changes in pain that I measured using the NRS, pre- (6.22 ± 1.9) and post-treatment (2.7 ± 1.3, $t(18) = 13.5$, $p < 0.001$) interventions were statistically significant, with a mean improvement of 3.5 (95% CI = 2.95, 4.05). I also identified my treatment intervention (TMR treatment coupled with RNT) that demonstrated the greatest improvements in my patients' pain (mean NRS change = - 6.4) and global outcomes (mean DPAS change = - 35.6, mean PSFS change = + 5.9).

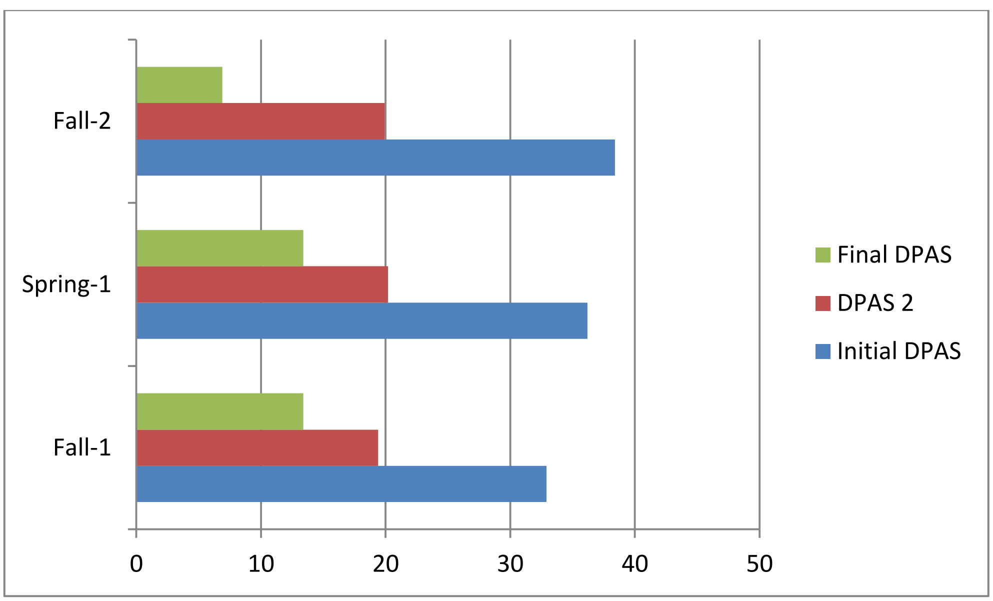

Chart 3.7: Fall-1, Spring-1, and Fall-2 mean DPA scores.

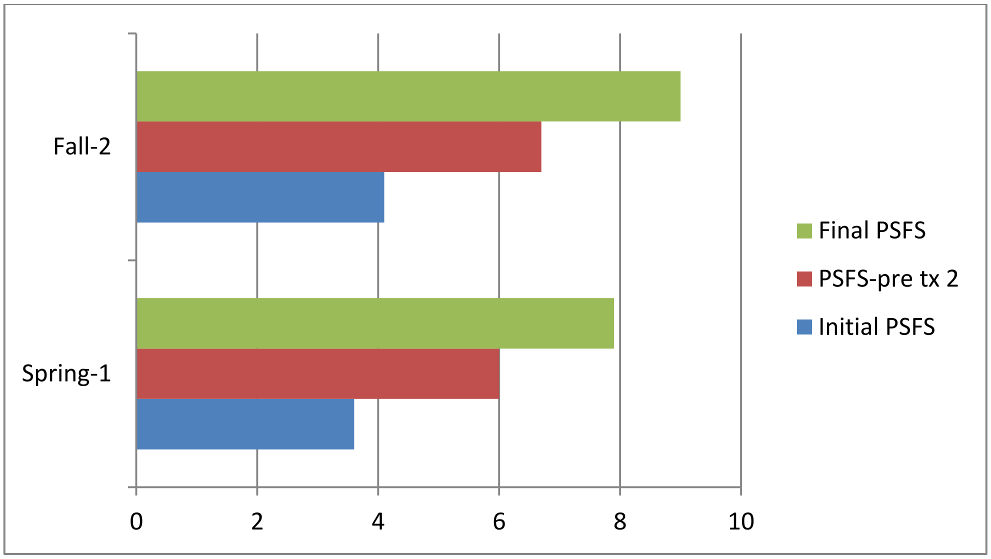

Chart 3.8: Spring-1 and Fall-2 mean PSFS scores.

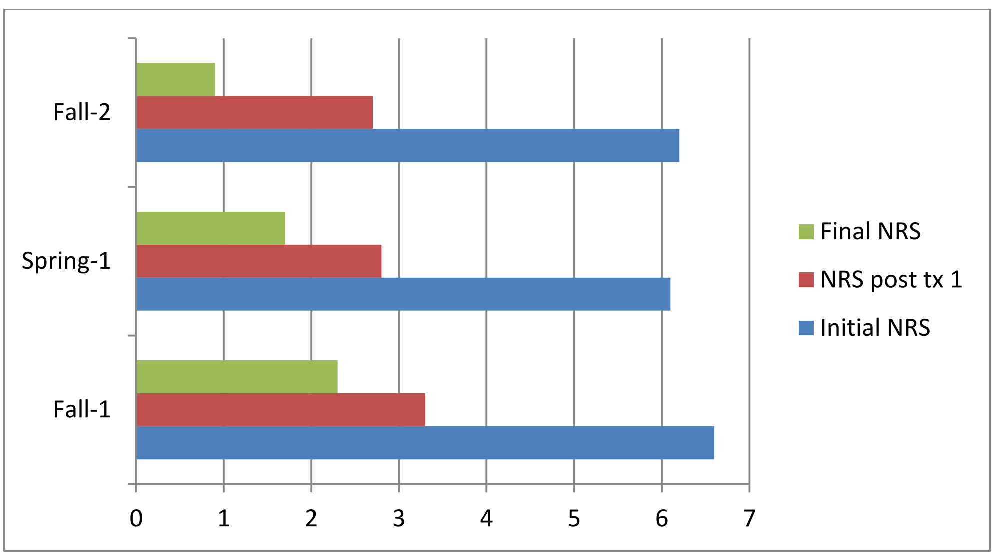

Chart 3.9: Fall-1, Spring-1, and Fall-2 mean NRS pain scores.

I was satisfied with my Fall-2 patient outcomes because I achieved "exceeded expectations" in 67% (*n* = 10) of my patients, "met expectations" in 26% (*n* = 4) of my patients, and "did not meet expectations" in 7% (*n* = 1) of my patients. The patient (ID #546) whose outcomes "did not meet expectations" had previously sustained a patellar fracture and had received surgical intervention before I began treating him. The patient's surgeon placed activity, movement, and treatment restrictions on the patient during his recovery, which limited my treatment options. The patient's injury also required adequate time to heal. Although I did not achieve my ideal criteria standard for outcomes in this patient's case, the patient and I were content with his outcomes, overall. His injury was a good reminder to me that the tissue healing process, which is necessary, takes time to complete.

Although I achieved statistically significant improvements in my patient outcomes in the Fall-2 and Spring-2 semesters, the validity of my statistically significant findings are limited. The treatment methods that I chose were not rigorously tested or considered examples of "best practice" in patient care. I based my clinical decisions (e.g. assessment paradigm and treatment intervention) on factors such as age, gender, sport, changes in outcomes measure, type and severity of dysfunction, and stage of healing, many of which varied among my patient population. Clinicians that consider adopting the clinical decisions that I made should do so with caution. Clinicians may then modify their clinical decisions as needed when results in patient care are not preferred.

My experience using *a priori* treatment designs during the Fall-2 semester significantly reduced the occurrence of my previously mentioned "shotgun approach." I was able to rationalize why I had chosen the treatment interventions that I did for particular movement dysfunctions. This allowed me to effectively identify my most successful interventions for each SFMA movement dysfunction. The result of my new awareness regarding my treatment effectiveness was that my patients required fewer treatment sessions, overall.

Impact of the Residency

Returning to the clinical environment after a one-year absence was a remarkable experience. My initial fear of encountering the same frustration I had had before transitioning to my faculty position did not return. I believe that this was due to the steps I took to advance my clinical practice. In particular, I credit my collection of patient outcomes, my focused clinical reasoning, my incorporation of new treatment interventions, and my renewed understanding of assessment paradigms.

My fellow ATs also saw changes in what they initially considered my "unconventional" practice. My new perspective on the use of ice, heat, ultrasound, and electrical stimulation for treatment was the biggest change. From the time that I returned to the clinic until the end of the Fall 2014 semester, I did not use any of the previously mentioned modalities in my patient care. How the athletic training staff remembered me and my clinical practice could not have been any more different from my clinical practice while in the DAT. The following list provides a comparison of my clinical practice before and after the DAT program:

1. *Patient Assessment*
   - *Pre-DAT: Focused on the patient's symptoms (pain, inflammation, apparent muscular weakness, and limited ROM); assumed that the patient's symptoms were the pathological problem*
   - *Post-DAT: Begin with systematic approach to identifying dysfunctions in movement patterns; consider regional interdependence as the pathoanatomical cause behind the patient's symptoms*
2. *Treatment Philosophy*

- *Pre-DAT- used interventions (ice, heat, electrical stimulation, and rest) that best suited my needs (time and setup simplicity); based my choice of treatment primarily on anecdotal evidence; made little to no effort in collecting patient outcomes.*
- *Post-DAT- implement* a priori *treatment designs to inform my intervention selection; emphasize patient education to improve global outcomes; make my treatment decisions from clinical practice-based evidence and my choice of interventions from evidence-based practice that is supported in literature; collect and use patient outcomes to evaluate my effectiveness as a clinician.*

3. *Professional Development*
    - *Pre-DAT- lacked awareness of my stagnant professional development; earned continuing education units (CEUs) were based on cost and ease of completion.*
    - *Post-DAT- continue to achieve an area of specialization (lower extremity injury risk assessment and prediction); attend seminars, workshops, and conventions that offer improvement in my clinical practice and/or area of specialization; implement plan to further advance my clinical practice and continue revising said plan.*

Summative Reflection

The progress of my clinical practice, as evidenced through the evaluation of my patient care, reflective practice, and clinical changes, has helped to demonstrate my progress toward becoming an advanced practitioner. When I consider the changes that I have made since the start of the DAT program, I believe that I have also taken great strides toward an area of specialization in lower extremity injury risk assessment and prediction. Most importantly, I have become aware of where I was in my clinical practice, where I am currently, and where I plan to be in the future. As previously mentioned in my Plan of Advanced Practice (Chapter 2), in order to improve my clinical practice, I created specific goals within my professional development, area of advanced practice, and professional and academic scholarship that I intended to achieve during and after my tenure in the DAT program. I made progress in all of the categories by completing the methods that I had previously determined would help me to accomplish my specific goals.

