Spring 2014

Health-Related Quality of Life in Physically Active Individuals with a History of Injury

Megan N. Houston
Old Dominion University

Recommended Citation

Houston, Megan N.. "Health-Related Quality of Life in Physically Active Individuals with a History of Injury" (2014). Doctor of Philosophy (PhD), Dissertation, Human Movement Sciences, Old Dominion University, DOI: 10.25777/5c74-7y44
https://digitalcommons.odu.edu/hms_etds/19

HEALTH-RELATED QUALITY OF LIFE IN PHYSICALLY ACTIVE INDIVIDUALS WITH A HISTORY OF INJURY

by

Megan N. Houston
B.S. May 2010, Mercyhurst University
M.Ed. August 2011, University of Virginia

A Dissertation Submitted to the Faculty of
Old Dominion University in Partial Fulfillment of the
Requirements for the Degree of

DOCTOR OF PHILOSOPHY

HUMAN MOVEMENT SCIENCE

OLD DOMINION UNIVERSITY

May 2014

Approved by:

Matthew C. Hoch (Director)

Johanna M. Hoch (Member)

Bonnie L. Van Lunen (Member)

ABSTRACT

HEALTH-RELATED QUALITY OF LIFE IN PHYSICALLY ACTIVE INDIVIDUALS WITH A HISTORY OF INJURY

Megan N. Houston
Old Dominion University, 2014
Director: Dr. Matthew C. Hoch

Individuals around the globe engage in physical activity for personal interest or general health and fitness. Although participation in regular physical activity is important for general health it also brings with it the risk of injury. Ankle sprains, anterior cruciate ligament tears, and concussions are just a few of the injuries sustained by physically active individuals with long-term implications. With the number of physically active individuals on the rise, sports-related injuries are of growing concern.

Health-related quality of life (HRQOL) is a personal evaluation of everyday functioning and well-being. A variety of injuries and health conditions associated with physical activity have been linked to HRQOL deficits. Despite these findings, the literature has yet to determine the influence of injury in physically active populations on the multidimensional profile of HRQOL.

The purpose of this dissertation was to explore the influence of injury history on HRQOL in physically active individuals. The purpose of the literature review was to systematically summarize the extent to which HRQOL deficits are present in individuals with chronic ankle instability (CAI) and adolescent and collegiate athletes. The purposes of these studies were to explore HRQOL differences between individuals with and without CAI, to determine if clinical and laboratory measures of function can predict HRQOL scores in individuals with CAI, and to examine the scale structure of the

Disablement in the Physically Active Scale (DPA), as well as, the influence of injury and participation on HRQOL in collegiate athletes.

The results of the systematic reviews suggest that CAI and sports-related injuries are associated with decreased HRQOL. In Project I, individuals with CAI displayed decreased HRQOL based on generic, region-specific, and dimension-specific patient-reported outcomes. In Project II, a combination of mechanical and functional impairments accounted for 17-36% of the variance associated with patient-reported outcomes related to physical function and fear. In Project III, collegiate athletes exhibited HRQOL deficits based on injury history, participation status, and time since last injury. Additionally, physical and mental subscales were identified within the existing structure of the DPA. The results of these studies expose the overlap between physical impairment and patient-reported outcomes and confirm that physically active individuals exhibit HRQOL deficits following injury. As a result, patient-reported outcomes should be used in clinical practice to treat the entire spectrum of disability.

ACKNOWLEDGEMENTS

First, I must acknowledge that the compilation of these projects would not have been possible without the financial contributions of Old Dominion University and the Mid-Atlantic Athletic Trainers' Association. The Darden College of Education Dissertation Fellowship allowed me to dedicate a year of my doctoral studies to executing a multi-site investigation that expanded our perception of health-related quality of life in collegiate athletes (Project III). As a former student-athlete, I am thankful to have had the opportunity to contribute to the ever-growing body of literature that benefits future athletes. Furthermore, I am ever grateful for the funds provided by the Mid-Atlantic Athletic Trainers' Association that aided Project II.

Next, I must recognize my committee, Dr. Matthew Hoch, Dr. Johanna Hoch, and Dr. Bonnie Van Lunen, for their persistent dedication to this dissertation. I would first like to thank Dr. M. Hoch for his endless guidance and encouragement throughout this process. Dr. M. Hoch's intellectual heft is matched only by his sincere character and down to earth humility and I am forever grateful to have had the opportunity to learn and grow under his mentorship. Matt, you have set an example of excellence as a mentor, investigator, professor, and role model, and I am truly privileged to have worked under your fearless leadership and for that I say thank you. Next, I would like to thank Dr. J. Hoch for her gracious guidance and constant enthusiasm over the past two years. Hanna, thank you for your continuous efforts and valuable insight as an investigator and for contributing countless hours to my growth as a research investigator and person. Lastly, I would like to thank Dr. Van Lunen for enhancing my skills and philosophies as an educator and for her mentorship throughout my doctoral studies.

To execute this collection of projects, it takes more than a devoted committee and

thus I would be remiss if I did not recognize the others that helped along the way. To my "minions", Michael and Jessica, thank you for dedicating your time and effort to the prolonged data collection sessions for Project II and for putting up with my methodical ways. I owe a very special thank you to Stefani Masterton and Nicole Emanato, as well as, the other athletic trainers that helped to facilitate and organize data collection sessions for Project III. Without your assistance I would not have been able to carry out such a prodigious project. To all of the past and present Master's and Doctoral students, thank you for lending a helping hand, providing perpetual mentorship, and everlasting friendships.

To finish, I must thank my family for providing unrelenting love, guidance, and support. To my parents, thank you for allowing me to pursue my dreams no matter how far away from home they take me and for continuously showing your love and support in the care packages that highlight the comforts of home. To my grandparents, who provided their unwavering support at the beginning of this academic excursion but unfortunately did not get to see it fulfilled, thank you for instilling the values of faith and family and for your relentless encouragement throughout my childhood and beyond. To my brother, Zach, thank you for continuously challenging my knowledge and reminding me the value of simplicity, you are truly an admirable role model. To the rest of my friends and family near and far, thank you for your steadfast support and encouragement throughout this journey.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Background

Individuals around the globe engage in physical activity for personal interest or general health and fitness. In the United States, participation in collegiate and high school athletics has reached an all-time high at approximately 8.1 million student-athletes.[1, 2] In addition, an estimated 44 million children participate in organized athletics.[3] While participation in regular physical activity is important for preventing hypokinetic diseases[4] and improving mental well-being and self-esteem,[5] physical activity also brings with it the risk of injury.

Annually, up to 4.3 million sports or recreational activity-related injuries are treated in U.S. emergency departments.[6, 7] However, this number does not reflect the various other sports-related injuries treated by other allied health care professionals. Within sports medicine, more than half of all sports-related injuries occur to the lower extremity.[8, 9] Injury epidemiology studies have proclaimed ankle sprains to be the most common injury suffered by high school and collegiate athletes.[8, 9] With ankle sprains occurring at an estimated rate of 23,000 per day,[10] long-term consequences such as osteoarthritis and participation restrictions post-injury are of growing concern.[11-13] However, ankle sprains are not the only sports-related injury with long-term consequences. Other injuries typically associated with athletic participation, such as anterior cruciate ligament (ACL) sprains and meniscal tears, have been linked to osteoarthritis.[14, 15] Additionally, sports-related concussions have been connected to cognitive impairment and dementia-related syndromes such as Alzheimer's disease.[16]

With the increasing number of physically active individuals it is important that following injury these patients receive the best treatment and care.

Disablement Models

Disablement is a global term that reflects the diverse consequences that injury may have on human functioning at many different levels.[17] First introduced in 1965,[18] disablement models are conceptual schemes or scientific models that form the basic architecture for clinical practice, research, and health care policy.[17] Disablement models provide the framework to assess impairment (i.e., loss or abnormality in body function or structure), functional limitations (i.e., restrictions in the performance of a person), and disability (i.e., a physical or mental limitation in a social context) in patients as a result of disease, disorder, or injury. Contemporary models of disablement include Nagi's Disablement Model,[18] the National Center for Medical Rehabilitation Research Disablement Model,[19] and the World Health Organization's International Classification of Functioning (ICF) Model.[20] All three models utilize a biopsychosocial approach to assess the overall health status of their patients, however the lack of a standard disablement model makes it difficult for health care professions to communicate, measure, and prioritize the health care needs of patients.

The World Health Organization's ICF model (Figure I.1) provides both a scientific basis and a quantifiable system for identifying and studying health care outcomes. The ICF Model[20] is unique in that it provides a synthesis of earlier disablement models. More importantly, the ICF framework looks beyond mortality and disease to focus on how people cope with their conditions.[21] The ICF model[20] emphasizes the whole person by addressing disablement at the origin, organ level, person level, and societal level as well as environmental and personal contributing factors.[22] Within the model, health condition is an umbrella term used to represent diseases, disorders, or injuries. Health condition is organized into three domains: body function and structure, activity, and participation.[21] Body functions are defined as the physiological functions of body systems and structures as anatomical parts such as organs and limbs.[21] Activity is the execution of a task or action by an individual, whereas participation is involvement in a life situation.[21] The ICF model's shift in focus from cause to impact places all health conditions on equal footing,[20, 21] thus affording clinicians and researchers a common framework to assess both disease and patient-oriented outcomes.

The unique framework of the ICF model can be adapted to suit various health care professions. Health care professionals within the sports medicine community not only treat a variety of health conditions but also a diverse patient population. Within the ICF model, the term health condition is applicable to any disorder, disease, or injury encountered by the clinician and patient individuality is captured in one of the three domains (i.e., body functions and structure, activity, participation) or one of two contextual factors (i.e., environmental or personal).[21, 23] Thus, it provides a conceptual framework for refocusing health care interventions on the unique needs of each patient. Adopting the ICF model within the sports medicine community would provide a common language for clinical outcomes assessment, enhancing evidence-based practice (EBP), and improving the overall quality of patient care.[23] A biopsychosocial view of health, the ICF model, provides a framework for studying the consequences of injury with emphasis on the person as a whole.

Patient-Centered Care

Patient-centered care is respectful of and responsive to individual patient preferences, needs, and values, ensuring patient values guide all clinical decisions.[24] An effective practitioner incorporates patient values, the best available evidence, and clinical expertise into treatment decisions and clinical practice, otherwise known as EBP.[25] Over the past decade, EBP has gained attention in both clinical and research settings of athletic training. Although the profession has made great strides in the production of disease-oriented evidence addressing disablement at the organ level, it has failed to equally incorporate patient-oriented evidence that matters (POEM). POEM emphasizes the effect of a disease or injury on a patient's health status[23] concentrating efforts on understanding disablement from the perspective of the person. Thus, a culmination of disease-oriented and patient-oriented evidence will contribute to a better understanding of disablement following injury.

While the World Health Organization's ICF model provides the framework for examining disablement, clinical outcome assessments are needed to understand the extent of impairment post-injury. Clinical outcome assessments include both clinician- and patient-based measures. Traditional clinician-based outcomes include goniometry, manual muscle testing, and circumference measures. Whereas, patient-based outcomes include information from the patient regarding impairments, function, and health-related quality of life (HRQOL).[22] Combining evidence from clinician- and patient-based outcomes will provide clinicians with a better understanding of disablement following injury. As a result, evidence obtained from clinical outcomes assessments can be used to monitor treatment outcomes and aid clinical decisions. However, to foster patient-centered care and facilitate EBP in athletic training, more POEM is needed.

Health-Related Quality of Life

Rather than recognize health as the absence of disease and disability, the World Health Organization conceptualized health as a positive state of physical, mental, and social well-being to be viewed as a continuum.[20] Emphasis on the multidimensional profile of health focused attention on the assessment and promotion of HRQOL.[26] Encompassing social, physical and psychological health components, HRQOL has become an important component of health surveillance.

Due to the multi-dimensional nature of HRQOL a variety of self-reported or patient-reported outcomes (PROs) have been designed to measure generic, region-specific, and dimension-specific health components. Generic outcomes, often referred to as global, are non-specific to body region or condition and designed to assess the patient's overall health.[27] Region-specific outcomes are specific to a joint (e.g. ankle) or region (e.g. lower extremity) of the body. Dimension-specific outcomes are used to capture one aspect of an individual's health, such as pain or injury-related fear. Utilizing HRQOL measures in athletic training clinical practice enhances the clinician's ability to incorporate patient values and perspectives; a vital component to the EBP model.[23]

Patient-Reported Outcomes

PROs are questionnaires or survey instruments that ask patients to self-report his or her perception of a condition, injury, and/or overall health status. Generic instruments, such as the Short Form-12 (SF-12),[28] Short-Form-36 (SF-36),[29] and Pediatric Outcomes Data Collection Instrument (PODCI)[30] capture a broad range of health status outcomes. Recent evidence measuring HRQOL with these PROs has suggested a decrease in

HRQOL in adolescent and collegiate athletes with a recent or serious injury compared to their uninjured counterparts.[31, 32] Region-specific PROs, such as the Foot and Ankle Ability Measure (FAAM),[33] have been developed to evaluate constructs of disablement for a specific region of the body (e.g., the foot and ankle). Recurrent ankle sprains,[34] knee injuries,[35] and concussions,[36] have all been associated with decreased function on a variety of region-specific PROs. Dimension-specific instruments, such as the Tampa Scale of Kinesiophobia (TSK)[37] and the Fear-Avoidance Beliefs Questionnaire (FABQ),[38] evaluate the presence of fear or other associated psychological barriers following physical impairment. While injury-related fear has presented in a variety of populations,[38-42] very few studies[43, 44] have examined injury-related fear in an athletic population. Moss et al.[43] identified differences in kinesiophobia scores among acutely injured athletes. Athletes with severe injuries, concussions, or a history of three or more injuries reported increased kinesiophobia. Furthermore, Houston et al.[44] observed a decrease in injury-related fear as acutely injured athletes returned to participation. Left unaddressed post-injury, HRQOL deficits could hinder the recovery process. Using a combination of PROs may allow athletic trainers to improve the quality of care provided by identifying HRQOL deficits related to generic, region-specific, or dimension-specific change.

Assessing clinical outcomes, such as HRQOL, is one way of promoting EBP and patient-centered care. However, the literature lacks substantial evidence regarding patient populations commonly treated by athletic trainers. Consequently, to gain a better understanding of the disablement process experienced by physically active individuals we can begin by exploring relationships between HRQOL and chronic ankle instability

(CAI).

Chronic Ankle Instability and Health-Related Quality of Life

CAI is a health condition characterized by residual symptoms that include feelings of giving way and instability, recurrent ankle sprains, and functional loss following the occurrence of one or more acute ankle sprains.[45] Roughly half of all ankle sprains in the United States occur during athletic activity[46, 47] and an estimated three million patients are treated in hospital emergency rooms or a physician's office each year.[48] Within the past decade, ankle sprains have represented approximately 80% of ankle injuries in athletics[49, 50] and military cadets[46] resulting in immense health-care costs.

Individuals that go on to develop CAI have reported decreased generic and region-specific HRQOL.[34, 51] Arnold et al.[51] found that participants with CAI reported lower SF-36 scores. Additionally, the study[51] identified a moderate positive correlation between SF-36 physical function domain scores and the FAAM. This relationship suggests that CAI may reduce overall HRQOL. Furthermore, Hale and Hertel[52] reported that participants with CAI (89.6% ± 9.1%) demonstrated significantly lower scores on the Foot and Ankle Disability Index (FADI) in comparison to healthy controls (99.9% ± 0.3%). Individuals with CAI have also reported decreased function on the Ankle Joint Functional Assessment Tool (AJFAT), Self-Reported Questionnaire of Ankle Function (SRQAF), FAAM-Sport, and FADI-Sport.[34, 53, 54] Using a variety of self-reported instruments, both generic and region-specific deficits have been detected in physically active individuals with CAI. However, it is unclear how CAI impacts dimension-specific aspects of HRQOL such as injury-related fear.

CAI has been attributed to both functional and mechanical impairments.[55, 56] However, the relationship between generic, region-specific, and dimension-specific outcomes and physical impairment remains unclear. For example, Wikstrom et al.[53] indicated that although functional performance, using a series of hop tests, did not differ between groups ($p=0.259$), self-assessed disability was significantly greater ($p<0.001$) in those with CAI than copers and healthy controls. Calculated effect sizes (Hedge's g) between CAI and coper groups and CAI and healthy controls indicated a large effect for FADI (Coper=0.70, Healthy=1.05), FADI-Sport (Coper=0.76, Healthy=0.97), and SRQAF (Coper=1.18, Healthy=2.34) scores.[53] Although CAI did not influence functional performance it appears to play a role in self-assessed disability.

Few studies[57, 58] have examined the relationship between mechanical impairment and HRQOL. Hubbard-Turner[57] examined the influence of mechanical impairment on self-reported function and concluded that mechanical laxity contributes to region-specific deficits as reported on the FADI. Anterior laxity strongly correlated with FADI ($r=-0.65$) and FADI-Sport ($r=-0.88$) scores and inversion rotation moderately correlated with FADI ($r=-0.53$) and FADI-Sport ($r=-0.45$) scores. Therefore, as anterior laxity or inversion rotation increased an individual's level of function as reported on both the FADI and FADI-Sport decreased. However, in a previous study[58] the relationship between ankle laxity and FADI and FADI-Sport scores was not statistically significant. The relationships observed between FADI and FADI-Sport scores and ankle laxity were weak, with correlation coefficients ranging from -0.055 to -0.255. The lack of significant findings in one study and not the other, along with the dearth of evidence examining the influence of other known CAI impairments on PROs warrants further investigation.

A variety of treatment and rehabilitation strategies such as taping, bracing, joint mobilizations, and balance training have been employed to negate impairments associated with CAI.[59-61] However, very few studies[61-63] have investigated the influence of such strategies on region-specific function via PROs. Hoch et al.[62] noted improvements on the FAAM and FAAM-Sport following a 2-week joint mobilization intervention. Furthermore, McKeon et al.[61] and Hale et al.[63] found similar improvements on the FADI and FADI-Sport following rehabilitation protocols. Hence, region-specific outcomes appear to be modifiable post-intervention.

Within the CAI literature, researchers have identified a link between physical impairment and self-reported function.[57] In addition, PROs appear to be responsive to standard treatment and rehabilitation strategies.[61-63] However, HRQOL needs to be further examined in this population due to inconsistent statistical results regarding the relationship between region-specific outcomes and mechanical impairment[57, 58] and the lack of evidence pertaining to relationships between generic and dimension-specific outcomes and physical impairment. Further exploration of the relationships between patient-oriented evidence and disease-oriented evidence may elucidate the most meaningful path to recovery.

Athletes and Health-Related Quality of Life

Competitive and recreational athletes sustain a variety of soft-tissue,[64-67] bone,[68, 69] and nerve injuries[70-72] due to direct trauma or repetitive stresses during sports participation. Sports-related injuries account for a significant amount of emergency medical care in the United States alone.[6, 7, 73] A meta-analysis of pediatric epidemiological sports injury studies from 1966 to 2006 found that most injuries occur to the lower extremity, predominately to the knee and ankle.[74] Similar trends were noted from 1988 to 2004 in collegiate athletes with ankle ligament sprains accounting for 15% of all reported injuries.[9] Furthermore, athletic injuries often result in time loss from competition[75-77] and substantial health-care costs.[78, 79] Examining the influence of injury on HRQOL in an athletic population may enhance the quality of care and reduce the long-term impact associated with musculoskeletal injuries in athletes. Therefore, athletes are another population worthy of further investigation.

Athletic populations have reported higher SF-36 and Pediatric Quality of Life Inventory (PedsQL) scores, indicating better HRQOL, in comparison to the general population.[80-82] However, with an estimated two million sports-related injuries reported each year in high school athletics alone[75] potential exists for those scores to fluctuate. The current literature suggests that adolescent athletes with a history of recent injury exhibit HRQOL deficits in comparison to their uninjured counterparts.[31] McAllister et al.[32] reached a similar conclusion in Division I collegiate athletes with a history of serious injury. Even athletes with a history of mild injury had lower scores on multiple components of the SF-36 compared to an uninjured cohort.[32] Additionally, athletes with a self-reported history of concussion have exhibited decreased HRQOL scores on the SF-36 and Headache Impact Test-6 (HIT-6) in comparison to uninjured athletes.[36, 83] However, it is important to point out that these studies are not without limitations.[31, 32, 36, 80-83] One major limitation is the lack of definition in injury history, time since injury, and classification of injury severity. Other limitations include lack of sport diversity in the data captured and lack of data on athletes not cleared for participation. Also, the investigations that have examined HRQOL in athletes have only administered generic outcomes (i.e. SF-36, PODCI, PedsQL) and one dimension-specific outcome (i.e. HIT-6).[32, 80] Lastly, the investigations have collected limited data on the types of injuries sustained by participants and the impact of time loss following injury.

While the literature suggests that injured athletes report lower HRQOL as measured by generic instruments,[31, 32, 36, 83] the influence of injury on other HRQOL dimensions is unknown. In addition, the literature has yet to determine the impact of participation factors such as injury location, injury severity, time since injury, and years of participation on HRQOL scores.

The lack of patient-oriented evidence to support the course of clinical treatment in athletic training is evident. If we can isolate factors that contribute to HRQOL deficits then athletic trainers can adjust their treatment approach to improve the quality of care received by the patient. Utilizing PROs to identify populations susceptible to HRQOL deficits and factors that contribute to decreased HRQOL will aid clinical decision-making. Therefore, further investigating relationships between HRQOL and athletes will promote patient-centered care and EBP.

The Problem

As the number of physically active individuals steadily increases so does the risk of sports-related injury. The majority of published evidence has been disease-oriented. However, an individual experiences a multitude of insufficiencies post-injury that clinical measures, such as range of motion and strength, exclude. Therefore, focus has shifted in the sports medicine community to POEM. The lack of POEM obstructs proper execution of the EBP model. Insufficient information regarding the patient's values and perspectives could hinder the overall quality of care. Left unaddressed altogether, POEM, such as HRQOL, may contribute to long-term consequences associated with sports-related injuries such as degenerative joint disease[11, 14, 84-86] and decreased physical activity.[87]

A variety of injuries and health conditions associated with physical activity have been linked to HRQOL deficits. Post-ankle sprain one in three individuals develop CAI[88] which has been associated with generic and region-specific HRQOL deficits.[34, 51] Post-ACL reconstruction, psychological variables, such as injury-related fear, have hindered function and return to sport.[39, 89] In addition, sports-related concussions have negatively influenced HRQOL outcomes.[36, 83] Despite these findings, the literature has yet to determine (1) the impact of CAI on dimension-specific constructs of HRQOL such as injury-related fear, (2) the relationship between HRQOL and mechanical and functional impairments associated with CAI and (3) the influence of injury history and participation factors on HRQOL scores in athletes. Therefore, examining the influence of sports-related injuries in physically active populations on the multidimensional profile of HRQOL and describing relationships between physical impairment post-injury and patient-oriented outcomes is essential to facilitate patient-centered care.

Purposes

There were four purposes of this dissertation. The first purpose was to systematically review the literature to examine HRQOL in individuals with CAI and adolescent and collegiate athletes. The second purpose was to determine if generic, region-specific, and dimension-specific health outcomes differ between individuals with and without CAI. The third purpose was to identify clinician and laboratory-oriented measures of function capable of predicting PRO scores in individuals with CAI. The fourth purpose was to examine the scale structure of the Disablement in the Physically Active Scale (DPA) and the influence of injury and participation factors on HRQOL in collegiate athletes. These studies were designed to address the following aims:

1. To systematically review the literature to examine HRQOL in individuals with CAI and adolescent and collegiate athletes the following questions were formulated:
    a. Are HRQOL deficits present in individuals with CAI?
    b. Are there HRQOL differences between adolescent and collegiate athletes and non-athletes?
    c. Are there HRQOL differences between uninjured adolescent and collegiate athletes and injured adolescent and collegiate athletes?
2. To determine if generic, region-specific, and dimension-specific health outcomes differ between individuals with and without CAI.
3. To identify clinician and laboratory-oriented measures of function capable of predicting PRO scores in individuals with CAI.
4. The following aims were formulated to explore HRQOL in collegiate athletes:
    a. To analyze the scale structure of the DPA.
    b. To examine the relationship between the DPA and FABQ in collegiate athletes with a history of injury.
    c. To compare HRQOL in collegiate athletes based on injury history, participation status, time since last injury, and injury severity.

Hypotheses

Hypothesis for Aim 1A: Within the literature, individuals with CAI will exhibit decreased HRQOL in comparison to healthy individuals.

Hypothesis for Aim 1B: Within the literature, adolescent and collegiate athletes will exhibit increased HRQOL in comparison to non-athletes.

Hypothesis for Aim 1C: Within the literature, uninjured adolescent and collegiate athletes will exhibit increased HRQOL in comparison to injured adolescent and collegiate athletes.

Hypothesis for Aim 2: Individuals with CAI will exhibit decreased generic and region-specific function and increased injury-related fear in comparison to healthy individuals.

Hypothesis for Aim 3: In individuals with CAI, a combination of clinician and laboratory-oriented measures will explain a significant amount of the variance associated with HRQOL scores.

Hypothesis for Aim 4A: Subscales associated with specific disablement components will be identified within the existing structure of the DPA.

Hypothesis for Aim 4B: The DPA will be related to FABQ scores in collegiate athletes with a history of injury.

Hypothesis for Aim 4C: Collegiate athletes will exhibit HRQOL deficits based on factors such as injury history, participation status, time since injury, and injury severity.

Overview

The methods, results, discussions, limitations, and conclusions of the four aforementioned aims are presented in the following sequence. Chapter II systematically summarizes the literature related to HRQOL in individuals with CAI

(Part A) and adolescent and collegiate athletes (Part B). Chapter III summarizes HRQOL comparisons between individuals with and without CAI. Chapter IV summarizes relationships between PROs and physical impairment in individuals with CAI. Chapter V summarizes the influence of injury history on HRQOL scores in collegiate athletes. To conclude, Chapter VI summarizes the findings of each study and discusses future research implications.

Operational Definitions

Chronic Ankle Instability (CAI): A health condition characterized by residual symptoms that include feelings of giving way and instability, recurrent ankle sprains, and functional loss following the occurrence of one or more acute ankle sprains.[45]

Evidence-Based Practice (EBP): An interdisciplinary approach to clinical practice that incorporates the best available evidence, clinical expertise, and patient values into treatment decisions.[25]

Fear-Avoidance Beliefs: A maladaptive emotional response toward an excessive fear of pain that can eventually lead to avoidance behavior.[90]

Health-Related Quality of Life (HRQOL): The self-reported assessment of physical, psychological, and social domains of health, influenced by personal experience, beliefs, preferences, and expectations.[91]

Injury-Related Fear: The concept of fear following injury including, but not limited to, fear-avoidance beliefs, kinesiophobia, or re-injury anxiety.

Injury-Severity: The following classification system based on calendar days lost due to injury was used to categorize injury severity.[75]

- *No Time Loss:* The participant did not miss any calendar days due to injury.

- *Mild:* The participant lost less than 8 days due to injury.
- *Moderate:* The participant lost 8 to 21 days due to injury.
- *Severe:* The participant lost greater than 21 days due to injury.

Kinesiophobia: An irrational debilitating fear of physical movement resulting from a feeling of vulnerability to painful injury or re-injury.[37]

Patient-Centered Care: Care that is respectful of and responsive to individual patient preferences, needs, and values, and ensuring that patient values guide all clinical decisions.[24]

Patient-Reported Outcome (PRO): A questionnaire that asks patients to self-report his or her perception of a condition, injury, and/or overall health status, and often referred to as patient-oriented outcomes.

- *Dimension-Specific Outcome:* A patient-reported outcome used to capture a specific medical condition or health dimension such as pain or fear of re-injury.
- *Generic Outcome:* A patient-reported outcome suitable for a wide variety of patient populations, non-specific to body region or condition and designed to assess the patient's overall health.
- *Region-specific Outcome:* A patient-reported outcome specific to a joint (e.g., ankle) or region (e.g., lower extremity) of the body.

Assumptions

For the purposes of this dissertation it will be assumed that:

For Chapter III:

1. Participants with a self-reported history of CAI will have the condition of interest.

2. Participants will provide honest answers on all PROs.

For Chapter IV:

1. Participants with a self-reported history of CAI will have the condition of interest.
2. Participants will provide honest answers on all PROs.
3. Participants will demonstrate their best effort during data collection.

For Chapter V:

1. Participants will recall and report injury history information to the best of their ability.
2. Participants will provide honest answers on all PROs.
3. If participants do not complete the injury history table but all of the PROs are complete, the investigators will assume they have no history of injury.
4. If participants do not select "yes" or "no" for "Are you currently injured?" the investigators will categorize them as "no" (i.e., uninjured) if the most recent injury reported was greater than six weeks ago and they answered "yes" to "Are you currently participating?".
5. To categorize the participant's most severe injury, the investigators will use the injury with the greatest time loss as reported by the participant.

Delimitations

For Chapter III:

1. Participants will be males and females between the ages of 18-30.
2. Participants will be considered physically active as defined by a four or higher on the NASA physical activity scale.

3. Participants will have self-reported CAI.
    a. Qualified by reporting a history of at least one ankle sprain, at least two episodes of "giving way" in the past three months, and answering "yes" to at least four questions on the Ankle Instability Instrument (AII).
4. Participants will have no history of lower extremity surgery.
5. Participants will not have sustained an ankle sprain in the last six weeks and no other lower extremity injuries in the last six months.

<u>For Chapter IV:</u>

1. Participants will be males and females between the ages of 18-50.
2. Participants will be considered physically active as defined by a four or higher on the NASA physical activity scale.
3. Participants will have self-reported CAI.
    a. Qualified by reporting a history of at least one ankle sprain, at least two episodes of "giving way" in the past three months, answering "yes" to at least five questions on the Ankle Instability Instrument (AII) and scoring less than a 24 on the Cumberland Ankle Instability Tool (CAIT).
4. Participants will have no history of lower extremity surgery.
5. Participants will be free from peripheral neuropathies or other health conditions that may influence postural control.
6. Participants will not have sustained an ankle sprain in the last six weeks and no other lower extremity injuries in the last six months.

7. Participants will complete all assessments barefoot and in a counterbalanced order.

For Chapter V:

1. Participants will be male and female National Collegiate Athletic Association (NCAA) student-athletes at the time of data collection.

Limitations

For Chapter III:

1. Due to the retrospective study design a casual link cannot be made between CAI and decreased HRQOL.
2. Participants with bilateral CAI were included.
3. The PROs were not administered in a counterbalanced order.

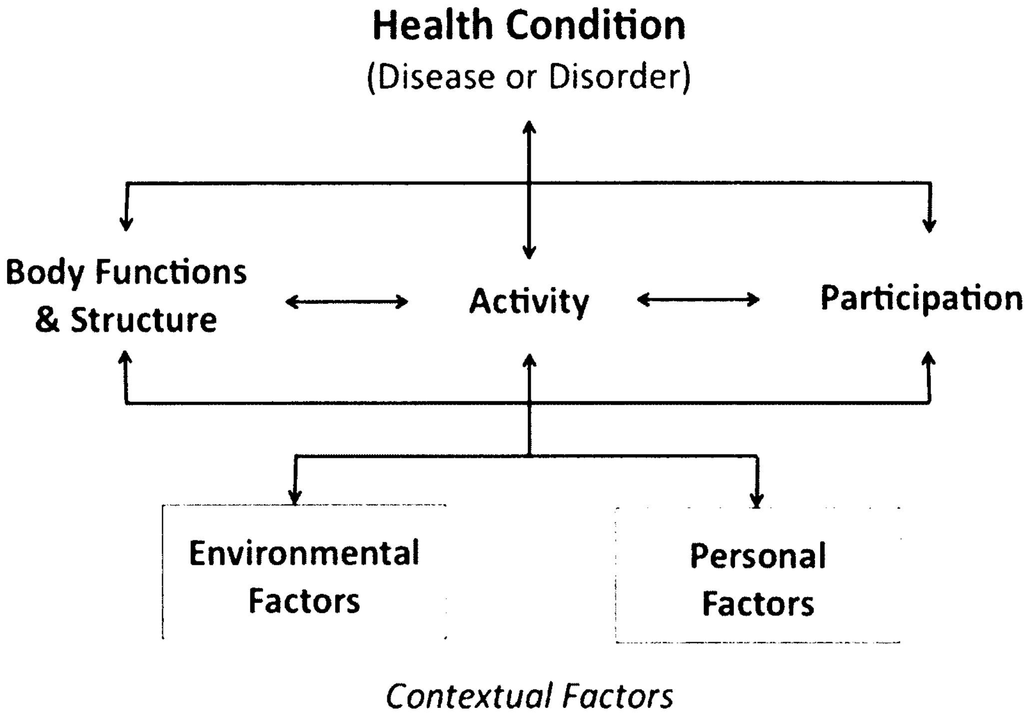
For Chapter IV:

1. Due to the retrospective design a casual link cannot be made between CAI and impairment.
2. The PROs were not administered in a counterbalanced order.
3. Reliability of the joint position sense measurement used in this study has not been established.

For Chapter V:

1. Musculoskeletal injury history was self-reported and collected retrospectively.
2. The data was collected from athletes at institutions that employed full time athletic training staffs and that were within close geographic proximity.

Figure I.1. World Health Organization's International Classification of Functioning (ICF) Model



*Reproduced, with the permission of the publisher, from *Towards a Common Language for Functioning, Disability and Health: ICF*, Geneva, World Health Organization, 2002 (Page 9, http://www.who.int/classifications/icf/training/icfbeginnersguide.pdf, accessed 03 April 2014)

CHAPTER II

REVIEW OF LITERATURE

The purpose of this chapter is to systematically review the literature regarding health-related quality of life (HRQOL) in 1) individuals with chronic ankle instability (CAI) and 2) adolescent and collegiate athletes. Chapter II Part A, Health-Related Quality of Life in Individuals with Chronic Ankle Instability: A Systematic Review, critically appraises the literature to determine the extent to which HRQOL deficits are present in individuals with CAI. Chapter II Part B, Health-Related Quality of Life in Adolescent and Collegiate Athletes: A Systematic Review, critically appraises the literature to answer the following questions: (1) Are there HRQOL differences between adolescent and collegiate athletes and non-athletes? (2) Are there HRQOL differences between uninjured adolescent and collegiate athletes and injured adolescent and collegiate athletes? Overall, this chapter provides a methodical overview of the literature related to HRQOL in individuals with CAI and athletes.

CHAPTER II: PART A

HEALTH-RELATED QUALITY OF LIFE IN INDIVIDUALS WITH CHRONIC ANKLE INSTABILITY: A SYSTEMATIC REVIEW

Introduction

Ankle sprains are the most commonly reported injury in collegiate and high school athletics, accounting for roughly 16% of all injuries;[9, 67] however other estimates have indicated that ankle sprains compose up to 45% of all athletic injuries.[50, 92] These injuries have placed an enormous burden on the health care industry with an estimated 4.4 billion dollars spent annually on treatment.[93] In addition to being a prevalent and costly injury, at least one-third of individuals who sustain an acute ankle sprain will develop chronic ankle instability (CAI).[94-96] CAI is characterized by residual symptoms that include feelings of giving way and instability, recurrent ankle sprains, and functional loss following the occurrence of one or more acute ankle sprains.[45] Residual symptoms associated with CAI can persist for decades[97] making it difficult for an individual to lead an active, healthy lifestyle. Furthermore, the repetitive trauma associated with recurrent ankle sprains often contributes to more serious conditions such as ankle osteoarthritis[11] for which there is a lack of effective treatments at this time.