My clinical progression is also demonstrated in the reflective journals that I have kept throughout the course of my time in the DAT program. The DAT faculty and cohort regularly responded to my clinical inquires, and the dialogue that occurred in the classroom provided me with opportunities for further reflection. The journals allowed me to express clinical victories, frustrations, and concerns among fellow professionals who responded with objective feedback that I could then reflect upon. To allow feedback from fellow clinicians, I will continue my reflective practice through online journaling. This will allow me to reevaluate my clinical decisions.

Through the DAT program, I came to understand the importance of remaining open-minded. I also recognized my need for clinical improvement. When I received constructive criticism from the DAT faculty and cohort, I made it a point to remember that the purpose of that criticism was for me to improve as a clinician and within my patient care. I am unsure of where I will take my professional practice after completion of the DAT program; however, I believe that the improvements I have made in my patient care may lead me toward a clinical setting once again. Regardless of my future professional setting, I look forward to the continual improvement of my clinical practice in athletic training.

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CHAPTER 4

LITERATURE REVIEW

Introduction

Female sport participation at the high school level has increased ten-fold in the past forty years (National Federation of State High School Associations, 2011). At the collegiate level, it has increased 6-fold (1972 to 2011) (Irick, 1981). Naturally, the rate at which female athletes are injured while participating in sport exposures has also increased (For the purposes of this chapter, sport *exposures* are defined as instances in which a given sport is engaged in, including practices, games, scrimmages, and tournament play.).

One type of injury that is commonly sustained by male and female athletes is an anterior cruciate ligament (ACL) tear. Colby et al. (2000) indicated that an ACL tear occurs once every 1,500 hours for athletes who play football, basketball, or soccer. According to Lohmander, Englund, Dahl, and Roos (2007), female student-athletes have a two to eight times greater likelihood of an ACL tear than male student-athletes. Hewett et al. (2005) determined that female athletes of all levels who participate in high-risk sports, such as volleyball, soccer, and basketball, have a 4.4% chance of sustaining an ACL injury each year, where a year is represented by 169 sport exposures. Lohmander et al. (2007) also stated that female collegiate-level athletes who play soccer or basketball have a 30% chance of sustaining an ACL injury within 1,000 exposures to athletic participation. That rate of injury is increasing by 1.6% per year (Hootman, Dick, & Agel, 2007). It has been suggested that this increase in ACL tears is the result of ineffective or improper conditioning, bracing, and diagnosing, and/or inadequate medical technology (Hootman et al., 2007). *Regional interdependence*, wherein one dysfunctional system or segment of the body causes another segment of the body abnormal stress (Freckleton & Pizzari, 2013; Verrall, Slavotinek, Barnes, Fon, & Spriggins, 2001; Erhard & Bowling, 1977) may also influence the risk of future ACL injury (Arnason et al., 2004; Hägglund, Waldén, & Ekstrand, 2006; Jacobsson et al., 2013).

Regardless of cause or occurrence rate, ACL tears are debilitating and often require surgery and months of rehabilitation. In addition, the future risk for osteoarthritis in patients who sustain an ACL tear is higher than for those who were never injured, even when those who were injured were treated through surgery (Lohmander et al., 2007; Meunier, Odensten, & Good, 2006). Investigators who observed the long term effects (11-15 years after injury) of an ACL injury concluded that an increased risk of developing osteoarthritis existed for those who received reconstructive ACL surgery rather than conservative treatment (Kessler et al., 2008; Kostogiannis et al., 2007).

In recent years, studies that focus on environmental and anatomical influences on the incidence of ACL tears have led researchers to develop numerous hypotheses regarding ACL injury risk factors. Investigators also agree that during athletic activity, ACL tears are most often sustained in non-contact settings as opposed to settings wherein athletes engage in physical contact (Gianotti, Marshall, Hume, & Bunt, 2009; Kobayashi et al., 2010; Olsen, 2004). Disagreement exists, however, regarding potential risk factors that predispose athletes to ACL tears (Ali & Rouhi, 2010; Dragoo, Braun, Durham, Chen, & Harris, 2012; Evans et al., 2011; Kobayashi et al., 2010).

The use of multi-faceted preventative programs that have been designed to address possible ACL risk factors has led to a decrease in the incidence of ACL tears (Bizzini, 2012; Gilchrist et al., 2008; Irmischer et al., 2004; Mandelbaum et al., 2005; Myers & Hawkins, 2010; Vescovi & VanHeest, 2009). In order for researchers to be able to continue to explore prospective and preventative measures to reduce the risk of non-contact ACL injury, health care professionals must be provided with valid, reliable, and practical screening tools. These tools provide valuable information regarding collegiate-level athletes' modifiable deficits (biomechanical and neuromuscular).

The purpose of this literature review is to assess potentially modifiable risk factors that are known contribute to non-contact ACL tears, to investigate ACL injury prevention programs, to review non-contact ACL risk-screening protocols, and to consider implications of incorporating Functional Movement Screen (FMS) and a prediction algorithm (knee abduction moment, or *KAM*) as part of a risk-assessment screening strategy. Movements observed in FMS and KAM will be reviewed for their relation to and measurable value on non-contact ACL injury risk.

Risk Factors for Non-contact ACL Injury

Modifiable intrinsic risk factors for a non-contact ACL injury in females include generalized and specific knee-joint laxity (Ergün, 2004; Schmitz & Shultz, 2013; Shultz, Carcia, & Perrin, 2004), hamstring-quadriceps strength ratio (Ahmad, 2005; Blackburn, Norcross, & Padua, 2011), pre-ovulatory phase of the menstrual cycle in females who are not using oral contraceptives (Heitz, Eisenman, Beck, & Walker, 1999; Martineau, Al-Jassir, Lenczner, & Burman, 2004; Wojtys, Huston, Boynton, Spindler, & Lindenfeld, 2002; Zazulak, Paterno, Myer, Romani, & Hewett, 2006), neuromuscular deficits throughout the lower extremities (LEs) and trunk (Baratta et al., 1988; Myer, 2005; Wojtys, Wylie, & Huston, 1996), undesired dynamic biomechanical joint positions (Decker, Torry, Wyland, Sterett, & Richard Steadman, 2003; Paterno et al., 2010), and proprioception/kinesthesia (Mandelbaum et al., 2005; Riemann & Lephart, 2002). These risk factors have contributed to the development of preventative programs that were designed specifically to address the incidence of ACL injury (Ford, Myer, & Hewett, 2014; Longo et al., 2012; Kathrin Steffen et al., 2013; Stevenson, Beattie, Schwartz, & Busconi, 2014). Non-contact ACL injury risk factors have also been incorporated into movement screens and LE injury prediction methods (Cook, 2010; Myer, Ford, Khoury, Succop, & Hewett, 2010b; Padua et al., 2009).

Appropriate preventive programs specifically tailored to an individual's sex may reduce the risk of non-contact ACL injuries. The possible reasons why females are two to eight times more likely to sustain a non-contact ACL injury than males (Lohmander et al., 2007) are important to consider. Measured values of modifiable intrinsic risk factors (knee laxity, quadriceps-hamstring strength ration, and valgus knee motion) in males are well within what experts consider preferred ranges regarding a lower non-contact ACL injury risk (Ahmad, 2005; Alentorn-Geli et al., 2009; Evans et al., 2011; Myer, 2005; Prodromos et al., 2007; Shultz et al., 2004; Yu, Lin, & Garrett, 2006). Females, however, have demonstrated measured values of these risk factors outside of preferred ranges (Ahmad, 2005; Blackburn, Norcross, Cannon, & Zinder, 2013; Blackburn, Riemann, Padua, & Guskiewicz, 2004; Lephart, Ferris, Riemann, Myers, & Fu, 2002). General knee joint laxity in males averaged 7.33mm ($\pm$ 1.27, $p < 0.05$), whereas females averaged 8.85mm of laxity ($\pm$ 1.86, $p > .05$) (Ahmad, 2005). Differences in hamstrings-quadriceps strength ratio between males (1.48 $\pm$ 0.33, $p > 0.05$) and females (2.06 $\pm$ 0.55, $p < .05$) were also noted. Valgus knee motion appears to differ significantly between males (5.3mm $\pm$ 0.5, $p = 0.005$) and females (7.3mm $\pm$ 0.5mm, $p = 0.005$), too (Ford, Myer, & Hewett, 2003). Other intrinsic modifiable risk factors exist; however, their contribution to incidence rate of non-contact ACL injury between sexes is debatable (Ali & Rouhi, 2010; Hewett, Ford, Hoogenboom, & Myer, 2010; Hutchings,

2013) when compared to joint laxity, hamstrings-quadriceps strength ratio, neuromuscular, valgus knee motion, joint position, and proprioceptive risk factors.

Muscular Fatigue

Although researchers have struggled to determine the extent to which muscular fatigue is a risk for ACL injury among male and female athletes (Fauno & Jakobsen, 2006), there is no doubt that muscle activity plays a role in protection of the ACL (Blackburn, Norcross, Cannon, & Zinder, 2013; Colby et al., 2000; Myer, 2005). Specific components of muscle activity that relate to muscle fatigue include joint stiffness, joint laxity, and anterior-posterior and anterior tibial translation within the knee (Blackburn et al., 2011; Hewett et al., 2005; Myer, Ford, Paterno, Nick, & Hewett, 2008; Shultz et al., 2004).

According to Chappell (2005), under fatigued conditions, both male and female athletes exhibit decreased knee flexion angle, increased proximal tibial anterior sheer force, and increased knee varus moments when performing a stop-jump task. Nyland, Caborn, Shapiro, and Johnson (1999) studied the effects of work-induced hamstring fatigue on the knee in a dynamic transverse plane. They determined that increased knee internal rotation during impact-force attenuation (the first stage in landing from an executed pivot-shift maneuver) demonstrates dynamic knee-control deficits during hamstring fatigue (Nyland et al., 1999). Melnyk and Gollhofer (2006) and Wojtys, Wylie, and Huston (1996) also provided evidence that supports the association of fatigue on the knee with ACL injury risk.