Traditionally, CAI research has focused on the pathophysiology of this condition by concentrating efforts on identifying mechanical and functional insufficiencies from a disease-oriented perspective.[56, 98, 99] In the last decade, researchers have expanded their efforts to include the patient's perception of his or her health status as patient-based outcomes are becoming increasingly recognized in health care.[100] This evolution led to the development of several patient-reported outcomes (PROs) to measure functional limitations in patients with CAI including the Ankle Joint Functional Assessment Tool (AJFAT),[54] Foot and Ankle Disability Index (FADI),[52] Foot and Ankle Ability Measure (FAAM),[33] and the Chronic Ankle Instability Scale (CAIS).[101] All of the aforementioned instruments are self-reported, meaning that they are completed by the patient, and have been used for a number of ankle conditions. The development of these instruments has enabled researchers and clinicians to collect outcomes that examine a range of activities of daily living and sport tasks from the patient's perspective.

In the CAI literature, both discriminative (e.g., Ankle Instability Questionnaire, Ankle Instability Instrument (AII)) and evaluative (e.g., FADI, FAAM) PROs have been used. Discriminative instruments are used to identify individuals with a particular pathology (e.g., CAI), whereas evaluative instruments measure an individual's perceived level of function.[102] Donahue et al.[103] reviewed seven instruments used to discriminate between participants with and without CAI and suggested the combination of the Cumberland Ankle Instability Tool (CAIT) and AII be used to determine ankle stability status. Furthermore, Eechaute et al.[104] assessed the clinimetric qualities of four evaluative instruments and concluded that the FADI and FAAM are the most appropriate tools to quantify functional limitations in patients with CAI. Despite these findings, the use of PROs has been inconsistent in the literature pertaining to CAI. To strengthen the reporting of CAI subject information and to further our knowledge about the limitations associated with this condition, the International Ankle Consortium recently released a position statement which recommended specific patient selection criteria for CAI research and advocated for the use of PROs to better describe this population.[105] Therefore, further examining PROs used in the CAI literature may help to better describe the population and improve our understanding of the condition for future research and clinical practice.

A variety of PROs have been used to compare self-reported functional limitations and health-related quality of life (HRQOL) in individuals with CAI to ankle sprain copers (i.e., individuals with a history of one ankle sprain with no residual symptoms) or healthy controls. Compared to ankle sprain copers and healthy populations, individuals with CAI appear to exhibit functional limitations and HRQOL deficits.[51] However, to our knowledge no one has provided a comprehensive review of the differences between groups. Providing a comprehensive systematic review that critically appraises the research literature may provide a better indication of the HRQOL deficits that may be present in those with CAI. Therefore, the purpose of this systematic review was to determine the extent to which HRQOL deficits are present in individuals with CAI.

Methods

Search Strategy

In March 2014, two investigators conducted a computerized search of EBSCO Host (CINAHL, MEDLINE, SportDiscus) and PubMed Central entries from their inception through March 15, 2014 to locate studies which compared HRQOL outcomes in individuals with CAI to ankle sprain copers or healthy controls (Table II.A.1). Search strategies were limited to studies written in English, reported in peer-reviewed journals, and those that involved humans. In addition to the electronic search, a hand search of reference lists, authors, and PROs of the articles screened for inclusion was performed to identify pertinent articles.

Criteria for Selecting Studies

All authors; not blinded to study author, place of publication, or results, reviewed the articles obtained by the systematic search for inclusion. Titles and abstracts of all articles were screened for eligibility based on the criteria listed below. In cases of eligibility uncertainty, the full text of the manuscript was screened.

Inclusion Criteria

The following criteria were used to select studies for inclusion in this systematic review:

- Studies comparing HRQOL outcomes in adults with CAI to ankle sprain copers or healthy controls.
    - Subjects in CAI groups were described as having CAI, functional ankle instability/insufficiency (FAI), mechanical ankle instability/insufficiency (MAI), or recurring ankle sprains.
    - Subjects in the ankle sprain coper group were described as having a history of at least one lateral ankle sprain, no residual symptoms, and had resumed all pre-injury activities without limitation.
    - Subjects in the healthy group were described as having no history of ankle sprain.
- Studies that utilized PROs (e.g., AJFAT, CAIT, FAAM) as a participant descriptor or as an outcome.
- Studies published in the English language.
- Studies published in peer-reviewed journals.

Exclusion Criteria

The following exclusion criteria were used to screen studies for this systematic review:

- Studies that required a minimal score on a PRO (i.e., FADI score <90%, CAIT score <24) as inclusionary criteria.
- Studies that contained duplicate data from a previously published study.
- Editorials, commentaries, case studies, guidelines, conference proceedings or review articles.

Assessment of Methodological Quality

An adapted, 16-item version of the original Downs and Black Quality Index[106] described by Munn et al.[107] was used to assess the methodological quality of the included studies. The index encompasses components of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement and has demonstrated high internal consistency and inter-rater reliability.[106] Based on the recommendations of Munn et al.[107] studies meeting <60% criteria were deemed low quality, 60 – 74.9% moderate quality, and >75% high quality. Two reviewers (MNH and MCH) independently performed the quality assessment for each of the included studies and disagreement was resolved by discussion or use of a third reviewer (JMH). Percent agreement was calculated to determine the agreement between the two reviewers.

Data Extraction and Statistical Analysis

After the literature search, the articles were initially filtered into two categories based on the between-group comparisons made in each study (CAI – ankle sprain copers, CAI – healthy controls). Additionally, a third comparison was made between ankle sprain copers and healthy controls when the data was available. Each category compared HRQOL scores between each of the subject pools. If a study made comparisons between more than one group then it was included in each category. The categories were further subdivided into the three HRQOL components: generic, region-specific, and dimension-specific. Generic outcomes are non-specific to body region or condition and designed to assess the patient's overall health (e.g., Short Form-36 (SF-36)).[27] Whereas, region-specific outcomes (e.g., FAAM) are specific to a joint or region of the body and dimension-specific (e.g., Tampa Scale of Kinesiophobia-17 (TSK-17)) outcomes are specific to a disease or health dimension such as fear of re-injury.

Hedges *g* effect sizes and 95% confidence intervals were calculated to examine the magnitude and precision of differences between groups.[108] Hedges *g* effect size is a unit-less measure and represents an effect that exists on a parametric distribution.[108] A positive effect size indicated lower HRQOL in the CAI group as compared to a healthy control or coper group. A positive effect size for the coper to healthy comparison indicated lower HRQOL in the coper group. Effect sizes were interpreted as weak ($\leq$0.40), moderate (0.41-0.69), or strong ($\geq$0.70).[109] To further describe trends in the data, a qualitative assessment of effect size and confidence intervals was performed by examining the differences in effect size estimates between groups and if the confidence intervals crossed zero.

Level of Evidence

Level of evidence for the included studies was assessed using method guidelines for systematic reviews adapted from the Cochrane Collaboration Back Review Group.[110] The guidelines suggest using five levels ranging from strong to no evidence. The levels were modified to include moderate quality studies. Consistent findings among multiple high quality studies was classified as *strong evidence.* Consistent findings among multiple moderate quality or low quality studies was considered *moderate evidence.* One moderate or one low quality study was categorized as *limited evidence*. Inconsistent findings among multiple studies was classified as *conflicting evidence*. If no studies had been conducted the classification was *no evidence*.

Results

Literature Search

The initial search strategy (Figure II.A.1) retrieved 344 articles. Ten additional records were obtained through a hand-search of references, authors, and PROs. Of the 124 articles assessed for eligibility, 27 studies[34, 51-54, 58, 111-131] met the inclusion criteria for this systematic review. Six articles were excluded due to duplicate data and an additional 91 were excluded due to lack of a control group, no HRQOL outcome, or the HRQOL instrument was used as inclusionary criteria for the study with minimal scores required for participation. The 27 studies were classified into the following categories based on group comparison: CAI and healthy controls, CAI and ankle sprain copers, and ankle sprain copers and healthy controls. Twenty-four articles[34, 51-54, 58, 111, 113-127, 130, 131] reported HRQOL outcomes between individuals with CAI and healthy controls. Seven articles[53, 112, 113, 121, 128-130] reported HRQOL outcomes between individuals with CAI and copers and four articles[53, 113, 121, 131] reported HRQOL outcomes between copers and healthy controls. Inclusion criteria, population, sample size, PRO, study design and quality index score are summarized in Table II.A.2.

Methodological Quality

Initially, the two reviewers agreed on 91.7% (396/432) of the items on the modified Downs and Black Index. Disagreements were resolved by discussion among the reviewers. Overall, quality scores for the studies ranged from 52.9% to 88.2% with 8 high quality studies (>75%), 16 moderate quality studies (60-74.9%) and 3 low quality studies (<60%).

Data Synthesis

Chronic Ankle Instability and Healthy Control

Twenty-four articles [34, 51-54, 58, 111, 113-127, 130, 131] compared HRQOL in individuals with CAI and healthy controls (Table II.A.3). The mean Downs and Black score for these articles was 70.8 ± 9.6%. All 24 articles provided sufficient data for the calculation of effect sizes. Effect sizes and 95% confidence intervals for HRQOL outcomes between individuals with CAI and healthy controls are presented in Figure II.A.2. Of the 53 comparisons examined, 52-point estimates indicated that HRQOL was lower in the CAI group; however, the confidence intervals of 2-point estimates crossed zero.

Effect sizes ranged from 0.00 to 3.79 suggesting that individuals with CAI report HRQOL deficits in comparison to healthy controls. For generic outcomes, a strong effect (0.73) was found for the SF-36 physical component summary (SF-36 PCS) suggesting that individuals with CAI report decreased physical health on the SF-36, however no effect was present for the SF-36 mental component summary (SF-36 MCS). Additionally, a strong effect (2.87) was observed for the Disablement in the Physically Active Scale (DPA) suggesting that individuals with CAI report increased disablement in comparison to healthy controls. A strong effect ranging from 0.96 to 3.79 was observed for region-specific outcomes. Effect sizes for the FAAM and FAAM-Sport ranged from 1.04 to 3.29 suggesting that individuals with CAI report decreased ankle function during activities of daily living and sport. Similarly, effect sizes for the FADI and FADI-Sport ranged from 0.96 to 2.71. Additionally, strong effects were found for the AJFAT (1.27 to 3.79), SRQAF (2.30), and CAIT (1.78 to 3.30). Lastly, both dimension-specific outcomes, the Fear-Avoidance Beliefs Questionnaire (FABQ) and the Tampa Scale of Kinesiophobia-11 (TSK-11), demonstrated strong effects (1.58-1.95) suggesting individuals with CAI exhibit heightened fear of re-injury.

Chronic Ankle Instability and Ankle Sprain Coper

Seven articles[53, 112, 113, 121, 128, 129, 131] compared HRQOL in individuals with CAI and ankle sprain copers (Table II.A.4). The mean Downs and Black score for these articles was 76.5 ± 11.8%. All seven articles provided sufficient data for the calculation of effect sizes. Effect sizes and 95% confidence intervals for HRQOL outcomes between individuals with CAI and copers are presented in Figure II.A.3. All 16 comparisons indicated that HRQOL was lower in the CAI group; however, 2 of the confidence intervals crossed zero.

Effect sizes ranged from 0.21 to 1.73 suggesting that individuals with CAI report HRQOL deficits in comparison to copers. No generic outcome scores were reported for this comparison. Moderate to strong effects (0.66 to 1.73) were found for all region-specific outcomes. A strong effect (1.22 to 1.73) was observed for the FAAM and FAAM-Sport suggesting that individuals with CAI report decreased ankle function during activities of daily living and sport. However, only moderate to strong effect sizes (0.66 to 1.27) were observed for the FADI and FADI-Sport. A strong effect was reported for the SRQAF (1.16). A weak effect (0.21) was observed for the only dimension-specific outcome suggesting that individuals with CAI report increased kinesiophobia in comparison to copers, however the confidence interval crossed zero.

Ankle Sprain Coper and Healthy Control

Four articles [53, 113, 121, 131] compared HRQOL between ankle sprain copers and healthy controls (Table II.A.5). The mean Downs and Black score for these articles was 83.9 ± 2.5%. All 4 articles provided sufficient data for the calculation of effect sizes. Effect sizes and 95% confidence intervals for HRQOL outcomes between copers and healthy controls are presented in Figure II.A.4. Of the 9 comparisons examined, 7 point estimates indicated HRQOL was lower in the coper group; however, 2-point estimates indicated lower HRQOL in the healthy group. Additionally, 8 of 9 confidence intervals crossed zero.

Effect sizes were inconsistent ranging from -0.24 to 0.73. No generic or dimension-specific outcomes were reported for this comparison. For region-specific outcomes, FAAM effect sizes ranged from -0.24 to 0.43. Two comparisons favored decreased FAAM scores in copers and one comparison suggested healthy controls exhibit decreased FAAM scores. Similar trends were identified for the FAAM-Sport, with effect sizes ranging from -0.13 to 0.73. Weak to moderate effects (0.27 to 0.42) were found for the FADI and FADI-Sport suggesting that copers exhibit decreased function in comparison to healthy controls. In addition, a moderate effect was found for the SRQAF (0.55) indicating decreased function in the coper group.

Level of Evidence

For generic outcomes there is moderate evidence to support differences between individuals with CAI and healthy controls. This recommendation is based off of consistent findings of two moderate quality studies.[51, 115] Generic outcomes have not been used to compare HRQOL in individuals with CAI and copers nor copers and healthy controls. For region-specific outcomes, there is strong evidence that individuals with CAI report lower scores than healthy controls and ankle sprain copers. This recommendation is based off of consistent findings of 27 studies,[34, 51-54, 58, 111-131] 8 of which were of high quality. However, there is conflicting evidence that differences exist between ankle sprain copers and healthy controls. This recommendation is based off of inconsistent findings among four high quality studies.[53, 113, 121, 131] For dimension-specific outcomes, there is limited evidence to suggest that fear of re-injury is heightened in individuals with CAI compared to healthy controls. This recommendation is based off of the findings of one moderate quality study.[115] Additionally, there is limited evidence to suggest that kinesiophobia scores are similar between individuals with CAI and copers. This recommendation is based off of the findings of one low quality study.[129] Fear of re-injury instruments have not been used to compare ankle sprain copers and healthy controls.

Discussion

The purpose of this systematic review was to determine the extent to which HRQOL deficits are present in individuals with CAI in comparison to ankle sprain copers and healthy controls. Additionally, HRQOL deficits were examined in ankle sprain copers in comparison to healthy controls when this data was available in the included studies. After reviewing the literature, our findings suggest that individuals with CAI experience HRQOL deficits, particularly when measured using region-specific outcomes. However, there is limited to moderate evidence to support deficits on dimension-specific and generic instruments. Furthermore, there is conflicting evidence that HRQOL deficits are present in ankle sprain copers in comparison to healthy controls. Consequently, the following discussion has been organized by outcome type (i.e., generic, region-specific, and dimension-specific) to generate a concise summary of each component of HRQOL.

Generic Instruments

Based on our systematic review, there is moderate evidence to suggest that individuals with CAI experience HRQOL deficits in comparison to healthy controls on generic instruments. Two moderate quality studies[51, 115] used generic instruments to compare HRQOL between individuals with CAI and healthy controls. Arnold et al.[51] used the SF-36 and found a strong effect (0.73) with a narrow confidence interval for the physical component (SF-36 PCS), however no effect was observed for the mental component (SF-36 MCS). The lack of consistency between outcome summary components may be attributed to differences in scale constructs. For example, the SF-36 PCS is a physical health summary consisting of four subscales that include physical functioning, physical role, bodily pain, and general health. Conversely, the SF-36 MCS is a mental health summary consisting of four subscales that include vitality, social functioning, emotional role, and mental health. Therefore, it may be that individuals with CAI report decreased physical health but mental health components are uninfluenced by the condition. However, Houston et al.[115] found a very strong effect (2.87) with a narrow confidence interval for the Disablement in the Physically Active Scale (DPA) and 4 of the 16 DPA items pertain to emotional well-being of the individual.

To better understand the influence of CAI on generic function more research is needed. Future research should examine the impact of CAI on other measures of generic function, such as the Short Form-12 (SF-12) to offer the advantage of brevity and consider selecting generic instruments better suited for the population under examination. For example, the DPA[132] was designed for use in physically active individuals and 16 of the 27 studies included in this review recruited physically active participants or athletes. Knowing that athletes exhibit better HRQOL on outcomes such as the SF-36,[32, 80] instrument appropriateness should be taken into consideration. Investigating the impact of CAI on generic function utilizing more than one outcome and an outcome appropriate for the population sampled will help to better describe deficits associated with the condition.

Region-Specific Instruments

Overall, we have strong evidence to suggest that individuals with CAI report lower region-specific outcomes than healthy controls and ankle sprain copers. Moderate to strong effects (0.66 to 3.79) demonstrated differences between CAI and healthy control groups and CAI and coper groups. The evidence to support such differences between region-specific measures unique to the foot and ankle region, including the FAAM, FADI, CAIT, and AJFAT was strong. Therefore, such measures should continue to be used in research and clinical practice to describe functional limitations in individuals with CAI. Furthermore, clinicians should begin monitoring patient progress via such outcomes to ensure a complete recovery following injury.

We found conflicting evidence to support region-specific differences between ankle sprain copers and healthy controls. A weak effect (-0.24) was observed suggesting that healthy controls report decreased function,[113] however a strong effect (0.73) was observed suggesting that copers report decreased function.[121] The lack of consistency between studies and the broad confidence intervals suggest there are no region-specific differences between copers and healthy controls. These findings further substantiate that individuals with CAI have unique impairments that create functional limitations.

Furthermore, individuals categorized as ankle sprain copers return to similar levels of activity and participation compared to healthy control subjects. Accordingly, functional limitations should be taken into consideration when attempting to discriminate between individuals with CAI and ankle sprain copers.

Dimension-Specific Instruments

The limited evidence regarding differences in dimension-specific outcomes makes it unclear how the fear of re-injury, kinesiophobia, or other HRQOL dimensions impact individuals with CAI. Two studies utilized fear of re-injury instruments to make comparisons. Houston et al.[115] used the Fear-Avoidance Beliefs Questionnaire (FABQ) and the TSK-11 to compare individuals with CAI to healthy controls. Both the FABQ (1.95) and the TSK-11 (1.58) exhibited strong effects indicating that those with CAI reported heightened fear of re-injury. The only other comparison using a dimension-specific outcome was between individuals with CAI and copers, therefore all participants had a history of at least one ankle sprain. Wikstrom[129] observed a weak effect (0.21) between groups suggesting that the CAI group reported increased kinesiophobia on the TSK-17 in comparison to the copers, but the confidence interval crossed zero. The weak relationship observed here, may be due to the fact that both groups have a history of ankle sprain. Therefore, more evidence is needed to understand how CAI or the history of previous injury impacts this aspect of function.

Implications for Clinical Practice

The results of this systematic review indicate that individuals with CAI report HRQOL deficits in comparison to ankle sprain copers and healthy controls; however, HRQOL deficits do not appear to be present in ankle sprain copers in comparison to healthy controls. While the lack of evidence pertaining to generic and dimension-specific outcomes is limited, it is apparent that CAI contributes to self-reported region-specific deficits. For this reason, clinicians should consider monitoring region-specific function when treating ankle sprains and CAI. Furthermore, collecting patient perception may reveal characteristics distinct to the individual's impairment and help to further guide the rehabilitation process. Tailoring rehabilitation efforts and treatments to the individual patient's goals and values will advance patient-centered care[24] and in turn may improve the quality of care provided by rehabilitation specialists.

Limitations

Although this systematic review was designed based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, limitations still need to be addressed. The electronic searches were conducted in databases considered to be the most relevant to CAI and were followed by a hand search of references, authors, and PROs in identified studies, however it is possible that other evidence is available. Our search was also limited to studies published in English and peer-reviewed journals but we do not believe any relevant articles were excluded with these search parameters. Additionally, although we excluded studies that had PRO criterion for subject inclusion, some studies may have had a PRO criterion that was not specified in the manuscript. Lastly, CAI or coper groups may have differed due to lack of a universal definition. However subjects in each of the studies included in the CAI group were defined as having CAI, MAI, FAI, or recurring ankle sprains and subjects included in the coper group were defined as having a history of at least one ankle sprain with no residual complications. Brown et al.[111] defined control participants as reporting no more than one mild to moderate sprain and no episodes of giving way and was therefore included as a coper group.

Conclusions

A systematic search of the literature revealed 27 studies that compared HRQOL outcomes in individuals with CAI, ankle sprain copers, and healthy controls. The evidence suggests that CAI is most likely associated with decreased HRQOL. However, HRQOL does not appear to be affected in ankle sprain copers who typically have a history of one acute ankle sprain. It is clear that region-specific outcomes are lower in individuals with CAI compared to ankle sprain copers and healthy controls. Therefore, region-specific outcomes should be taken into consideration when treating CAI and ankle sprains. However, the relationship between CAI and generic and dimension-specific outcomes remains unclear and warrants further investigation. By investigating the impact of CAI on all components of HRQOL we may further our understanding of this multifaceted condition.

Table II.A.1. Search Strategy

Step	Search Terms	Boolean Operator	EBSCO Host	PubMed
1	Chronic Functional Mechanical Recurrent	OR	1,339,297	1,187,097
2	Ankle		13,487	35,904
3	Instability Insufficiency Sprains	OR	12,804	149,136
4	1, 2, 3	AND	1,113	1,631
5	Coper Healthy Uninjured	OR	622,314	397,729
6	Assessment Form Function Instrument Measure Outcome Patient-assessed Patient-report Questionnaire Self-report Scale Score	OR	5,176,268	6,339,137
7	4, 5, 6	AND	187	213
Duplicates Removed			56	0
TOTAL			**131**	**213**
Duplicates				*86

*Total number of duplicates between EBSCO Host and PubMed

Table II.A.2. Methodological Summary of the Studies Included

Study	Inclusion Criteria	Population	CAI (n)	Control (n)	Coper (n)	PRO	Study Design	Quality Index Score (%)
Arnold et al.[51]	FAI defined as ≥1 ankle sprain, ≥1 EGW per month, and a score <28 on the CAIT.	Physically Active	34	34	--	FAAM-ADL FAAM-Sport SF-36	Cross-sectional	70.6%
Brown et al. 2008[112]	A history of acute ankle sprain within the past 5 years that required immobilization for ≥3 days. MAI and FAI groups reported ≥2 EGW in the last year. MAI (+) anterior drawer and/or talar tilt. FAI and copers (-) anterior drawer and talar tilt.	Recreationally Active	MAI (21) FAI (21)	--	21	FADI-ADL FADI-Sport	Case-control	70.6%
Brown et al. 2010[111]	CAI defined as a history of ≥1 moderate to severe ankle sprain that required ≥3 days of immobilization or NWB, with ≥2 EGW in the last year. Control participants reported 1 mild to moderate sprain and did not complain of EGW.	Recreationally Active	24	--	24	CAIT	Case-control	64.7%
Carcia et al.[34]	CAI defined as ≥2 ankle sprains, EGW and residual symptoms during functional activities that limit their ability to participate.	NCAA DII Athletes	15	15	--	FAAM-ADL FAAM-Sport	Cross-sectional	88.2%
Croy et al.[113]	CAI defined as a history of recurrent ankle sprains and reported instability on ≥2 AII questions. A coper as a history of 1 ankle sprain ≥1 year ago with no residual symptoms of instability or EGW.	Recreationally Active	20	20	20	FAAM-ADL FAAM-Sport	Cross-sectional	88.2%

Table II.A.2. (cont.)

Study	Inclusion Criteria	Population	CAI (*n*)	Control (*n*)	Coper (*n*)	PRO	Study Design	Quality Index Score (%)
Feger et al.[114]	CAI defined as a history of >1 ankle sprain with the initial sprain occurring >1year ago and current self reported functional deficits (FAAM-Sport <85%).	Physically Active	15	15	--	FAAM-ADL	Case-Control	64.71%
Hale & Hertel[52]	CAI defined as a history of ankle sprain with pain and/or limping for ≥1 day, chronic weakness, pain or instability attributed to the initial injury, and giving way in the last 6 months.	Recreationally Active	29	12	--	FADI-ADL FADI-Sport	Repeated-measures	52.9%
Houston et al.[115]	CAI as defined by a history of ≥1 ankle sprain, ≥2 EGW in the past 3 months, and ≥4 yeses on the AII.	Physically Active	25	25	--	DPA FAAM-ADL FAAM-Sport FABQ TSK-11	Case-control	70.59%
Hubbard et al. 2005[58]	CAI as defined by the Ankle History Questionnaire.	--	15	15	--	FADI-ADL FADI-Sport	Case-control	70.6%
Hubbard et al. 2006[117]	CAI as defined by the Functional Ankle Instability Questionnaire.	--	30	30	--	FADI-ADL FADI-Sport	Case-control	82.4%
Hubbard & Cordova[116]	CAI as defined by the Ankle Instability Questionnaire.	--	20	20	--	FADI-ADL FADI-Sport	Case-control	70.6%
Kipp & Palmieri-Smith[118]	CAI defined as having sustained ≥1 ankle sprain and repeated episodes of instability.	Recreationally Active	11	11	--	FADI-ADL FADI-Sport	Case-control	64.7%
Marshall et al.[119]	CAI defined as ≥1 ankle sprain in the last year that required medical treatment and ≥1 day of missed work or training, EGW or instability of the ankle, and no current pain.	--	12	12	--	CAIT FADI-ADL FADI-Sport	Case-control	70.6%
Nauck & Lohrer[120]	CAI as defined by the Ankle Injury History Questionnaire.	--	Con (17) Pre (24)	SS (31) VB (37)	--	FAAM-ADL FAAM-Sport	Cross-sectional	52.9%

Table II.A.2. (cont.)

Study	Inclusion Criteria	Population	CAI (n)	Control (n)	Coper (n)	PRO	Study Design	Quality Index Score (%)
Plante & Wikstrom[121]	CAI defined as an initial ankle sprain that required immobilization and/or NWB for ≥3 days, multiple EGW in the past year, ≥1 recurrent sprain 3-6 months prior to participation, and a score <22 on the AJFAT. A coper as an initial ankle sprain that required immobilization and/or NWB for ≥3 days but have resumed physical activity without limitation for ≥12 months prior to participation and an AJFAT score >22.	Active Adults	25	20	21	FAAM-ADL FAAM-Sport	Case-control	82.4%
Ross et al. 2005[127]	FAI defined as ≥2 ankle sprains (1 of which required ≥3 days of immobilization) and ≥2 EGW.	--	10	10	--	AJFAT	Case-control	70.6%
Ross & Guskiewicz[126]	FAI defined as ≥2 ankle sprains (1 of which required ≥3 days of immobilization) and ≥2 EGW.	Physically Active	CCT (10) SCT (10) Control (10)	CCT (10) SCT (10) Control (10)	--	AJFAT	Case-control	64.7%
Ross et al. 2008[123]	FAI defined as ≥2 ankle sprains (1 of which required ≥3 days of immobilization) and ≥2 EGW.	--	15	15	--	AJFAT	Case-control	64.7%
Ross et al. 2009[124]	FAI defined as ≥2 ankle sprains (1 of which required ≥3 days of immobilization) and ≥2 EGW.	--	22	22	--	AJFAT	Case-control	64.7%
Ross et al. 2011[122]	FAI defined as ≥1 ankle sprain and ≥2 EGW in the last year.	--	17	17	--	AJFAT	Case-control	70.6%
Ross et al. 2013[125]	FAI defined as a history of ankle sprains and ≥2 EGW in the last year.	Recreationally Active	12	12	--	AJFAT	Case-control	64.7%

Table II.A.2. (cont.)

Study	Inclusion Criteria	Population	CAI (n)	Control (n)	Coper (n)	PRO	Study Design	Quality Index Score (%)
Rozzi et al.[54]	A functionally unstable ankle defined as ≥2 unilateral ankle sprains and a current sense of weakness or instability.	Active University Students	13	13	--	AJFAT	Repeated-measures	70.6%
Steib et al.[128]	FAI defined as ≥1 moderate to severe ankle sprain within 5 years of the study and report ≥2 EGW within the last 12 months. Copers defined as 1 moderate to severe ankle sprain within 5 years, no residual symptoms and a full return to pre-injury activity >6 months before testing.	Athletes from University Sports Programs	19	--	19	FAAM FAAM-Sport	Case-control	76.5%
Wikstrom et al.[53]	CAI defined as an ankle sprain that required immobilization and/or NWB for ≥3 days, multiple EGW, ≥1 recurrent sprain 3-6 months prior to study participation, and a score <22 on the AJFAT. A coper as the same ankle sprain criteria but have resumed all pre-injury physical activity without limitation for ≥12 months and a score >22 on the AJFAT.	Recreationally Active	24	24	24	FADI SRQAF	Case-control	82.4%

Table II.A.2. (cont.)

Study	Inclusion Criteria	Population	CAI (n)	Control (n)	Coper (n)	PRO	Study Design	Quality Index Score (%)
Wikstrom[129]	CAI defined as an ankle sprain that required immobilization and/or NWB for ≥3 days, multiple EGW, ≥1 recurrent sprain 3-6 months prior to study participation, and a score <22 on the AJFAT. Copers defined as the same ankle sprain criteria but have resumed all pre-injury physical activity without limitation for ≥12 months and a score >22 on the AJFAT.	--	29	--	29	TSK-17	Cross-sectional	52.9%
Wright et al.[131]	CAI defined as a history of an ankle sprain that required protected WB, immobilization, or limited activity for ≥24 hours, ≥2 EGW in the past year and a score ≤27 on the CAIT. Coper defined as having a history of an ankle sprain that required protected WB or immobilization, but no complaints of ankle instability or EGW and had resumed all preinjury activities.	Physically Active	23	23	23	FAAM FAAM-Sport	Cross-sectional	82.4%
Wright & Arnold[130]	FAI defined as ≥1 ankle sprain that required protected WB, immobilization and/or limited activity for ≥24 hours and ≥1 monthly EGW.	--	32	32	--	CAIT	Case-control	76.5%

Abbreviations: AJFAT, Ankle Joint and Foot Assessment Tool; CAI, Chronic Ankle Instability; CAIT, Cumberland Ankle Instability Tool; Con, Conservative; EGW, Episode of giving way; FAI, Functional Ankle Instability; FAAM, Foot and Ankle Ability Measure; FADI, Foot and Ankle Disability Index; HRQOL, Health-Related Quality of Life; NWB, Non-weight bearing; Pre, Pre-surgical; SF-36, Short Form-36; SRQAF, Self-Report Questionnaire of Ankle Function; SS, Sport Students; TSK-17, Tampa Scale of Kinesiophobia-17; VB, Volleyballers; WB, Weight bearing.

Table II.A.3. Effect Size and 95% Confidence Intervals for the Chronic Ankle Instability and Healthy Comparison

Study	Patient-Reported Outcome	Hedge's g	Lower Limit	Upper Limit
	Generic Instruments			
Arnold et al.[51]	SF-36 PCS[a]	0.73	0.24	1.22
Arnold et al.[51]	SF-36 MCS[b]	0.00	-0.48	0.48
Houston et al.[115]	DPA[c]	2.87	2.08	3.66
	Region-Specific Instruments			
Arnold et al.[51]	FAAM[d]	1.29	0.77	1.81
Carcia et al.[34]	FAAM[e]	2.14	1.25	3.04
Croy et al.[113]	FAAM[f]	1.15	0.48	1.82
Feger et al.[114]	FAAM[g]	2.48	1.53	3.43
Houston et al.[115]	FAAM[h]	1.38	0.76	1.99
Nauck & Lohrer (Con. vs. SS)[120]	FAAM[i]	1.47	0.81	2.13
Nauck & Lohrer (Con. vs. VB)[120]	FAAM[j]	1.58	0.94	2.23
Nauck & Lohrer (Pre. vs. SS)[120]	FAAM[k]	2.12	1.46	2.79
Nauck & Lohrer (Pre. vs. VB)[120]	FAAM[l]	2.25	1.60	2.90
Plante & Wikstrom[121]	FAAM[m]	1.46	0.80	2.13
Wright et al.[131]	FAAM[n]	1.39	0.74	2.03
Hale & Hertel[52]	FADI[o]	1.31	0.58	2.04
Hubbard et al. 2005[58]	FADI[p]	1.18	0.41	1.96
Hubbard et al. 2006[117]	FADI[q]	2.71	2.01	3.41
Hubbard & Cordova[116]	FADI[r]	2.19	1.41	2.97
Kipp & Palmieri-Smith[118]	FADI[s]	1.40	0.47	2.34
Marshall et al.[119]	FADI[t]	1.52	0.61	2.43
Wikstrom et al.[53]	FADI[u]	1.04	0.43	1.64
Arnold et al.[51]	FAAM-Sport[v]	2.54	1.90	3.18
Carcia et al.[34]	FAAM-Sport[w]	2.40	1.46	3.34
Croy et al.[113]	FAAM-Sport[x]	1.89	1.15	2.64
Houston et al.[115]	FAAM-Sport[y]	2.04	1.36	2.73
Nauck & Lohrer (Con. vs. SS)[120]	FAAM-Sport[z]	1.20	0.56	1.83
Nauck & Lohrer (Con vs. VB)[120]	FAAM-Sport[aa]	2.24	1.53	2.95
Nauck & Lohrer (Pre vs. SS)[120]	FAAM-Sport[bb]	2.63	1.90	3.35
Nauck & Lohrer (Pre. vs. VB)[120]	FAAM-Sport[cc]	3.29	2.52	4.07
Plante & Wikstrom[121]	FAAM-Sport[dd]	1.59	0.92	2.27
Wright et al.[131]	FAAM-Sport[ee]	1.04	0.42	1.65
Hale & Hertel[52]	FADI-Sport[ff]	1.85	1.07	2.63
Hubbard et al. 2005[58]	FADI-Sport[gg]	1.83	0.98	2.69
Hubbard et al. 2006[117]	FADI-Sport[hh]	2.07	1.45	2.70
Hubbard & Cordova[116]	FADI-Sport[ii]	2.53	1.69	3.36
Kipp & Palmieri-Smith[118]	FADI-Sport[jj]	1.70	0.73	2.68
Marshall et al.[119]	FADI-Sport[kk]	1.17	0.30	2.03
Wikstrom et al.[53]	FADI-Sport[ll]	0.96	0.36	1.56
Ross et al. 2005[127]	AJFAT[mm]	2.15	1.05	3.26
Ross & Guskiewicz (CCT)[126]	AJFAT[nn]	3.18	1.86	4.50
Ross & Guskiewicz (SCT)[126]	AJFAT[oo]	1.56	0.56	2.56
Ross & Guskiewicz (Control)[126]	AJFAT[pp]	2.70	1.48	3.91
Ross et al. 2008[123]	AJFAT[qq]	3.55	2.40	4.70

Table II.A.3. (cont.)