Because athletes' muscles are generally more fatigued in later stages of athletic events, some researchers believe that ACL injuries occur with greater frequency at this time. However, when studying injury rates of a limited sample population of female soccer players (n = 113), Fauno and Jakobsen (2006) observed that ACL injuries sustained in the first half of an athletic competition were just as frequent in occurrence as ACL injuries sustained in the second half. More research, including research of larger sample populations, must be completed in order to evaluate the extent to which muscle fatigue is linked with injury rates. Clinicians should consider muscular fatigue as a substantial risk factor associated with ACL injury cautiously.

Joint Laxity

Anterior knee joint laxity may influence muscle activation patterns of surrounding musculature, thereby increasing the risk of non-contact ACL tears. Shultz, Carcia, and Perrin (2004) studied 21 National Collegiate Athletic Association (NCAA) Division I female student-athletes with below-average anterior knee laxity (3 to 5 millimeters) and 21 with above-average anterior knee laxity (7 to 14 millimeters). Participants underwent a forward and either internal or external rotation perturbation (a physical external force) of the trunk and thigh while on a weight-bearing shank. A reflex delay of 16 ms in the activation of the biceps femoris muscle upon perturbation was found among members of the group with above-average knee laxity when compared to the group with below-average knee laxity. Shultz et al. (2004) noted that females with increased anterior laxity in a healthy knee may be less sensitive to joint displacement or loading. The investigators also stated that less sensitivity to joint displacement or loading might delay the action of mechanoreceptors located within the ACL. Mechanoreceptors provide sensory feedback that allows the hamstring reflex arc and quadriceps inhibition to occur (Solomonow, 2006). A delay in feedback may result in injury to the ACL. Females with above-average anterior knee laxity risk the delay of adequate tension, causing the concurrent need for more active control from gastrocnemius and hamstring muscles to compensate for reduction in passive knee joint stability (Schultz et al., 2004).

Generalized joint laxity (laxity in multiple joints, such as the wrist, fingers, knee, and elbow) may increase the risk of ACL injury in female athletes (Myer et al., 2008). Researchers tested participants' (n = 95) laxity at 5 sites (knee hyperextension $p = 0.02$, elbow hyperextension $p = 0.92$, thumb opposition $p = 0.80$, fifth-finger hyperextension $p = 0.71$, and side-to-side differences in anterior-posterior tibiofemoral translation $p = 0.002$) and determined that the 2 knee joint laxity tests (knee hyperextension and anterior-posterior tibiofemoral translation) best indicated which participants were at the highest risk for an ACL injury. Given the apparent increased risk for ACL injury associated with knee joint laxity (Myer et al., 2008; Shultz et al., 2004), the musculature surrounding the knee appears to play a significant role in reducing excessive knee laxity.

Hormonal Influence

Sex hormones in female athletes may influence joint and/or anterior knee laxity (Kim, Kumar, & Kim, 2010; Schmitz & Shultz, 2013), particularly during the ovulatory or post-ovulatory phases (Heitz et al., 1999; Mathor, Achado, Wajchenberg, & Germek, 1985; Slauterbeck et al., 2002). Not all researchers have identified a relationship between anterior knee laxity and the menstrual cycle (Beynnon et al., 2005; Karatzias et al., 2011; Romani, Patrie, Curl, & Flaws, 2003); however, the evidence is substantial.

A study by Martineau et al. (2004) and Wojtys et al. (2002) showed that knee laxity and the rate of traumatic injuries appear to decrease in women who use oral contraceptives. Knowledge of contraceptive effects on knee laxity and traumatic injury rate is important information for health care professionals, parents, coaches, and active females who participate in high-risk sports to possess (Belanger, Burt, Callaghan, Clifton, & Gleberzon, 2013; Hewett, Zazulak, & Myer, 2007). However, ethical issues exist in regards to what health care professionals, parents, and coaches do with the information. Health care professionals may consider disseminating the information in a group setting, from an educational perspective, rather than broaching the potentially controversial subject of contraception with a female athlete on a one-on-one basis (Little, Griffin, Kelly, Dickson, & Sadler, 1998).

Strength Ratio

The hamstring muscle reduces the load the ACL normally encounters as anterior sheer force increases (Baratta et al., 1988; More et al., 1993; Chappell, 2005; Liu & Maitland, 2000; More et al., 1993). Ahmad (2006) sought to determine whether hamstring-quadriceps strength ratio influenced knee stability and/or joint laxity among recreational soccer players (n = 123). Maximum hamstring and quadriceps strength measurements were collected using a handheld dynamometer. Participants were separated into four groups to observe maturity-related inter-gender differences. Ahmad discovered less laxity in mature boys (14 years of age and older) compared to the other 3 groups ($p = 0.0015$). He also anticipated that the boys' and girls' hamstring and quadriceps strength would increase as they matured. Notably, a large difference existed in hamstring strength increases when comparing mature boys with mature girls: Mature boys' average hamstring strength increased 179%, while mature girls' average hamstring strength increased 27% (Ahmad, 2006). However, Ahmad also observed a 50% increase in quadriceps strength among mature girls, creating an unhealthy quadriceps-hamstring ratio of 2.06—far greater than the other groups. The large ratio may be undesirable, due to the quadriceps' biomechanical influence of anterior sheer forces on the tibia during contraction (Ahmad, 2006).

The disproportionate activation of musculature in the thigh is considered a primary risk factor for ACL injuries (Podraza & White, 2010; Shultz, 2008; Solomonow et al., 1987) Colby, Francisco, Yu, Kirkendall, Finch, and Garrett (2000) quantitatively characterized quadriceps and hamstring muscle activation when they determined knee flexion angles during motions frequently used in soccer, such as the eccentric motions of sidestep-cutting, cross-cutting, stopping, and landing. The results of this study indicated high-level quadriceps activation beginning just before the foot strike and peaking in mid-eccentric motion (Colby et al., 2000). Increased quadriceps activation occurred for all maneuvers, with the highest being 161% during the landing maneuver. Conversely, hamstring muscle activation was consistently submaximal, with minimum muscle activity (14%) during the landing maneuver. The participants' foot strike occurred at an average of 22 degrees of knee flexion in all maneuvers (Colby et al., 2000). Joint angles (e.g. knee flexion) is a biomechanical consideration that, like strength ratio, has long been considered a contributing factor to ACL injury (Chappell, Creighton, Giuliani, Yu, & Garrett, 2007; Hewett et al., 2005; McLean, Huang, & van den Bogert, 2005; Paterno et al., 2010). The relationship between, and contribution of muscular strength ratio and knee joint biomechanics is important to consider in regards to ACL injury risk.

Knee Joint Biomechanics

Joint biomechanics is the study of body-joint movement and function during a given action, skill, or task. Decreased knee flexion angle is believed to increase ACL loading during the landing phase of the stop-jump task, which, in turn, increases the risk of a non-contact ACL tear (Chappell, 2005). Yu, Lin, and Garrett (2006), observed a correlation between hip and knee-joint motion and impact forces in the knee. The investigators measured 30 physically-active males and 30 physically-active females during a stop-jump task. The investigators collected three-dimensional videographic and force-plate data during the task to measure joint angles and impact landing force. The investigators hypothesized that hip and knee flexion-extension angular velocity would correlate with peak vertical ground and posterior reaction forces at landing from a stop-jump task. Instead, Yu et al. discovered that hip and knee joint motion, at foot contact with the ground, influenced ground reaction forces. The Yu et al. study is supported by other research that indicates that hip and knee joint motion and angles affect loads on the ACL (Heijne et al., 2004; Nunley, Wright, Renner, Yu, & Garrett, 2003). As more flexion occurs in the hip and knee during landing, the knee may encounter lower impact forces (Yu et al., 2006). Clinicians and individuals who work with athletic populations should consider training individuals to land with greater knee and hip flexion motion and angles to help dissipate ground reaction forces in the knee (Barry Paul Boden, Torg, Breit, & Sheehan, 2013; Pollard, Sigward, & Powers, 2010).

Myers and Hawkins (2010) used biomechanical principles to determine if peak anterior tibial sheer force (a measure of ACL loading) in the knee could be reduced through movement mechanics alterations without sacrificing performance. The investigators recruited 14 female basketball players to perform a jump-stop action using their normal mechanics and using modified movement mechanics. The participants were instructed to perform a jump-stop similar to those performed in practice drills. Additionally, the participants were taught to increase amplitude of the jump prior to landing, thereby increasing the amount of knee flexion at landing and striking the ground with toes, first. Every participant that used modified movement mechanics reduced their peak tibial sheer force by an average of 56.4% during the jump-stop task. All participants maintained or improved their jump heights using the modified movement mechanics (2.5 cm average increase). Myers and Hawkins have provided active female individuals with what purports to be an advantageous instructional tool that is intended to decrease the risk and incidence rate of non-contact ACL injuries.

Although jumping mechanics appear to impact non-contact ACL injury risk, landing mechanics appear to play a role, too (Kernozek, Ragan, Willson, Koehler, & Lopez, 2012; Lephart et al., 2002; Liederbach, Kremenic, Orishimo, Pappas, & Hagins, 2014; Quatman et al., 2014; Withrow, Huston, Wojtys, & Ashton-Miller, 2006; Yu et al., 2006). Open kinetic chain-landing mechanics believed to cause higher incidence of non-contact ACL injuries are the stationary jump-and-land mechanism (JLM) and the stop-jump mechanism (SJM), which occurs from a running scenario. Both the JLM and SJM are observed throughout ACL-based research (Borotikar, Newcomer, Koppes, & McLean, 2008; Chappell, 2005; Decker et al., 2003; Delahunt et al., 2012; Lephart et al., 2002; Liederbach et al., 2014; Orishimo, Kremenic, Pappas, Hagins, & Liederbach, 2009; Yu et al., 2006). Through the investigation of LE biomechanics during the landing of a stop-jump task in males and females, Yu et al. (2006) determined that hip-joint motion that occurred at the moment when the foot first made contact with the ground mattered more than the initial angle of the hip joint. Subsequently, active hip and knee flexion motions reduce impact forces during landing.

Studies demonstrate a correlation between the knee abduction moment (also known as knee valgus moment) at ground contact between females who sustain a non-contact ACL injury and those who do not (Hewett et al., 2005; Hewett, Torg, & Boden, 2009; Kristianslund, Faul, Bahr, Myklebust, & Krosshaug, 2012; Myer, Ford, Khoury, Succop, & Hewett, 2010a; Quatman et al., 2014; Withrow et al., 2006). The greatest knee abduction moment is generally accepted as the moment of contact between the foot and the ground during the deceleration of the initial stance phase (the phase at which the lowest vertical position of the body center is achieved), when the knees are closest to each other (Noyes, Barber-Westin, Fleckenstein, Walsh, & West, 2005; Zazulak et al., 2006). The knee abduction moment can be reduced by improving the biomechanics of the knee through neuromuscular training (Hewett et al., 2005; Myer, Ford, Brent, & Hewett, 2007; Noyes et al., 2005). Clinicians who work closely with individuals who engage in sports with a high incidence rate of ACL injury should make an effort to reduce their knee abduction moment.

Noyes, Barber-Westin, Fleckenstein, Walsh, and West (2005) studied the differences in lower limb control based on gender using the drop-jump test screen. The investigators observed increased knee abduction moment among females during landing. After a neuromuscular training program (Sportsmetrics) was implemented, the participants who originally had increased knee separation (23 ± 9 cm) demonstrated notable improvement (29 ± 8 cm, $p < 0.01$) (Noyes et al., 2005). Other studies that used the drop-jump landing task as a measurable variable agree with Noyes et al. (Delahunt et al., 2012; Mclean et al., 2007; Mokhtarzadeh et al., 2013; Orishimo et al., 2009); however, specific joint angles, knee moments, and knee motions associated with high-risk injury joint biomechanics warrant further research.

Observing a more uncommonly measured property of muscle tissue, Blackburn, Norcross, and Padua (2013) attempted to determine the influence of hamstring stiffness on landing biomechanics related to ACL injury. Blackburn et al. hypothesized that hamstring stiffness was associated with LE landing biomechanics, therefore influencing non-contact ACL injury risk. Previously, Blackburn et al. (2011) determined that with controlled external perturbations, healthy individuals with greater hamstring stiffness also displayed less anterior tibial translation. The Blackburn et al. (2013) study quantified hamstring stiffness and captured LE three-dimensional kinematics and kinetics using a motion-capture system. Additionally, the researchers measured peak knee flexion and valgus angles, vertical and posterior ground reaction forces, anterior tibial sheer force, internal knee extension and varus moments, and knee flexion angles at instances of each peak kinetic variable (Blackburn et al., 2013). Blackburn et al. determined that the internal knee valgus moment was 3.6 times smaller in the high-stiffness group ($p = 0.02$) and noted a trend ($p = 0.07$) in data that identified a peak anterior tibial sheer force that was 1.1 times smaller in the high-stiffness group. The investigators proposed that heightened resistance to knee extension may lead to a more flexed knee, producing a preferred position in landing biomechanics. Congruent with Blackburn's 2013 study, Boden, Griffin, and Garrett (2000) observed greater flexibility in ACL-injured subjects' hamstrings muscles compared to their uninjured cohorts.

Hamstrings stiffness may help reduce loading effects associated with non-contact ACL injury (Kubo et al., 2009). The reduced loading effects during landing activity, often observed in sports associated with a higher incidence in ACL injury can potentially decrease the incidence of ACL injury. Determining effective types of training to increase hamstring stiffness should be considered in a prevention program.

Neuromuscular Control and Proprioception

Proprioception and neuromuscular control (NMC) appear to associate with one another. Mandelbaum et al. (2005) defined neuromuscular control as the unconscious efferent response to an afferent signal regarding dynamic joint stability. Lephart, Ferris, Riemann, Myers, and Fu (2002) added that proprioception is afferent information arising from internal peripheral areas of the body, thus contributing to postural control, joint stability, and several conscious sensations. Proprioceptive information gained from proprioceptors in the knee joint is crucial in sending feedback to motor control units and in optimizing joint position sense and kinesthesia (joint motion). The feedback gained from joint proprioceptors can elicit a neuromuscular reflex response, or active movement, to reduce the strain on tissues (Dhaher, Tsoumanis, Houle, & Rymer, 2005). As excessive external forces are applied to the knee, the neuromuscular reflex response that is initiated from proprioceptor stimuli enhances stability of the knee (Dhaher et al., 2005; Shultz et al., 2000).

Investigators have generally agreed that improved NMC at the knee joint decreases the incidence of ACL injuries among various female athletic populations (Caraffa, Cerulli, Projetti, Aisa, & Rizzo, 1996; Hewett, Lindenfeld, Riccobene, & Noyes, 1999; Hewett, Stroupe, Nance, & Noyes, 1996). Deficits of trunk NMC (Zazulak, Hewett, Reeves, Goldberg, & Cholewicki, 2007) have also been shown to correlate with a higher incidence of ACL injury. Injury prevention programs often emphasize the improvement of truck and lower body NMC (Gilchrist et al., 2008; Irmischer et al., 2004; Mandelbaum et al., 2005). Investigators have expressed concern that injury prevention programs may not adequately reduce the ACL injury risk in individuals with greater NMC deficits (Hewett et al., 2005).

Movement Screening and Assessment

Although studies of the foundational movement patterns related to non-contact ACL injury risk are limited (Chorba, Chorba, Bouillon, Overmyer, & Landis, 2010), clinicians using LE risk screens have demonstrated success at identifying individuals with high-risk LE movement patterns (Padua et al., 2009). The Landing Error Scoring System (LESS) clinical assessment tool identifies individuals whose biomechanics are considered high-risk while the participant is in the act of performing a jump-landing rebound task (Padua et al., 2009). Smith et al. (2012) compared LESS scores with ACL injury rates of active individuals (n = 5,054). Investigators did not identify a correlation between LESS scores and participants' risk of sustaining an ACL injury overall (p = 0.32) or within each subgroup (p = 0.16-0.67) (Smith et al., 2012). Smith suggested that the sample population of military subjects originally used in the creation of LESS might limit the tool's effectiveness when used among different populations.

In an attempt to validate a clinic-based prediction tool, Myer, Ford, Khoury, Succop, and Hewett (2010a) developed a bridge between laboratory-based models and clinic-based techniques of high-knee abduction moments (KAM). Laboratory and clinic measures of knee valgus, body mass, tibia length, knee flexion range of motion, and quadriceps-hamstrings ratio were tested separately. All clinic-based measurements indicated a high correlation with measures derived from laboratory-based surrogate tests. The same investigators developed a clinician-friendly nomogram in a previous study (Myer et al., 2010b) and with the same clinical measures (i.e. knee valgus, body mass, tibia length, knee flexion range of motion, and quadriceps-hamstrings ratio). The investigators used the nomogram to predict the probability of participants demonstrating high KAM and therefore posing higher non-contact ACL injury-risk landing mechanics. Thus, Myer et al. (2010a) may have provided a reliable measurement screen for clinicians to help identify individuals who are at an increased risk of non-contact ACL injury due to high KAM probability.

Results of future studies observing different populations may strengthen KAM value in health care professions. Using data from a previous study, Goetschius et al. (2012) sought to determine the ability of the nomogram created by Myer and cohorts to identify KAM probability of female participants (n = 1,855) who ranged in age and skill level from high school to college. First-time non-contact ACL injuries occurred in twenty participants over three years. A relationship was not observed in KAM probability and ACL-injured participants when compared to matched, uninjured “control” athletes. Myer et al. (2013) responded to the journal editor of the Goetschius et al. (2012) study, emphasizing concerns in the study’s methodology. An investigation into the procedure that took place in Goetschius' study revealed that the drop-jump landing that was performed resembled LESS methods more than it resembled the procedure in the Myer et al. (2010a) study. Activity exposure and potential change in drop-jump vertical test landing biomechanics throughout the three-year period were not measured, which may also have impacted results (Goetschius et al., 2012). The neuromuscular properties of female change as age increases (Hass et al., 2005; Hewett, Lindenfeld, Riccobene, & Noyes, 1999; Shimokochi & Shultz, 2008; Zebis, Andersen, Bencke, Kjær, & Aagaard, 2009). Future researchers may consider studying different populations to determine the true findings.

The FMS was created to rank movement patterns in healthy individuals (Cook, 2010). Studies have not determined any relationship between overall FMS or specific movement scores and the incidence rate of non-contact ACL injuries. Kiesel, Plisky, and Voight (2007) investigated the relationship between professional football players’ scores on the FMS and their rate of incidence of a serious injury. Investigators administered and graded FMS movements among participants before pre-season training and concluded that participants with an FMS score of equal to or less than 14 had 11 times the risk of sustaining an injury when compared to participants with FMS scores of higher than 14 (Kiesel et al., 2007). Chorba et al. (2010) conducted a similar study using FMS to predict injury rates in female collegiate student-athletes. Participants with FMS scores of 14 or less had a 4-fold increase in

LE injury risk (Chorba et al., 2010). These studies (Chorba et al., 2010; Kiesel et al., 2007) demonstrate that the FMS may identify and predict individuals at higher risk of injury. Studies of larger and more general populations of active individuals may further strengthen the value of the FMS to clinicians.

Lower Extremity Injury Prediction

Investigators have used overall FMS score to identify participants' LE injury risk (Chorba et al., 2010; Lehr et al., 2013; Peate, Bates, Lunda, Francis, & Bellamy, 2007; White, 2013). Chorba et al. and Peate et al. did not define what they considered to be "LE injuries" in their studies. Lehr et al. (2013) used injury-risk algorithm categories and field-expedient screening as predictors of LE non-contact injury. The FMS and lower-quarter Y-balance test were used for screening, and the Move2Perform injury risk algorithm categorized participants into one of four risk assessments. Risk assessment categories were based on overall FMS score, specific FMS movement scores, previous injury history, FMS clearing screen tests, demographic information, presence of pain, lower quarter Y-balance test score, and asymmetry in FMS and lower-quarter Y-balance test. Lehr classified a non-contact LE injury as "…any insult from the hip to the foot, caused by a mechanism other than a direct outside force, requiring medical intervention, and resulting in one or more days of time lost from participation in sports-related activities" (Lehr et at., 2013). Non-contact LE injuries reported in the study were specified by type and included the following: ankle sprain, anterior shin pain, hamstrings strain, quadriceps strain, hip flexor strain, ACL sprain, adductor strain, calf/achilles strain, gluteus maximus strain, hip labral tear, hip iliotibial band syndrome, knee meniscus tear, and plantar fasciitis (Lehr et al., 2013). Other investigators that have observed LE injury rates did not provide a definition of what a non-contact LE injury is in their methods or data collection (Chorba et al., 2010; Dossa, Cashman, Howitt, West, & Murray, 2014; Peate et al., 2007). This limits clinicians' ability to recreate the study and accurately compare results.