Study	**Patient-Reported Outcome**	**Hedge's g**	**Lower Limit**	**Upper Limit**
Ross et al. 2009[124]	AJFAT[rr]	3.45	2.52	4.39
Ross et al. 2011[122]	AJFAT[ss]	2.78	1.84	3.72
Ross et al. 2013[125]	AJFAT[tt]	3.79	2.45	5.12
Rozzi et al.[54]	AJFAT[uu]	1.27	0.43	2.12
Wikstrom et al.[53]	SRQAF[vv]	2.30	1.57	3.03
Brown et al. 2010[111]	CAIT[ww]	2.28	1.55	3.00
Marshall et al.[119]	CAIT[xx]	1.78	0.84	2.73
Wright & Arnold[130]	CAIT[yy]	3.30	2.55	4.06
	Dimension-Specific			
Houston et al.[115]	FABQ[zz]	1.95	1.28	2.62
Houston et al.[115]	TSK-11[aaa]	1.58	0.94	2.21

Abbreviations: CAIT, Cumberland Ankle Instability Tool; CCT, Conventional Coordination Training; Con., Conservative Treatment; DPA, Disablement in the Physically Active Scale; FAAM, Foot and Ankle Ability Measure; FABQ, Fear-Avoidance Beliefs Questionnaire; FADI, Foot and Ankle Disability Index; Pre., Pre-surgical; SCT, Stimulation Coordination Training; SRQAF, Self-Report Questionnaire of Ankle Function; SS, Sports Students; TSK-11, Tampa Scale of Kinesiophobia-11; VB, Volleyballers.

Table II.A.4. Effect Size and 95% Confidence Intervals for the Chronic Ankle Instability and Ankle Sprain Coper Comparison

Study	Patient-Reported Outcome	Hedge's g	Lower Limit	Upper Limit
	Region-Specific Instruments			
Croy et al.[113]	FAAM[a]	1.23	0.55	1.91
Plante & Wikstrom[121]	FAAM[b]	1.33	0.69	1.98
Steib et al.[128]	FAAM[c]	1.22	0.53	1.91
Wright et al.[131]	FAAM[d]	1.22	0.59	1.85
Brown et al. 2008 MAI[112]	FADI[e]	1.21	0.55	1.86
Brown et al. 2008 FAI[112]	FADI[f]	0.66	0.04	1.28
Wikstrom et al.[53]	FADI[g]	0.69	0.11	1.27
Croy et al.[113]	FAAM-Sport[h]	1.42	0.73	2.12
Plante & Wikstrom[121]	FAAM-Sport[i]	1.38	0.74	2.03
Steib et al.[128]	FAAM-Sport[j]	1.26	0.57	1.96
Wright et al.[131]	FAAM-Sport[k]	1.73	1.05	2.40
Brown et al. 2008 MAI[112]	FADI-Sport[l]	1.27	0.61	1.94
Brown et al. 2008 FAI[112]	FADI-Sport[m]	0.93	0.29	1.56
Wikstrom et al.[53]	FADI-Sport[n]	0.75	0.16	1.34
Wikstrom et al.[53]	SRQAF[o]	1.16	0.55	1.77
	Dimension-Specific Instruments			
Wikstrom[129]	TSK-17[p]	0.21	-0.30	0.73

Abbreviations: FAI, Functional Ankle Instability; FAAM, Foot and Ankle Ability Measure; FADI, Foot and Ankle Disability Index; MAI, Mechanical Ankle Instability; SRQAF, Self-Report Questionnaire of Ankle Function; TSK-17, Tampa Scale of Kinesiophobia-17.

Table II.A.5. Effect Size and 95% Confidence Intervals for the Ankle Sprain Coper and Healthy Comparison

Study	Patient-Reported Outcome	Hedge's g	Lower Limit	Upper Limit
	Region-Specific Instruments			
Croy et al.[113]	FAAM[a]	-0.24	-0.87	0.38
Plante & Wikstrom[121]	FAAM[b]	0.43	-0.20	1.05
Wright et al.[131]	FAAM[c]	0.25	-0.33	0.83
Wikstrom et al.[53]	FADI[d]	0.42	-0.15	0.99
Croy et al.[113]	FAAM-Sport[e]	0.64	0.00	1.27
Plante & Wikstrom[121]	FAAM-Sport[f]	0.73	0.09	1.36
Wright et al.[131]	FAAM-Sport[g]	-0.13	-0.70	0.45
Wikstrom et al.[53]	FADI-Sport[h]	0.27	-0.29	0.83
Wikstrom et al.[53]	SRQAF[i]	0.55	-0.02	1.13

Abbreviations: FAAM, Foot and Ankle Ability Measure; FADI, Foot and Ankle Disability Index; SRQAF, Self-Report Questionnaire of Ankle Function

Figure II.A.1. Flow Chart of the Study Selection Process

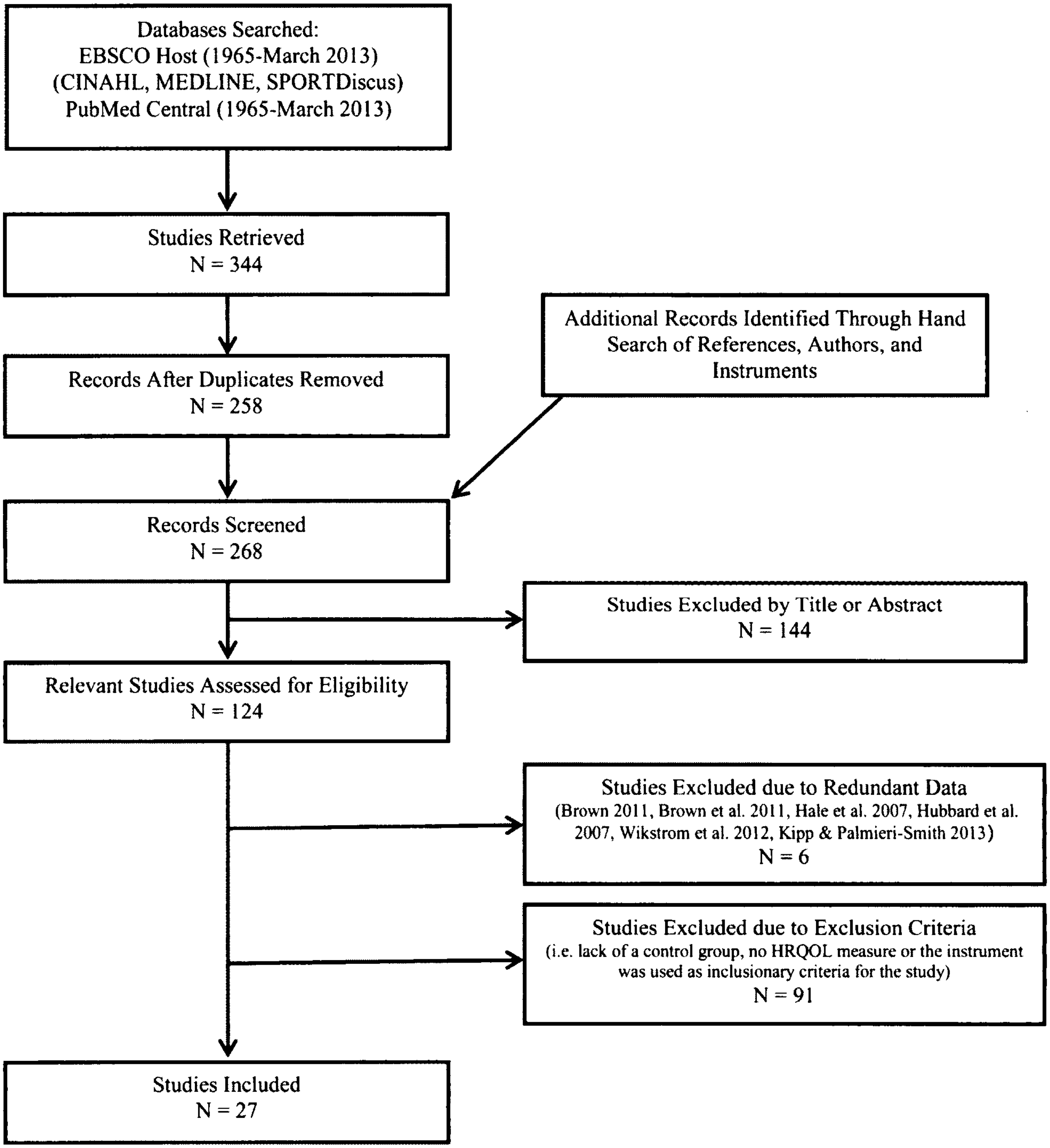


Figure II.A.2. Forest Plot of Hedge's g Effect Sizes and 95% Confidence Intervals for the Chronic Ankle Instability and Healthy Comparison. Letter superscripts correspond to actual values reported in Table II.A.3.

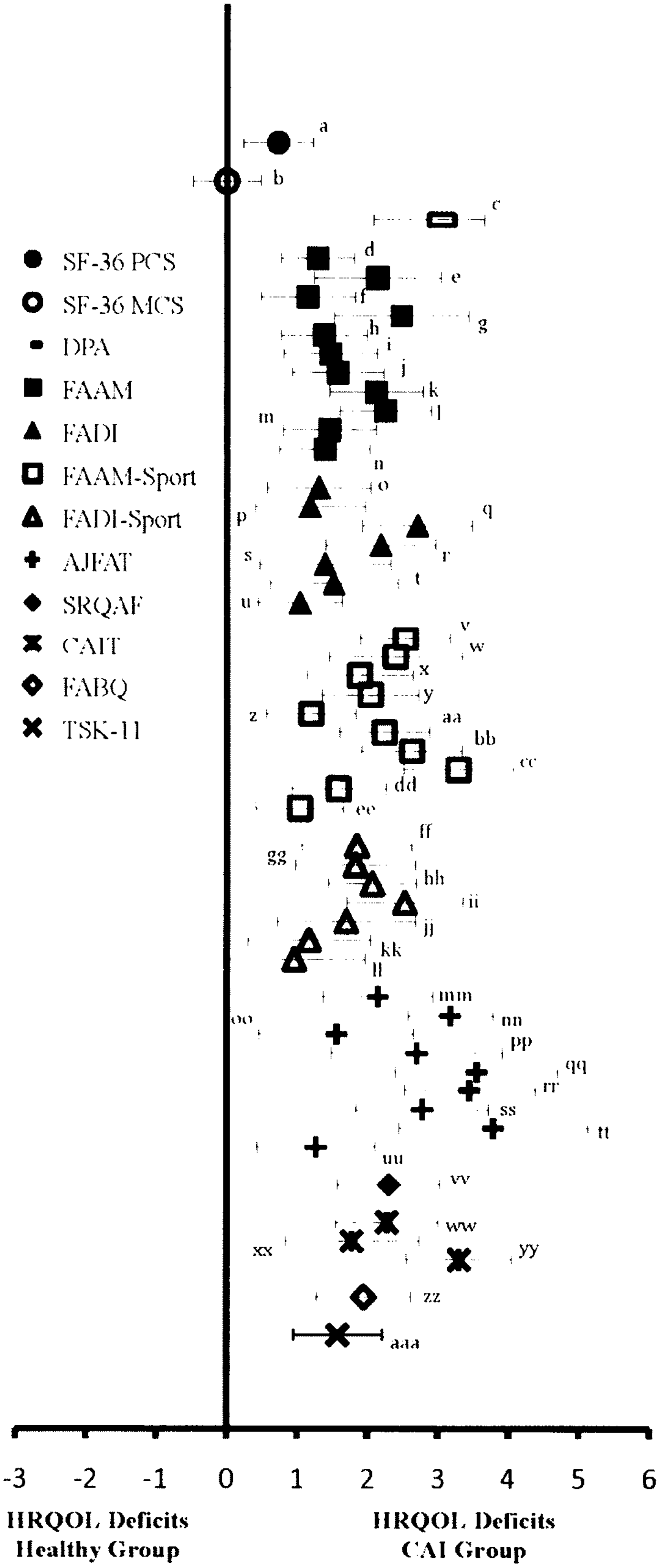


Figure II.A.3. Forest Plot of Hedge's g Effect Sizes and 95% Confidence Intervals for the Chronic Ankle Instability and Ankle Sprain Coper Comparison. Letter superscripts correspond to actual values reported in Table II.A.4.

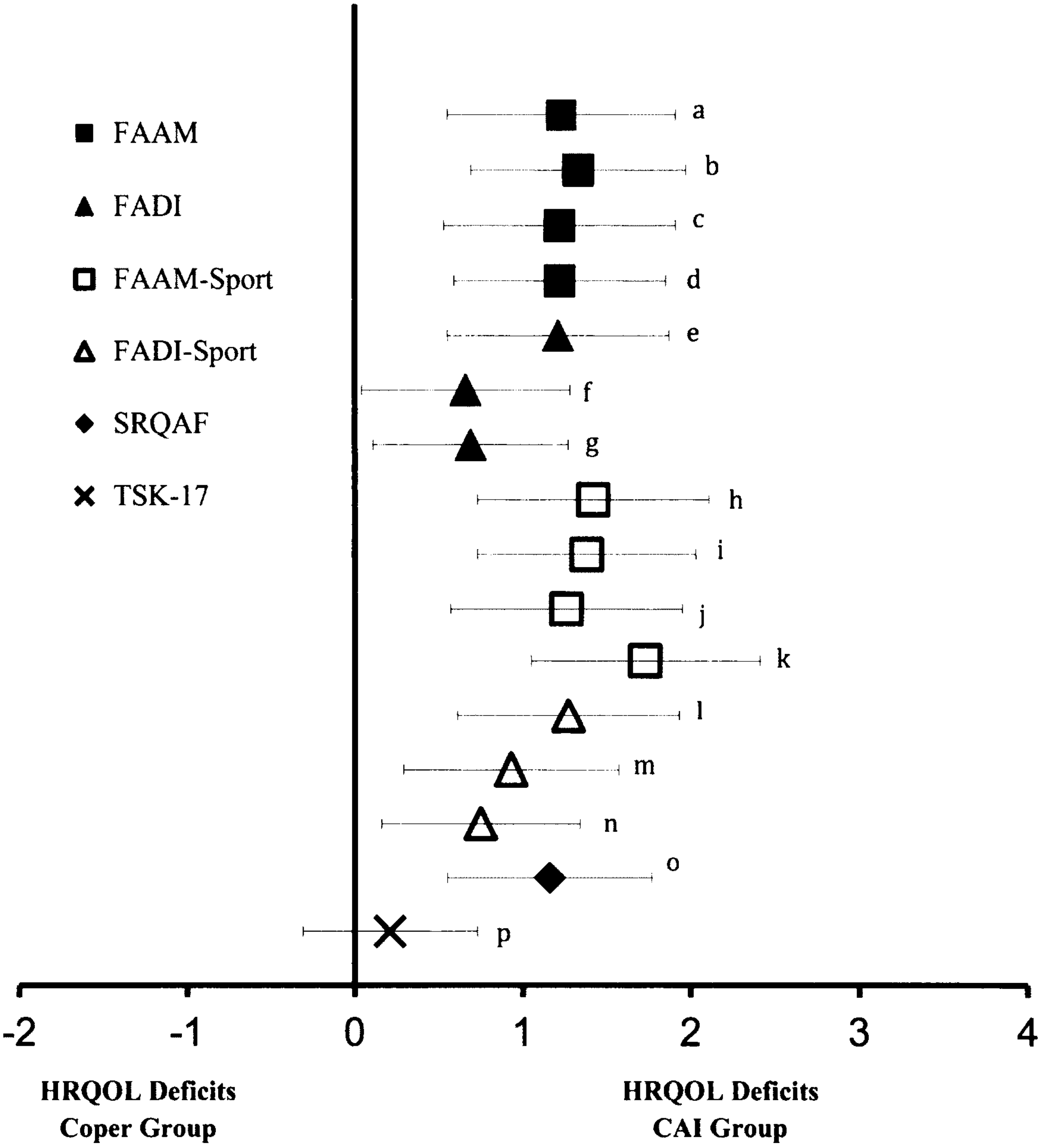
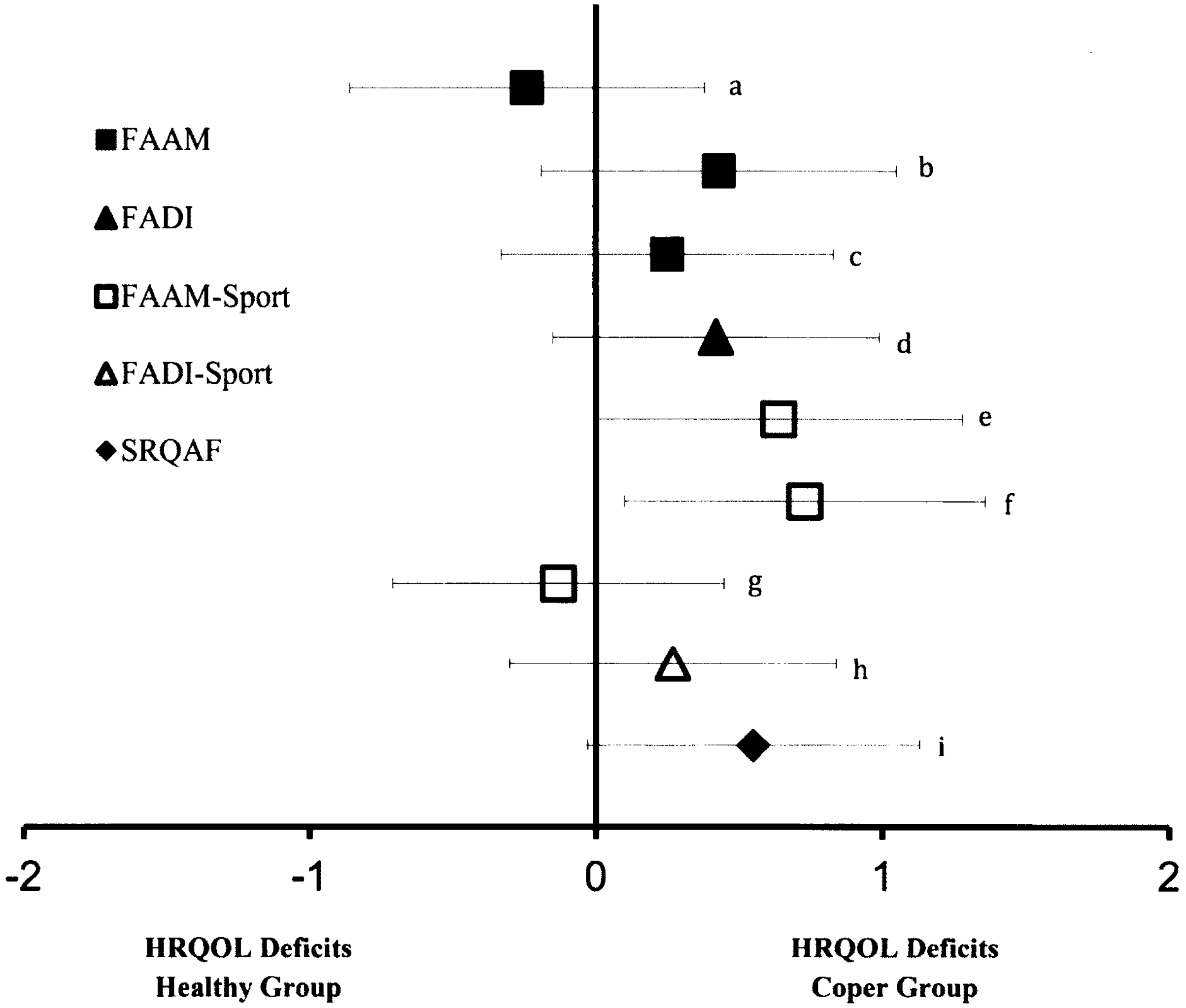


Figure II.A.4. Forest Plot of Hedge's g Effect Sizes and 95% Confidence Intervals for the Ankle Sprain Coper and Healthy Comparison. Letter superscripts correspond to actual values reported in Table II.A.5.



CHAPTER II: PART B

HEALTH-RELATED QUALITY OF LIFE IN ATHLETES: A SYSTEMATIC REVIEW

Introduction

Participation in interscholastic and intercollegiate athletics has drastically increased in the past decade.[2, 9] Despite the health benefits associated with physical activity, those who participate in athletics are at risk for sports-related injuries. Following injury, an individual experiences a range of physical and psychosocial detriments. Traditional examination of sports-related injuries predominantly occurs via clinician-based assessments such as range of motion, strength, or balance. However, these assessments do not provide insight into the patient's perception of their health status,[32] nor do they always correlate with an individual's overall health status.[133-137] Understanding what is most important to the patient facilitates whole-person health care. Therefore, focus has shifted to patient-reported outcomes (PROs) to measure the patient's experience and values following medical treatments, interventions, and practices.

Professional orthopaedic and sports medicine organizations[138-142] have emphasized the need for clinicians to utilize PROs in addition to standard clinician assessments to further our understanding of the short- and long-term consequences of injury and efficacy of treatments. PROs are typically categorized as region-specific, dimension-specific, and generic. Region-specific and dimension-specific PROs focus on a particular body region, disease, or health dimension. Examples of these often utilized in sports medicine are the International Knee Documentation Committee (IKDC),[143] Foot and Ankle Ability Measure (FAAM),[33] and Disabilities of the Arm, Shoulder and Hand

(DASH).[144] However, generic outcomes are broad in scope and typically focus on health-related quality of life (HRQOL), a multi-dimensional approach to health care encompassing social, physical, and psychological health components.[26, 145, 146] HRQOL has become an important component of health surveillance. The utilization of generic instruments in clinical practice allows clinicians to identify HRQOL deficits post-injury and track recovery throughout the rehabilitation process.

Several studies[31, 32, 36, 80-83] have utilized generic outcomes such as the Short Form-36 (SF-36), Pediatric Outcomes Data Collection Instrument (PODCI), and the Pediatric Quality of Life Inventory (PedsQL) to measure HRQOL in athletes and non-athletes as well as the impact of sports-related injury on HRQOL. Although the evidence suggests that normative values for athletic populations differ from the general population,[80-82] and between injured and uninjured athletes[31, 32, 36, 83] this evidence has yet to be synthesized. Therefore, the purpose of this systematic review was to answer the following questions: (1) Are there HRQOL differences between adolescent and collegiate athletes and non-athletes? (2) Are there HRQOL differences between uninjured adolescent and collegiate athletes and injured adolescent and collegiate athletes?

Methods

Search Strategy

A computerized literature search was completed in August 2013 utilizing: EBSCO Host (CINAHL, MEDLINE, SportDiscus) and PubMed Central entries from their inception through August 1, 2013. All authors reviewed the articles obtained by the systematic search for inclusion. Titles and abstracts of all articles were screened for eligibility based on the criteria listed below. In cases of eligibility uncertainty, the full text of the manuscript was screened. In addition, a hand search of the reference lists of the articles screened for inclusion was performed to identify pertinent articles.

Criteria for Selecting Studies

Inclusion Criteria

The following criteria were used to select studies for inclusion in this systematic review:

- Studies comparing HRQOL outcomes in athletes and non-athletes or in injured and uninjured athletes.
- Subjects were described as current interscholastic or intercollegiate athletes.
- Healthy or uninjured subjects were defined as medically cleared for participation.
- Injured subjects were defined as a self-reported recent injury or having a history of musculoskeletal injury or concussion.
- Studies utilizing generic self-reported instruments (e.g., SF-36, PODCI) as their primary outcome measure.
- Studies published in the English language.
- Studies published in peer-reviewed journals.

Exclusion Criteria

The following exclusion criteria were used to screen studies for this systematic review:

- Articles that included retired athletes.
- Articles that limited participants to those with chronic disease (e.g., asthma).
- Articles that only used region-specific or dimension-specific instruments (e.g., IKDC, FAAM, DASH).
- Articles that described the development of an instrument to assess HRQOL.

- Editorials, commentaries, case studies, guidelines, conference proceedings, or review articles.

Assessment of Methodological Quality

An adapted 16-item version of the original Downs and Black Quality Index[106] described by Munn et al.[107] was used to assess the methodological quality of the included studies. The index encompasses components of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement and has demonstrated high internal consistency and inter-rater reliability.[106] Based on the recommendations of Munn et al.[107] studies meeting < 60% of the criteria were deemed low quality, 60 – 74.9% moderate quality, and > 75% high quality. Two reviewers (MNH and JMH) independently performed the quality assessment for each of the included studies and disagreement was resolved by discussion or use of a third reviewer (MCH). Percent agreement was calculated to determine the agreement between the two reviewers.

Data Extraction and Statistical Analysis

The variables of interest for this systematic review were generic PROs that assessed HRQOL. For the purposes of this review all studies that assessed HRQOL were included, regardless of which generic instrument was used. To determine if HRQOL is better in athletes compared to non-athletes, studies that compared generic HRQOL outcomes between an athletic population and a non-athletic population were included in the analysis. Furthermore, to determine if HRQOL is better in uninjured athletes compared to injured athletes, studies that compared generic HRQOL outcomes between an uninjured athletic population and an injured athletic population were included in the analysis. If a study addressed both questions, it was included in both analyses.

For both questions, Hedges *g* effect sizes and 95% confidence intervals were calculated to examine the magnitude and precision of differences between groups.[108] Hedges *g* effect size is a unit-less measure and represents an effect that exists on a parametric distribution.[108] For studies that reported non-parametric data, adaptation methods from Hozo et al[147] were used to estimate the mean and variance. A positive effect size for Question I indicated better HRQOL in athletes as compared to non-athletes. A positive effect size for Question II indicated better HRQOL in uninjured athletes as compared to injured athletes. Effect sizes were interpreted as weak (less than 0.40), moderate (0.41 and 0.69), or strong (greater than 0.70).[109] In addition to statistical comparisons, qualitative assessments of effect size and confidence intervals were performed by examining differences in effect size estimates or if the confidence interval crossed zero.

Strength of Recommendation

The strength of recommendation for the included studies was assessed using the Strength-of-Recommendation Taxonomy (SORT)- Strength-of-Recommendation Grades.[148] This taxonomy was used as a framework to assess the quality of evidence used to answer each question. The taxonomy includes ratings of A, B, or C. Grade A evidence represents a systematic review of consistent, good-quality patient-oriented evidence. Grade B evidence represents a systematic review of inconsistent or limited-quality patient-oriented evidence and grade C represents consensus for disease-oriented evidence, usual practice, expert opinion, or case series. Patient-oriented evidence can be defined as outcomes that would be of importance to the patient, such as symptom improvement and quality of life. As opposed to disease-oriented evidence, such as blood pressure or pathological findings, that may or may not reflect improvements in patient outcomes.

Results

Literature Search

The initial search strategy (Figure II.B.1) retrieved 33 articles. Of the 24 articles screened, 5 studies met the inclusion and exclusion criteria for this systematic review. Two additional studies were identified through a hand search of the references resulting in a total of seven eligible studies. The seven studies were classified into the following categories based on group comparison: athletes and non-athletes (Table II.B.2) and uninjured athletes and injured athletes (Table II.B.3). Four articles compared HRQOL in athletes and non-athletes (Question I) and five articles compared HRQOL in uninjured athletes and injured athletes (Question II).

Methodological Quality

Initially, the two reviewers agreed on 72.3% (81/112) of the items on the modified Downs and Black Index. Disagreements were resolved by discussion among the reviewers and the use of a third reviewer (MCH). Quality scores for the studies that compared athletes and non-athletes ranged from 70.6%-82.4% with two high quality studies (>75%) and two moderate quality studies (60-74.9%). Quality scores for the studies that compared uninjured athletes and injured athletes ranged from 70.6%-88.2% with three high quality studies (>75%) and two moderate quality studies (60-74.9%).

Data Synthesis

Question I

Four articles[32, 80-82] met the inclusion criteria to answer this question (Table

II.B.2). The mean Downs and Black score for these articles was 75% ± 5.6%. Of the four articles, three[80-82] provided sufficient data for the calculation of effect sizes and 95% confidence intervals (Figure II.B.2). Of the 14 comparisons examined, 12-point estimates were positive, indicating HRQOL was better in athletes compared to non-athletes; however, the 95% confidence interval of 1-point estimate crossed zero.

Effect sizes and 95% confidence intervals are presented in Table II.B.4. PedsQL effect sizes ranged from 0.35 to 0.48 suggesting a weak to moderate effect that athletes report increased HRQOL on the PedsQL in comparison to non-athletes. None of the effect sizes calculated for the PedsQL-Total were negative nor did the 95% confidence intervals cross zero. SF-36 effect sizes ranged from -0.02 to 0.75 favoring better HRQOL in athletes. Weak to moderate effects (-0.02 to 0.54) were observed for SF-36 physical component summary (SF-36 PCS) scores. Of the five physical health comparisons, four-point estimates were positive and none of the associated confidence intervals crossed zero. Weak to strong (0.29 to 0.75) effects were observed for SF-36 mental component summary (SF-36 MCS) scores. All five of the mental health point estimates were positive and none of the confidence intervals crossed zero indicating that athletes exhibit better HRQOL on the SF-36 MCS in comparison to non-athletes. A weak effect (-0.12) was observed for the only PODCI score calculated. Although the point estimate was negative, suggesting that non-athletes report better HRQOL on the PODCI, the confidence interval crossed zero.

Question II

Five articles[31, 32, 36, 80, 83] met the inclusion criteria to answer this question (Table II.B.3). The mean Downs and Black score for these articles was 77.6% ± 7.7%. All five articles[31, 32, 36, 80, 83] provided sufficient data for the calculation of effect sizes. Of the 25 comparisons examined, 23-point estimates were positive, indicating that HRQOL was better in uninjured athletes compared to injured athletes; however, the 95% confidence interval of 9-point estimates crossed zero.

Effect sizes and 95% confidence intervals are presented in Table II.B.5. SF-36 effect sizes ranged from -0.09 to 3.34 favoring better HRQOL in uninjured athletes. Weak to strong effects (0.08 to 3.34) were observed for SF-36 PCS. All 12 physical health point estimates were positive; however, 4 of the confidence intervals crossed zero. For the SF-36 MCS, weak effects (-0.09 to 0.38) were observed. Of the 12 mental health comparisons, 10-point estimates were positive; however, 5 of the confidence intervals crossed zero. Overall, the effect sizes for mental and physical components of the SF-36 suggested that uninjured athletes exhibit better HRQOL in comparison to injured athletes. A strong effect (4.40) was observed for the only PODCI comparison. The positive point estimate and the 95% confidence interval did not cross zero, suggesting uninjured athletes report better HRQOL on the PODCI than injured athletes.

Strength of Recommendation

For Question I, there is Grade A evidence that suggests athletes report better HRQOL than non-athletes. This recommendation is based off of consistent findings of two high quality studies and two moderate quality studies. For Question II, there is Grade A evidence that suggests uninjured athletes report better HRQOL than injured athletes. This recommendation is based off of consistent findings of three high quality studies and two moderate quality studies.

Discussion

The purpose of Question I was to determine if HRQOL was better in athletes compared to non-athletes. The results of our systematic review demonstrate Grade A evidence that HRQOL is better in athletes than non-athletes. Four of the seven studies[32, 80-82] included in the review compared generic HRQOL outcomes between athletes and non-athletes. Although data from McAllister et al.[32] could not be used to calculate effect sizes between groups; 12 of 14-point estimates calculated were positive suggesting that athletes report better HRQOL. The positive effect sizes imply that involvement in athletics may benefit overall health status. In addition, the differences noted suggest that normative values for HRQOL may not be accurate for athletes, as most have been established in non-athletic populations.[149-151] Accordingly, normative values should be established in athletic populations to ensure a complete and proper recovery following injury.

Within Question I, two studies[32, 80] compared SF-36 outcomes between collegiate athletes and non-athletes. In a sample of 562 NCAA Division-I athletes, McAllister et al.[32] found that athletes reported increased emotional role ($p<.001$) and mental health ($p<.002$) when compared to sex- and age-matched norms of the general U.S. population. However, in a larger sample ($n=696$), Huffman et al.[80] reported that NCAA athletes exhibit better HRQOL on all domains of the SF-36 except for bodily pain ($p=0.05$) when compared to a similarly aged sample from the U.S. general population. Although the effect size for bodily pain in this review was positive, the confidence interval for bodily pain encompassed zero suggesting that athletes may report lower bodily pain scores. Consistent with the findings of this review, both collegiate studies[32, 80] concluded that athletes exhibit better HRQOL on the SF-36 in comparison to previously established normative data for the general population.

The other two studies[81, 82] that answered Question I compared HRQOL in adolescent athletes and non-athletes. Both studies concluded that adolescent athletes report increased generic HRQOL, however our point estimates for the PODCI and SF-36 PCS were negative. Although point estimates for the PODCI and SF-36 PCS were negative, suggesting that non-athletes report better HRQOL, the effects observed were weak and the confidence intervals crossed zero. Therefore, the results should be interpreted with caution. The weak effect may be attributed to our use of summary scores in the effect size calculations. The PODCI Global score is a summary of all subscale scores and athletes reported lower scores on pain/comfort and basic mobility subscales. Similarly, the SF-36 PCS is a summary of physical health and athletes reported significantly lower scores for bodily pain. These findings further support Huffman et al.'s[80] lack of bodily pain differences between collegiate and non-collegiate athletes suggesting that athletic participation may generate a negative physical impact on the body. Consistent with the findings of this review, adolescent athletes reported significantly better HRQOL on a number of subscales pertaining to mental, emotional, and physical well-being in comparison to non-athletes. However, athletes may perceive bodily pain and basic mobility differently due to the physical impact of athletics on the body, particularly the risk of sports-related injury.

The purpose of Question II was to determine if HRQOL was better in uninjured athletes compared to injured athletes. The results of our systematic review demonstrate Grade A evidence that HRQOL is better in uninjured athletes than injured athletes. Five of the seven studies[31, 32, 36, 80, 83] included in the review compared generic HRQOL outcomes between uninjured athletes and injured athletes. Point estimates for 23 of 25 comparisons were positive, suggesting that uninjured athletes report better HRQOL on generic instruments. The differences noted between uninjured athletes and injured athletes suggest that injury may negatively impact overall health status.

Within Question II, three studies[32, 80, 83] compared generic HRQOL outcomes between uninjured collegiate athletes and injured collegiate athletes. In agreement with the findings of this review, Huffman et al.[80] reported that uninjured athletes exhibited better HRQOL in all eight domains of the SF-36 in comparison to injured athletes. Similarly, McAllister et al.[32] reported that uninjured athletes reported better HRQOL on the SF-36 than athletes with a significant or mild injury. However, two of the point estimates calculated for McAllister et al.[32] were negative suggesting that injured athletes report better HRQOL. These negative point estimates may be attributed to the type of injuries reported. Although the overall effect was weak, the two negative point estimates were comparisons made between uninjured athletes and athletes with a "mild" injury. Mild was defined as injuries that had minimal or no effect on participation, practice, or play.[32] Therefore, a mild injury may not have been significant enough to impact the athlete's HRQOL. Kuehl et al.[83] took a slightly different approach and focused on differences between athletes with and without a history of concussion. Even though all four of the concussion point estimates were positive for the SF-36, the confidence intervals crossed zero suggesting that these findings be interpreted with caution. It appears as though the number of previous concussions influence HRQOL as effect sizes were stronger for athletes with a history of three or more concussions as opposed to individuals with a history of one or two concussions. Although the definition of injured athlete varied, the evidence still suggests that uninjured athletes report better HRQOL than collegiate athletes with a current injury, history of musculoskeletal injury, or history of sports-related concussion.

The other two studies[31, 36] that answered Question II compared HRQOL in uninjured and injured adolescent athletes. The same primary investigator compared adolescent athletes with a recent musculoskeletal injury to uninjured athletes[31] and athletes with a self-reported history of concussion to athletes with no history of concussion.[36] Although all five-point estimates were positive, the SF-36 PCS confidence interval crossed zero for athletes with a history of concussion[36] and the SF-36 MCS confidence interval crossed zero for athletes with a musculoskeletal injury.[31] From these findings we can speculate that concussions may only impact mental components of HRQOL leaving physical components unscathed. Accordingly, musculoskeletal injuries may only impact physical components of HRQOL and have minimal mental impact. In general, the evidence obtained to answer Question II suggests that both uninjured collegiate and adolescent athletes report better HRQOL than injured athletes.

Practical Implications

Overall, the results of this systematic review indicate that athletes report better HRQOL than non-athletes and that uninjured athletes report better HRQOL than injured athletes. While athletic participation appears to improve overall health status, the impact of sports-related injury has the potential to decrease HRQOL. Therefore, clinicians should monitor HRQOL post-injury to ensure a complete recovery. However, knowing that athletes report better HRQOL than non-athletes, clinicians should establish baseline scores during pre-season or utilize instruments that have established normative values for an athletic population.[80] The utilization of baseline HRQOL outcomes or appropriate normative values will allow clinicians to identify potential deficits post-injury and track recovery during the rehabilitation process.

To further understand HRQOL differences between athletes and non-athletes as well as the impact of injury on athletes more research is needed. Future research should examine other generic measures of HRQOL, such as the Disablement in the Physically Active Scale (DPA),[132] and expand to other dimensions of HRQOL, such as region-specific and dimension-specific outcomes. Utilizing instruments like the DPA that are specifically designed for athletic populations, in combination with other outcomes that target different dimensions of health, may help elucidate the most meaningful deficits. Future research should also examine the influence of factors such as time since injury, injury severity, injury location, and years of participation on HRQOL. Additionally, injury data should be collected prospectively to avoid recall bias.

Limitations

This systematic review was designed based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, however limitations still need to be addressed. The electronic searches were conducted in databases considered to be the most relevant to HRQOL and athletes and were followed by a hand search of references in identified studies; however it is possible that other evidence is available. Our search was also limited to studies published in English and peer-reviewed journals but we do not believe any relevant articles were excluded with these search parameters. In regards to our statistical analyses, effect sizes for Question I could not be calculated for McAllister et al.[32] Additionally, non-parametric data from McLeod et al.[31] was converted to parametric data in order to calculate effect sizes. Furthermore, one study[80] did not report summary scores for the SF-36 so effect sizes for all subscales had to be computed. Subscale scores from the other studies were removed from the analyses to avoid redundant information. Lastly, three studies[32, 80, 82] included in this review used normative data for their non-athlete and uninjured groups which may have been outdated or influenced by geographic location.

Conclusions

A systematic search of the literature revealed seven studies that compared HRQOL outcomes in athletes and non-athletes and injured and uninjured athletes. All four of the studies that compared HRQOL in athletes and non-athletes found that athletes reported better HRQOL on generic instruments. The five studies that compared HRQOL in injured and uninjured athletes found that uninjured athletes reported better HRQOL on generic instruments. The evidence obtained from this review suggests that HRQOL differs in athletes and non-athletes and in uninjured and injured athletes. Such differences should be taken into consideration when providing health care for an athletic population. Furthermore, knowing HRQOL differences exist on generic instruments should promote the use of region-specific and dimension-specific instruments in research and clinical care.

Table II.B.1. Search Strategy

Step	Search Terms	Boolean Operator	EBSCO Host	PubMed
1	Health-related quality of life		5,365	18,102
2	Adolescent High school Interscholastic Adult College Intercollegiate NCAA	OR	420,825	4,903,768
3	Athletes		51,985	19,743
4	1, 3	AND	23	16
5	1, 2, 3	AND	17	16
Duplicates				*9

*Total number of duplicates between EBSCO Host and PubMed

Table II.B.2. Methodological Summary for Question I

Authors	Quality Index Score (%)	Study Design	Inclusion Criteria	No. Athletes	No. Non-athletes	HRQOL Outcome
Lam et al.[82] (2013)	70.59	Cross-sectional	Adolescent (age 14-18) athletes cleared for participation in an interscholastic sport that did not report a current injury or illness.	2,659	1,464 (Varni et al.[152])	PedsQL
Snyder et al.[81] (2010)	82.35	Cross-Sectional	High school students who reported participation in a school sponsored interscholastic or club sport.	219	106	SF-36 PODCI
Huffman et al.[80] (2008)	70.59	Cross-Sectional	NCAA Division I and II athletes who had been cleared for participation.	696	Normative Data	SF-36
McAllister et al.[32] (2001)	76.47	Cross-Sectional	Division I collegiate athletes who reported no current injuries.	404	Normative Data	SF-36

Abbreviations: HRQOL, Health-Related Quality of Life; NCAA, National Collegiate Athletic Association; PedsQL, Pediatric Quality of Life Inventory; PODCI, Pediatric Outcomes Data Collection Instrument; SF-36, Short form-36

Table II.B.3. Methodological Summary for Question II

Study	Quality Index Score (%)	Study Design	Inclusion Criteria	Injured Athletes (n)	Uninjured Athletes (n)	HRQOL Outcome
McLeod et al.[31] (2009)	70.59	Cross-sectional	Adolescent athletes with a self-reported history of an injury within the past week.	45	160	SF-36 PODCI
Huffman et al. [80] (2008)	70.59	Cross-sectional	NCAA Division I and II athletes that reported having a previous injury but were cleared for active participation at the time of survey administration.	390	244	SF-36
McAllister et al. [32] (2001)	76.47	Cross-sectional	Division I collegiate athletes with a self-reported history of a current injury.	158	404	SF-36
Kuehl et al.[83] (2010)	82.35	Cross-sectional	Intercollegiate athletes with a self-reported history of concussion.	133	169	SF-36
McLeod et al.[36] (2010)	88.24	Cross-sectional	High school students with a self-reported history of concussion.	140	126	SF-36

Abbreviations: HRQOL, Health-Related Quality of Life; NCAA, National Collegiate Athletic Association; PODCI, Pediatric Outcomes Data Collection Instrument; SF-36, Short Form-36

Table II.B.4. Effect Sizes and 95% Confidence Intervals for Question I

Study	HRQOL Instrument	Hedge's g	Lower Limit	Upper Limit
Lam et al.[82]	PedsQL Total (14y.o.)[a]	0.35	0.21	0.49
Lam et al.[82]	PedsQL Total (15y.o.)[b]	0.48	0.35	0.62
Lam et al.[82]	PedsQL Total (16y.o.)[c]	0.37	0.18	0.55
Snyder et al.[81]	SF-36 PCS[d]	-0.02	-0.25	0.21
Huffman et al.[80]	SF-36 Physical Functioning[e]	0.52	0.35	0.68
Huffman et al.[80]	SF-36 Physical Role[f]	0.27	0.10	0.44
Huffman et al.[80]	SF-36 Bodily Pain[g]	0.17	0.00	0.33
Huffman et al.[80]	SF-36 General Health[h]	0.54	0.37	0.71
Snyder et al.[81]	SF-36 MCS[i]	0.29	0.05	0.52
Huffman et al.[80]	SF-36 Vitality[j]	0.44	0.27	0.60
Huffman et al.[80]	SF-36 Social Functioning[k]	0.75	0.58	0.92
Huffman et al.[80]	SF-36 Emotional Role[l]	0.73	0.56	0.90
Huffman et al.[80]	SF-36 Mental Health[m]	0.63	0.46	0.80
Snyder et al.[81]	PODCI Global[n]	-0.12	-0.35	0.11

Abbreviations: PedsQL, Pediatric Quality of Life Inventory; PODCI, Pediatric Outcomes Data Collection Instrument; SF-36, Short Form-36; SF-36 PCS, Physical Component Summary; SF-36 MCS, Mental Component Summary

Table II.B.5. Effect Sizes and 95% Confidence Intervals for Question II

Study	HRQOL Instrument	Hedge's g	Lower Limit	Upper Limit
Kuehl et al.[83] (3+ Concussions)	SF-36 PCS[a]	0.31	-0.04	0.65
Kuehl et al.[83] (1-2 Concussions)	SF-36 PCS[b]	0.08	-0.17	0.34
Huffman et al.[80]	SF-36 Physical Functioning[c]	0.17	0.01	0.33
Huffman et al.[80]	SF-36 Physical Role[d]	0.18	0.02	0.34
Huffman et al.[80]	SF-36 Bodily Pain[e]	0.48	0.32	0.65
Huffman et al.[80]	SF-36 General Health[f]	0.23	0.07	0.39
McAllister et al.[32] (Serious-Men)	SF-36 PCS[g]	1.13	0.68	1.57
McAllister et al.[32] (Mild-Men)	SF-36 PCS[h]	0.40	0.11	0.68
McAllister et al.[32] (Serious-Women)	SF-36 PCS[i]	0.70	0.29	1.11
McAllister et al.[32] (Mild-Women)	SF-36 PCS[j]	0.29	-0.04	0.61
McLeod et al. 2009[31]	SF-36 PCS[k]	3.34	2.88	3.80
McLeod et al. 2010[36]	SF-36 PCS[l]	0.08	-0.16	0.32
Kuehl et al.[83] (3+ Concussions)	SF-36 MCS[m]	0.30	-0.04	0.65
Kuehl et al.[83] (1-2 Concussions)	SF-36 MCS[n]	0.05	-0.20	0.30
Huffman et al.[80]	SF-36 Vitality[o]	0.21	0.05	0.37
Huffman et al.[80]	SF-36 Social Functioning[p]	0.28	0.12	0.44
Huffman et al.[80]	SF-36 Emotional Role[q]	0.16	0.00	0.32
Huffman et al.[80]	SF-36 Mental Health[r]	0.17	0.01	0.33
McAllister et al.[32] (Serious-Men)	SF-36 MCS[s]	0.38	-0.06	0.82
McAllister et al.[32] (Mild-Men)	SF-36 MCS[t]	-0.09	-0.37	0.20
McAllister et al.[32] (Serious-Women)	SF-36 MCS[u]	0.19	-0.22	0.59
McAllister et al.[32] (Mild-Women)	SF-36 MCS[v]	-0.08	-0.41	0.24
McLeod et al. 2009[31]	SF-36 MCS[w]	0.21	-0.12	0.54
McLeod et al. 2010[36]	SF-36 MCS[x]	0.33	0.08	0.57
McLeod et al. 2009[31]	PODCI Global[y]	4.40	3.86	4.94

Abbreviations: PODCI, Pediatric Outcomes Data Collection Instrument; SF-36, Short Form-36; SF-36 PCS, Physical Component Summary; SF-36 MCS, Mental Component Summary

Figure II.B.1. Flow Chart of the Study Selection Process

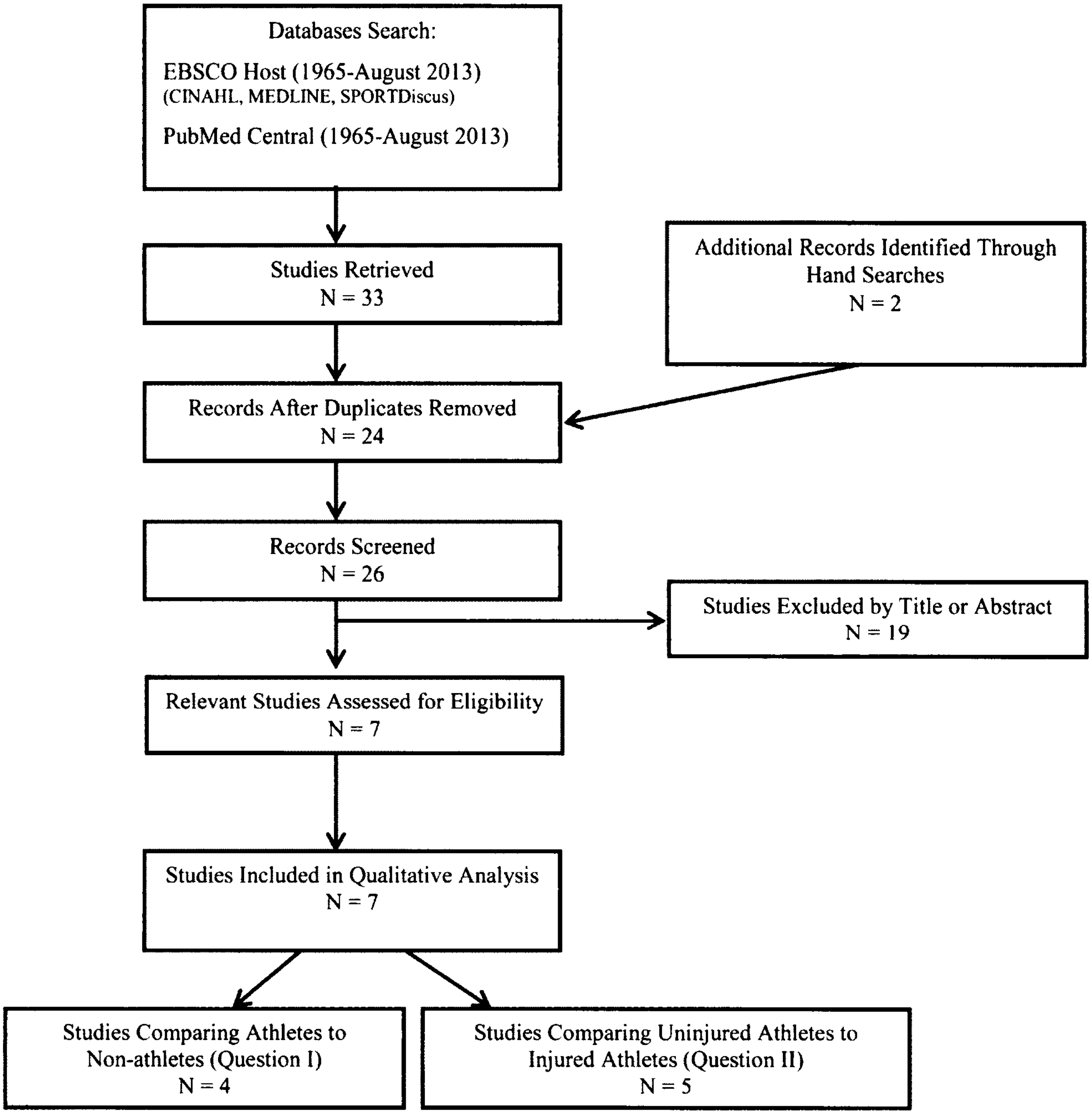


Figure II.B.2. Forest Plot of Hedge's g Effect Sizes and 95% Confidence Intervals for Question I. Letter superscripts correspond to actual values reported in Table II.B.4.

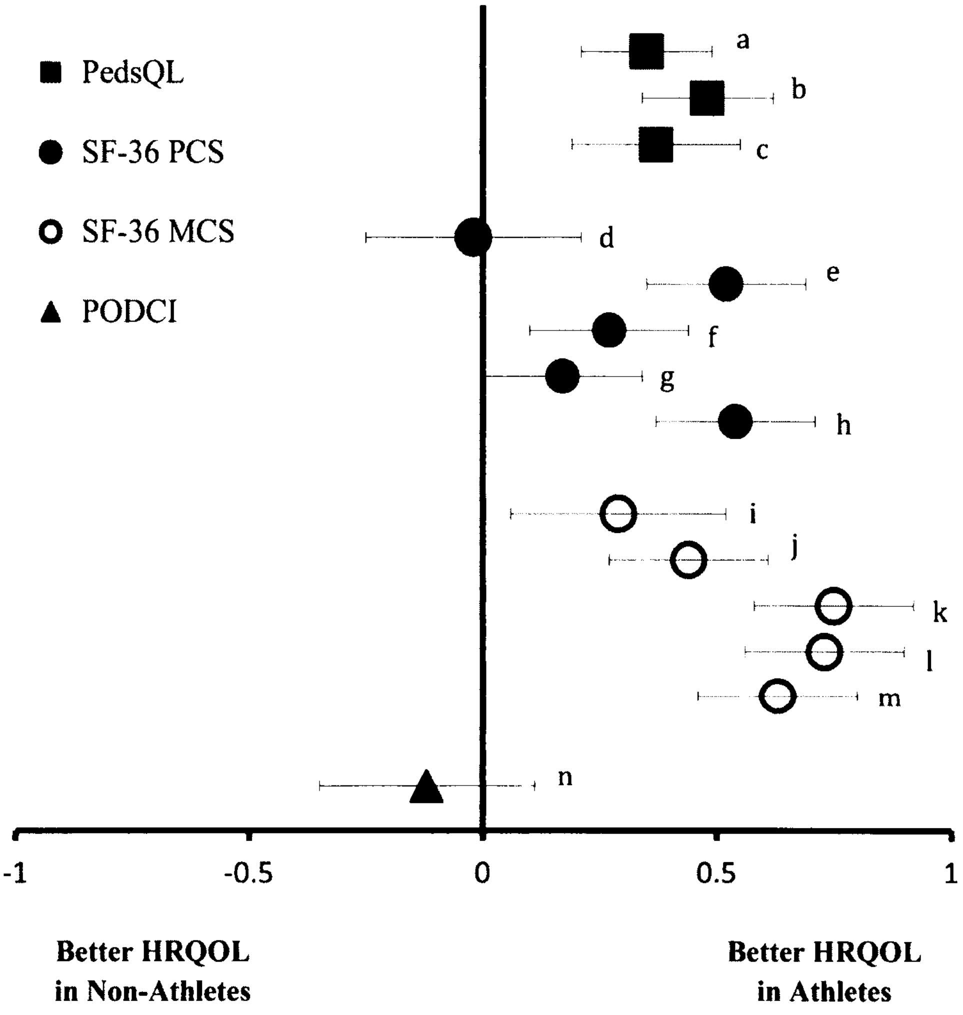
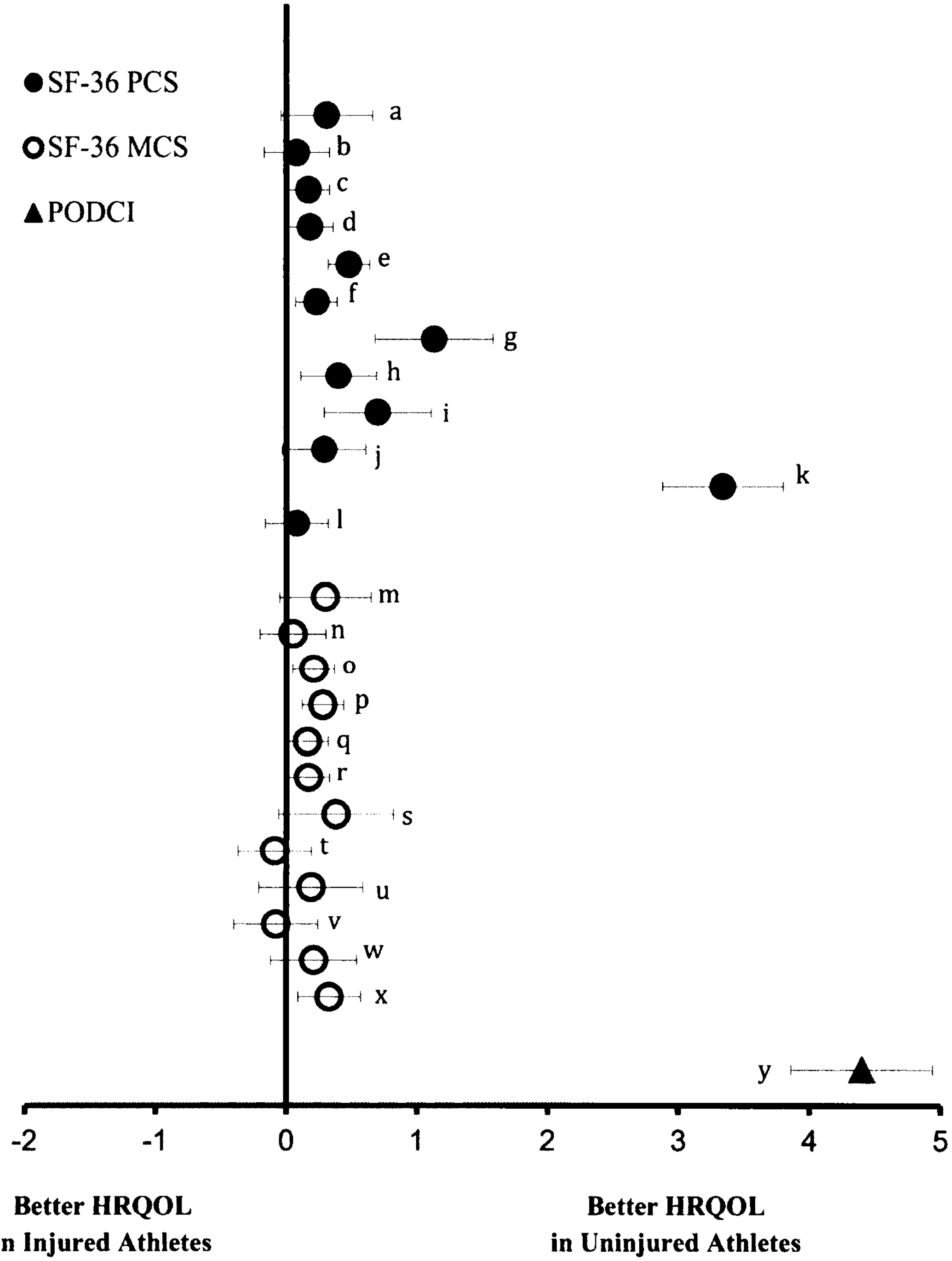


Figure II.B.3. Forest Plot of Hedge's g Effect Sizes and 95% Confidence Intervals for Question II. Letter superscripts correspond to actual values reported in Table II.B.5.



CHAPTER III

PROJECT I: HEALTH-RELATED QUALITY OF LIFE IN INDIVIDUALS WITH CHRONIC ANKLE INSTABILITY

Introduction

Individuals around the globe engage in physical activity for personal interest or general health and fitness, subjecting the ankle to various conditions in which injury could occur. Roughly half of all ankle sprains in the United States occur during athletic activity [46, 47] and an estimated three million patients seek treatment in hospital emergency rooms or in a physician's office each year.[48] Within the past decade, ankle sprains have represented approximately 80% of ankle injuries in athletics[49, 50] and military cadets[46] resulting in immense health-care costs. To further contribute to the problem, up to 74% of patients that sustain a single ankle sprain go on to develop residual symptoms that may persist years after the initial injury,[94] with many developing chronic ankle instability (CAI).[13, 96, 153] CAI or recurring ankle sprains and repetitive giving way of the ankle during functional activities has been linked to both mechanical and functional impairments.[55] These impairments are thought to contribute to long-term limitations and restrictions in recreational and occupational activities that consequently impact health-related quality of life (HRQOL).[13, 154]

Encompassing social, physical, and psychological health components, HRQOL is a multi-dimensional approach to health care[26] that has become an integral part of health surveillance. Due to the multi-dimensional nature of HRQOL, a variety of self-reported instruments have been designed to measure generic, region-specific, and dimension-specific health components. Generic instruments are non-specific to body region or condition and designed to assess the patient's overall health whereas region-specific instruments can be specific to a joint or region of the body such as the lower extremity.[27] Dimension-specific instruments capture specific medical conditions or health dimensions such as pain or fear of re-injury. Fear of re-injury is the concept of fear following injury including but not limited to kinesiophobia, fear-avoidance beliefs, or re-injury anxiety. Self-reported instruments enhance the clinician's ability to incorporate patient values and perspectives and are a vital component to the evidence-based practice (EBP) model.[23]

CAI has been associated with decreased HRQOL based on generic and region-specific outcomes.[34, 51] Individuals with CAI have reported decreased generic function on the Short Form-36 (SF-36).[51] Furthermore, Arnold et al.[51] found a moderate positive correlation between SF-36 physical function domain scores and the Foot and Ankle Ability Measure (FAAM), a region-specific measure of function that includes both activities of daily living (FAAM-ADL) and sport subscales (FAAM-Sport). This relationship suggests that CAI may reduce overall HRQOL. Individuals with CAI have also reported decreased function on other region-specific instruments such as the Ankle Joint Functional Assessment Tool (AJFAT), Foot and Ankle Disability Index (FADI), and FADI-Sport.[34, 52-54] Using a variety of self-reported instruments, both generic and region-specific deficits have been detected in physically active individuals with CAI.

Despite identifying generic and region-specific HRQOL deficits in those with CAI, considerably more research is required to determine the extent to which CAI influences the multidimensional profile of HRQOL. Therefore, examining generic function using a scale designed for physically active individuals or dimension-specific measures, such as kinesiophobia and fear-avoidance beliefs, could reveal more about the condition. Scores on the Disablement in the Physically Active Scale (DPA), Tampa Scale of Kinesiophobia-11 (TSK-11), and Fear-Avoidance Beliefs Questionnaire (FABQ) have yet to be examined in this population. However, using the TSK-11 Lentz et al[41] identified kinesiophobia as a contributor to lower-extremity disability in those with various foot and ankle pathologies. The relationship between generic, region-specific, and dimension-specific self-reported outcomes needs further exploration in individuals with CAI. Utilizing instruments that encompass the multidimensional profile of HRQOL will enhance the clinician's ability to incorporate patient values and perspectives into rehabilitation and outcome assessments.

CAI has been linked to long-term, residual symptoms that affect daily life and sport activity.[13] While fear of re-injury has been associated with a variety of orthopedic conditions[40, 42, 89, 155] there is little evidence to support the presence of kinesiophobia or fear-avoidance beliefs in patients with CAI. Wikstrom[129] reported that TSK-17 scores did not differ between individuals with CAI and copers, however both groups reported elevated levels of kinesiophobia. Left unaddressed, generic and region-specific functional deficits as well as fear of re-injury may contribute to long-term consequences associated with CAI such as degenerative joint disease[11] and decreased physical activity[13] which may predispose these individuals to other hypokinetic diseases. Therefore, the primary purpose of this investigation was to determine if generic, region-specific, and dimension-specific health outcomes differ between individuals with and without CAI. The secondary purpose was to examine relationships between instruments and between injury history characteristics and instrument scores in the CAI group. We hypothesized that individuals with CAI would exhibit decreased generic and region-specific function and an increase in fear of re-injury characteristics, such as kinesiophobia and fear-avoidance beliefs, in comparison to healthy individuals. Additionally, relationships would exist between health-related outcome instruments and between injury history characteristics and instrument scores.

Methods

This investigation used a case-control design to examine differences between individuals with and without CAI. The independent variable was group (CAI and healthy) and the dependent variables included generic (DPA), region-specific (FAAM-ADL and FAAM-Sport), and dimension-specific (TSK-11 and FABQ) health-related outcomes.

Participants

Twenty-five physically active participants with CAI (7 males, 18 females, age=21.9±2.5 years, height=170.2±9.1 cm, mass=70.0±11.4 kg) were gender and limb matched to twenty-five physically active participants with no history of ankle sprain (7 males, 18 females, age=22.0±2.1 years, height=167.4±9.1 cm, mass=64.8±11.2 kg). All participants reported a score of four or greater on the National Aeronautics and Space Administration (NASA) Physical Activity Scale. Median scores on the NASA Physical Activity Scale for the CAI and healthy group were 6.5 and 6 respectively, indicating these individuals participated in physical activity 1 to 3 hours per week. Participants were included in the CAI group if they reported a history of at least one lateral ankle sprain, two episodes of "giving way" in the past three months, and answered "yes" to four or more questions on the Ankle Instability Instrument (AII). Participants were excluded if they reported having an ankle sprain in the previous six weeks, a lower extremity injury in the past six months, or any history of lower extremity surgery. In the event of bilateral CAI, the ankle with the most reported episodes of giving way on the AII was considered the involved limb for the purposes of this study. Participant characteristics are reported in Table III.1. All participants completed an informed consent document approved by the University's Institutional Review Board.

Procedures

All participants reported to the laboratory for a single testing session. After reading and signing the informed consent document, participants completed the AII, NASA Physical Activity Scale, FAAM-ADL, FAAM-Sport, FABQ, TSK-11, and DPA instruments in the aforementioned order. The AII and NASA Physical Activity Scale were used as inclusionary instruments. The TSK-11 and FABQ were used to quantify fear of re-injury and the FAAM and DPA, region-specific and generic function, respectively. The investigators administered the survey instruments in paper format. Participants were asked to complete all seven instruments as instructed by the directions at the top of each page. The investigator did not provide further explanation unless the participant asked for clarification in which the investigator attempted to provide an unbiased response. Following completion, the primary investigator examined the instruments for missing items and asked the participant to respond to any identified cases. The primary investigator scored all of the survey instruments for analysis based on the guidelines established for each instrument.

Instrumentation

Disablement in the Physically Active Scale

The DPA[132] is a 16-item generic outcome instrument designed by athletic trainers for physically active individuals. The multidimensional scale is rooted in both current disablement and HRQOL paradigms. Responses are based on a 5-point Likert scale ranging from 'no problem' to 'severe.'[132] Each item is weighted equally, and DPA scores range from 0 to 64 with higher scores indicating increased disablement. High test-retest reliability (ICC=0.943) and internal consistency (α=0.890-0.908) values have been reported for the DPA.[132]

Foot and Ankle Ability Measure

The FAAM is a region-specific instrument designed to quantify activity limitations and participation restrictions associated with foot and ankle conditions.[33] Comprised of two subscales, the FAAM-ADL contains 21 items while the FAAM-Sport scale contains eight items. All items are scored on a 5-point Likert scale (0-4) from 'no difficulty at all' to 'unable to do'. Scores range from 0-84 (FAAM-ADL) and 0-32 (FAAM-Sport) and are transformed into percentages, with 100% representing no functional loss. Test-retest reliability for the FAAM-ADL and Sport were 0.89 and 0.87, respectively.[33] Internal consistency for the FAAM-ADL and Sport were 0.98 and 0.96.[33]

Tampa Scale of Kinesiophobia- 11

The TSK-11 is an 11-item questionnaire designed to assess fear of movement/re-injury while offering the advantage of brevity. All items are based on a 4-point Likert scale in which patient options range from 'strongly disagree' to 'strongly agree'. TSK-11 scores range from 11 to 44 with higher scores indicating a higher degree of kinesiophobia. Although a shortened-format, the TSK-11 has demonstrated similar factor structure, internal consistency (α=0.79), test-retest reliability (ICC=0.81), and validity to the original TSK-17.[156] The shortened-version has been used extensively in orthopedic populations, including low back pain,[156] neck and shoulder pain,[157, 158] and lower-extremity disability.[39]

Fear-Avoidance Beliefs Questionnaire

The FABQ[38] is a 16-item questionnaire designed to assess fear-avoidance beliefs. Each item is scored on a 7-point Likert scale from 'completely disagree' to 'completely agree'. FABQ scores range from 0 to 66 with higher scores representing increased fear-avoidance beliefs. High test-retest reliability (ICC=0.77-0.90) and internal consistency (α=0.79-0.91) have been reported for the instrument.[159]

Statistical Analyses

Separate Mann-Whitney U tests were used to determine if differences existed in generic, region-specific, and dimension-specific health-related outcomes between individuals with and without CAI. The significance level was set at $p \leq 0.01$ to adjust for multiple comparisons. As a secondary analysis, Spearman's rho correlations were used to examine relationships between instruments, as well as, between instruments and injury history characteristics in the CAI group. Correlation coefficients of 0.01 to 0.39 were interpreted as weak relationships, 0.40 to 0.69 moderate, and 0.70 to 1.0 strong.[160] The α level for correlations was set at $p \leq 0.05$. All analyses were conducted using the SPSS program (version 21.0; SPSS Inc, Chicago, IL).

Results

Significant differences were identified between the CAI group and healthy group for generic, region-specific, and dimension-specific health-related outcomes (Table III.2). Compared with healthy individuals, those with CAI reported decreased function on the FAAM-ADL, FAAM-Sport, and DPA ($p<0.001$). Individuals with CAI also reported increased fear of re-injury on both the TSK-11 and FABQ ($p<0.001$). Within the CAI group, Spearman's rho correlations between outcomes revealed a strong positive correlation between the FAAM-ADL and FAAM-Sport ($r=0.774$; $p<0.01$). No other significant correlations were identified between instruments ($p>0.05$). Correlation coefficients between each instrument are presented in Table III.3.

Discussion

Our primary purpose was to determine if generic, region-specific, and dimension-specific health-related outcomes differed between individuals with and without CAI. We also examined relationships between outcome scores, as well as, between outcome scores and injury history characteristics within the CAI group to determine if there was any association between instruments. Overall, we found that individuals with CAI report decreased generic and region-specific function as well as increased fear of re-injury in comparison to healthy individuals. Additionally, within the CAI group we identified a strong positive relationship between the FAAM-ADL and FAAM-Sport but no other significant relationships were identified between instruments.

Between Group Comparisons

We hypothesized that individuals with CAI would display generic and region-specific deficits in addition to heightened fear of re-injury characteristics such as kinesiophobia and fear-avoidance beliefs. Our results confirmed this hypothesis as individuals with CAI reported lower scores on the FAAM and higher scores on the DPA, FABQ, and TSK-11 (Table III.2). Although other investigations[34, 51, 52] have reported decreased generic and region-specific functional scores in individuals with CAI, to our knowledge no one has examined generic function using an instrument designed for physically active individuals or fear of re-injury in this population. Our results are in agreement with findings in other populations such as athletes with musculoskeletal injuries,[132] individuals with patellofemoral pain,[161] patients post ACL-reconstruction[162] and a variety of other orthopedic conditions.[163-165] These findings highlight the need to evaluate function local to the ankle, as well as, globally to fully understand the scope of HRQOL changes in patients with CAI.

The results of our investigation suggest that CAI influences dimension-specific health-related outcomes associated with fear of re-injury and fear avoidance beliefs. While others have measured generic and region-specific function in this population, only one study has examined fear of re-injury. Wikstrom[129] compared fear of re-injury using the original TSK-17 (score range=17-68) in ankle sprain copers (TSK-17=30.5±5.7) and individuals with CAI (TSK-17=31.6±4.4) and reported that kinesiophobia scores do not differ between groups (Cohen's d effect size=0.22). Rather than interpret these findings as insignificant or clinically relevant, it may be that both groups reported elevated levels of kinesiophobia. The elevated TSK-17 scores in both CAI and coper groups suggests that kinesiophobia may still be present in ankle sprain copers even though they may have resumed physical activity levels without limitation and additional injury. In the current study, we used a healthy control (TSK-11=13.4±2.7) group to compare to individuals with CAI (TSK-11=19.1±4.3) using the TSK-11 (score range=11-44) and identified a large magnitude of difference between groups (Cohen's d effect size = 1.59). The heightened fear of re-injury scores reported by individuals with a history of ankle sprain reiterates the importance of assessing the multidimensional profile of HRQOL. Overall, these studies suggest that fear of re-injury should be further examined in individuals with a history of ankle sprain.