Brumitt, Heiderscheit, Manske, Niemuth, and Rauh, (2013) investigated the efficacy of functional tests to predict LE and low back injury. The standing long jump (SLJ), single-leg hop (SLH), and the lower extremity functional test (LEFT) were measured on collegiate-level athletes (N = 193) before their athletic season began. Brumitt then observed the participants during their sport seasons for injuries. Lower extremity injury was defined as "…any muscle, joint, or bone problem/injury of the LE that occurred either during practice or competition that required the athlete to be removed from that day's event or to miss a subsequent practice or competition" (Brumitt et al., 2013). Investigators determined that asymmetry in SLH for distance (> 10%) among female participants increased their risk of ankle/foot injury 4-fold (OR = 4.4, 95%, CI: 1.2, 15.4; $p = 0.02$). Male participants who performed SLH distances of at least 75% of their height in either leg had 3 times the risk of low back or LE injury (OR = 3.6, 95%, CI: 1.2, 11.2 for the right LE; OR = 3.6, 95% CI: 1.2, 11.2 for left LE). Female participants who completed the LEFT in 118 seconds or more had a 6-fold increased likelihood of a thigh or knee injury (OR = 6.4, 95%, CI: 1.3, 31.7). The investigators did not find a correlation between the SLJ distance and time-loss injury to the LE or low back. Nevertheless, Brumitt et al. recommended further investigation with the LEFT and SLH for distance in specific athletic populations as a pre-participatory exam tool for LE and low back injury risk (Brumitt et al., 2013).

Butler, Lehr, Fink, Kiesel, and Plisky (2013) compared non-contact LE injury incidence and dynamic balance performance in college football players (N = 59). The Star

Excursion Balance Test (SEBT) measured participants' dynamic balance using the lower-quarter Y-balance test™ protocol. Butler defined a non-contact LE injury as "…lower extremity injury trauma that required medical intervention and resulted in time loss of more than 1 day from participation in sports-related activities" (Butler et al., 2013). Butler modified the definition from a prior study (Plisky, Rauh, Kaminski, & Underwood, 2006) that used identical measures but did not differentiate between contact and non-contact injuries. Incidence of injury was tracked using Sports Injury Monitoring System (SIMS, Flantech, Iowa City, Iowa) over a single American football season. Six participants sustained a LE non-contact injury during the observed season. Butler determined, through ROC curve analysis, that a cutoff point of 89.6% limb length composite score maximized sensitivity (100%) and specificity (71.7%) and identified all 6 injured participants. Additionally, 15 uninjured participants were identified as "at risk" for a non-contact LE injury (positive likelihood ratio: 3.5, 95%, CI: 2.4, 5.3) (Butler et al., 2013). This created a higher-than-preferred false positive rate in participants at potentially increased risk. Conversely, the use of the *a posteriori*-determined cutoff point (89.6%) resulted in the ruling out of the increased risk of participants sustaining a non-contact LE injury (Butler et al., 2013). Further studies should consider a larger sample size and broadened participant inclusion criteria, with the SEBT using the lower-quarter Y-balance test protocol for identifying individuals at risk for non-contact LE injuries.

ACL Injury Prevention Programs

One ACL injury prevention program that is utilized in youth athletics and has demonstrated promising results in regards to reducing ACL injury rates (Gilchrist et al., 2008; Mandelbaum et al., 2005) is the Prevent Injury and Enhance Performance (PEP) program, developed by the Santa Monica Orthopaedic and Sports Medicine group (Mandelbaum et al., 2005). The PEP program, which consists of a warm-up followed by stretching, strengthening, plyometrics, and sports-specific activities addresses potential deficits in strength and focuses on the stabilization of muscles around the knee joint. The PEP program includes activities that improve range of motion, LE strength, proprioception and kinesthesia, and neuromuscular control. As a result, the PEP program is intended to improve modifiable deficits present in individuals who are at high risk for ACL injury (Mandelbaum et al., 2005).

Mandelbaum et al. (2005) incorporated the PEP program into competitive female youth soccer players' warmups. The participants (n= 5,703 players) were placed in an intervention or control group and were observed over a 2-year period. The control group performed a warm-up designed by their individual coach, and data in the form of injury reports were collected on a weekly basis. The investigators observed a reduction in ACL injury rates in the intervention group during the first and second observed seasons (88% and 74%, respectively). Mandelbaum asserted that a prophylactic training program focused on developing neuromuscular control of the LE might address proprioceptive and biomechanical deficits observed in high-risk female athletic populations.

The PEP program requires very little equipment and may be performed in the same place as regular athletic practice (Mandelbaum et al., 2005). It includes instructions that are intended to train individuals on proper soft-landing form and posture. Traditional warm-up routines are essentially replaced with 15-20 minutes of PEP activities. The PEP program, which was originally created to reduce the incidence of ACL injury in female soccer players, may be difficult to incorporate into other sports (Gilchrist et al., 2008). Additionally, lack of coach/participant compliance and unknown outcomes for different age groups may negatively affect the observed reduction in sustained ACL injuries (Mandelbaum et al., 2005).

Pfeiffer, Shea, Roberts, Grandstrand, and Bond (2006) examined the Knee Ligament Injury Prevention (KLIP) program, a 20-minute strength and plyometric-based training program performed twice a week for 9 weeks. The KLIP program is used to improve jump-landing and running-deceleration mechanics, thereby reducing non-contact ACL injury risk. Participants (n = 1,439 female athletes) who were observed by Pfeiffer et al. for a 2-year period played soccer, basketball, or volleyball. The treatment group performed the KLIP program, which is incorporated before or after training sessions such as regular team practice, in-season; the control group did not utilize the KLIP program. The optimal amount of practice time when the KLIP program is performed remains unidentified. Pfeiffer et al. observed no difference in ACL injury rates between groups: Both groups sustained three ACL injuries over the course of the two-year period. Investigators noted that the incidence rate was lower than expected within the control group compared to epidemiologic studies that indicated higher rates. Investigators also stated that nine weeks may not have been sufficient time for neuromuscular adaptations to occur in the treatment group. Irmischer et al. (2004) used the KLIP program to determine whether peak vertical impact forces and rate-of-force development changed. The investigators' findings demonstrated reductions in both vertical impact force and force development rate, suggesting that the nine-week KLIP program altered landing strategies in women, possibly reducing the risk of future knee injury. One limitation of the study was the small, uncontrolled population sample who were considered active if they achieved 30 minutes of physical activity at least 3 days per week. Investigators using the KLIP program in future research may consider observing high-level female athletes for similar findings. Nevertheless, the findings indicated that mechanics of the LE can be altered through KLIP training (Irmischer et al., 2004).

Steffen, Myklebust, Olsen, Holme and Bahr (2008) observed effectiveness of the “11” program in reducing injuries in young female soccer players. The “11” includes 10 exercises and 1 fair-play component in place of traditional warm-up. The exercises focus on balance, core stability, eccentric hamstring strength, and dynamic stabilization. In the Steffen et al. study, teams (n = 2,100 players) were assigned to an intervention or control group. The intervention group used the “11” program 52% of the time throughout the season, which was notably less often than the researchers’ suggestion for usage. Steffen et al. observed no change in injury rates using the “11” injury prevention program. Future investigators should consider whether higher coach adherence to implementing the program would influence the data differently.

The International Federation of Association Football (FIFA) FIFA 11+ program was built from the “11” program, with some revisions to provide variety as well as difficulty in exercise progression (Soligard et al., 2008). Longo, Loppini, Berton, Marinozzi, & Denaro (2012) observed elite male basketball players with regards to their utilization of the FIFA 11+ program and injury rates. After one season, the investigators identified significant differences between most injury classifications. Lower injury rates were recognized in the intervention group in overall injuries (p = 0.0004), training injuries (p = 0.007), severe injuries (p = 0.004), acute injuries (p = 0.0001), leg injuries (p = 0.007), LE injuries (p = 0.022), hip and groin injuries (p = 0.023), and trunk injuries (p = 0.013). Longo et al. concluded that injury rates decreased in elite male basketball players due to the incorporation of the FIFA 11+ program.

Steffen et al. (2013) explored participant adherence to the FIFA 11+ program while collecting performance and injury-rate data. The investigators observed improvements in functional balance along with reduced injury risk among participants who strictly adhered to the FIFA 11+ program (Steffen et al., 2013). Other researchers (Gilchrist et al., 2008; Irmischer et al., 2004; Longo et al., 2012; Mandelbaum et al., 2005; Pfeiffer et al., 2006; Steffen et al., 2008; and Steffen et al., 2013) found participant compliance to affect injury rates, as well.

Summary

It is predicted that the incidence rate of non-contact ACL injuries among collegiate-level student-athletes will continue to rise by 1.3% each year (Hootman et al., 2007). Understanding components and influences of modifiable risk factors associated with non-contact ACL injuries is important before clinicians consider implementing an injury preventive program. Modifiable risk factors addressed in this literature review included the following: muscular fatigue (Chappell, 2005; Mclean et al., 2007; Wojtys et al., 1996), hormonal influence (Beynnon et al., 2005; Heitz et al., 1999; Wojtys et al., 2002), specific and general joint laxity (Kim et al., 2010; Myer et al., 2008; Shultz et al., 2004), hamstrings-quadriceps strength ratio (Ahmad, 2005), joint biomechanics (Decker et al., 2003; Hass et al., 2005; Liederbach et al., 2014), LE landing biomechanics (Blackburn et al., 2013; Chappell, 2005; Delahunt et al., 2012), proprioception (Butler et al., 2013; Myer, 2005), and NMC (Baratta et al., 1988; Hewett et al., 2005). Although gender is a non-modifiable risk factor, understanding why females are two to eight times more likely to sustain an ACL injury than males (Lohmander et al., 2007) is also important when considering ACL injury prevention. Clinicians may then know which ACL injury risk factors to identify and improve in females that demonstrate undesired traits (e.g. increased muscular fatigue, increased joint laxity, decreased hamstrings-quadriceps strength ratio, poor joint and/or landing biomechanics, poor proprioception, and decreased NMC).