Relationships in the Chronic Ankle Instability Group

We hypothesized that relationships would exist between health-related outcome instruments. We observed a strong positive correlation (r=0.774) between the FAAM subscales. The correlation between the subscales suggests they measure similar constructs which is logical since they are both assessing activity limitations and participation restrictions specific to the foot and ankle. However, there were no significant relationships between generic, region-specific, or dimension-specific outcomes. The weak correlation between generic and region-specific instruments suggests that the DPA and FAAM are measuring different aspects of function and that both should continue to be used. Furthermore, the weak correlation between the TSK-11 and FABQ suggests these outcomes capture different aspects of fear of re-injury and both should continue to be used. Overall, these finding suggests that generic, region-specific, and dimension-specific health-related outcomes should be assessed in individuals with CAI utilizing a variety of outcome instruments.

Finally, the number of previous ankle sprains, episodes of giving way, or physical activity level did not significantly correlate to any instruments. While we believe our sample represented individuals across the continuum of CAI it does not appear basic injury history characteristics greatly influenced the instrument scores in this study. Examining how more specific functional and mechanical impairments contribute to generic, region-specific, and dimension-specific HRQOL may provide more insight into HRQOL deficits. For example, Hubbard et al.[57] identified a strong relationship between ankle laxity and region-specific function using the FADI and FADI-Sport. As scores on the FADI (r=-0.65) and FADI-Sport (r=-0.88) decreased, anterior laxity increased. Moderate negative correlations were also identified between FADI (r=-0.53) and FADI-Sport (r= -0.45) scores and inversion laxity. This suggests that relationships may exist between mechanical and functional deficits and health-related outcomes which should be explored in future investigations.

Clinical Implications

Limited evidence exists for generic[51] and fear of re-injury outcomes in individuals with CAI, but based on the results of this investigation, these elements may be critical to understanding the consequences of clinical interventions. In our investigation, individuals with CAI reported functional deficits and fear of re-injury in relationship to their unstable ankle. Left unaddressed, such components may contribute to long-term consequences associated with the condition. While the exact cause of the reported deficits is unknown, previous investigators have shown that various rehabilitation techniques improve region-specific measures of function.[61-63] Hence, region-specific measures of function appear to be modifiable. To our knowledge no one has examined the influence of ankle instability rehabilitation techniques on generic outcomes or fear of re-injury. To evaluate treatment efficacy and better monitor patient status, clinicians should utilize generic, region-specific, and dimension-specific outcomes.

To provide a clinical interpretation of our findings we examined our data in the contexts of minimal detectable change (MDC) and minimal clinically important difference (MCID) scores when reported in the literature. The MDC indicates the amount of change required to exceed measurement variability.[166] Whereas the MCID indicates the smallest difference that a patient perceives as a change in health status.[167] In individuals with CAI, MDC scores of 3.96%[62] and 7.9%[62] have been reported for the FAAM-ADL and FAAM-Sport, respectively. The median difference between groups in the current study was 9% for the FAAM-ADL and 12% for the FAAM-Sport, indicating that these subjects not only displayed significant differences compared to the healthy group but that there is room for clinically meaningful improvement. For the DPA, physically active individuals with persistent injuries had an MDC score of 4.21 and an MCID score of 9 points.[132] Again, the median difference of 14 points between our groups exceeded both scores indicating that subjects with CAI displayed significantly lower HRQOL compared to the healthy group but also the possibility for clinically meaningful improvement exists on this instrument as well. The MDC and MCID scores for the TSK-11 and FABQ have not been reported for individuals with CAI or a population similar to the physically active individuals included in this study and should be a consideration for future research.

Limitations

The present study was not without limitations. First, due to the retrospective study design a causal link cannot be made between CAI and decreased health-related outcomes. Second, the data was collected from a sample of physically active individuals between the ages of 18 and 30, thus our results are not applicable to younger or older cohorts of individuals with CAI. Similarly, more homogenous groups of individuals with CAI such as elite or collegiate athletes may respond differently than general physically active individuals. In addition, some of the participants had a history of bilateral ankle sprains or instability that may have contributed to decreased generic function or increased fear of re-injury. Of our sample of individuals with CAI, 6 reported bilateral CAI, 4 reported unilateral CAI, and 15 reported a range of bilateral ankle sprain histories. An exploratory analysis between those with bilateral and unilateral instability indicated that there were no differences in DPA (p=0.48), TSK-11 (p=0.61), or FABQ (p=0.07) scores. Lastly, the outcome instruments were not administered in a counterbalanced order. The effect of administration sequence with these instruments is unknown at this time; however the opportunity for bias may exist based on the order individuals complete these instruments. Future investigations may consider counterbalancing the administration of HRQOL instruments, examining these results in more specific subgroups with CAI, and investigating the influence of bilateral instability.

Conclusions

Individuals with CAI displayed decreased generic and region-specific function and increased fear of re-injury. Post-ankle sprain clinicians should evaluate the patient's perception of function using both generic and region-specific instruments as well as assess the individual's fear of re-injury. Functional deficits and psychological barriers should be taken into consideration when treating individuals with CAI to improve the quality of patient care. Future investigations should evaluate the relationship between health-related outcomes and mechanical and functional insufficiencies associated with CAI.

Table III.1. Participant Characteristics for Age, Height, Mass (mean ± SD) and Episodes of Giving Way, Previous Ankle Sprains, and Physical Activity Level (median (IQ range)) for the Chronic Ankle Instability and Healthy Groups

	CAI	Healthy
Age	21.9 ± 2.5 y	22.0 ± 2.1 y
Height	170.8 ± 8.6 cm	167.4 ± 9.1 cm
Mass	69.8 ± 11.7 kg	64.8 ± 11.2 kg
Episodes of giving way	3.0 (2.0-5.5)	0.0 (0.0-0.0)
Previous ankle sprains	3.0 (1.5-5.0)	0.0 (0.0-0.0)
NASA physical activity scale	6.5 (5.0-7.3)	6.0 (5.0-7.0)

Abbreviations: CAI, Chronic Ankle Instability; NASA, National Aeronautics and Space Administration.

Table III.2. Median, Interquartile Range and Mann-Whitney U P-Values for Health-Related Outcomes for the Chronic Ankle Instability and Healthy Groups

	CAI	Healthy	p-value
DPA	14 (11-19)	0 (0-0)	<0.001
FAAM-ADL	91 (85-93)	100 (100-100)	<0.001
FAAM-Sport	78 (69-86)	100 (100-100)	<0.001
TSK-11	18 (17-21)	13 (11-16)	<0.001
FABQ	13 (9-26)	0 (0-3)	<0.001

Abbreviations: CAI, Chronic Ankle Instability; DPA, Disablement in the Physically Active Scale; FAAM-ADL, Foot and Ankle Ability Measure-Activities of Daily Living; FAAM-Sport, Foot and Ankle Ability Measure-Sport; TSK-11, Tampa Scale of Kinesiophobia-11; FABQ, Fear-Avoidance Beliefs Questionnaire.

Table III.3. Spearman's Rho Correlations Between Health-Related Outcomes and Inclusion Criteria in the Chronic Ankle Instability Group

	DPA	FAAM-ADL	FAAM-Sport	TSK-11	FABQ
DPA	1				
FAAM-ADL	-.216	1			
FAAM-Sport	-.296	.774*	1		
TSK-11	.371	-.070	-.219	1	
FABQ	-.038	-.103	.003	.210	1
Episodes of giving way	-.043	-.029	-.088	-.389	-.010
Previous ankle sprains	.269	-.286	-.363	.018	.089
NASA physical activity scale	-.172	.014	-.143	-.267	.090

Abbreviations: DPA, Disablement in the Physically Active; FAAM-ADL, Foot and Ankle Ability Measure-Activities of Daily Living; FAAM-Sport, Foot and Ankle Ability Measure-Sport; TSK-11, Tampa Scale of Kinesiophobia-11; FABQ, Fear-Avoidance Beliefs Questionnaire; NASA, National Aeronautics and Space Administration.
*$p<0.05$

CHAPTER IV

PROJECT II: CLINICAL AND LABORATORY PREDICTORS OF HEALTH-RELATED QUALITY OF LIFE IN INDIVIDUALS WITH CHRONIC ANKLE INSTABILTIY

Introduction

Ankle sprains are common injuries experienced by physically active individuals. Approximately 23,000 sprains occur each day in the United States,[55] resulting in over $4 billion in annual aggregate health care costs. To further confound the problem, up to 70% of people who sustain a single ankle sprain experience additional ankle sprains, recurrent bouts of joint instability, and decreased health-related quality of life (HRQOL) which are the hallmark characteristics of a health condition known as chronic ankle instability (CAI).[55, 94] Therefore, the prevelance of CAI coupled with long-term consequences including degenerative joint disease, physical inactivity, and decreased HRQOL advocates for further understanding of this condition.

In comparison to individuals with no history of ankle sprains, those with CAI have reported functional deficits in activities of daily living and sports-related activities, as well as, elevated levels of injury-related fear.[51, 52, 115] Such deficits, collectively referred to as HRQOL, have been captured on a variety of generic, region-specific, and dimension-specific patient-reported outcomes (PROs). PROs are self-reported questionnaires that ask questions regarding the patient's perception of his or her condition, injury, or overall health status.[27] In people with CAI, PRO instruments such as the Short-Form-36 (SF-36),[29] Foot and Ankle Ability Measure (FAAM),[33] and Tampa Scale of Kinesiophobia-11 (TSK-11)[156] have been used to evaluate health-related quality of life. Furthermore, kinesiophobia has been reported to be the strongest single contributor to self-reported function in patients with foot and ankle pathologies.[41] While this dimension-specific aspect of function has not been extensively investigated in those with CAI, it may be critical to understanding the health condition. Therefore, generic, region-specific, and dimension-specific aspects of self-reported function require further investigation in those with CAI.

Despite the knowledge of functional loss in those with CAI, it remains unclear how the multitude of mechanical and functional impairments[55] demonstrated by these individuals contribute to the described decrements in HRQOL. The most defined areas of impairment include postural control deficits,[168] strength deficits,[169] sensory alterations,[170] and mechanical alterations.[56] While each of these areas of impairment create unique CAI-related deficits, it is likely that an interaction between impairments is responsible for this clinical phenomenon. Despite the vast amount of research examining structural and functional impairment, it remains unclear which impairment or group of impairments may contribute to the self-reported loss of function and injury-related fear in individuals with CAI. Identifying the strongest contributors to functional loss and injury-related fear may point researchers and clinicians in a direction towards a combination of interventions which may be most beneficial from the perspective of body structure and function (impairment), the person (activity), and the person in their environment (participation).

Patient perception of his or her health status is becoming increasingly recognized in health care, some would even argue that it is the most important criterion for judging the effectiveness of treatment.[100] Examining the potential relationships between measures of self-reported function and impairments in postural control, strength, sensation, and ankle mechanics may elucidate the most meaningful paths towards developing evidence-based rehabilitation strategies for those with CAI. Therefore, the purpose of this study was to identify clinician and laboratory-oriented measures of function capable of predicting PRO scores in individuals with CAI. It is hypothesized that a combination of measures will explain a significant amount of the variance associated with generic, region-specific, and dimension-specific outcomes in those with CAI.

Methods

Design

A cross-sectional design was employed for this study. Four PROs and 17 clinician and laboratory-oriented measures of function including measures of static and dynamic postural control, isometric strength, plantar cutaneous sensation, joint position sense, dorsiflexion range of motion, and ankle arthrometry were assessed during a single-testing session.

Participants

Forty physically active individuals with CAI (13 males, 27 females), were recruited from a large public university community over a one year period to participate in this study. Participants were included if they reported a score of four or greater on the National Aeronautics and Space Administration (NASA) Physical Activity Scale, reported a history of at least one or more ankle sprains, and at least one episode of "giving way" in the last three months. Additionally, all participants had to answer "yes" to five or more questions on the Ankle Instability Instrument (AII) and score less than 24 on the Cumberland Ankle Instability Tool (CAIT).[103] Participants were excluded if they had experienced any lower extremity injuries in the last six months, had a history of lower extremity surgery, or suffered from any neurological disorders that could influence balance. In the event of bilateral CAI, the ankle with the lower CAIT score was considered the involved limb for the purposes of this study. Participant characteristics are reported in Table IV.1. All participants completed an informed consent document approved by the University's Institutional Review Board.

Instrumentation

An Accusway Plus force plate (AMTI; Watertown, MA) was used to assess static postural control. Center of pressure data was sampled at 50Hz and separated into anterior-posterior (AP) and medial-lateral (ML) directions and analyzed as time-to-boundary (TTB) variables. A handheld dynamometer (MicroFET2™, Hoggan Health Industries, Inc., West Jordan, UT) was used to assess isometric strength at the ankle. A 20-piece Semmes-Weinstein Monofilament kit (Texas Medical Design, Inc., Stafford, TX) was used to evaluate plantar cutaneous sensation. Lastly, a 6-degree of freedom Hollis Ankle Arthrometer (Blue Bay Research Inc., Navarre, FL) was used to measure mechanical stability at the ankle.

Procedures

All participants reported to the laboratory for a single testing session. After agreeing to participate, participants completed two inclusionary instruments (i.e., AII and CAIT) and four PROs (i.e., Short Form-12 (SF-12), Disablement in the Physically Active Scale (DPA), Fear-Avoidance Beliefs Questionnaire (FABQ), and FAAM). Upon completion of the inclusionary and outcome instruments, participants completed seven tests to examine mechanical and functional impairments in the involved limb. Testing order for the clinician and laboratory-oriented measures were counterbalanced using a

Latin square. Individual testing procedures are described below.

Patient-Reported Outcomes

Four PRO instruments were used to measure self-reported function: the SF-12,[28] the DPA,[132] the FABQ,[38] and the FAAM.[33] The SF-12[28] is a generic health survey with physical (SF-12 PCS) and mental (SF-12 MCS) component summary scales. The DPA[132] is a generic measure of health used in the evaluation of physically active individuals with musculoskeletal injuries. DPA scores range from 0 to 64 with higher scores representing functional limitations and decreased emotional well-being. The FABQ[38] is a dimension-specific measure of health used to examine fear-avoidance beliefs. FABQ scores range from 0 to 66 with higher scores representing increased fear-avoidance beliefs. The FAAM[33] is a region-specific measure of health used to assess the physical performance of individuals with a broad range of ankle and foot musculoskeletal disorders. Comprised of two subscales the FAAM assesses physical function related to activities of daily living (FAAM-ADL) and sport (FAAM-Sport). FAAM-ADL and FAAM-Sport scores range from 0 to 100% with 100% representing normal function. All four PRO instruments have demonstrated sufficient reliability.[28, 34, 38, 132] After meeting the inclusion criteria, participants completed the paper format of the SF-12v2, 4-week recall. Upon completion of the SF-12, all other instruments were completed electronically on a laptop computer.

Static Postural Control

Participants performed three 10-second, single-limb eyes-closed trials on a force plate. Participants were instructed to remain as still as possible with their hands on their hips, and the contralateral lower extremity at 45° of knee flexion and 30° of hip flexion (Figure IV.1). TTB variables included the mean of TTB minima in the AP (TTBAP-mean) and ML (TTBML-mean) directions and the standard deviation of TTB minima in the AP (TTBAP-SD) and ML (TTBML-SD) directions. The mean of the TTB minima provides an estimate of the time a person has to make postural corrections while the standard deviation of TTB minima indicates the number of solutions used to maintain single-limb stance.[61, 171] Therefore, lower values indicate that less time was available to make postural corrections and fewer solutions were available to maintain single-limb stance, representing a more constrained sensorimotor system.[172, 173] For each measure, the mean of all three trials was used for statistical analysis. Intersession reliability for TTB variables have ranged from poor to moderate (ICC=0.40-0.75).[174]

Dynamic Postural Control

Dynamic postural control was assessed using the anterior, posteromedial, and posterolateral directions of the Star Excursion Balance Test (SEBT) (Figure IV.2). Participants were positioned and aligned with a tape measure on the floor and instructed to maintain a single-limb stance, maximally reach with the other extremity, briefly touch down at the point of maximal reach, and return to the starting position. A trial was repeated if the subject placed excessive weight on the reaching limb, moved the stance foot from the starting position, or was unable to maintain balance. The SEBT has been shown to have strong intratester and intertester reliability after controlling for learning effects, intraclass correlation coefficients (ICC) values ranged from 0.81-0.96.[175, 176] Therefore, four practice trials were performed in each direction and then three repetitions were performed and recorded.[177] Reach distances were averaged and normalized to leg length for analysis.

Isometric Strength

A handheld dynamometer was used to assess dorsiflexion, inversion, and eversion isometric strength. Subjects were positioned supine with the foot suspended off the table. All procedures were consistent with Kelln et al.[178] Intratester ICC values have ranged from 0.77-0.97.[178] Therefore, the same investigator performed all strength assessments. Subjects were instructed to ramp into a three to five second maximal effort contraction with the examiner applying unmoving resistance (Figure IV.3). Subjects performed one practice trial for each motion followed by three trials that were recorded and averaged for analysis. No significant rest periods were allotted between trials and peak force was recorded to the nearest 0.1N.

Plantar Cutaneous Sensation

Plantar cutaneous sensation was assessed at the center of the heel using Semmes-Weinstein Monofilaments (Figure IV.4). Semmes-Weinstein Monofilaments are thin nylon fibers of varying weights, which are applied perpendicular to the skin until a "C" shape is formed. Participants were instructed to verbally indicate when they felt a monofilament. Based on the participant's perceptual response, the weight of the filament was decreased or increased in accordance with a 4-2-1 stepping algorithm[179] until the lowest detectable weight was determined. Higher detection thresholds represent decreased sensitivity. The lowest weighted filament detected by each subject was included in the statistical analysis.

Joint Position Sense

The participant was positioned supine on an evaluation table with a bubble inclinometer secured to the lateral aspect of the foot using two velcro straps (i.e., one strap around the head of the fifth metatarsal and the second around the mid-shaft) (Figure IV.5). The examiner placed the ankle into 10° of plantarflexion using a standard goniometer and then instructed the subject to close their eyes and concentrate on that position. After five seconds, the examiner instructed the subject to move the ankle through the entire range of motion and then indicate when they had returned to the preset position. Each participant completed one practice trial to allow for familiarization with the testing procedure. The absolute number of degrees deviated from three test trials was averaged for analysis.

Dorsiflexion Range of Motion

The Weight Bearing Lunge Test for dorsiflexion range of motion (Figure IV.6) was performed using the knee-to-wall principle.[180] Participants were positioned facing a wall, with their foot perpendicular to the wall, and their heel firmly planted. Participants were instructed to lunge forward until contact was made between the anterior knee and the wall while the calcaneous remained firmly planted on the ground. A tape measure on the floor was used to measure the distance between the great toe and the wall providing a measure of dorsiflexion in centimeters. Three trials of the farthest distance from the wall in which the subject made contact and the calcaneous remained planted on the ground were recorded and used for analysis. The Weight-Bearing Lunge Test has demonstrated excellent intertester and intratester reliability (ICC=0.97-0.99).[181]

Ankle-Subtalar Joint Stability

Using previously described methods[182] to assess ankle-subtalar joint stability, AP and inversion-eversion (IE) loads were applied using an instrumented arthrometer (Figure IV.7). The involved ankle was loaded to 125N anteriorly immediately followed by a load of 125N in the posterior direction. After three AP trials were collected 4,000Nm of torque was applied during inversion immediately followed by 4,000Nm of eversion. Three trials were carried out for each direction by the same investigator, averaged and used for analysis. High ICC values (0.91-0.99) have been reported for intratester ankle arthrometry.[183]

Statistics

Six separate backward multiple linear regression analyses were conducted with each PRO serving as the criterion variable and the clinician and laboratory-oriented measures serving as predictor variables. The backward regression method was selected due to the limited amount of theoretical literature available. All outliers ±3 standard deviations away from the mean were removed from the data set. To reduce the number of predictor variables, Pearson product moment correlations were performed between criterion and predictor variables (Table IV.4). All predictors that had an r-value of $r \geq 0.200$ were considered for each model. Additionally, Pearson correlations were performed between predictor variables to account for collinearity (Table IV.5). In the event that predictor variables were highly correlated ($r \geq 0.700$), the predictor with the greatest correlation coefficient with the criterion variable was selected for the final model. For a summary of the variable selection process consult Figure IV.8. Significance was set a priori at $p<0.05$. Cohen's f^2 was used to estimate the effect size of the models. Effect size strengths were interpreted as small (0.02-0.14), medium (0.15-0.34), and large (≥0.35).[184] Descriptive statistics were calculated as mean ± standard deviation for all variables except for plantar cutaneous sensation index values in which median and range were used. All statistical analyses were conducted with SPSS Version 21.0 (SPSS, Inc., Chicago, IL).

Results

Forty subjects with CAI completed the study. Descriptive statistics for criterion and predictor variables are reported in Tables IV.2 and IV.3, respectively. Correlation coefficients between predictor and criterion variables are reported in Table IV.4 and correlation coefficients between predictors are reported in Table IV.5 All six backward regression models are summarized with effect sizes in Table IV.6. Plantar cutaneous sensation and dorsiflexion range of motion were significant predictors of SF-12 PCS scores, explaining 37% of the variance. No significant predictors were observed for SF-12 MCS scores (p=0.10). TTBAP-SD, SEBT-posterolateral reach distance, and posterior joint laxity were significant predictors of DPA scores, explaining 32% of the variance. TTBAP-MM, anterior joint laxity, and eversion rotation were significant predictors of FABQ scores, explaining 56% of the variance. TTBAP-MM and SEBT-posterolateral reach distance were significant predictors of FAAM-ADL scores, explaining 37% of the variance. TTBAP-MM and eversion rotation were significant predictors of FAAM-Sport scores, explaining 20% of the variance. Cohen's f^2 effect sizes ranged from small to large (0.08-0.56). All of the regression models had variance inflation factors less than ten, indicating no multicollinearity.

Discussion

The purpose of this study was to identify clinician and laboratory-oriented measures of function capable of predicting PRO scores in individuals with CAI. As hypothesized, the results of this study indicate that a combination of CAI impairments explain a significant amount of the variance in generic, dimension-specific, and region-specific PROs. This was supported by the strong effect size exhibited in three of the six models. Of the seven CAI impairment areas investigated, only five (i.e., static postural control, dynamic postural control, dorsiflexion range of motion, plantar cutaneous sensation, and ankle arthrometry) significantly contributed to the majority of the PRO scores. Although a combination of variables contributed to physical components of generic and region-specific function and fear-avoidance beliefs, no significant predictors were identified for the mental component of the SF-12.

While several clinical and laboratory measures accounted for a significant amount of the variance associated with PRO scores it is important to consider the overall strength of the models. The strongest model produced was for the FABQ with an effect size of 0.56. This is not surprising as limitations in physical function have been associated with elevated levels of fear in patients with patellofemoral[40] and low back pain.[185, 186] The SF-12 PCS and FAAM-ADL models were also strong with an effect size of 0.37. The DPA and FAAM-Sport models exhibited medium effects of 0.32 and 0.20, respectively. The weaker effects exhibited by the DPA and FAAM-Sport models could be attributed to the immeasurable factors that play a role in sport activities. For example, the questionnaires did not address specific agility tasks or the ability to perform dynamic activities at high speeds. Moreover, the DPA scale contains four items that incorporate quality of life components much like the SF-12 MCS that demonstrated a weak effect. Overall, the medium to strong effects observed for the significant models indicate that postural control, plantar cutaneous sensation, and mechanical aspects of function, such as dorsiflexion range of motion and joint laxity, should be taken into consideration when treating individuals with CAI.

With added emphasis on evidence-based practice in athletic training and sports medicine,[22, 23] this study was designed to promote the combined engagement of patient, clinician, and laboratory-oriented evidence (i.e., the PCL Model).[187] In previous investigations,[51, 115] individuals with CAI have reported functional insufficiencies, elevated levels of injury-related fear, and decreased HRQOL on patient-oriented assessments. Additionally, those with CAI have exhibited functional and mechanical impairments on clinician-oriented and laboratory-oriented assessments.[55] The results of this study highlight the multifactorial biopsychosocial nature of CAI as a combination of functional and mechanical impairments contributed to the individuals' perceptions of function and fear as measured by the PROs.

To our knowledge this is the first study to identify clinician and laboratory-oriented contributors to PROs in individuals with CAI. Our findings indicate that a unique combination of clinician-oriented and laboratory-oriented measures contributed to the PRO scores in this sample of individuals with CAI. Clinician-oriented measures (i.e., plantar cutaneous sensation, Weight-Bearing Lunge Test, and SEBT) contributed to SF-12 PCS, DPA, and FAAM-ADL scores, whereas laboratory-oriented measures (i.e., TTB measures of postural control and instrumented arthrometry) contributed to DPA, FABQ, FAAM-ADL, and FAAM-Sport scores. Furthermore, none of the measures significantly contributed to SF-12 MCS scores suggesting that other factors, such as injury history, access to rehabilitation, social support, gender, or age, may influence the individual's mental health and well-being. These findings reiterate the importance of whole-person health care and suggest an integration of treatment strategies to improve patient outcomes.

Although a combination of factors play a role in CAI,[55] the results of this study expose the overlap between patient, clinician, and laboratory-oriented evidence. Knowing that unique aspects of postural control, dorsiflexion range of motion, plantar cutaneous sensation, and ankle arthrometry contribute to 17-36% of the variance associated with PRO scores, such factors should be taken into consideration when treating patients with CAI. Implementing evidence-based treatment strategies to target the physical impairments known to contribute to PRO scores may in turn improve function and overall quality of life.

Clinical Implications

Previous rehabilitation protocols[63, 188] for CAI have included comprehensive strategies to negate the various mechanical and functional impairments associated with the condition. The findings of this investigation highlight rehabilitation targets that may contribute to the disablement experienced by the individual. A variety of rehabilitation techniques have been proposed to influence the five clinician and laboratory measures of function identified as predictors of PRO scores in this study. Figure IV.9 depicts the clinician and laboratory-oriented impairments identified in this investigation, with suggested rehabilitation techniques, and tests for periodic evaluation.

Various rehabilitation strategies[188, 189] have been utilized to modify the physical impairments associated with CAI. The information obtained in this study supports interventions proposed to improve postural control, sensation, mechanical restrictions, and joint stability. Balance exercises,[54, 63, 190] foot orthotics,[191, 192] plantar massage,[193] joint mobilizations,[62] taping,[116] and bracing[194] have all been employed to treat such impairment areas. More importantly, there is evidence to support the use of balance exercises,[61] foot orthotics,[191] and joint mobilizations[62] to improve self-reported function. To date, no studies have examined the combination of these interventions. Therefore, balance-training, foot orthotics, and joint mobilization interventions should be strategies considered for CAI rehabilitation programs.

Although there are a variety of strategies to influence the functional and mechanical impairments associated with CAI it is imperative to consider the unique needs of the individual patient as evidence-based practice is the integration of clinician expertise, the best available evidence, and patient values.[25] Thus, if a patient does not report elevated levels of fear or functional limitations on a PRO, the aforementioned intervention strategies may be futile. Additionally, clinicians need to consider the PRO deficits reported by the individual and aim to address the contributing impairments based on the evidence provided here and in future literature. Furthermore, patient-oriented, clinician-oriented, and laboratory-oriented measures, when accessible, should be evaluated periodically to monitor patient progress and formulate treatment modifications as needed.

Limitations

As with any study, it is important to acknowledge limitations. First, there are an assortment of environmental and personal factors, such as injury history or additional health ailments, that could influence physical function and PRO scores. Second, the data sample was collected from physically active individuals between the ages of 18 and 42, thus the results are not applicable to sedentary, adolescent, or elderly populations of individuals with CAI. Also, although the FAAM and SF-12 scores were representative of other CAI studies,[34, 51] the other PROs have not been thoroughly examined in this population and therefore it is unknown if the scores observed for the DPA or FABQ are generalizable to others with CAI. Lastly, this study only addressed well-established CAI impairments. There are other components more proximal in the kinematic chain that may contribute to the impairments associated with CAI. In addition, factors such as rehabilitation compliance may influence the multifaceted condition. Future investigations may consider examining the results in specific subgroups, such as those with and without a history of rehabilitation, and investigating the influence of other potential contributing factors which may be present throughout the lower extremity. Additional research efforts should assess the accuracy of the models by observing the influence of rehabilitation techniques, aimed at targeting the identified predictors, on PRO scores.

Conclusions

In conclusion, measures of postural control, dorsiflexion range of motion, plantar cutaneous sensation, and ankle arthrometry contributed to a significant proportion of the variance associated with PRO scores in those with CAI. Although a combination of factors play a role in CAI, the results of this study expose the overlap between patient, clinician, and laboratory-oriented evidence. Consequently, knowing that clinician and laboratory measures of function contribute to a proportion of the variance associated with PROs accentuates the value of evidence-based practice. Therefore, utilizing rehabilitation strategies that focus on the functional and mechanical impairments known to contribute to PRO scores may in turn improve physical function and overall quality of life in individuals with CAI. Other variables should be examined to address mental components of health-related quality of life, as there were no significant predictors for SF-12 MCS scores.

Acknowledgement

This study was supported by the Mid Atlantic Athletic Trainers' Association. The investigators would also like to thank Michael Gabriner and Jessica Kirby for their assistance with data collection on this project.

Table IV.1. Participant Characteristics and Inclusionary Criteria.

	Mean ± SD
Age	23.3±4.8 y
Height	168.9±9.2 cm
Mass	72.0±14.4 kg
NASA Physical Activity Scale	6.7±1.7
Previous Ankle Sprains	3.5±1.6
Episodes of "Giving Way" in the Last 3 Months	5.9±7.9
Time Since Last Significant Ankle Sprain	23.6±22.7 months
Ankle Instability Instrument Yeses	6.6±1.4
Cumberland Ankle Instability Tool Score	16.3±4.6

Table IV.2. Descriptive Statistics for the Health-Related Quality of Life Measures.

Criterion Variable	Mean ± SD
Short Form-12 Physical Component Score	56.2±4.7
Short Form-12 Mental Component Score	52.9±5.3
Disablement in the Physically Active Scale	12.2±10.6
Fear-Avoidance Beliefs Questionnaire	19.0±11.4
Foot and Ankle Ability Measure-Activities of Daily Living	86.1±11.8 %
Foot and Ankle Ability Measure-Sport	71.3±17.5 %

Table IV.3. Descriptive Statistics for the Clinician and Laboratory-Oriented Measures of Function.

Predictor Variable	Mean ± SD or Median (IQ Range)
Static Postural Control	
TTBML-MM	0.8±0.2 s
TTBAP-MM	2.2±0.6 s
TTBML-SD	0.7±0.2 s
TTBAP-SD	1.4±0.4 s
Dynamic Postural Control	
SEBT-Anterior Reach Distance	81.2±5.5 %
SEBT-Posteromedial Reach Distance	90.4±8.8 %
SEBT-Posterolateral Reach Distance	80.7±11.2 %
Isometric Strength	
Dorsiflexion	89.8±39.1 N
Inversion	89.7±42.2 N
Eversion	87.4±36.9 N
Plantar Cutaneous Sensation	4.08 (3.61-5.46)
Joint Position Sense	5.6±2.8°
Dorsiflexion Range of Motion	7.8±3.5 cm
Ankle Arthrometry	
Anterior Joint Laxity	8.4±2.3 mm
Posterior Joint Laxity	4.5±2.0 mm
Inversion Rotation	30.9±6.4°
Eversion Rotation	20.3±4.4°

Abbreviations: SEBT, Star Excursion Balance Test; TTBML-MM, Time-to-boundary mean minima for the medial-lateral direction; TTBAP-MM, Time-to-boundary mean minima for the anterior-posterior direction; TTBML-SD, Time-to-boundary standard-deviation of mean minima for the medial-lateral direction; TTBAP-SD, Time-to-boundary standard deviation of mean minima for the anterior-posterior direction.

Table IV.4. Correlation Coefficients Between Predictor and Criterion Variables.

	SF-12 PCS	SF-12 MCS	DPA	FABQ	FAAM-ADL	FAAM-S
TTBML-MM	0.068	0.119	-0.078	-0.177	0.166	-0.047
TTBAP-MM	0.065	0.151	-0.239*	**-0.328***	**0.290***	**0.243***
TTBML-SD	0.052	0.181	-0.031	-0.094	0.134	-0.086
TTBAP-SD	0.007	0.103	**-0.264***	-0.242*	0.279*	0.163
SEBT-Anterior Reach	0.015	0.016	0.010	-0.037	0.065	0.105
SEBT-Posteromedial Reach	0.156	-0.021	-0.233*	0.007	0.283*	0.154
SEBT-Posterolateral Reach	0.102	-0.080	**-0.278***	-0.016	**0.433***	0.185
Dorsiflexion Strength	0.151	0.051	-0.032	0.050	0.096	-0.064
Inversion Strength	0.087	0.021	-0.009	-0.077	0.039	-0.132
Eversion Strength	**0.202***	-0.114	-0.072	-0.126	0.077	-0.036
Plantar Cutaneous Sensation	**-0.288***	**0.205***	-0.015	0.055	-0.016	-0.165
Joint Position Sense	-0.050	0.157	0.063	0.167	0.008	-0.150
Dorsiflexion Range of Motion	**0.384***	-0.005	0.007	0.106	0.158	**0.207***
Anterior Joint Laxity	0.069	0.073	**0.202***	**0.242***	-0.129	0.014
Posterior Joint Laxity	0.105	**-0.267***	**0.227***	0.016	0.016	-0.002
Inversion Rotation	0.140	-0.120	0.049	**-0.207***	0.004	0.090
Eversion Rotation	0.032	-0.020	-0.035	**-0.294***	0.058	**0.248***

Abbreviations: DPA, Disablement in the Physically Active Scale; FAAM, Foot and Ankle Ability Measure: ADL, Activities of Daily Living and S, Sport; FABQ, Fear-Avoidance Beliefs Questionnaire; SEBT, Star Excursion Balance Test; SF-12, Short Form-12: PCS, Physical Component Summary and MCS, Mental Component Summary; TTBML-MM, Time-to-boundary mean minima for the medial-lateral direction; TTBAP-MM, Time-to-boundary mean minima for the anterior-posterior direction; TTBML-SD, Time-to-boundary standard-deviation of mean minima for the medial-lateral direction; TTBAP-SD, Time-to-boundary standard deviation of mean minima for the anterior-posterior direction.

*Met r-value criteria of $r \geq 0.200$

Variables entered into the regression model are **bold**.

Table IV.5. Pearson Product Moment Correlation Coefficients Between Predictor Variables.