The PEP, "11," KLIP, and FIFA 11+ programs consist of exercise components that differ slightly from those incorporated by the other programs and include strength, balance, agility, neuromuscular control, and dynamic and core stabilization. Individuals with deficits in any of the aforementioned exercise components may possess a higher risk of an ACL injury (Ali & Rouhi, 2010; Dragoo et al., 2012; Evans et al., 2011; Kobayashi et al., 2010; Lephart et al., 2002; Lin et al., 2009; Mandelbaum et al., 2005; Melnyk & Gollhofer, 2006; Wojtys et al., 1996). Current literature on foundational movement patterns, specifically ACL injury rates, is limited (Chorba et al., 2010). Current screen and assessment tools used to predict non-contact ACL injury risk are also lacking. However, Myer et al. (2010b) created a clinician-friendly nomogram that indicates the overall probability that individuals with a high KAM value may therefore possess a higher risk of future non-contact ACL injury. Chorba et al. (2010) and Kiesel et al. (2007) observed similar results when using the FMS to predict lower-extremity injury rates in participants who scored 14 points or lower. The FMS may predict individuals at higher risk of LE injury (Chorba et al., 2010; Kiesel et al., 2007). Correlations among FMS composite score, FMS specific movement scores, and KAM value may exist. Continued investigations of potential correlations will offer insight toward an optimal movement and scoring tool that can identify females who are at a higher risk of non-contact ACL injuries.

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CHAPTER 5

APPLIED CLINICAL RESEARCH

Non-contact Anterior Cruciate Ligament and Lower Extremity Injury Risk Prediction Using Functional Movement Screen and Knee Abduction Moment: An Epidemiological Observation of Female Intercollegiate Athletes

Submitted to the Journal of Athletic Training

Abstract

Context: Modifiable risk factors associated with non-contact anterior cruciate ligament (ACL) injuries are highly debated, yet the incidence rate of ACL injury continues to increase. Measures of movement quality may be an effective method to identify high injury-risk individuals.

Objective: To investigate whether a movement screen and/or a drop-jump landing task identifies female individuals at a higher risk for sustaining non-contact lower extremity (LE) injuries, particularly ACL injuries

Design: Cohort study

Setting: Clinical and athletic department facilities

Patients or Other Participants: 187 women that played collegiate soccer, volleyball, or basketball

Main Outcome Measure: Weekly injury report of participants who sustained a non-contact LE injury. Participants completed a movement screen and drop-jump landing task. Movement screen scores and KAM values were compared between injured and uninjured sample populations.

Results: A statistically significant difference ($t = 1.98$, $P = 0.049$) was observed in the FMS scores between the injured (ACL and LE injury) and uninjured groups. Prior ACL injury was also a significant predictor of LE injury (OR = 4.4, $P = 0.01$).

Conclusions: The FMS can be used to help identify collegiate female athletes at a higher risk of sustaining a non-contact ACL or LE injury. Female collegiate athletes that score 14 or less on the FMS screen have a greater chance of sustaining a non-contact LE injury.

Key Words: functional movement screen, knee abduction moment, anterior cruciate ligament

Key Point: Women who have had a prior ACL injury should have their functional movement patterns evaluated using the FMS.

Introduction

Current studies indicate more and more individuals are participating in athletics at the collegiate level.[1,2] Subsequently, anterior cruciate ligament (ACL) injuries are increasing every year. Researchers claim an annual increase in ACL injury of 1.3%.[3] Female collegiate level athletes may be two to eight times more likely than males to sustain an ACL injury.[4,5] Investigators generally agree that the most common mechanism of an ACL injury occurs in a non-contact setting.[6–8] Debate exists, however, over internal/external and modifiable/non-modifiable risk factors that influence non-contact ACL injury mechanisms.

Preventative programs may decrease the rate of non-contact ACL injuries.[9–11] These programs were created by injury prevention experts who attempted to address apparently deficient and prevalent modifiable risk factors. Current programs include the PEP (prevent injury and enhance performance), FIFA (International Association Football Federation) 11, FIFA 11+, and KLIP (knee ligament injury prevention) programs. Current research indicates that the PEP and FIFA 11+ programs may decrease the incidence rate of ACL and lower extremity injuries.[9–11] Mandelbaum et al[10] and Steffen et al[11] concluded that adherence rate among participants is the primary determinant of a successful injury prevention program. Addressing global deficits using a prevention program may not be sufficient in specific populations with increased risk factors outside the norm.

Investigators have suggested that, among females, a high knee abduction moment (KAM) as observed in landing mechanics may be associated with an increased risk of ACL injury.[12–14] Myer, Ford, Khoury, Succop, and Hewett[15] attempted to validate a clinician-based prediction tool (KAM nomogram) that was designed to establish a probability of individuals to demonstrate high knee load (KAM) landing mechanics. Clinical measures, including knee valgus motion, body mass, tibia length, knee flexion range of motion, and quadriceps-hamstrings (quadham) ratio were used to quantify the probability that participants who demonstrate high KAM (21.74 Nm) during a drop-jump landing (DJL) task possess a higher risk of ACL injury.[16]

The Functional Movement Screen (FMS) is a ranking and grading system that uses seven fundamental movement patterns to observe an individual's quality of movement.[17] Each of the seven FMS movements is graded separately and assigned a specific movement score. The sum of the FMS movement scores comprises the FMS composite score. While the FMS screen has not been established as a best-practice injury risk screening tool, researchers have used FMS composite scores as baselines in research designs with intervention programs intended to improve the FMS composite score after implementation.[18] Researchers claim that increasing the composite FMS score may reduce the risk of injury.[18–20]

The purpose of our study was to determine whether or not FMS scores and probabilities of KAM identify female intercollegiate athletes at a higher risk of sustaining a non-contact ACL and/or LE injury. Movement screens (e.g., FMS) combined with a risk assessment measure (e.g., KAM probability) may improve clinicians' ability to identify individuals at increased risk of non-contact ACL and/or lower extremity (LE) injury. Our research investigation was guided by the following questions:

1) Do FMS composite scores and KAM probabilities identify female participants at a higher risk for sustaining a non-contact ACL and/or LE injury?

2) Do FMS specific movement scores and clinical measures of KAM identify female participants at a higher risk for sustaining a non-contact ACL and/or LE injury?

3) What combination of FMS movement scores and KAM values (probabilities and clinical measures) best predict non-contact ACL and/or LE injury in female participants?

Methods

Participants

The study was conducted at five National Association of Intercollegiate Athletics (NAIA) institutions. The research design and study were approved by the University of Idaho Institutional Review Board (Appendix A).

For this study, we recruited 217 female NAIA collegiate-varsity-level athletes who played soccer (n = 63), basketball (n = 92), or volleyball (n = 62). Among the student-athletes who volunteered to participate in the study (88% participation rate), 191 were eligible, given our age criterion of 18-25 years old (average age of participants = 19.5 ± 1.21 years). However, our exclusion criteria was such that 187 of the volunteers were allowed to participate in the study. Our exclusion criteria included: 1) any injury status not allowing participation in sport, 2) request from physician not to engage in activity or exercise, and 3) any reason given by the participant or the primary investigator (PI) that is seen as potentially harmful to the participant were she to engage in the study.

Written consent was received the day of data collection. Each participant also completed a pre-participation survey (Appendix B). All eligible participants (n = 187) performed the DJL task. Five participants began the FMS but did not complete all of the movements, due to time constraints. Partial data that we collected from the five participants were included in the statistical analyses; however, any FMS movement not performed was given no value during data analyses.

Instrumentation

Functional Movement Screen movements were rated by the PI using the FMS test kit (Chatham, Virginia). The FMS movements included a hurdle step, inline lunge, shoulder mobility test, active straight-leg raise, trunk stability push-up, rotary stability test, and deep squat. Each movement was graded on quality and ability to produce optimal movement. The movements were scored using an ordinal scale from one to three. Pain that was reported by the participants during any movement pattern resulted in a score of zero. Three pain provocation screens were also conducted in the FMS screen.

In order to identify clinical measures necessary to determine each participants' probability of demonstrating high KAM, participants completed the DJL task. The DJL task involved performing a sports-specific jumping task three times from a 31 cm wooden box constructed by the PI (Figure 1). The participants then dropped down, and, upon landing, immediately jumped as high as possible. Tape lines were applied 35 cm apart[12,14] on top of the wooden box to allow for the minimum foot/ankle separation necessary to observe adequate knee valgus motion.[12] Using a previously validated clinic-based assessment tool,[15] the probability of demonstrating high KAM (21.74 Nm) was determined by measuring knee flexion and valgus motion during the DJL task. The participants' DJLs were recorded using two off-the-shelf camcorders (Panasonic V550) in frontal and sagittal planes. Virtualdub video analysis software version 1.10.4 (Cambridge, Massachusetts) was used to capture still images of knee flexion angles and knee valgus motion from the recordings. ImageJ software version 1.48 (U. S. National Institute of Health, Bethesda, Maryland) was used to measure the change in knee flexion angles and knee valgus motion from the still images. Participant body mass was measured with a Health-o-Meter® weight scale, called, The Doctor's Scale® model HDM770-05 (Boca Raton, Florida). The body mass measures were used to help identify participants' KAM probability.

Procedures

Participants were grouped with their respective athletic teams for FMS and KAM data collection and were measured in the athletic training clinic or in the gym of their institution. For the sake of participants' privacy, measures were collected behind a tri-fold screen. The PI measured and recorded all participant data. Tibia length was measured in centimeters, using a standard measuring tape, from the lateral knee joint line to the lateral malleolus.

Movement screening instruction and demonstrations were conducted in groups (teams). At the completion of the FMS screen, groups were provided an introduction to the DJL task. The PI demonstrated the DJL task to each group but did not offer instruction regarding DJL mechanics. If desired, participants could perform one to two practice DJL tasks.

When ready, the participants dropped directly down from the box, landed, and immediately performed a maximal jump. The participants were encouraged to mimic the jump they would perform in their sport. For example, jumping for a rebound was suggested to basketball participants, jumping to block a hit was suggested to volleyball participants, and jumping to head a ball was suggested to soccer participants. Mimicking sport activity may help participants to be less concerned that they are being evaluated,[21] leading to more natural jump and landing biomechanics.

The PI then watched the video-recorded DJL tasks and identified the jump of each participant that produced greatest knee valgus position. The knee flexion angle was measured from the same DJL attempt that produced the greatest knee valgus position. Knee flexion angle one (F1) was measured from the sagittal view at the video frame just prior to foot contact with the ground (Figure 2). Knee flexion angle two (F2) was measured from the video frame demonstrating greatest knee flexion motion (Figure 3). Knee flexion range of motion (ROM) value was determined by subtracting F1 from F2 (F1-F2 = knee flexion ROM value). Knee valgus position one (V1) was measured from the frontal view at the video frame just prior to foot contact with the ground (Figure 4). Knee valgus position two (V2) was identified at the video frame with maximal medial position of the knee joint center (Figure 5). Knee valgus motion value was determined by subtracting V1 from V2 (V1-V2= knee valgus motion value). The knee flexion and valgus motion values were used to help determine each participant's probability of demonstrating high KAM (21.74 Nm) during the DJL task.

The PI contacted each institution's head athletic trainer weekly through email requesting that he/she refer to the PI any female participants who sustained an apparent ACL or non-contact LE injury. An apparent ACL injury was defined as any knee injury that a medical professional clinically assessed and diagnosed as a possible ACL injury. A non-contact LE injury was defined as any injury at or below the hip which was not caused by a physical external force (i.e. an opposing player, a ball, or referee) and which resulted in the participant's inability to participate in her sport for at least 48 hours.

Participants who sustained an apparent ACL injury (n = 6) were sent an online survey via email (Appendix C). The survey questionnaire sought to determine the nature of the injury, whether or not the athlete's hormone levels could have affected her susceptibility to injury, and the potential contribution of biomechanical factors on the injury.

Results

Data Analysis

Data analyses were conducted using International Business Machines (IBM) SPSS statistics (version 21.0; SPSS Inc., Chicago, IL) and SAS/STAT software (version 9.3; SAS Institute Inc., Cary, NC). The descriptive statistics located in the following section were compiled from data on both injured and non-injured groups. In order to identify potential relationships within each group, independent variables (i.e., KAM probability, KAM clinical measures, FMS composite score, and FMS specific movement scores) were observed using univariate analyses (i.e., frequency, central tendency, and dispersion). Independent samples *t*-test were used to compare mean data sets between participants who sustained a non-contact ACL or LE injury, and those who did not. The variables in this test include the following:

- FMS composite score
- FMS specific movement scores (i.e., lunge, deep squat, straight leg raise, shoulder mobility, rotary stability, pushup, and hurdle step)
- KAM probability
- KAM clinical measures (i.e., knee valgus motion, knee flexion motion, tibia length, body mass, and quadham ratio)

The researchers used exact logistic regression analyses to identify whether FMS composite score and/or KAM probability best predicted non-contact LE and ACL injury. We used standard logistic regression analyses to determine which combination of FMS specific scores and KAM clinical measures best predicted non-contact ACL and LE injury. The α was set at .05.

Descriptive Statistics

Table 1 provides descriptive statistics for FMS composite and specific movement scores. Descriptive statistics for the clinical measures used to determine the KAM probability are found in Table 2.

Table 1. Descriptive Statistics for FMS Movements

	Minimum Score	Maximum Score	Mean ± SD	
Total FMS	5	20	15.22	2.69
Hurdle	0	3	2.24	0.61
Lunge	0	3	2.45	0.76
SLR	0	3	2.28	1.01
Shoulder	0	3	2.69	0.75
Pushup	0	3	2.28	0.97
Rotation	0	3	1.74	0.79
Deep squat	0	3	1.67	0.78

Table 2. Descriptive Statistics for KAM Clinical Measures

	Minimum Score	Maximum Score	Mean ± SD	
Probability	0.33	0.997	0.856	0.152
Tibia[a]	37	49	41.65	2.35
body mass[b]	47.2	140.3	69.57	12.65
Quadham	1.57	2.5	1.8	0.13
Flexion[c]	17	107.5	66	13.8
Valgus[a]	0	11.6	4.21	3

[a] Measured in cm
[b] Measured in kg
[c] Measured in degrees

Seventeen participants sustained a non-contact LE injury during the observation period. The injured participants' FMS mean composite score (14 ± 3.46) was lower when compared to the non-injured participants (15.35 ± 2.58). The average probability of KAM (high knee load) of injured participants (0.892 ± 0.11) was higher when compared to the non-injured participants (0.852 ± 0.16). Group comparisons were conducted using the Independent samples *t*-test on injured (LE injury) and non-injured participants' FMS composite score (t = 1.98, P = 0.049, 95% CI = 0.01, 2.69) and KAM probability (t = -1.084, P = 0.28, 95% CI = -0.112, 0.03) (Table 3 and Table 4).

Table 3. Independent Samples *t*-test of LE Injuries

		n	Mean	±	SD	*t*	*P*	95% CI
FMS	No injury	166	15.35		2.58	1.98	0.049	0.01, 2.69
	Sustained a LE injury	17	14.00		3.46			
KAM	No injury	170	0.852		0.16	-1.084	0.28	-0.11, 0.03
	Sustained a LE injury	17	0.892		0.11			

Table 4. Independent Samples *t*-test of Non-contact ACL Injuries

		n	Mean	±	SD	*t*	*P*	95% CI
FMS	No ACL injury	179	15.30		2.61	2.45	0.015	0.64, 5.95
	Sustained ACL injury	4	12.00		4.83			
KAM	No ACL injury	183	0.857		0.15	0.389	0.7	-0.122, 0.182
	Sustained ACL injury	4	0.827		0.16			

Of the six ACL injuries that were reported during our study, two resulted from contact initiated by a separate individual (teammate or opposing player) and four were non-contact ACL injuries. Our data analyses only considered the ACL and LE injuries that were non-contact in nature. Independent samples *t*-test for movement scores of ACL injured versus non-ACL injured patients were significantly different, statistically, in the FMS screen (FMS composite score, *P* = 0.015; KAM probability, *P* = 0.7) (Table 4). The average FMS composite score of ACL injured participants (12 ± 4.83) was lower when compared to the uninjured ACL participants (15.3 ± 2.61). The average KAM probability was unexpectedly higher in the uninjured ACL participants (0.857 ± 0.15) compared to the ACL injured group (0.827 ± 0.16). The KAM probability and clinical measures of KAM were reviewed for outlier cases within our sample population. All data points were within three standard deviations from the mean.

The clinical measures used to identify the KAM probability, that demonstrated poorer scores among the injured participants (body mass, quadham ratio, and valgus motion) are evident in Table 5.

Table 5. Clinical Measures of KAM and LE Injuries

		Mean	± *SD*
KAM probability	No injury	0.852	0.156
	Sustained an injury	0.892	0.109
Tibia[a]	No injury	41.68	2.41
	Sustained an injury	41.4	1.7
Body mass[b]	No injury	69.51	13.08
	Sustained an injury	70.08	8.09
Quadham	No injury	1.79	0.13
	Sustained an injury	1.8	0.08
Flexion[c]	No injury	65.99	13.81
	Sustained an injury	66.18	14.45
Valgus[a]	No injury	4.12	3.05
	Sustained an injury	4.99	2.31

[a] Measured in centimeters
[b] Measured in kg
[c] Measured in degrees

The components of the FMS screen that demonstrated poorer movements among the injured participants include the lunge, straight leg raise, pushup, truck rotation stability, and deep squat (Table 6).

Table 6. FMS Movements (Point Based) and LE Injuries

		Mean	± *SD*
Total FMS	No injury	15.35	2.58
	sustained an injury	14	3.46
Hurdle	No injury	2.24	0.61
	sustained an injury	2.24	0.56
Lunge	No injury	2.49	0.7
	sustained an injury	2.06	1.14
SLR	No injury	2.29	1
	sustained an injury	2.24	1.15
Shoulder	No injury	2.7	0.73
	sustained an injury	2.59	0.87
pushup	No injury	2.31	0.96
	sustained an injury	2	1.06
rotational	No injury	1.77	0.78
	sustained an injury	1.47	0.87
deep squat	No injury	1.7	0.74
	sustained an injury	1.41	1.07

Participants who reported sustaining prior ACL injuries (before the investigation) (n = 27) demonstrated poorer FMS composite scores in the FMS movement screen (13.84 ± 3.611) when compared to participants who did not report a prior ACL injury (15.30 ± 2.732, *P* = 0.04). Participants who reported having undergone one or more knee surgeries (n = 29) also demonstrated poorer FMS composite scores in the FMS movement screen (14.45 ± 2.84) when compared to participants who did not report a prior knee surgery (15.37 ± 2.65). This data indicates that participants who had prior knee surgery demonstrated poorer functional movement compared to non-injured participants. Although the difference between the FMS composite score means was not statistically significant (*P* = 0.09), heath care professionals may consider the difference to be clinically meaningful.

The observed numerical difference between injured and uninjured participants' FMS composite scores was statistically significant in the FMS movement screen (*P* = 0.049). Cohen's *d* was estimated at 0.3 and 0.08 for FMS and KAM, respectively. These are very small effect sizes (*r* = 0.15 and 0.04) based on Cohen's[22] guidelines.

The uninjured group (n = 170) was associated with a FMS composite score mean of 15.35 (± 2.58) and a KAM probability mean of 0.852 (± 0.16). By comparison, the injured group (n = 17) was associated with numerically poorer movement scores, with a FMS composite score mean of 14 (± 3.46) and a KAM probability mean of 0.892 (± 0.11).

To test our hypothesis that there is a statistically significant difference between the movement scores of the injured (non-contact ACL or LE injury) and uninjured participants, an independent samples *t*-test was performed for each group. Specific movement scores and clinical measures within FMS and KAM were also evaluated between the injured and uninjured groups. The independent samples *t*-test of FMS composite score and LE injury was associated with a statistically significant difference (*t* = 1.98, *P* = 0.049) between the injured and uninjured groups. The independent samples *t*-test of KAM probability was not associated with a statistically significant difference (*t* = -1.084, *P* = 0.28) between the injured and uninjured groups.

Using an exact logistic regression model, previous ACL injury and FMS composite score were demonstrated to be the strongest predictors of non-contact LE injury (Table 7). Exact logistic regression was used due to the small sizes of the non-contact LE and ACL injured groups (n = 17 and 4).

Table 7. Non-contact Lower Extremity Injury Logistic Regression

	Model Set 1 Movement Only		**Model Set 2 Controlling for Prior Injury and Pain**	
	OR (95% CI)	***P***	**OR (95% CI)**	***P***
KAM	1.12 (0.68-1.83)	0.65	1.19 (.69-2.06)	0.52
FMS	0.64 (.401-1.03)	0.06	0.75 (.42-1.37)	0.35

Results are based on exact logistic regression models.

The results from Model Set 1 (effect of movement scores on LE injury) indicated that the effect of FMS composite score on the logistic odds of sustaining an LE injury was trending towards statistically significant ($P = 0.06$) (Table 7). With every one standard deviation increase (improvement) in FMS composite score (2.69 points), the odds of sustaining an LE injury decreased by more than 35% (OR = 0.64). We categorized the participants' KAM probability into high- and low-risk groups, based on a cut point of ≥ 0.80. Our results indicated that probability of high KAM, using a threshold cut-point of 0.80 as "high-risk," did not predict non-contact LE injury ($P = 0.284$).