	TTBML-MM	TTBAP-MM	TTBML-SD	TTBAP - SD	SEBT-Ant	SEBT-Pm	SEBT-Pl	Df. Strength	Inv. Strength	Ev. Strength	Pl. Cut. Sen.	JPS	Df. ROM	Ant. Laxity	Post. Laxity	Inv. Rotation
TTBAP-MM	0.587															
TTBML-SD	0.833*	0.250														
TTBAP-SD	0.532	0.921*	0.160													
SEBT-Ant.	-0.144	-0.117	-0.144	-0.132												
SEBT-PM	-0.116	-0.118	-0.115	-0.075	0.532											
SEBT-PL	-0.085	0.030	-0.176	0.053	0.444	0.818*										
Df. Strength	0.331	-0.098	0.398	-0.074	0.155	0.290	0.183									
Inv. Strength	0.375	0.092	0.399	0.137	0.085	0.350	0.219	0.837*								
Ev. Strength	0.207	-0.069	0.304	-0.054	0.029	0.402	0.203	0.742*	0.863*							
Pl. Cut. Sen.	0.036	-0.207	0.105	-0.123	-0.251	-0.123	-0.073	-0.073	-0.136	-0.054						
JPS	0.211	0.097	0.001	0.209	0.268	0.233	0.255	0.292	0.355	0.224	0.253					
Df. ROM	0.064	-0.006	0.013	0.036	0.293	0.258	0.201	0.433	0.286	0.182	0.062	0.283				
Ant. Laxity	0.010	-0.075	-0.011	-0.049	0.072	-0.056	-0.191	0.265	0.068	0.021	-0.164	-0.099	0.215			
Post. Laxity	-0.223	0.159	-0.329	0.122	-0.09	-0.136	0.078	-0.414	-0.243	-0.310	0.004	0.016	-0.093	-0.037		
Inv. Rotation	-0.038	0.010	-0.066	0.011	0.402	0.200	0.082	0.328	0.348	0.313	-0.237	0.060	0.404	0.386	0.016	
Ev. Rotation	-0.274	-0.261	-0.327	-0.219	0.224	0.092	-0.039	-0.054	-0.045	0.112	0.024	0.093	0.182	0.205	0.006	0.474

Abbreviations: Ant, Anterior; Df, Dorsiflexion; Ev, Eversion; Inv, Inversion; JPS, Joint Position Sense; Pl Cut Sen, Plantar Cutaneous Sensation; PL, Posterolateral; PM, Posteromedial; Post, Posterior; ROM, Range of Motion; SEBT, Star Excursion Balance Test; TTBML-MM, Time-to-boundary mean minima for the medial-lateral direction; TTBAP-MM, Time-to-boundary mean minima for the anterior-posterior direction; TTBML-SD, Time-to-boundary standard-deviation of mean minima for the medial-lateral direction; TTBAP-SD, Time-to-boundary standard deviation of mean minima for the anterior-posterior direction.

*Correlation coefficient ≥0.700

Table IV.6. Backward Regression Model Summaries.

Regression Model	**R^2**	**p-value**	**Cohen's f^2**	**N**
SF-12 PCS Eversion Strength, Plantar Cutaneous Sensation*, Dorsiflexion ROM*	0.27	0.005	0.37	38
SF-12 MCS Plantar Cutaneous Sensation, Posterior Joint Laxity	0.07	0.100	0.08	39
DPA TTBAP-SD*, SEBT-Posterolateral*, Anterior Joint Laxity, Posterior Joint Laxity*	0.24	0.020	0.32	39
FABQ TTBAP-MM*, Anterior Joint Laxity*, Inversion Rotation, Eversion Rotation*	0.36	0.001	0.56	39
FAAM-ADL TTBAP-MM*, SEBT-Posterolateral*	0.27	0.004	0.37	39
FAAM-Sport TTBAP-MM*, Dorsiflexion ROM, Eversion Rotation*	0.17	0.040	0.20	39

Abbreviations: DPA, Disablement in the Physically Active Scale; FAAM, Foot and Ankle Ability Measure: ADL, Activities of Daily Living and S, Sport; FABQ, Fear-Avoidance Beliefs Questionnaire; ROM, Range of Motion; SEBT, Star Excursion Balance Test; SF-12, Short Form-12: PCS, Physical Component Summary and MCS, Mental Component Summary; TTBAP-MM, Time-to-boundary mean minima for the anterior-posterior direction; TTBAP-SD, Time-to-boundary standard deviation of mean minima for the anterior-posterior direction.

*Significant predictor at 0.05 level

Figure IV.1. Eyes-Closed Single Limb Stance for Static Postural Control.

Figure IV.2. Anterior, Posteromedial, and Posterolateral Reach Directions for the Star Excursion Balance Test.

Figure IV.3. Investigator Providing Unmoving Resistance for Dorsiflexion Strength.

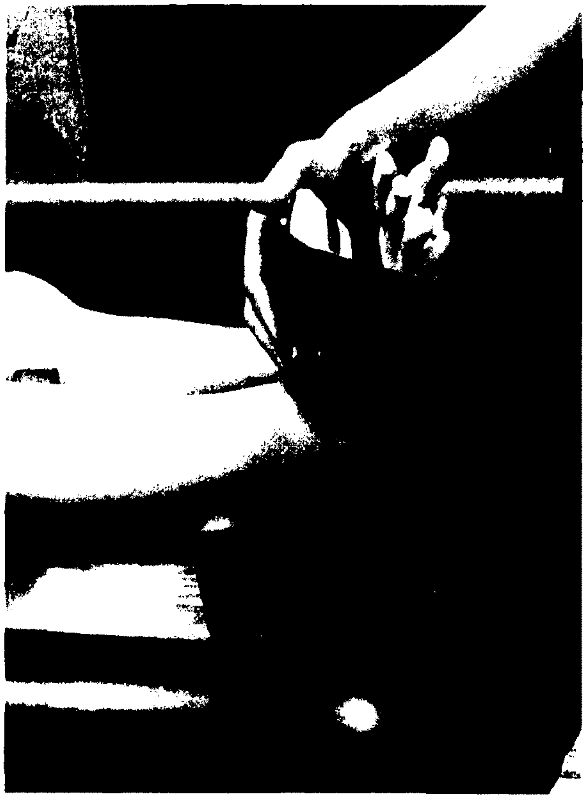


Figure IV.4. Test Site for Plantar Cutaneous Sensation Using Semmes-Weinstein Monofilaments.

Figure IV. 5. Inclinometer Placement for Joint Position Sense Testing.

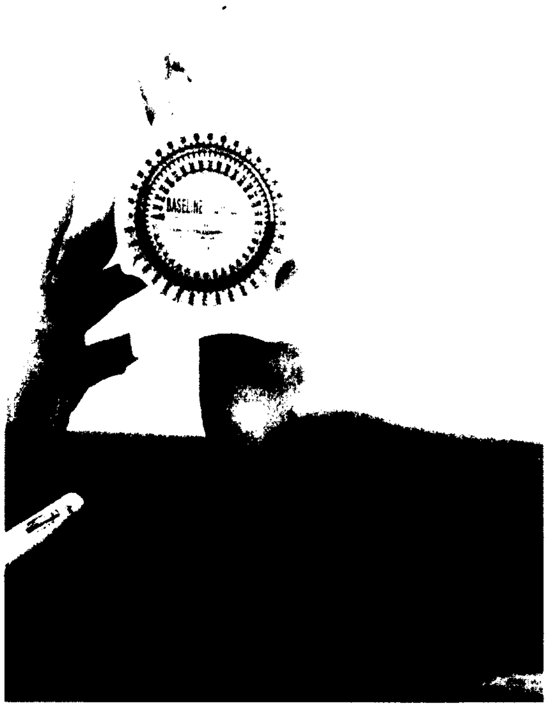


Figure IV.6. Weight-Bearing Lunge Test to Assess Dorsiflexion Range of Motion.

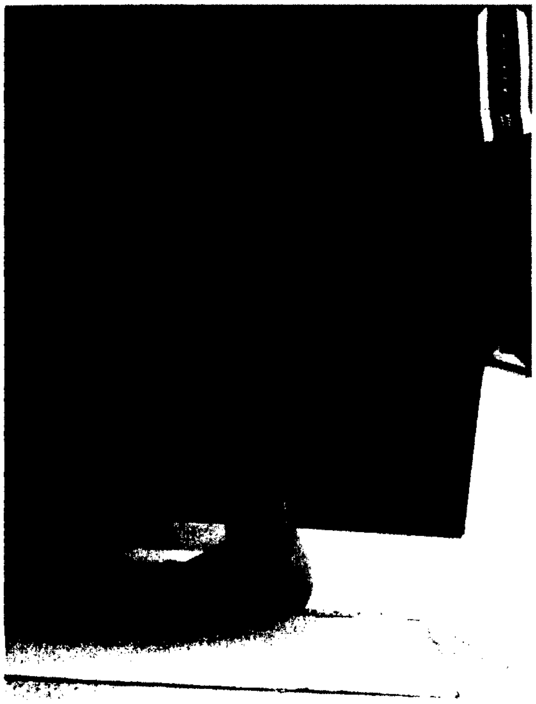


Figure IV.7. Instrumented Ankle Arthrometer Used to Assess Anterior-Posterior Displacement and Inversion-Eversion Rotation.

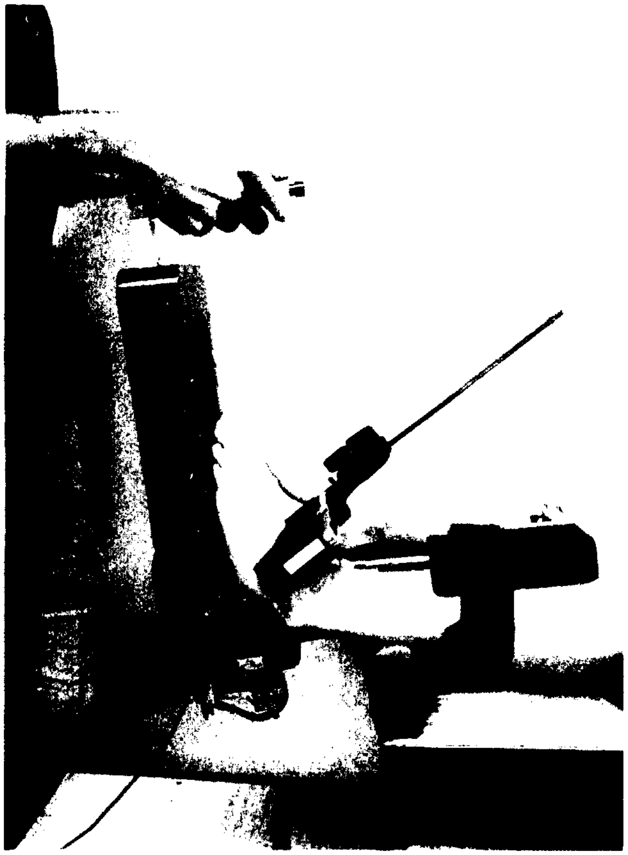


Figure IV.8. Summary of the Variable Selection Process for Multiple Regression.

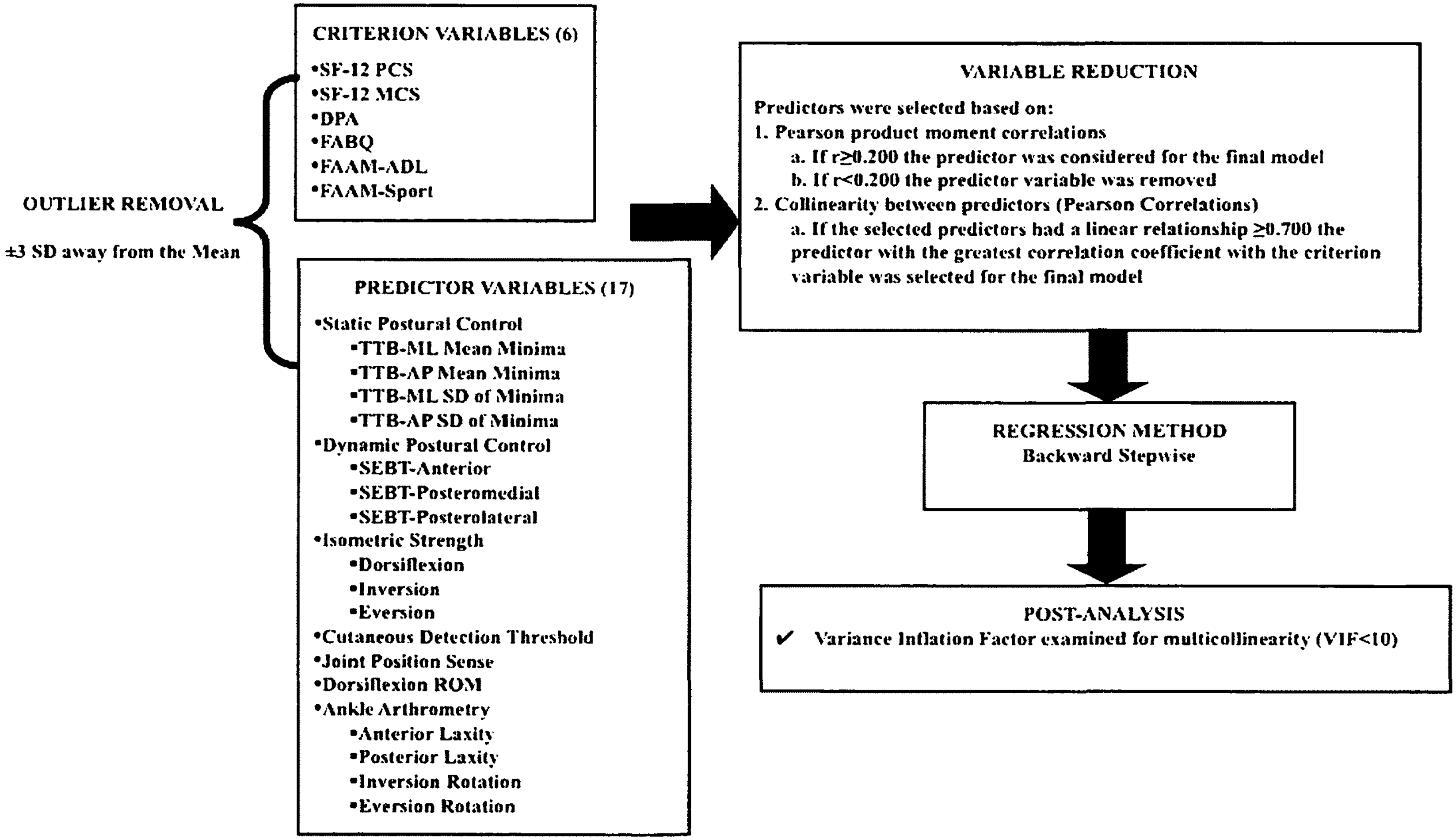


Figure IV.9. Evidence-Based Rehabilitation Strategies for Individuals with Chronic Ankle Instability.

PREDICTORS OF HRQOL	REHABILITATION STRATEGIES	PERIODIC ASSESSMENT
Dynamic Balance ***SEBT-PL:*** **DPA, FAAM-ADL**	**Balance Exercises** **Foot Orthotics**	**Star Excursion Balance Test**
Static Balance ***TTBAP-SD:*** **DPA** ***TTBAP-MM:*** **FABQ, FAAM-ADL & Sport**	**Balance Exercises** **Foot Orthotics**	**Force Plate**
Plantar Cutaneous Sensation **SF-12 PCS**	**Plantar Massage**	**Semmes-Weinstein Monofilaments**
Dorsiflexion ROM **SF-12 PCS**	**Joint Mobilizations** **Stretching**	**Weight-Bearing Lunge Test**
Ankle Arthrometry ***Anterior Laxity:*** **FABQ** ***Posterior Laxity:*** **DPA** ***Inversion Rotation:*** **FABQ, FAAM-Sport**	**Taping** **Bracing**	**Ankle Arthrometer**

CHAPTER V

PROJECT III: HEALTH-RELATED QUALITY OF LIFE ASSESSMENT IN COLLEGIATE ATHLETES

Introduction

Participation in National Collegiate Athletic Association (NCAA) athletics has drastically increased in the past decade.[9] While participation in athletics is generally associated with significant benefits, approximately 750,000 injuries occur each year during participation.[195] Following injury, an individual experiences a myriad of insufficiencies that encompass both physical and psychosocial aspects of health. Encompassing social, physical, and psychological health components, health-related quality of life (HRQOL) is a multi-dimensional approach to health care that has become an important component of health surveillance.[26] Utilizing HRQOL measures in athletic training clinical practice enhances the clinician's ability to incorporate the patient's values and perspectives; a vital component to the evidence-based practice (EBP) model.[23] Effective practitioners of EBP incorporate the best available evidence, clinical expertise, and the patient's values and perspectives into treatment decisions.[25]

As health care professionals, it is vital we incorporate EBP into the treatment of our patients in the athletic training clinic to improve patient outcomes.[23] One area of major focus in the field of athletic training is the incorporation of patient-oriented outcome measures. Patient-oriented outcomes focus on aspects of health which are more meaningful to the patient and often utilize survey instruments, specifically patient-reported outcome (PRO) instruments, to solicit the patient's perception of health status.[23]

PROs can be used to further our understanding of the short- and long-term consequences of injury and the effects of rehabilitation strategies.

PROs that measure HRQOL address functioning in everyday life and evaluate personal well-being. Generic questionnaires, such as the Short-Form-36 (SF-36)[29] and Pediatric Outcomes Data Collection Instrument (PODCI)[30] capture a broad range of health status outcomes. However, very few studies have compared HRQOL scores between healthy collegiate athletes and those with a history of injury.[32, 80] Recent evidence measuring HRQOL with these PROs has suggested a decrease in HRQOL in adolescent and collegiate athletes with a recent or serious injury compared to their uninjured counterparts.[31, 32] However, both the SF-36 and PODCI were designed for use in the general population and may not be appropriate instruments for use in athletes. Knowing that athletes exhibit better HRQOL[32, 80, 81] on these instruments it is imperative to investigate the utility of other instruments in an athletic population.

The Disablement in the Physically Active Scale (DPA),[196] a population-specific PRO, was developed by athletic trainers to evaluate constructs of disability in physically active populations. However, DPA data in collegiate athletes is limited[132] and the structure of the scale has not been examined for individual factors that may represent subscales. Other PROs, such as the SF-36 and PODCI, contain subscales with composite scores for physical health or pain and comfort. A better understanding of HRQOL in collegiate athletes via the DPA could provide researchers with insight regarding the patient's functional status and psychosocial well-being that may need to be addressed during recuperation from injury. Furthermore, injury-related fear questionnaires, such as the Fear-Avoidance Beliefs Questionnaire (FABQ),[38] have been used to evaluate the presence of fear or other associated psychological barriers following physical impairment. For example, injury-related fears have been heightened in individuals with patellofemoral pain[161] and post ACL-reconstruction,[162] as well as, in acutely injured athletes.[44] Although injury-related fears appear to decrease as acutely injured athletes recover,[44] it is unclear what role fear may play beyond the acute phase of injury. Examining disablement and injury-related fear in an athletic population may expose social, physical, or psychological differences between injured and non-injured athletes. Using a combination of these types of instruments may allow athletic trainers to improve the quality of care provided by identifying HRQOL deficits that could hinder the recovery process following injury.

While the DPA scale includes items designed to assess impairment, functional limitations, disability, and quality of life,[132] the scale has yet to be analyzed for summary components. Additionally, the relationship between the DPA and FABQ in those with a history of injury is unknown. Lastly, the literature has yet to determine the influence of injury history, participation status, time since last injury, and injury severity on DPA and FABQ scores. Therefore, our primary objective was to collect injury history information and measures of HRQOL in collegiate athletes to address the following aims: (1) to analyze the scale structure of the DPA, (2) to examine the relationship between the DPA and FABQ in collegiate athletes with a history of injury, and (3) to compare HRQOL in collegiate athletes based on injury history, participation status, time since last injury, and injury severity. We hypothesized that (1) subscales associated with specific disablement components would be identified within the existing structure of the DPA, (2) the DPA would strongly correlate to FABQ scores in collegiate athletes with a history of injury, and (3) athletes would exhibit HRQOL deficits based on factors such as injury history, participation status, time since injury, and injury severity.

Methods

Design

This study employed a cross-sectional design. All participants were asked to complete a packet that contained an injury history form and two PRO instruments during a single collection session. Independent variables included injury history, participation status, time since last injury, and injury severity and dependent variables included DPA and FABQ scores.

Participants

Four hundred and sixty-seven collegiate athletes (199 males, 268 females; 19.5±1.3 years, 173.9±10.5 cm, 71.9±13.6 kg) were recruited from two large public universities and one small private college over a six month period to participate in this study. Participants were included if they were an NCAA athlete eligible to compete during the 2013-2014 season. Athletes were included regardless of participation status, however, athletes participating in club or recreational sports were excluded. The population sampled **contained athletes from 17 different NCAA sports competing at Division I and Division III institutions. Athletic participation and class information are reported in Table V.1. Athletes ranged from freshman to 5th year seniors with a lifetime participation average of 10.4±4.0 years in their respective sport.** The study was approved by each University's Institutional Review Board and voluntary completion of the study packet was deemed consent to participate.

Procedures

The investigators attended team meetings and practices to recruit participants. During the data collection session, the athletes were asked to review a cover letter and upon agreeing to participate complete an injury history form and two PROs. Following completion of the injury history form, participants completed the DPA and FABQ in a counterbalanced order. Participants were instructed to complete both PROs as instructed by the instrument's directions. Participants required approximately 15 minutes to complete the injury history form and PROs .

Injury History Form

The injury history form (Appendix A) captured basic demographic, injury history, and athletic participation information. Demographic information was self-reported and included age, gender, year in school, height, and weight. Pertinent injury information included past history with a brief description that included time loss, time since most recent injury, and injury severity for the most recent injury. No time restrictions were instituted for injury history, participants were instructed to report any injury that they could recall over the course of their lifetime. Participation information included current participation status, sport, NCAA division of competition, and total years of participation in their current sport. If participants did not complete the injury history table but both PROs were complete, it was assumed the participant had no history of injury. In the event that the participant did not complete a question or provided a subjective answer the following procedures were employed:

- Participants that did not answer "yes" or "no" to "Are you currently injured?" were categorized as "no" (i.e., uninjured) if the most recent injury reported was greater than six weeks ago and they answered "yes" to "Are you currently participating?".

- Participants that did not answer "yes" or "no" to "Are you currently participating?" were categorized as "yes" (i.e., participating) if they answered "no" to "Are you currently injured?".
- If the participant reported "multiple" or "a few" for injury quantity or time loss, the investigators recorded the response as two.
- If a participant reported "a season" or "a practice" for time loss, the investigators recorded a season as three months and a practice as one day.
- If the participant reported a range for injury quantity (i.e., 3-4 ankle sprains) or time loss (i.e., 2-3weeks), the minimum was recorded for injury quantity and the maximum was used for time loss.

Disablement in the Physically Active Scale

The DPA[132] is a generic outcome instrument designed by athletic trainers for physically active individuals. The multidimensional scale is rooted in both current disablement and HRQOL paradigms. The 16-item scale contains questions related to impairment, functional limitations, disability, and quality of life. Responses are based on a 5-point Likert scale, where one indicates that a patient does not have a problem with the listed item and five indicates that a patient is severely affected by the problem.[132] Each item is weighted equally, and DPA scores range from 0 to 64. All 16-items are tallied and then 16 points are subtracted from the final tally, to make zero the floor. Higher scores indicate functional limitations and decreased emotional well-being. High test-retest reliability (ICC=0.943) and internal consistency (α=0.890-0.908) values have been reported for the DPA.[132] The DPA is open access and no license is required.

Fear-Avoidance Beliefs Questionnaire

The FABQ[38] is a dimension-specific outcome instrument designed to assess fear-avoidance beliefs. The questionnaire consists of 16 items subdivided into two scales, the FABQ-Physical Activity (FABQ-PA) and the FABQ-Work (FABQ-W). To apply the FABQ in athletes, we used adaptation methods as described by van Baar et al.[197] The term 'back' was changed to 'injury' and the term 'work' to 'sport' throughout the form. Items are scored on a 7-point Likert scale from 0 to 6. Patient options range from 'completely disagree' to 'completely agree'. FABQ scores range from 0 to 66 with higher scores representing increased fear-avoidance beliefs. High test-retest reliability (ICC=0.77-0.90) and internal consistency (Cronbach α=0.70-0.89) have been reported for the instrument in patients with low back pain.[159] Similarly, in patients with patellofemoral pain, Cronbach alpha values of the FABQ-PA and FABQ-W were 0.72 and 0.89, respectively.[40] The FABQ is open access and no license is required.

Statistical Analyses

All statistical analyses were conducted with SPSS Version 21.0 (SPSS, Inc., Chicago, IL). Missing nominal values were deleted listwise on a test-to-test basis. Missing values for the DPA and FABQ were treated conservatively and replaced with the mean value for the individual participant if fewer than 20% of the items were missing. Participants missing more than 20% of their DPA or FABQ items were removed from analyses involving those PROs.

Using all participants, a principal component analysis was conducted on the 16 items of the DPA with oblique rotation (promax). The oblique rotation was selected due to the expected correlations between variables as the items were from the same instrument. The Kaiser-Meyer-Olkin measure was used to verify sampling adequacy (KMO>0.5) and Bartlett's test of sphericity ($p<0.05$) was used to justify that the correlations between the items were suitable for principal component analysis. Factors with eigenvalues greater than Kaiser's criterion of 1 that explained greater than 5% of the variance were retained. Additionally, the scree plot was checked for points of inflexion. Cronbach's alpha values were calculated to examine internal consistency within subscale components identified by the analysis.

For all other analyses, nonparametric tests were employed as an initial Kolmogorov-Smirnov test indicated that all dependent variables violated the assumption of normality ($p<0.001$). Spearman's Rho correlations were used to examine relationships between the DPA, or any identified DPA subscale, and the FABQ in athletes with a history of injury. Correlation coefficients (r_s) were interpreted as weak (0.01-0.39), moderate (0.40-0.69), and strong (0.70-1.0).[160] The coefficients of determination (R^2) were examined for each correlation to determine the percent of variance explained.

Lastly, separate Kruskal-Wallis tests were used to compare DPA and FABQ outcomes in athletes based on injury history (currently injured, history of injury, or no history of injury), participation status (full participation, participating injured, or not participating due to injury), time since last injury (less than six weeks, six weeks to one year, one year to five years, or greater than five years), and injury severity (no time loss, mild, moderate, or severe). For injury severity, the most recent injury reported and the most severe injury in their history were categorized for analyses. Injury severity was classified with respect to recovery time before return to sport participation (no time loss

(0 days), mild (<8 days), moderate (8-21 days), or severe (>21 days)).[75] Additionally, the athlete's perception of injury severity (i.e., mild, moderate, severe) was used to categorize their most recent injury. Alpha was set a priori at $p<0.05$ for all analyses. In the event of significant Kruskal-Wallis tests, Mann-Whitney U tests were performed to determine where group differences occurred. A p-value correction was used to account for multiple comparisons ($p<0.017$). For Mann-Whitney U tests, the z value was used to estimate effect size (r). To calculate r, the z value was divided by the square root of the sample size ($r=z/\sqrt{n}$).[198] Effect size strengths were interpreted as small (0.10-0.29), medium (0.30-0.49), and large (≥ 0.50).[199] Descriptive statistics are reported as median and interquartile range for each analysis.

Results

Participant Demographics

Four hundred and sixty-nine athletes volunteered to participate in the study. Of the 469 volunteers, 467 returned complete packets and two returned incomplete packets (0.004%) and were therefore removed from all data analyses. A total of 2,017 current and past injuries were reported. Ankle sprains (20.6%) were the most common injuries reported followed by injuries to the wrist and hand (11.3%). For a complete breakdown of injuries by region see Figure V.1.

Missing Data

Of the 467 participants included, approximately 4% did not answer "yes" or "no" to "Are you currently participating?" and roughly 8% did not answer "yes" or "no" to "Are you currently injured?". Those items were filled in by the investigators as described in the procedures. For the independent variables (injury history, participation status, time since last injury, injury severity), less than 10% of the sample had missing data for any one variable and thus were deleted listwise on a test-to-test basis. Eleven participants were removed from all DPA analyses for missing more than 20% of the items (N=456). For all FABQ analyses, three participants were removed for missing more than 20% of the items (N=435). Less than 1% of the data had to be filled for the DPA and FABQ. In no cases did the missing data exceed 5% for any single item on the DPA or FABQ.

Principal Component Analysis

Principal component analysis indicated that a 2-factor structure was present for the DPA. Questions 1-12 loaded on Factor 1 and Questions 13-16 loaded on Factor 2. All items had a factor loading of at least 0.58 (Table V.2). Questions 1-12 address items related to impairment, activity limitations, and participation restrictions and Questions 13-16 address items specific to psychosocial and emotional well-being. Consideration of item content suggested that Factor 1 concerned physical function while Factor 2 concerned mental well-being. Therefore, we believe it is appropriate to identify items clustered around Factor 1 as a DPA-Physical subscale and items clustered around Factor 2 as a DPA-Mental subscale (Appendix B). Overall, the two factors accounted for 65.1% of the variance in responses on the DPA. The Kaiser-Meyer-Olkin measure verified sampling adequacy (KMO=0.939) and Bartlett's test of sphericity (x^2 (120)=5022.19, $p<0.001$) indicated that the correlations between items were suitable for principal component analysis. The new 2-factor structure of the DPA demonstrated high internal consistency. Cronbach's alpha values were 0.941 for the DPA-Physical subscale and 0.878 for the DPA-Mental subscale.

Instrument Correlations

In athletes with a history of injury, a moderate positive relationship was identified between the DPA-Physical and DPA-Mental subscales (r_s =0.486, R^2=0.24, p<0.001). Additionally, a moderate positive correlation was identified between the DPA-Physical subscale and FABQ (r_s=0.503, R^2=0.25, p<0.001) and a weak positive relationship was identified between the DPA-Mental subscale and FABQ (r_s=0.266, R^2=0.07, p<0.001).

Group Comparisons

The identification of a 2-factor structure for the DPA allowed for comparisons based on injury history, participation status, time since injury, and injury severity to be made for the DPA-Physical and DPA-Mental subscales. The groups did not differ by age, height, or mass (p>0.100) for any of the independent variables examined. Data from the FABQ was only used to make comparisons in athletes that reported a history of injury.

Injury History

Based on injury history, 29% percent of the sample reported a current injury, 65% reported a history of injury but no current injuries, and 6% reported no history of injury. Group differences were identified for the DPA-Physical and DPA-Mental subscales (Table V.3). Follow-up comparisons revealed that currently injured athletes demonstrated increased DPA-Physical scores, indicating decreased function, in comparison to athletes with a history of injury (p=<0.001, r=0.59) and athletes with no history (p=<0.001, r=0.53). No differences were detected between athletes with a history of injury and no history (p=0.054). Athletes with a current injury also demonstrated increased DPA-Mental scores, indicating decreased well-being, in comparison to athletes with a history of injury (p=0.001, r=0.17). However, DPA-Mental scores did not differ for currently injured and no history groups (p=0.481) or between history of injury and no history groups (p=0.237). For the FABQ, athletes currently injured reported significantly higher scores than athletes with a history of injury that had recovered (p<0.001, r=0.38).

Participation Status

Of the athletes that reported participation status, 68% were engaged in full participation, 22% were participating injured, and 7% were not participating due to a current injury. A total of 13 participants (3%) reported that they were uninjured and not participating and were removed from the analysis as the reason as to why they were not participating was unclear. All HRQOL measures significantly differed based on participation status (Table V.4). For the DPA-Physical subscale, follow-up comparisons revealed that all three groups significantly differed (all p's<0.001). Athletes not participating due to injury reported increased scores in comparison to fully participating (r=0.46) and participating injured groups (r=0.40) and athletes participating injured reported increased scores in comparison to those engaged in full participation without injury (r=0.52). For the DPA-Mental subscale, athletes participating injured (p=0.010, r=0.13) and out due to injury (p=0.003, r=0.16) scored significantly higher than athletes engaged in full participation without injury, indicating decreased well-being when compared to their uninjured, fully-participating peers. No differences were detected between athletes participating injured and athletes not participating due to injury (p=0.199). In athletes with a history of injury, FABQ scores significantly differed for all three groups (all p's<0.001). Athletes out due to injury reported increased scores in comparison to full participation (r=0.36) and participating injured groups (r=0.36) and athletes participating injured reported increased scores in comparison to those engaged in full participation (r=0.31).

Time Since Last Injury

In athletes with a history of injury that had returned to participating, 32% percent reported that their most recent injury had been less than six weeks, 36% selected six weeks to one year ago, 27% selected one year to five years ago, and 5% selected greater than five years ago. Due to the limited sample in the greater than five years ago category, those athletes were combined with the one to five years ago category and labeled as greater than one year for analyses. Based on time since last injury, the DPA-Physical subscale and FABQ differed between groups, however no differences were detected for the DPA-Mental subscale (Table V.5). Follow-up comparisons revealed that athletes in the less than six weeks group scored significantly higher on the DPA-Physical subscale, indicating decreased function, than athletes in the greater than one year group (p=0.013, r=0.18). No differences were detected between the other groups for the DPA-Physical subscale (all p's>0.071) or between groups for the FABQ (all p's>0.018).

Injury Severity

Based on time to return to play for the most recent injury, 22% of athletes sustained no time loss injuries, 24% mild injuries, 22% moderate injuries, and 32% severe injuries. Based on time to return to play for the most severe injury, 7% of athletes sustained no time loss injuries, 13% mild injuries, 22% moderate injuries, and 58% severe injuries. Lastly, based on the athlete's perception of severity for their most recent injury, 39% chose mild, 47% chose moderate, and 14% chose severe. No HRQOL differences were detected between groups for any of the injury severity comparisons (Table V.6).

Discussion

The purpose of this study was to analyze the existing structure of the DPA, examine relationships between the DPA and fear-avoidance beliefs in athletes with a history of injury, and compare HRQOL scores based on injury and participation factors. Using principal component analysis, a 2-factor structure was identified for the DPA which resulted in the formation of the DPA-Physical and DPA-Mental subscales. In athletes with a history of injury, a moderate correlation was identified between subscales and between the DPA-Physical subscale and FABQ, however the correlation between the DPA-Mental subscale and FABQ was weak. Additionally, HRQOL differences were detected between groups based on injury history, participation status, and time since last injury, however injury severity did not appear to influence PRO scores. The following discussion has been structured to analyze the sample obtained and highlight each of the purposes.

Participant Demographics

Even though the data was self-reported and collected retrospectively, the sample displayed characteristics similar to those reported in previous literature.[9] In the present study, ankle sprains were the most common injury accounting for roughly 20% of all injuries reported. Moreover, 56% of the 2,017 injuries described occurred to the lower extremity. These values are similar to previous NCAA injury surveillance data, in which, ankle sprains were the most common injury (15%) and more than 50% of all injuries occurred to the lower extremity.[9] Likewise, concussions and anterior cruciate ligament (ACL) injuries displayed comparable rates. Roughly 10% of the injuries described in the current data were concussions and 2% ACL injuries. In comparison, over a sixteen year time period, approximately 5% of all NCAA injuries recorded were concussions and 3% involved the ACL.[9] Thus, the injuries reported in the current sample seem to be representative of the NCAA population.