Model Set 2 (Table 7) contains the effect of FMS composite score on the log-odds of sustaining an LE injury when controlling for prior knee surgery and pain reported during the FMS screen. Neither FMS composite score nor KAM probability predicted LE injury, when pain during the FMS screen and prior knee surgery were controlled ($P = 0.52$ and 0.35). However, the odds of participants who reported sustaining a prior ACL injury and/or knee surgery sustaining a subsequent non-contact LE injury were 4.4 times greater than participants without prior ACL injury and/or knee surgery (OR = 4.40, 95% CI: 1.32, 14.47, $P = 0.01$). Pain reported during the FMS screen did not predict LE injury ($P = 0.39$).

Given the small incidence of non-contact ACL injury (n = 4), the model set for non-contact ACL injury (Table 8) was more exploratory. The results from the exact logistic regression models indicated that FMS composite score was a significant predictor of ACL injury. Additionally, with every 1 standard deviation increase (improvement) in the FMS composite score, the odds of sustaining a non-contact ACL injury decreased by 60% (OR = 0.40, $P = 0.03$). Our results appeared to indicate that the KAM probability (high risk cut-point of ≥ 0.80) did not predict non-contact ACL injury ($P = 0.64$).

Table 8. Non-contact ACL Injury Odds-ratio and p-values

	Movement Only	
	OR (95% CI)	***P***
KAM	0.76 (.248-2.08)	0.64
FMS	0.40 (0.17-0.93)	0.03

Results are based on exact logistic regression models.

When considering all combinations of the FMS specific movement scores and KAM clinical measures, there were no statistically significant predictors of ACL or LE injury ($P > 0.05$ for all). The effect of FMS lunge on LE injury was approaching statistical significance ($P = 0.08$) such that increased lunge scores were associated with decreased odds of sustaining a non-contact LE injury (OR = 4.40, 95% CI: 1.32, 14.47). The combined effect of the valgus (KAM) clinical measure and the FMS lunge on LE injury was the strongest predictor ($P = 0.11$) when all FMS movements and KAM clinical measures were considered.

Discussion

We conducted this study to determine if movement screens (FMS and KAM) could be used to predict non-contact LE injury in female participants and to identify the combination of movement scores that best predicts injury. The cut-off for the FMS composite score that best predicted non-contact LE injury was 14. A cut-off score of 14 or less is congruent with recent literature that also identified individuals at a higher risk of sustaining an injury.[20,24–26]

Previous research demonstrates that ≥ 74 Nm of knee abduction represents high KAM, and ≤ 7.6 Nm of knee abduction represents low KAM.[15] Myer et al identified females with knee abduction > 25.3 Nm at a greater risk of sustaining an ACL injury.[29] It is important to note that the KAM nomogram indicates the probability that individuals will demonstrate 21.74 Nm of undesired knee load during landing mechanics. Some of our participants likely possessed knee loads greater than 21.74 Nm. These knee loads were not measured.

Hewett et al[14] determined that the average female athlete has about a 4.4% risk of suffering a non-contact ACL injury when the high-risk sport (basketball, soccer, or volleyball) is played year round (169 activity exposures). We observed participants in this study only while “in season” (about 90 activity exposures). The adjusted average risk of suffering an ACL injury was 2.7%. Our participant sample size (N = 187) was expected to produce 5 ACL injuries (rounded down from 5.1). The sample population in our investigation sustained the anticipated ACL injury rate when considering all confirmed contact and non-contact ACL injuries (n = 6).

The injured groups’ FMS specific movement scores were numerically lower (poorer) in six out of the seven movements; however, differences between the injured and uninjured groups were not statistically significant ($P > 0.05$). Although the statistical analyses for KAM probability did not indicate significant differences between the injured and uninjured groups, there was a trend that indicates that poorer clinical measures in KAM (i.e., higher knee valgus motion, body mass, quadham ratio, and/or KAM probability) may help to identify participants who are more at risk of non-contact LE injuries.

Future Research

Future research regarding FMS composite score and KAM probability should be conducted to further demonstrate whether individuals with poorer movement scores possess a greater likelihood to sustain a non-contact ACL and/or LE injury. Investigators should consider observing a larger sample size, which may result in a higher number of reported injuries. Increasing the length of time in which injury surveillance occurs may also result in a higher number of non-contact LE injuries.

Conclusion

The FMS composite score can be used to help identify collegiate female athletes at a higher risk of sustaining a non-contact ACL and/or LE injury. The FMS screen and KAM probability algorithm (nomogram) are easily implemented into clinical settings representative of collegiate female athletes. Female individuals who score 14 or less on the FMS screen have a greater chance of sustaining a non-contact LE injury.

Figure 1. Wooden box jump

Figure 2. Knee valgus position 1

Figure 3. Knee valgus position 2

Figure 4. Knee flexion angle 1

Figure 5. Knee flexion angle 2

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APPENDIX A: PROTOCOL APPROVAL FROM INSTITUTIONAL REVIEW BOARD FROM THE UNIVERSITY OF IDAHO

University *of* Idaho
Office of Research Assurances
Institutional Review Board
875 Perimeter Drive, MS 3010
Moscow ID 83844-3010
Phone: 208-885-6162
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irb@uidaho.edu

To: Jeffrey Seegmiller

From: Traci Craig, Ph.D.,
Chair, University of Idaho Institutional Review Board
University Research Office
Moscow, ID 83844-3010

Date: 8/25/2014 8:24:57 PM

Title: Non-contact anterior cruciate ligament injury risk prediction using functional movement screen and Knee abduction moment: an epidemiological observation

Project: 14-169
Approved: August 25, 2014
Renewal: August 24, 2015

On behalf of the Institutional Review Board at the University of Idaho, I am pleased to inform you that the protocol for the above-named research project is approved as offering no significant risk to human subjects.

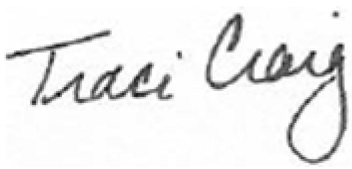
This study may be conducted according to the protocol described in the application without further review by the IRB. As specific instruments are developed, each should be forwarded to the ORA, in order to allow the IRB to maintain current records. Every effort should be made to ensure that the project is conducted in a manner consistent with the three fundamental principles identified in the Belmont Report: respect for persons; beneficence; and justice.

This IRB approval is not to be construed as authorization to recruit participants or conduct research in schools or other institutions, including on Native Reserved lands or within Native Institutions, which have their own policies that require approvals before Human Participants Research Projects can begin. This authorization must be obtained from the appropriate Tribal Government (or equivalent) and/or Institutional Administration. This may include independent review by a tribal or institutional IRB or equivalent. It is the investigator's responsibility to obtain all such necessary approvals and provide copies of these approvals to ORA, in order to allow the IRB to maintain current records.

As Principal Investigator, you are responsible for ensuring compliance with all applicable FERPA regulations, University of Idaho policies, state and federal regulations.

This approval is valid until August 24, 2015.

Should there be significant changes in the protocol for this project, it will be necessary for you to submit an amendment to this protocol for review by the Committee using the Portal. If you have any additional questions about this process, please contact me through the portal's messaging system by clicking the ‘Reply’ button at the top of this message.



Traci Craig, Ph.D.

University of Idaho Institutional Review Board: IRB00000843, FWA00005639

APPENDIX B: PRE-PARTICIPATION SURVEY

Thank you for agreeing to be a part of this research study. Please answer the questions below to the best of your ability. The information below will be reviewed by the investigator of the study (Scott Landis). All information will be stored in a locked file cabinet located within a locked office. Answering the questions below will improve accuracy of the study. However, you are not required to answer them if you wish not to.

Name: ________________________________
Date of Birth: __________________________ (MM/DD/YY)
Primary College Sport: ___________________

1. Do you play 2 or more sports at your college? (Circle one) YES NO

   If YES, what is/are the other sport(s) you play? ____________________________

2. Do you play primarily for the reserve team in your primary sport (i.e. junior varsity)?
   (Circle one) YES NO NOT SURE

3. Have you ever been told by a health care professional (e.g. athletic trainer, medical doctor, physical therapist) that you injured your ACL (anterior cruciate ligament) in your knee? *The ACL is a support structure in the knee*.
   (Circle one) YES NO

4. Have you ever had knee surgery (or surgeries)? (Circle one) YES NO

   If YES, what was the surgery (or surgeries) for? Write 'Not sure' if you do not remember.
   ____

5. Do you know about the Functional Movement Screen™?
   (Circle one) YES NO NOT SURE

   If YES, do you know the movements performed in the screen?

   (Circle one) YES NO NOT SURE

6. Have you been cleared to participate in your primary sport (this season)?

   (Circle one) YES NO NOT SURE

   If No, why have you not been cleared? (If unsure, leave blank)

   ____

APPENDIX C: ONLINE FOLLOW-UP ACL INJURY SURVEY

Thank you for taking the time to complete this survey. All information you provide will be held in strictest confidence.

All questions are related to your most recent knee injury, unless otherwise stated.

Please answer the following questions to the best of your ability. You are free to not answer any question. The survey should take 2-3 minutes.

1. Please enter your First and Last name.
2. What was the date your most recent knee injury occurred (month and day)? (if you do not know, write 'Not Sure')
3. Did your knee injury occur while participating in your collegiate sport (during practice, training, scrimmage, or game)?
4. Did anyone else (teammate, opponent, or referee) physically make contact with you when, or immediately before the knee injury occurred?

Studies indicate that hormone levels may influence females' risk of injuries. The following questions will help determine if hormone levels may have influenced your most recent knee injury.

5. When your knee injury occurred, were you on your monthly period?
6. To the best of your memory, what was the ***start*** and ***end*** date of your last menstrual cycle (period)?
7. Are you currently using any contraceptives (hormonal birth control)?
8. Had you ever been diagnosed with an ACL tear prior to your current knee injury?
9. Prior to your current ACL injury, were you using an ACL prevention program?

Thank you for taking the time to complete this survey.

If you have any questions, concerns, or comments regarding the study, please contact me. Also, you are free to withdraw from the study at any time.

Principle Investigator: Scott Landis
land2450@vandals.uidaho.edu
423-775-7275