Principal Component Analysis

Principal component analysis revealed a 2-factor structure for the DPA which resulted in the creation of DPA-Physical and DPA-Mental subscales. The identification of subscales allows researchers and clinicians to examine the consequences of impairment as separate physical and mental entities much like the structure of the SF-36. Although the SF-36 has physical and mental composite scores, the instrument was not designed for use in athletic cohorts. Previous studies[32, 80] have used the SF-36 to assess HRQOL in collegiate athletes and noted substantial differences between athletes and age-matched controls from the general population, reiterating that it may not be an appropriate instrument for athletes. However, the results of this study suggest that the DPA may offer a comparable alternative. Additionally, the clinical feasibility and brevity of the 16-item DPA offers clinicians and student-athletes an efficient tool.

The identified subscales distinguish between the physical and social phenomena that contribute to disability. DPA-Physical items relate to impairment, activity limitations, and participation restrictions, whereas DPA-Mental items pertain to psychosocial characteristics of quality of life. Although the DPA provides a beneficial overview of a patient's health status, analyzing the scale as separate constructs may provide distinct insight that can be used to tailor treatment and rehabilitation strategies. Such strategies can then be used to treat the entire spectrum of disability, emphasizing patient-centered, whole-person health care.[23]

Instrument Correlations in Athletes with a History of Injury

The correlation coefficients between PROs revealed weak to moderate correlations. Not surprisingly, the correlation between the DPA subscales was moderate. Although principal component analysis revealed that the items loaded on different factors, the subscales were created from the same instrument that had previously demonstrated high internal consistency.[132] Conversely, correlations between the independent subscales and FABQ differed. A moderate correlation was identified between the DPA-Physical subscale and FABQ, whereas the correlation between the DPA-Mental subscale and FABQ was weak. The weaker correlations between the DPA-Mental subscale and FABQ were unexpected as both instruments target psychosocial aspects of health. However, the FABQ was designed to assess psychological impairment, whereas the DPA-Mental subscale solicits social aspects of well-being such as altered relationships and changes in mood. The stronger relationship identified between the FABQ and DPA-Physical subscale may be attributed to the fact that fear-avoidance beliefs about physical activity and sport behaviors may impair some of the physical attributes measured on the DPA-Physical subscale.

Although the correlations between all of the PROs were significant it is important to consider the percent of explained variance. The DPA-Physical subscale and FABQ shared the most variance at 25% suggesting that despite the moderate correlation between PROs a significant portion of the variance is left unexplained. The DPA subscales shared 24% of the variance and the DPA-Mental subscale and FABQ shared the least at 7%. These findings reiterate the importance of collecting both generic and dimension-specific outcomes, as the DPA subscales and FABQ appear to measure different constructs of impairment, each instrument contributing components vital to understanding the dynamic nature of disability following injury.

Injury History

Athletes with a current injury reported decreased HRQOL in comparison to athletes with a history of injury and those with no history. More specifically, currently injured athletes reported functional limitations on the DPA-Physical subscale and increased fear-avoidance beliefs on the FABQ. Although the currently injured group displayed similar deficits on the DPA-Mental subscale, they did not significantly differ from participants with no history of injury. Furthermore, the effect size between currently injured and history of injury groups was weak ($r=0.17$) suggesting that emotional well-being as measured on the DPA-Mental subscale may not be impacted by injury. Similar trends have been identified in adolescent athletes. McLeod et al.[31] observed significant differences between injured and uninjured athletes for physical components of the SF-36 ($p<0.001$), but not for SF-36 mental components ($p=0.787$). Additionally, no HRQOL differences were detected between athletes with a history of injury and those with no history. Interestingly, these findings are consistent with the current literature in which injury has served as a strong predictor of lower SF-36 scores,[32] however inconsistent in that athletes with a history of injury do not appear to exhibit HRQOL deficits in comparison to the athletes with no history. Huffman et al.[80] found that any history of injury, even minor injuries, had a detrimental effect on an athlete's perception of health status on the SF-36. The only domain in which athletes with a history of injury did not report significant deficits on the SF-36 was emotional role. Therefore, although there are minor inconsistencies between the results of the current study and previous literature, emotional well-being appears uninfluenced regardless of injury status.

It is essential to note that there are principal differences between the studies by McAllister et al.[32] and Huffman et al.[80] and the present report. In the cohort collected at the University of California at Los Angeles,[32] history of injury was not taken into consideration. Although history of injury was considered in the later NCAA cohort,[80] history of injury was not clearly defined and only athletes cleared for participation were included. Therefore, the sample size for the previous cohort of NCAA athletes with no history of injury (N=244)[80] was significantly larger than the present study (N=28) and may have contributed to the differences observed between groups. Additionally, the substantially larger sample size for the no history group suggests that the athletes may have only been asked to recall injury history information within a specified time frame. Hence, the importance of investigating the influence of participation status, time since last injury, and injury severity.

Participation Status

Participation status had a significant impact on HRQOL in athletes. Athletes out due to injury and those participating injured, exhibited functional limitations, decreased well-being, and increased fear-avoidance beliefs in comparison to uninjured athletes engaged in full participation. Although better in healthy athletes, DPA-Mental scores did not differ in injured athletes regardless of participation status. The weak effect sizes (r=0.13-0.16) observed between the healthy and injured groups suggests that injury may not alter emotional well-being enough to cause concern. However, functional limitations and fear-avoidance beliefs should be taken into consideration when treating athletes with injuries.

These findings draw attention to the fact that despite returning to play, athletes engaged in competition with an existing injury still display HRQOL deficits. Such deficits could hinder the individual's ability to perform or ultimately contribute to further injury. Thus, HRQOL should be considered in conjunction with physical markers and functional testing when making return to play decisions. Integrating PROs to measure HRQOL, in combination with physical and functional assessments, would address the individual's impairment from a biopsychosocial perspective. Utilizing a multidimensional approach may prevent future complications and improve the overall quality of care received by the patient.

Time Since Last Injury

In athletes with a history of injury who had recovered, time since last injury appeared to influence HRQOL. Athletes who had experienced an injury less than six weeks ago reported HRQOL deficits on the DPA-Physical subscale in comparison to athletes that were greater than one year post-injury, however no differences were noted for DPA-Mental or FABQ scores. These results should be interpreted with caution as the effect observed for FABQ differences (r=0.17), although not significant, was very similar to the effect observed between groups for DPA-Physical scores (r=0.18). Thus, FABQ scores may still be elevated in athletes up to six weeks post-injury. However, DPA-mental scores do not seem to be influenced by time since last injury. Further substantiating the reoccurring theme that emotional well-being as measured by the DPA does not appear to be influenced by injury.

Injury Severity

Both objective and subjective ratings were used to classify injury severity.

Regardless of the classification system, be it time loss or individual perception, injury severity did not influence HRQOL. Moreover, history did not play a role as injury severity comparisons were made between groups for the most recent injury reported, as well as, the most severe injury reported. Conversely, McAllister et al.[32] found that serious injury was a predictor of lower scores on all eight components of the SF-36 and that mild injuries were predictive of four of the eight SF-36 components. It is important to note that McAllister et al.[32] examined injury severity in currently injured athletes and that the method for classifying injury severity vastly differed from the present investigation. Currently injured athletes were removed from the injury severity analysis in the present study so that injury severity could be objectively quantified by calendar days lost due to injury. To better understand the influence of injury severity on HRQOL more research is needed.

Limitations

It is important to acknowledge the limitations associated with this study. First, all of the injury history information was self-reported and thus collected retrospectively. Accordingly, the potential for recall bias exists. However, within the literature other medical professions have used self-reported history to obtain patient information.[200-202] Second, the retrospective nature of the design inhibits causal links from being established as there are various other factors that may cause PRO scores to fluctuate, such as academic stress, illness, or major life events like the death of a friend or family member. Furthermore, the data was collected from athletes that were both in and out of season and only 5% of the sample were participating in equipment intensive contact sports. At this time, it is unclear how administration time point or sport intensity contribute to PRO scores. Lastly, although the data was collected at both public and private institutions with diverse student-athletes, the institutions were within close geographic proximity and employed full-time athletic training staffs. Future research should capture HRQOL outcomes prospectively to eliminate recall bias and account for other factors that may contribute to fluctuations. Furthermore, future investigations should extend HRQOL beyond the DPA and FABQ to evaluate the influence of injury on other outcomes that offer regional perceptions of impairment following injury. Additionally, to aid rehabilitation strategies future studies should evaluate the patient's perception of impairment, activity limitations, and participation restrictions following universal sports-related injuries, such as ankle sprains, ACL tears, and concussions.

Conclusions

Athletes with a current injury exhibited HRQOL deficits as measured by the newly defined DPA subscales and FABQ. While those individuals participating injured reported better HRQOL than the athletes sidelined due to injury, deficits were still present and should be monitored to ensure a complete recovery. HRQOL should also be observed in recovered athletes up to six weeks post-injury as time since comparisons suggest that athletes may report deficits up to one year. Although injury severity did not appear to impact HRQOL in this study, it should be taken into consideration as athletes with severe injuries may experience prolonged participation restrictions. From the results of this study, it is clear that injury negatively influences HRQOL. While the exact contributors are unknown it is imperative that clinicians assess HRQOL post-injury. Identifying the patient's perception of impairment will help facilitate evidence-based treatment and rehabilitation strategies that target the physical and psychosocial aspects of health.

Acknowledgements

This study would not have been possible without the support provided to the primary investigator by the Darden College of Education Fellowship at Old Dominion University. The investigators would also like to acknowledge and thank Stefani Masterton and Nicole Emanato, as well as, the other athletic trainers for their efforts in facilitating and organizing data collection sessions for this project.

Table V.1. Athletic Participation Information for All Participants (N=467).

	N (%)
NCAA Competitive Division	
Division I	299 (64%)
Division II	168 (36%)
Year in School	
Freshman	165 (35.3%)
Sophomore	117 (25.1%)
Junior	108 (23.1%)
Senior	74 (15.8%)
5th Year	3 (0.6%)
Sport	
Baseball	39 (8.4%)
Basketball	39 (8.4%)
Cross Country	17 (3.6%)
Field Hockey	32 (6.9%)
Football	24 (5.1%)
Golf	15 (3.2%)
Lacrosse	41 (8.8%)
Sailing	17 (3.6%)
Softball	31 (6.6%)
Soccer	60 (12.8%)
Swimming & Diving	37 (7.9%)
Tennis	17 (3.6%)
Track & Field	43 (9.2%)
Volleyball	27 (5.8%)
Wrestling	22 (4.7%)
Other	6 (1.3%)

Table V.2. Pattern Matrix for the Principal Component Analysis (N=456).

	Factor 1	Factor 2
Factor 1: Disablement in the Physically Active-Physical Subscale		
Pain	.791	
Motion	.736	
Muscular Functioning	.725	
Stability	.806	
Changing Directions	.840	
Daily Actions	.785	
Maintaining Positions	.583	
Skill Performance: 1) Running, jumping, kicking, throwing & catching	.914	
Skill Performance: 2) Coordination, agility, precision & balance	.793	
Overall Fitness	.676	
Participation in Activities: 1) Leisure activities, hobbies, & games	.798	
Participation in Activities: 2) Sport(s) of preference	.877	
Factor 2: Disablement in the Physically Active -Mental Subscale		
Well-Being: 1) Increased uncertainty, stress, pressure, and/or anxiety		.845
Well-Being: 2) Altered relationships with team, friends, and/or colleagues		.894
Well-Being: 3) Decreased overall energy		.837
Well-Being: 4) Changes in my mood and/or increased frustration		.846

Table V.3. Injury History Comparisons for the Disablement in the Physically Active Scale (DPA) and Fear-Avoidance Beliefs Questionnaire (FABQ).

	N	Median (Interquartile Range)	p-value
DPA-Physical†#			
Currently Injured	131	21.00 (12.00-27.00)	0.000*
History of Injury	297	3.00 (0.00-10.00)	
No History of Injury	28	1.00 (0.00-7.75)	
DPA-Mental†			
Currently Injured	131	3.00 (0.00-6.00)	0.002*
History of Injury	297	1.00 (0.00-4.00)	
No History of Injury	28	2.00 (0.00-6.00)	
FABQ†			
Currently Injured	133	36.00 (27.00-43.00)	0.000*
History of Injury	302	25.00 (12.00-34.00)	

† Significant difference between Currently Injured & History of Injury

#Significant difference between Currently Injured & No History

Table V.4. Participation Status Comparisons for the Disablement in the Physically Active Scale (DPA) and Fear-Avoidance Beliefs Questionnaire (FABQ).

	N	Median (Interquartile Range)	p-value
DPA-Physical†#^			
Full Participation	311	3.00 (0.00-10.00)	0.000*
Participating Injured	99	16.00 (10.00-24.00)	
Not Participating due to Injury	32	29.00 (22.00-36.75)	
DPA-Mental†#			
Full Participation	311	1.00 (0.00-4.00)	0.001*
Participating Injured	99	2.00 (0.00-6.00)	
Not Participating due to Injury	32	4.00 (0.25-8.00)	
FABQ†#^			
Full Participation	291	25.00 (12.00-34.00)	0.000*
Participating Injured	99	34.00 (26.00-41.00)	
Not Participating due to Injury	34	46.00 (35.50-52.25)	

† Significant difference between Full Participation & Participating Injured
#Significant difference between Full Participation & Not Participating due to Injury
^Significant difference between Participating Injured & Not Participating due to Injury

Table V.5. Time Since Comparisons for the Disablement in the Physically Active Scale (DPA) and Fear-Avoidance Beliefs Questionnaire (FABQ) in Athletes that had Recovered from a Previous Injury.

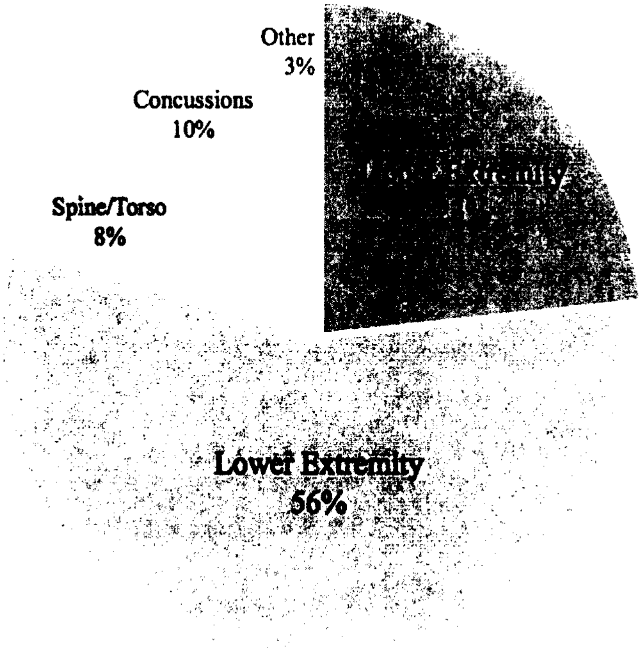
	N	Median (Interquartile Range)	p-value
DPA-Physical#			
Less than 6 Weeks	92	4.00 (1.00-12.00)	0.037*
6 Weeks to 1 Year	105	3.00 (1.00-10.00)	
Greater than 1 Year	90	2.00 (0.00-7.00)	
DPA-Mental			
Less than 6 Weeks	92	1.00 (0.00-5.00)	0.216
6 Weeks to 1 Year	105	1.00 (0.00-4.00)	
Greater than 1 Year	90	0.00 (0.00-4.00)	
FABQ			
Less than 6 Weeks	93	28.00 (15.50-34.50)	0.036*
6 Weeks to 1 Year	107	26.00 (14.00-35.00)	
Greater than 1 Year	93	22.00 (3.00-32.50)	

#Significant differences between Less than Six Weeks & Greater than One Year

Table V.6. Injury Severity Comparisons for the Disablement in the Physically Active Scale (DPA) and Fear-Avoidance Beliefs Questionnaire (FABQ) in Athletes that had Recovered from a Previous Injury.

	N	Median (Interquartile Range)	p-value
Time Loss Ranking: Most Recent Injury			
DPA-Physical			
No Time Loss	59	3.00 (0.00-10.00)	0.785
Mild (<8 days lost)	67	4.00 (0.00-10.00)	
Moderate (8-21 days lost)	59	3.00 (1.00-7.00)	
Severe (>21 days lost)	84	4.00 (1.00-9.00)	
DPA-Mental			
No Time Loss	59	1.00 (0.00-5.00)	0.938
Mild (<8 days lost)	67	1.00 (0.00-4.00)	
Moderate (8-21 days lost)	59	1.00 (0.00-4.00)	
Severe (>21 days lost)	84	0.00 (0.00-4.00)	
FABQ			
No Time Loss	58	25.50 (12.75-33.00)	0.945
Mild (<8 days lost)	67	22.00 (13.00-33.00)	
Moderate (8-21 days lost)	61	25.00 (12.00-35.00)	
Severe (>21 days lost)	89	23.00 (9.00-34.50)	
Time Loss Ranking: Most Severe Lifetime			
DPA-Physical			
No Time Loss	19	0.00 (0.00-9.00)	0.244
Mild (<8 days lost)	36	4.00 (0.00-9.25)	
Moderate (8-21 days lost)	62	3.50 (0.75-15.00)	
Severe (>21 days lost)	163	4.00 (1.00-10.00)	
DPA-Mental			
No Time Loss	19	0.00 (0.00-9.00)	0.814
Mild (<8 days lost)	36	0.00 (1.00-4.00)	
Moderate (8-21 days lost)	62	1.00 (0.00-5.00)	
Severe (>21 days lost)	163	0.00 (0.00-4.00)	
FABQ			
No Time Loss	18	21.50 (0.00-30.25)	0.184
Mild (<8 days lost)	36	21.00 (7.25-30.00)	
Moderate (8-21 days lost)	64	25.00 (15.00-34.75)	
Severe (>21 days lost)	168	26.50 (12.00-36.00)	
Athlete's Perception of Most Recent Injury			
DPA-Physical			
Mild	115	3.00 (0.00-9.00)	0.178
Moderate	135	4.00 (1.00-11.00)	
Severe	40	5.00 (1.00-9.75)	
DPA-Mental			
Mild	115	1.00 (0.00-4.00)	0.971
Moderate	135	1.00 (0.00-4.00)	
Severe	40	1.00 (0.00-4.00)	
FABQ			
Mild	115	25.00 (6.00-34.00)	0.523
Moderate	139	25.00 (14.00-34.00)	
Severe	41	27.00 (12.50-38.50)	

Figure V.1. Percentage of Injuries Reported by Region.



CHAPTER VI

CONCLUSIONS

The overall purpose of this dissertation was to gain a better understanding of the multidimensional profile of health-related quality of life (HRQOL) following injury in physically active individuals. Prior to conducting the research inquiries, the literature was searched to systematically summarize the extent to which HRQOL deficits are present in individuals with chronic ankle instability (CAI) and athletes. Subsequently, the following purposes were formulated to contribute to the current literature. The purpose of Project I was to examine HRQOL differences between individuals with and without CAI on generic, region-specific, and dimension-specific patient-reported outcomes (PROs). The purpose of Project II was to identify clinician and laboratory-oriented measures of function capable of predicting PRO scores in individuals with CAI. Lastly, the purpose of Project III was to examine the scale structure of the Disablement in the Physically Active Scale (DPA) and the influence of injury and participation factors on HRQOL in collegiate athletes. To provide a summary of the findings, the following hypotheses have been revisited:

<u>Hypothesis for Aim 1A:</u> Within the literature, individuals with CAI will exhibit decreased HRQOL in comparison to healthy individuals.

Findings: The hypothesis was confirmed that individuals with CAI exhibit HRQOL deficits in comparison to healthy individuals; particularly when examined with region-specific PROs.

<u>Hypothesis for Aim 1B:</u> Within the literature, adolescent and collegiate athletes will exhibit increased HRQOL in comparison to non-athletes.

Findings: The hypothesis was confirmed that athletes exhibit increased HRQOL than non-athletes on generic PRO instruments.

Hypothesis for Aim 1C: Within the literature, uninjured adolescent and collegiate athletes will exhibit increased HRQOL in comparison to injured adolescent and collegiate athletes.

Findings: The hypothesis was confirmed that uninjured athletes exhibit increased HRQOL than injured athletes on generic PRO instruments.

Hypothesis for Aim 2: Individuals with CAI will exhibit decreased generic and region-specific function and increased injury-related fear in comparison to healthy individuals.

Findings: The hypothesis was confirmed that individuals with CAI exhibited decreased generic and region-specific function, as measured by the DPA and Foot and Ankle Ability Measure (FAAM), and increased injury-related fear, as measured by the Tampa Scale of Kinesiophobia-11 (TSK-11) and Fear-Avoidance Beliefs Questionnaire (FABQ), in comparison to healthy individuals. Other findings included the lack of relationships between PROs, as well as, between the PROs and injury history characteristics.

Hypothesis for Aim 3: In individuals with CAI, a combination of clinician and laboratory-oriented measures will explain a significant amount of the variance associated with HRQOL scores.

Findings: The hypothesis was confirmed that a combination of clinician and laboratory-oriented measures (i.e., postural control, dorsiflexion range of motion, plantar cutaneous sensation, and ankle arthrometry) contribute to a significant portion of the variance associated with PRO scores in individuals with CAI.

Hypothesis for Aim 4A: Subscales associated with specific disablement components will be identified within the existing structure of the DPA.

Findings: The hypothesis was confirmed as two subscales, the DPA-Physical and DPA-Mental, were identified within the existing structure of the DPA.

Hypothesis for Aim 4B: The DPA will be related to FABQ scores in collegiate athletes with a history of injury.

Findings: The hypothesis was confirmed that relationships exist between the identified DPA subscales and the FABQ, however the relationships were weak to moderate.

Hypothesis for Aim 4C: Collegiate athletes will exhibit HRQOL deficits based on factors such as injury history, participation status, time since injury, and injury severity.

Findings: The hypothesis was confirmed for three of the four factors as the athletes displayed HRQOL deficits based on injury history, participation status, and time since injury. However, this hypothesis was not confirmed for injury severity as no differences were detected between PRO scores for individuals with no time loss, mild, moderate, and severe injuries.

Summary and Clinical Applications

Prior to Project I CAI had been associated with decreased HRQOL on generic and region-specific PROs,[34, 51] however, the extent to which CAI influenced dimension-specific outcomes was unknown. Project I detected HRQOL differences between individuals with and without CAI on generic, region-specific, and dimension-specific PROs. These results highlight the multidimensional profile of HRQOL and enhance the current literature by detecting fear of re-injury characteristics and reaffirming that generic and region-specific deficits are present in individuals with CAI. While the exact cause of the reported deficits is unknown, left unaddressed, the deficits may contribute to long-term consequences associated with the condition. Thus, clinicians should utilize generic, region-specific, and dimension-specific outcomes to better monitor patient status and evaluate treatment efficacy.

The findings of Project I prompted further exploration of the relationships between HRQOL and the physical impairments associated with CAI, hence Project II. In Project II, measures of postural control, dorsiflexion range of motion, plantar cutaneous sensation, and ankle arthrometry were identified as predictors of PRO scores. Thus, exposing the overlap between patient, clinician, and laboratory-oriented evidence and the relationship between body function/structure and activity limitations and participation restrictions. In theory, targeting the physical impairments known to contribute to PRO scores may improve physical function and HRQOL in individuals with CAI. Thus, clinicians can utilize balance exercises,[54, 63, 190] foot orthotics,[191, 192] plantar massage,[193] joint mobilizations,[62] taping,[116] and bracing[194] to treat the identified impairments. However, rehabilitation programs should be tailored to match the unique needs of the patient, as not all CAI patients will exhibit all of the physical impairments identified in this study nor may HRQOL be contributing to their overall disability.

To better understand the multidimensional profile of HRQOL following injury the population was expanded to collegiate athletes for Project III. In Project III, HRQOL was influenced by injury history, participation status, and time since last injury. In general, athletes with a current injury reported HRQOL deficits. Although athletes participating injured reported better HRQOL than athletes sidelined due to injury, deficits were still present in comparison to those uninjured. Furthermore, athletes appear to exhibit HRQOL deficits up to six weeks post-injury. Currently, it is unclear whether or not HRQOL contributes to athletic performance or if such deficits may be cause for concern in academic environments. Consequently, such outcomes should be monitored throughout the rehabilitation process and up to six weeks post-injury to ensure a complete recovery.

Project III was also used to explore the scale structure of the DPA and correlations between the DPA and FABQ in athletes with a history of injury. As a result DPA-Physical and DPA-Mental subscales were identified. As previously mentioned, injured athletes displayed HRQOL deficits, however DPA-Mental differences were subtle in comparison to the differences noted on the DPA-Physical subscale and FABQ suggesting that injury may not influence emotional well-being. These findings highlight the value in assessing multiple dimensions of HRQOL. Moreover, the relationships between instruments were weak to moderate at best, further supporting the idea that the DPA-Physical, DPA-Mental, and FABQ capture different dimensions of HRQOL. Accordingly, clinicians should utilize a combination of PRO instruments to identify and target physical impairments, activity limitations, and participation restrictions, as well as, contextual factors that may contribute to the patient's disability following injury.

It is evident from the results of these studies that following injury, physically active individuals exhibit HRQOL deficits. As a result, clinicians must recognize the value in whole-person health care and acknowledge that each patient copes with injury in their own unique way. PROs provide an outlet for the patient and a resource for clinicians to obtain pertinent information regarding the individual's perception of physical impairment, activity limitations, and participation restrictions following injury. This information can be used to design and implement evidence-based treatment and rehabilitation strategies that emphasize the best available evidence, clinical expertise, and patient values. Overall, this dissertation highlights the impact of injury on the multidimensional profile of HRQOL and reiterates the usefulness of implementing PROs as clinical outcome assessment tools. Utilizing PROs to capture the patient's perception of disablement following injury is vital to improving the overall quality of care provided and ensuring a complete recovery.

REFERENCES

1. National Collegiate Athletic Association. 1981-1982--2011-2012 NCAA Sports Sponsorship and Participation Rates Report. Indianapolis, IN. 2012.
2. National Federation of State High School Associations. 2011-2012 High School Athletics Participation Survey. Indianapolis, IN; 2012.
3. Moreno MA. Advice for patients. Children and organized sports. *Arch Pediatr Adolesc Med.* 2011;165(4):376.
4. Warburton DE, Nicol CW, Bredin SS. Health benefits of physical activity: the evidence. *Can Med Assoc J.* 2006;174(6):801-809.
5. Valois RF, Zullig KJ, Huebner ES, Drane JW. Physical activity behaviors and perceived life satisfaction among public high school adolescents. *J Sch Health.* 2004;74(2):59-65.
6. Gotsch K, Annest J, Holmgreen P, Gilchrist J. Nonfatal sports-and recreation-related injuries treated in emergency departments-United States, July 2000-June 2001. Morbidity and Mortality Weekly Report. 2002;51(33):736-740.
7. US Consumer Product Safety Commission. NEISS: National Electronic Injury Surveillance System Data Highlights. 2012.
8. Fernandez WG, Yard EE, Comstock RD. Epidemiology of lower extremity injuries among U.S. high school athletes. *Acad Emerg Med.* 2007;14(7):641-645.
9. Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: summary and recommendations for injury prevention initiatives. *J Athl Train.* 2007;42(2):311-319.
10. Kannus P, Renstrom P. Treatment for acute tears of the lateral ligaments of the ankle. Operation, cast, or early controlled mobilization. *J Bone Joint Surg Am.* 1991;73(2):305-312.
11. Valderrabano V, Hintermann B, Horisberger M, Fung TS. Ligamentous posttraumatic ankle osteoarthritis. *Am J Sport Med.* 2006;34(4):612-620.
12. Gross P, Marti B. Risk of degenerative ankle joint disease in volleyball players: study of former elite athletes. *Int J Sports Med.* 1999;20(1):58-63.
13. Verhagen RA, de Keizer G, van Dijk CN. Long-term follow-up of inversion trauma of the ankle. *Arch Orthop Trauma Surg.* 1995;114(2):92-96.
14. Lohmander LS, Englund PM, Dahl LL, Roos EM. The long-term consequence of anterior cruciate ligament and meniscus injuries: osteoarthritis. *Am J Sport Med.* 2007;35(10):1756-1769.
15. Øiestad BE, Engebretsen L, Storheim K, Risberg MA. Knee osteoarthritis after anterior cruciate ligament injury a systematic review. *Am J Sport Med.* 2009;37(7):1434-1443.
16. Guskiewicz KM, Marshall SW, Bailes J, et al. Association between recurrent concussion and late-life cognitive impairment in retired professional football players. *Neurosurgery.* 2005;57(4):719-726.
17. Jette AM. Physical disablement concepts for physical therapy research and practice. *Phys Ther.* 1994;74(5):380-386.
18. Nagi S. Some conceptual issues in disability and rehabilitation. In: Sussman M, ed. *Sociology and Rehabilitation.* Washington, DC: American Sociological Association; 1965: 100-113.

19. National Advisory Board for Medical Rehabilitation Research. Research Plan for the National Center for Medical Rehabilitation Research: Washington, DC: National Institutes of Child Health and Human Development, National Institutes of Health, Department of Health and Human Services 1993.
20. World Health Organization. International Classification of Functioning, Disability and Health: ICF. Geneva, Switzerland: WHO; 2001.
21. Jette AM. Toward a common language for function, disability, and health. *Phys Ther.* 2006;86(5):726-734.
22. Valovich McLeod TC, Snyder AR, Parsons JT, Bay RC, Michener LA, Sauers EL. Using disablement models and clinical outcomes assessment to enable evidence-based athletic training practice, part II: clinical outcomes assessment. *J Athl Train.* 2008;43(4):437-445.
23. Snyder AR, Parsons JT, Valovich McLeod TC, Bay RC, Michener LA, Sauers EL. Using disablement models and clinical outcomes assessment to enable evidence-based athletic training practice, part I: disablement models. *J Athl Train.* 2008;43(4):428-436.
24. Institute of Medicine Committee on Quality of Health Care in America. Crossing the Quality Chasm: A New Health System for the 21st Century. Washington, DC: National Academy Press; 2001.
25. Sackett DL, Rosenberg WM, Gray JA, Haynes RB, Richardson WS. Evidence based medicine: what it is and what it isn't. *BMJ.* 1996;312(7023):71-72.
26. Parsons JT, Snyder AR. Health-related quality of life as a primary clinical outcome in sport rehabilitation. *J Sport Rehabil.* 2011;20(1):17-36.
27. Snyder AR, Valovich McLeod TC. Selecting patient-based outcome measures. *Athlet Ther Today.* 2007;12(6):12-15.
28. Ware JE, Jr., Kosinski M, Keller SD. A 12-item short-form health survey: construction of scales and preliminary tests of reliability and validity. *Med Care.* 1996;34(3):220-233.
29. Ware JE, Jr., Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Med Care.* 1992;30(6):473-483.
30. Daltroy LH, Liang MH, Fossel AH, Goldberg MJ. The POSNA pediatric musculoskeletal functional health questionnaire: report on reliability, validity, and sensitivity to change. Pediatric Outcomes Instrument Development Group. Pediatric Orthopaedic Society of North America. J Pediatr Orthop. 1998;18(5):561-571.
31. Valovich McLeod TC, Bay RC, Parsons JT, Sauers EL, Snyder AR. Recent injury and health-related quality of life in adolescent athletes. *J Athl Train.* 2009;44(6):603-610.
32. McAllister DR, Motamedi AR, Hame SL, Shapiro MS, Dorey FJ. Quality of life assessment in elite collegiate athletes. *Am J Sport Med.* 2001;29(6):806-810.
33. Martin R, Irrgang J, Burdett R, Ped C, Conti S, Van Swearingen J. Evidence of validity for the Foot and Ankle Ability Measure (FAAM). *Foot Ankle Int.* 2005;26(11):968-983.
34. Carcia CR, Martin RL, Drouin JM. Validity of the Foot and Ankle Ability Measure in athletes with chronic ankle instability. *J Athl Train.* 2008;43(2):179-183.

35. McGuine TA, Winterstein A, Carr K, Hetzel S, Scott J. Changes in self-reported knee function and health-related quality of life after knee injury in female athletes. *Clin J Sport Med.* 2012;22(4):334-340.
36. Valovich McLeod TC, Bay RC, Snyder AR. Self-reported history of concussion affects health-related quality of life in adolescent athletes. *Athl Train Sports Health Care.* 2010;2(5):219-226.
37. Kori S, Miller R, Todd D. Kinisophobia: A new view of chronic pain behavior. *Pain Management.* 1990;3(1):35-43.
38. Waddell G, Newton M, Henderson I, Somerville D, Main CJ. A Fear-Avoidance Beliefs Questionnaire (FABQ) and the role of fear-avoidance beliefs in chronic low-back-pain and disability. *Pain.* 1993;52(2):157-168.
39. Kvist J, Ek A, Sporrstedt K, Good L. Fear of re-injury: a hindrance for returning to sports after anterior cruciate ligament reconstruction. *Knee Surg Sports Tr A.* 2005;13(5):393-397.
40. Piva S, Fitzgerald G, Irrgang J, et al. Associates of physical function and pain in patients with patellofemoral pain syndrome. *Arch Phys Med Rehabil.* 2009;90(2):285-295.
41. Lentz TA, Sutton Z, Greenberg S, Bishop MD. Pain-related fear contributes to self-reported disability in patients with foot and ankle pathology. *Arch Phys Med Rehabil.* 2010;91(4):557-561.
42. Lentz TA, Barabas JA, Day T, Bishop MD, George SZ. The relationship of pain intensity, physical impairment, and pain-related fear to function in patients with shoulder pathology. *J Orthop Sport Phys Ther.* 2009;39(4):270-277.
43. Moss R, Slobounov S. Neural, behavioral and psychological effects of injury in athletes. In: Slobounov S, Sebastianelli W, eds. *Foundations of Sport-Related Brain Injuries.* New York, NY: Springer; 2006:407–430.
44. Houston MN, Cross KM, Saliba SA, Hertel J. Injury-related fear in acutely injured interscholastic and intercollegiate athletes. *Athl Train Sports Health Care.* 2014;6(1):15-23.
45. Delahunt E, Coughlan GF, Caulfield B, Nightingale EJ, Lin C, Hiller CE. Inclusion criteria when investigating insufficiencies in chronic ankle instability. *Med Sci Sports Exerc.* 2010;42(11):2106-2121.
46. Waterman BR, Belmont PJ, Jr., Cameron KL, Deberardino TM, Owens BD. Epidemiology of ankle sprain at the United States Military Academy. *Am J Sport Med.* 2010;38(4):797-803.
47. Waterman BR, Owens BD, Davey S, Zacchilli MA, Belmont PJ, Jr. The epidemiology of ankle sprains in the United States. *J Bone Joint Surg Am.* 2010;92(13):2279-2284.
48. Schappert SM, Rechtsteiner EA. Ambulatory medical care utilization estimates for 2007. Vital and Health Statistics, Series 13. 2011(169):1-38.
49. Nelson AJ, Collins CL, Yard EE, Fields SK, Comstock RD. Ankle injuries among United States high school sports athletes, 2005-2006. *J Athl Train.* 2007;42(3):381-387.
50. Fong DT, Hong Y, Chan LK, Yung PS, Chan KM. A systematic review on ankle injury and ankle sprain in sports. *Sports Med.* 2007;37(1):73-94.
51. Arnold BL, Wright CJ, Ross SE. Functional ankle instability and health-related

quality of life. *J Athl Train.* 2011;46(6):634-641.

52. Hale SA, Hertel J. Reliability and sensitivity of the Foot and Ankle Disability Index in subjects with chronic ankle instability. *J Athl Train.* 2005;40(1):35-40.
53. Wikstrom EA, Tillman MD, Chmielewski TL, Cauraugh JH, Naugle KE, Borsa PA. Self-assessed disability and functional performance in individuals with and without ankle instability: a case control study. *J Orthop Sports Phys Ther.* 2009;39(6):458-467.
54. Rozzi SL, Lephart SM, Sterner R, Kuligowski L. Balance training for persons with functionally unstable ankles. *J Orthop Sports Phys Ther.* 1999;29(8):478-486.
55. Hertel J. Functional anatomy, pathomechanics, and pathophysiology of lateral ankle instability. *J Athl Train.* 2002;37(4):364-375.
56. Hubbard TJ, Kramer LC, Denegar CR, Hertel J. Contributing factors to chronic ankle instability. *Foot Ankle Int.* 2007;28(3):343-354.
57. Hubbard-Turner T. Relationship between mechanical ankle joint laxity and subjective function. *Foot Ankle Int.* 2012;33(10):852-856.
58. Hubbard TJ, Olmsted-Kramer LC, Hertel J, Sherbondy P. Anterior-posterior mobility of the talus in subjects with chronic ankle instability. *Phys Ther Sport.* 2005;6(3):146-152.
59. Handoll HHG, Rowe BH, Quinn KM, de Bie R. Interventions for preventing ankle ligament injuries. *Cochrane Database Syst Rev.* 2001(3):CD000018.
60. Hoch MC, McKeon PO. Joint mobilization improves spatiotemporal postural control and range of motion in those with chronic ankle instability. *J Orthop Res.* 2011;29(3):326-332.
61. McKeon PO, Ingersoll CD, Kerrigan DC, Saliba E, Bennett BC, Hertel J. Balance training improves function and postural control in those with chronic ankle instability. *Med Sci Sports Exerc.* 2008;40(10):1810-1819.
62. Hoch MC, Andreatta RD, Mullineaux DR, et al. Two-week joint mobilization intervention improves self-reported function, range of motion, and dynamic balance in those with chronic ankle instability. *J Orthop Res.* 2012.
63. Hale SA, Hertel J, Olmsted-Kramer LC. The effect of a 4-week comprehensive rehabilitation program on postural control and lower extremity function in individuals with chronic ankle instability. *J Orthop Sports Phys Ther.* 2007;37(6):303-311.
64. Daneshvar DH, Nowinski CJ, McKee AC, Cantu RC. The epidemiology of sport-related concussion. *Clin Sports Med.* 2011;30(1):1-17.
65. Cross KM, Gurka KK, Saliba S, Conaway M, Hertel J. Comparison of hamstring strain injury rates between male and female intercollegiate soccer athletes. *Am J Sports Med.* 2013;41(4):742-748.
66. Swenson DM, Collins CL, Best TM, Flanigan DC, Fields SK, Comstock RD. Epidemiology of knee injuries among U.S. high school athletes, 2005/2006-2010/2011. *Med Sci Sports Exerc.* 2013;45(3):462-469.
67. Swenson DM, Collins CL, Fields SK, Comstock RD. Epidemiology of U.S. high school sports-related ligamentous ankle injuries, 2005/06-2010/11. *Clin J Sport Med.* 2013;23(3):190-196.
68. Swenson DM, Henke NM, Collins CL, Fields SK, Comstock RD. Epidemiology

of United States high school sports-related fractures, 2008-09 to 2010-11. *Am J Sports Med.* 2012;40(9):2078-2084.

69. Iwamoto J, Takeda T. Stress fractures in athletes: review of 196 cases. *J Orthop Sci.* 2003;8(3):273-278.
70. Lee S, Saetia K, Saha S, Kline DG, Kim DH. Axillary nerve injury associated with sports. *Neurosurg Focus.* 2011;31(5):E10.
71. Cho D, Saetia K, Lee S, Kline DG, Kim DH. Peroneal nerve injury associated with sports-related knee injury. *Neurosurg Focus.* Nov 2011;31(5):E11.
72. Toth C. Peripheral nerve injuries attributable to sport and recreation. *Phys. Med Rehabil Clin N Am.* 2009;20(1):77-100.
73. Burt CW, Overpeck MD. Emergency visits for sports-related injuries. *Ann Emerg Med.* 2001;37(3):301-308.
74. Caine D, Caine C, Maffulli N. Incidence and distribution of pediatric sport-related injuries. *Clin J Sport Med.* 2006;16(6):500-513.
75. Powell JW, Barber-Foss KD. Injury patterns in selected high school sports: a review of the 1995-1997 seasons. *J Athl Train.* 1999;34(3):277-284.
76. Lundblad M, Waldėn M, Magnusson H, Karlsson J, Ekstrand J. The UEFA injury study: 11-year data concerning 346 MCL injuries and time to return to play. *Br J Sports Med.* 2013;47:759-762.
77. Miller BS, Downie BK, Johnson PD, et al. Time to return to play after high ankle sprains in collegiate football players a prediction model. *Sports Health.* 2012;4(6):504-509.
78. Shorter NA, Jensen PE, Harmon BJ, Mooney DP. Skiing injuries in children and adolescents. *J Trauma.* 1996;40(6):997-1001.
79. De Loës M, Dahlstedt LJ, Thomee R. A 7-year study on risks and costs of knee injuries in male and female youth participants in 12 sports. *Scand J Med Sci Sports.* 2000;10(2):90-97.
80. Huffman GR, Park J, Roser-Jones C, Sennett BJ, Yagnik G, Webner D. Normative SF-36 values in competing NCAA intercollegiate athletes differ from values in the general population. *J Bone Joint Surg Am.* 2008;90(3):471-476.
81. Snyder AR, Martinez JC, Bay RC, Parsons JT, Sauers EL, Valovich McLeod TC. Health-related quality of life differs between adolescent athletes and adolescent nonathletes. *J Sport Rehabil.* 2010;19(3):237-248.
82. Lam KC, Valier AR, Bay RC, McLeod TC. A unique patient population? Health-related quality of life in adolescent athletes versus general, healthy adolescent individuals. *J Athl Train.* 2013;48(2):233-241.
83. Kuehl MD, Snyder AR, Erickson SE, Valovich McLeod TC. Impact of prior concussions on health-related quality of life in collegiate athletes. *Clin J Sport Med.* 2010;20(2):86.
84. Lohmander LS, Ostenberg A, Englund M, Roos H. High prevalence of knee osteoarthritis, pain, and functional limitations in female soccer players twelve years after anterior cruciate ligament injury. *Arthritis Rheum.* 2004;50(10):3145-3152.
85. Kujala UM, Kaprio J, Sarna S. Osteoarthritis of weight bearing joints of lower limbs in former elite male athletes. *BMJ.* 1994;308(6923):231.
86. Spector TD, Harris PA, Hart DJ, et al. Risk of osteoarthritis associated with long-

term weight-bearing sports: a radiologic survey of the hips and knees in female ex-athletes and population controls. *Arthritis Rheum.* 1996;39(6):988-995.

87. Verhagen R, Keizer G, Dijk CN. Long-term follow-up of inversion trauma of the ankle. *Arch Orthop Trauma Surg.* 1995;114(2):92-96.
88. Itay S, Ganel A, Horoszowski H, Farine I. Clinical and functional status following lateral ankle sprains; followup of 90 young adults treated conservatively. *Orthop Rev.* 1982;11(5):73-76.
89. Lentz TA, Tillman SM, Indelicato PA, Moser MW, George SZ, Chmielewski TL. Factors associated with function after anterior cruciate ligament reconstruction. *Sports Health.* 2009;1(1):47-53.
90. Lethem J, Slade PD, Troup JD, Bentley G. Outline of a Fear-Avoidance Model of exaggerated pain perception--I. *Behav Res Ther.* 1983;21(4):401-408.
91. Testa MA, Simonson DC. Assessment of quality-of-life outcomes. *N Engl J Med.* 1996;334(13):835-840.
92. Ferran NA, Maffulli N. Epidemiology of sprains of the lateral ankle ligament complex. *Foot Ankle Clin.* 2006;11(3):659-662.
93. Soboroff SH, Pappius EM, Komaroff AL. Benefits, risks, and costs of alternative approaches to the evaluation and treatment of severe ankle sprain. *Clin Orthop Relat Res.* 1984(183):160-168.
94. Anandacoomarasamy A, Barnsley L. Long term outcomes of inversion ankle injuries. *Br J Sports Med.* 2005;39(3):e14.
95. Konradsen L, Bech L, Ehrenbjerg M, Nickelsen T. Seven years follow-up after ankle inversion trauma. *Scand J Med Sci Sports.* 2002;12(3):129-135.
96. Braun BL. Effects of ankle sprain in a general clinic population 6 to 18 months after medical evaluation. *Arch Fam Med.* 1999;8(2):143-148.
97. Lofvenberg R, Karrholm J, Lund B. The outcome of nonoperated patients with chronic lateral instability of the ankle: a 20-year follow-up study. *Foot Ankle Int.* 1994;15(4):165-169.
98. Hertel J. Sensorimotor deficits with ankle sprains and chronic ankle instability. *Clin Sports Med.* 2008;27(3):353-370.
99. Hubbard TJ, Hertel J. Mechanical contributions to chronic lateral ankle instability. *Sports Med.* 2006;36(3):263-277.
100. Parker J, Nester CJ, Long AF, Barrie J. The problem with measuring patient perceptions of outcome with existing outcome measures in foot and ankle surgery. *Foot Ankle Int.* 2003;24(1):56-60.
101. Eechaute C, Vaes P, Duquet W. The chronic ankle instability scale: clinimetric properties of a multidimensional, patient-assessed instrument. *Phys Ther Sport.* 2008;9(2):57-66.
102. Kirshner B, Guyatt G. A methodological framework for assessing health indices. *J Chronic Dis.* 1985;38(1):27-36.
103. Donahue M, Simon J, Docherty CL. Critical review of self-reported functional ankle instability measures. *Foot Ankle Int.* 2011;32(12):1140-1146.
104. Eechaute C, Vaes P, Van Aerschot L, Asman S, Duquet W. The clinimetric qualities of patient-assessed instruments for measuring chronic ankle instability: a systematic review. *BMC Musculoskelet Disord.* 2007;8:6.
105. Gribble PA, Delahunt E, Bleakley C, et al. Selection criteria for patients with

chronic ankle instability in controlled research: a position statement of the international ankle consortium. *J Orthop Sports Phys Ther.* 2013;43(8):585-591.

106. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *J Epidemiol Community Health.* 1998;52(6):377-384.
107. Munn J, Sullivan SJ, Schneiders AG. Evidence of sensorimotor deficits in functional ankle instability: a systematic review with meta-analysis. *J Sci Med Sport.* 2010;13(1):2-12.
108. Borenstein M, Hedges LV, Higgins JPT, Rothstein HR. *Introduction to Meta-analysis.* West Sussex, United Kingdom: John Wiley & Sons, Ltd; 2009.
109. Cohen J. *Statistical Power Analysis for the Behavioral Sciences.* 2nd ed. Hillsdale, NJ: Lawrence Erlbuam Assoc.; 1988.
110. Van Tulder M, Furlan A, Bombardier C, Bouter L. Updated method guidelines for systematic reviews in the cochrane collaboration back review group. *Spine.* 2003;28(12):1290-1299.
111. Brown CN, Bowser B, Orellana A. Dynamic postural stability in females with chronic ankle instability. *Med Sci Sports Exerc.* 2010;42(12):2258-2263.
112. Brown C, Padua D, Marshall SW, Guskiewicz K. Individuals with mechanical ankle instability exhibit different motion patterns than those with functional ankle instability and ankle sprain copers. *Clin Biomech.* 2008;23(6):822-831.
113. Croy T, Saliba SA, Saliba E, Anderson MW, Hertel J. Differences in lateral ankle laxity measured via stress ultrasonography in individuals with chronic ankle instability, ankle sprain copers, and healthy individuals. *J Orthop Sports Phys.* Ther. 2012;42(7):593-600.
114. Feger M DL, Hart J, Hertel J. Lower extremity muscle activation in patients with and without chronic ankle instability. *J Athl Train.* In press.
115. Houston MN, Van Lunen BL, Hoch MC. Health-related quality of life in individuals with chronic ankle instability. *J Athl Train.* In press.
116. Hubbard TJ, Cordova M. Effect of ankle taping on mechanical laxity in chronic ankle instability. *Foot Ankle Int.* 2010;31(6):499-504.
117. Hubbard TJ, Hertel J, Sherbondy P. Fibular position in individuals with self-reported chronic ankle instability. *J Orthop Sports Phys Ther.* 2006;36(1):3-9.
118. Kipp K, Palmieri-Smith RM. Principal component based analysis of biomechanical inter-trial variability in individuals with chronic ankle instability. *Clin Biomech.* 2012;27(7):706-710.
119. Marshall PW, McKee AD, Murphy BA. Impaired trunk and ankle stability in subjects with functional ankle instability. *Med Sci Sports Exerc.* 2009;41(8):1549-1557.
120. Nauck T, Lohrer H. Translation, cross-cultural adaption and validation of the German version of the Foot and Ankle Ability Measure for patients with chronic ankle instability. *Br J Sports Med.* 2011;45(10):785-790.
121. Plante JE, Wikstrom EA. Differences in clinician-oriented outcomes among controls, copers, and chronic ankle instability groups. *Phys Ther Sport.* 2013;14(4):221-226.
122. Ross SE, Linens SW, Wright CJ, Arnold BL. Balance assessments for predicting functional ankle instability and stable ankles. *Gait Posture.* 2011;34(4):539-542.

123. Ross SE, Guskiewicz KM, Gross MT, Yu B. Assessment tools for identifying functional limitations associated with functional ankle instability. *J Athl Train.* 2008;43(1):44.
124. Ross S, Guskiewicz K, Gross M, Yu B. Balance measures for discriminating between functionally unstable and stable ankles. *Med Sci Sports Exerc.* 2009;41(2):399.
125. Ross SE, Linens SW, Wright CJ, Arnold BL. Customized noise-stimulation intensity for bipedal stability and unipedal balance deficits associated with functional ankle instability. *J Athl Train.* 2013;48(4):463-470.
126. Ross SE, Guskiewicz KM. Effect of coordination training with and without stochastic resonance stimulation on dynamic postural stability of subjects with functional ankle instability and subjects with stable ankles. *Clin J Sport Med.* 2006;16(4):323-328.
127. Ross SE, Guskiewicz KM, Yu B. Single-leg jump-landing stabilization times in subjects with functionally unstable ankles. *J Athl Train.* 2005;40(4):298.
128. Steib S, Hentschke C, Welsch G, Pfeifer K, Zech A. Effects of fatiguing treadmill running on sensorimotor control in athletes with and without functional ankle instability. *Clin Biomech.* 2013;28(7):790-795.
129. Wikstrom EA. Fear of re-injury does not differ between those with and without chronic ankle instability. *J Sports Sci Med.* 2011;10:771-772.
130. Wright CJ, Arnold BL. Fatigue's effect on eversion force sense in individuals with and without functional ankle instability. *J Sport Rehabil.* 2012;21:127-136.
131. Wright CJ, Arnold BL, Ross SE, Ketchum J, Ericksen J, Pidcoe P. Clinical examination results in individuals with functional ankle instability and ankle-sprain copers. *J Athl Train.* 2013;48(5):581-589.
132. Vela LI, Denegar CR. The Disablement in the Physically Active Scale, part II: the psychometric properties of an outcomes scale for musculoskeletal injuries. *J Athl Train.* 2010;45(6):630-641.
133. Binkley J. Measurement of functional status, progress and outcome in orthopaedic clinical practice. *Orthop Phys Ther Pract.* 1999;11(1):14-21.
134. Wilson IB, Cleary PD. Linking clinical variables with health-related quality of life. A conceptual model of patient outcomes. *JAMA.* 1995;273(1):59-65.
135. Bruyere O, Honore A, Rovati LC, et al. Radiologic features poorly predict clinical outcomes in knee osteoarthritis. *Scand J Rheumatol.* 2002;31(1):13-16.
136. Dawes DJ, Meterissian S, Goldberg M, Mayo NE. Impact of lymphoedema on arm function and health-related quality of life in women following breast cancer surgery. *J Rehabil Med.* 2008;40(8):651-658.
137. Tomaino MM, Miller RJ, Burton RI. Outcome assessment following limited wrist fusion: objective wrist scoring versus patient satisfaction. *Contemp Orthop.* 1994;28(5):403-410.
138. Rineberg BA. A call to leadership. The role of orthopaedic surgeons in musculoskeletal outcomes research. *J Bone Joint Surg Am.* 1990;72(10):1439-1440.
139. Rineberg BA. Managing change during complex times. *J Bone Joint Surg Am.* 1990;72(6):799-800.
140. Johnson RJ. Outcomes research in the AOSSM. *Am J Sports Med.*

1994;22(6):734-738.

141. Hertel J. Research training for clinicians: The crucial link between evidence-based practice and third-party reimbursement. *J Athl Train.* 2005;40(2):69-70.

142. National Athletic Trainers' Association. *Advancing Outcomes of Care in Athletic Training Summit: A Road Map for the Future.* Dallas, Tx; May 18, 2007.

143. Irrgang JJ, Anderson AF. Development and validation of health-related quality of life measures for the knee. *Clin Orthop Relat Res.* 2002(402):95-109.

144. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand). *Am J Ind Med.* 1996;29(6):602-608.

145. Guyatt GH, Feeny DH, Patrick DL. Measuring health-related quality of life. *Ann Intern Med.* 1993;118(8):622-629.

146. Patrick DL, Deyo RA. Generic and disease-specific measures in assessing health status and quality of life. *Med Care.* 1989;27:217-232.

147. Hozo SP, Djulbegovic B, Hozo I. Estimating the mean and variance from the median, range, and the size of a sample. *BMC Med Res Methodol.* 2005;5:13.

148. Ebell MH, Siwek J, Weiss BD, et al. Strength of recommendation taxonomy (SORT): a patient-centered approach to grading evidence in the medical literature. *Am Fam Physician.* 2004;69(3):548-556.

149. Chia EM, Rochtchina E, Wang JJ, Mitchell P. Utility and validity of the self-administered SF-36: findings from an older population. *Ann Acad Med Singapore.* 2006;35(7):461-467.

150. Lyons RA, Perry HM, Littlepage BN. Evidence for the validity of the Short-form 36 Questionnaire (SF-36) in an elderly population. *Age Ageing.* 1994;23(3):182-184.

151. Jenkinson C, Wright L, Coulter A. Criterion validity and reliability of the SF-36 in a population sample. *Qual Life Res.* 1994;3(1):7-12.

152. Varni JW, Burwinkle TM, Seid M. The PedsQL as a pediatric patient-reported outcome: reliability and validity of the PedsQL Measurement Model in 25,000 children. *Expert Rev Pharmacoecon Outcomes Res.* 2005;5(6):705-719.

153. Gerber JP, Williams GN, Scoville CR, Arciero RA, Taylor DC. Persistent disability associated with ankle sprains: a prospective examination of an athletic population. *Foot Ankle Int.* 1998;19(10):653-660.

154. Hiller CE, Nightingale EJ, Raymond J, et al. Prevalence and impact of chronic musculoskeletal ankle disorders in the community. *Arch Phys Med Rehabil.* 2012;93(10):1801-1807.

155. Swinkels-Meewisse IE, Roelofs J, Verbeek AL, Oostendorp RA, Vlaeyen JW. Fear of movement/(re)injury, disability and participation in acute low back pain. *Pain.* 2003;105(1-2):371-379.

156. Woby SR, Roach NK, Urmston M, Watson PJ. Psychometric properties of the TSK-11: a shortened version of the Tampa Scale for Kinesiophobia. *Pain.* 2005;117(1-2):137-144.

157. George S, Dover G, Fillingim R. Fear of pain influences outcomes after exercise-induced delayed onset muscle soreness at the shoulder. *Clin J Pain.* 2007;23(1):76.

158. Bot SD, van der Waal JM, Terwee CB, et al. Predictors of outcome in neck and

shoulder symptoms: a cohort study in general practice. *Spine.* 2005;30(16):E459-470.

159. Jacob T, Baras M, Zeev A, Epstein L. Low back pain: Reliability of a set of pain measurement tools. *Arch Phys Med Rehabil.* 2001;82(6):735-742.
160. Lomax RG. *Statistical concepts: A second course for education and the behavioral sciences.* Mahwah, NJ: L. Erlbaum Associates; 1998.
161. Piva SR, Fitzgerald GK, Wisniewski S, Delitto A. Predictors of pain and function outcome after rehabilitation in patients with patellofemoral pain syndrome. *J Rehabil Med.* 2009;41(8):604-612.
162. Chmielewski TL, Jones D, Day T, Tillman SM, Lentz TA, George SZ. The association of pain and fear of movement/reinjury with function during anterior cruciate ligament reconstruction rehabilitation. *J Orthop Sports Phys Ther.* 2008;38(12):746-753.
163. Vlaeyen JW, Crombez G. Fear of movement/(re)injury, avoidance and pain disability in chronic low back pain patients. *Man Ther.* 1999;4(4):187-195.
164. Swinkels-Meewisse EJ, Swinkels RA, Verbeek AL, Vlaeyen JW, Oostendorp RA. Psychometric properties of the Tampa Scale for kinesiophobia and the fear-avoidance beliefs questionnaire in acute low back pain. *Man Ther.* 2003;8(1):29-36.
165. Mintken PE, Cleland JA, Whitman JM, George SZ. Psychometric properties of the Fear-Avoidance Beliefs Questionnaire and Tampa Scale of Kinesiophobia in patients with shoulder pain. *Arch Phys Med Rehabil.* 2010;91(7):1128-1136.
166. Michener LA, Leggin BG. A review of self-report scales for the assessment of functional limitation and disability of the shoulder. *J Hand Ther.* 2001;14(2):68-76.
167. Schmitt JS, Di Fabio RP. Reliable change and minimum important difference (MID) proportions facilitated group responsiveness comparisons using individual threshold criteria. *J Clin Epidemiol.* 2004;57(10):1008-1018.
168. Arnold BL, De La Motte S, Linens S, Ross SE. Ankle instability is associated with balance impairments: a meta-analysis. *Med Sci Sports Exerc.* 2009;41(5):1048-1062.
169. Arnold BL, Linens SW, de la Motte SJ, Ross SE. Concentric evertor strength differences and functional ankle instability: a meta-analysis. *J Athl Train.* 2009;44(6):653-662.
170. McKeon JM, McKeon PO. Evaluation of joint position recognition measurement variables associated with chronic ankle instability: a meta-analysis. *J Athl Train.* 2012;47(4):444-456.
171. Hertel J, Olmsted-Kramer LC, Challis JH. Time-to-boundary measures of postural control during single leg quiet standing. *J Appl Biomech.* 2006;22(1):67-73.
172. van Emmerik RE, van Wegen EE. On the functional aspects of variability in postural control. *Exerc Sport Sci Rev.* 2002;30(4):177-183.
173. Hertel J, Olmsted-Kramer LC. Deficits in time-to-boundary measures of postural control with chronic ankle instability. *Gait Posture.* 2007;25(1):33-39.
174. Hoch MC, Mullineaux DR, Andreatta RD, et al. Effect of a 2-week joint mobilization intervention on single-limb balance and ankle arthrokinematics in those with chronic ankle instability. *J Sport Rehabil.* 2014;23(1):18-26.

175. Hertel J, Miller S, Denegar C. Intratester and intertester reliability during the Star Excursion Balance Tests. *J Sport Rehabil.* 2000;9(2):104-116.
176. Hertel J, Braham RA, Hale SA, Olmsted-Kramer LC. Simplifying the star excursion balance test: analyses of subjects with and without chronic ankle instability. *J Orthop Sports Phys Ther.* 2006;36(3):131-137.
177. Robinson RH, Gribble PA. Support for a reduction in the number of trials needed for the star excursion balance test. *Arch Phys Med Rehabil.* 2008;89(2):364-370.
178. Kelln BM, McKeon PO, Gontkof LM, Hertel J. Hand-held dynamometry: reliability of lower extremity muscle testing in healthy, physically active,young adults. *J Sport Rehabil.* 2008;17(2):160-170.
179. Dyck PJ, O'Brien PC, Kosanke JL, Gillen DA, Karnes JL. A 4, 2, and 1 stepping algorithm for quick and accurate estimation of cutaneous sensation threshold. *Neurology.* 1993;43(8):1508-1512.
180. Hoch MC, Andreatta RD, Mullineaux DR, et al. Two-week joint mobilization intervention improves self-reported function, range of motion, and dynamic balance in those with chronic ankle instability. *J Orthop Res.* 2012;30(11): 1798-17804.
181. Bennell KL, Talbot RC, Wajswelner H, Techovanich W, Kelly DH, Hall AJ. Intra-rater and inter-rater reliability of a weight-bearing lunge measure of ankle dorsiflexion. *Aust J Physiother.* 1998;44(3):175-180.
182. Kovaleski JE, Gurchiek LR, Heitman RJ, Hollis JM, Pearsall AW. Instrumented measurement of anteroposterior and inversion-eversion laxity of the normal ankle joint complex. *Foot Ankle Int.* 1999;20(12):808-814.
183. Hubbard TJ, Kovaleski JE, Kaminski TW. Reliability of intratester and intertester measurements derived from an instrumented ankle arthrometer. *J Sport Rehabil.* 2003;12(3):208-220.
184. Cohen J. A power primer. *Psychol Bull.* 1992;112(1):155-159.
185. Crombez G, Vlaeyen JW, Heuts PH, Lysens R. Pain-related fear is more disabling than pain itself: evidence on the role of pain-related fear in chronic back pain disability. *Pain.* 1999;80(1-2):329-339.
186. Fritz JM, George SZ, Delitto A. The role of fear-avoidance beliefs in acute low back pain: relationships with current and future disability and work status. *Pain.* 2001;94(1):7-15.
187. McKeon PO, McKeon JMM, Mattacola CG, Lattermann C. Finding context: a new model for interpreting clinical evidence. *Int J of Athl Train Ther.* 2011;16(5):10-13.
188. Donovan L, Hertel J. A new paradigm for rehabilitation of patients with chronic ankle instability. *Phys Sportsmed.* 2012;40(4):41-51.
189. Holmes A, Delahunt E. Treatment of common deficits associated with chronic ankle instability. *Sports Med.* 2009;39(3):207-224.
190. Corbin DM, Hart JM, McKeon PO, Ingersoll CD, Hertel J. The effect of textured insoles on postural control in double and single limb stance. *J Sport Rehabil.* 2007;16(4):363-372.
191. Sesma AR, Mattacola CG, Uhl TL, Nitz AJ, McKeon PO. Effect of foot orthotics on single-and double-limb dynamic balance tasks in patients with chronic ankle instability. *Foot Ankle Spec.* 2008;1(6):330-337.

192. Hamlyn C, Docherty CL, Klossner J. Orthotic intervention and postural stability in participants with functional ankle instability after an accommodation period. *J Athl Train.* 2012;47(2):130-135.
193. Leclaire J, Wikstrom E. Massage for postural control in individuals with chronic ankle instability. *Athl Train Sports Health Care.* 2012;4:213-219.
194. Miller H, Needle AR, Swanik CB, Gustavsen GA, Kaminski TW. Role of external prophylactic support in restricting accessory ankle motion after exercise. *Foot Ankle Int.* 2012;33(10):862-869.
195. Bergandi TA. Psychological variables relating to the incidence of athletic injury: A review of the literature. *Int J Sport Psychol.* 1985;16(2):141-149.
196. Vela LI, Denegar C. Transient disablement in the physically active with musculoskeletal injuries, part I: A descriptive model. *J Athl Train.* 2010;45(6):615-629.
197. Van Baar M, Assendelft W, Dekker J, Oostendorp R, Bijlsma J. Effectiveness of exercise therapy in patients with osteoarthritis of the hip or knee: A systematic review of randomized clinical trials. *Arthritis Rheum.* 1999;42(7):1361-1369.
198. Fritz CO, Morris PE, Richler JJ. Effect size estimates: current use, calculations, and interpretation. *J Exp Psychol Gen.* 2012;141(1):2-18.
199. Coolican H. *Research methods and statistics in psychology*: Routledge; 2009.
200. Bourgeois FT, Porter SC, Valim C, Jackson T, Cook EF, Mandl KD. The value of patient self-report for disease surveillance. *J Am Med Inform Assoc.* 2007;14(6):765-771.
201. Honkanen K, Honkanen R, Heikkinen L, Kroger H, Saarikoski S. Validity of self-reports of fractures in perimenopausal women. *Am J Epidemiol.* 1999;150(5):511-516.
202. Klasser GD, de Leeuw R, Albuquerque RJ. Self-report health questionnaire: a necessary and reliable tool in dentistry. *Gen Dent.* 2005;53(5):348-354.

APPENDIX A

INJURY HISTORY FORM

Subject ID__________

Sport: ________________________ NCAA Division: ☐I ☐II ☐III

Age:______

Year in School: ☐Fr ☐So ☐Jr ☐Sr ☐5th Yr Sr

Height:_____in

Gender: ☐Male ☐Female

Weight:______lbs

How many years have you participated in your sport? __________

How many years have you participated in your sport at the collegiate level? __________

Are you currently participating in all athletic related activities for the current athletic season? ☐Yes ☐No

Are you currently injured? ☐Yes ☐No

Have you ever had?	Yes	No	Brief Description/Diagnosis How many times?; Structure Injured (e.g. ACL, Labrum, Tibia); Type of Injury (e.g. Fracture, Dislocation)	For each injury specify how long were you **unable to participate** (days, wks, months)?	Surgery Yes/No
EXAMPLE: Knee Injury	X		**1 ACL tear, 2 MCL sprains**	**ACL (9mos), MCL (3wks & 6wks)**	**Y-ACL**
Concussion					
Neck Injury					
Stingers/Burners					
Back Injury					
Rib/Rib Cage Injury					
Shoulder Injury					
Elbow Injury					
Wrist/Hand Injury					
Hip Injury					
Thigh Injury					
Knee Injury					
Lower Leg Injury					
Shin Splints					
Ankle Sprain					
Foot/Toe Injury					

Additional injury history. (Face/Jaw, Chest, Kidney, Hernia, etc.) *Please include how many times, how long you were unable to participate, and a brief description.*

____

____

____

What was your most recent injury (Provide Description)? ____

Your most recent injury was approximately how long ago? ☐<6wks ☐>6wks-1yr ☐>1yr-5yrs ☐>5yrs

How would you classify your most recent injury? ☐Mild ☐Moderate ☐Severe

Briefly explain why you chose the classification above:____

____

APPENDIX B

DISABLEMENT IN THE PHYSICALLY ACTIVE

PHYSICAL AND MENTAL SUBSCALES

DPA-Physical Subscale

	1	2	3	4	5
Pain- "Do I have **pain**?"	☐	☐	☐	☐	☐
Motion- "Do I have impaired **motion**?" Ex. Decreased range/ease of motion, flexibility, and/or increased stiffness	☐	☐	☐	☐	☐
Muscular Functioning- "Do I have impaired **muscle function**?" Ex. Decreased strength, power, endurance, and/or increased fatigue	☐	☐	☐	☐	☐
Stability- "Do I have impaired **stability**?" Ex. The injured area feels loose, gives out, or gives way	☐	☐	☐	☐	☐
Changing Directions- "Do I have difficulty with **changing directions** in activity?" Ex. Twisting, turning, starting/stopping, cutting, pivoting	☐	☐	☐	☐	☐
Daily Actions- "Do I have difficulty with **daily actions** that I would normally do?" Ex. Walking, squatting, getting up, lifting, carrying, bending over, reaching, and going up/down stairs	☐	☐	☐	☐	☐
Maintaing Positions- "Do I have difficulty **maintaining the same position** for a long period of time?" Ex. Standing, sitting, keeping the arm overhead, or sleeping	☐	☐	☐	☐	☐
Skill Performance- "Do I have difficulties with **performing skills** that are required for physical activity?"					
1) Ex. Running, jumping, kicking, throwing & catching	☐	☐	☐	☐	☐
2) Ex. Coordination, agility, precision & balance	☐	☐	☐	☐	☐
Overall Fitness- "Do I have difficulty maintaining my **fitness** level?" Ex. Conditioning, weight lifting & cardiovascular endurance	☐	☐	☐	☐	☐
Participation in Activites- "Do I have difficulty with **participating in activities**?"					
1) Ex. Particpating in leisure activities, hobbies, and games	☐	☐	☐	☐	☐
2) Ex. Participating in my sport(s) of preference	☐	☐	☐	☐	☐

DPA-Mental Subscale

Well-Being- "Do I have difficulties with the following...?"	1	2	3	4	5
1) Increased uncertainty, stress, pressure, and/or anxiety	☐	☐	☐	☐	☐
2) Altered relationships with team, friends, and/or colleagues	☐	☐	☐	☐	☐
3) Decreased overall energy	☐	☐	☐	☐	☐
4) Changes in my mood and/or increased frustration	☐	☐	☐	☐	☐

Adapted from: Vela LI, Denegar C. Transient disablement in the physically active with musculoskeletal injuries, part I: A descriptive model. *J Athl Train.* 2010;45(6):615-629.

VITA

Megan N. Houston

Department of Study

Old Dominion University
Department of Human Movement Sciences
Student Recreation Center
Norfolk, VA 23529

Education

May 2014	Doctor of Philosophy, Human Movement Science Old Dominion University	 Norfolk, Virginia
August 2011	Master of Education, Kinesiology-Athletic Training University of Virginia	 Charlottesville, Virginia
May 2010	Bachelor of Science, Athletic Training Mercyhurst University	 Erie, Pennsylvania

Publications

Houston MN, Van Lunen BL, Hoch MC. Health-related quality of life in individuals with chronic ankle instability. *Journal of Athletic Training.* In Press.

Houston MN, Hodson VE, Adams KKE, Hoch JM. The effectiveness of whole-body vibration training on improving hamstring flexibility in physically active adults: A critically appraised topic. *Journal of Sport Rehabilitation.* In Press.

Gabriner ML, Braun BA, **Houston MN**, Hoch MC. The effectiveness of foot orthotics on improving postural control in individuals with chronic ankle instability: A critically appraised topic. *Journal of Sport Rehabilitation.* In Press.

Powell MR, Powden CP, **Houston MN,** Hoch MC. Plantar cutaneous sensitivity and balance in individuals with and without chronic ankle instability. *Clinical Journal of Sports Medicine.* Epub Ahead of Print.

Houston MN, Hoch MC. Ankle laxity influences function in individuals with chronic ankle instability: A clinical research review. *International Journal of Athletic Therapy & Training.* 2014; 19(2): 20-22.

Houston MN, Cross KM, Saliba SA, Hertel J. Injury-related fear in acutely injured interscholastic and intercollegiate athletes. *Athletic Training & Sports Health Care.* 2014;(6)1: 15-23.

Houston MN, McKeon PO, Hoch MC. Foot and Ankle Ability Measure scores in patients with chronic ankle instability following joint mobilization. *International Journal of Athletic Therapy & Training.* 2013;(18)2: 4-7.