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An examination of group agreement among functional ankle instability participant inclusion criteria

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AN EXAMINATION OF GROUP AGREEMENT AMONG FUNCTIONAL ANKLE INSTABILITY PARTICIPANT INCLUSION CRITERIA

An Abstract of a Thesis

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ABSTRACT

Functional ankle instability (FAI) has been commonly identified in the literature as a cause of ankle injury and dysfunction. However, the participant selection criteria for FAI research have not been consistent. Numerous authors have used various selection criteria, with seemingly no two criteria being alike. Although these inconsistencies in FAI research participant selection criteria may explain the contradictions that have been reported in FAI research, the true nature of these selection criteria differences is unknown. It is uncertain exactly if, and to what magnitude, these selection criteria differed. The purpose of this study was to examine group agreement regarding selection criteria among authors who recruit participants with self-reported functional ankle instability. In addition, the prevalence of functional ankle instability will be identified.

One hundred ninety physically active high school and college-aged participants, (74 men, 19.0 yrs $\pm$ 2.49, 115 women, 18.5 yrs $\pm$ 2.13) were asked to respond to a questionnaire consisting of 113 criteria items that represented a culmination of 25 authors' inclusion criteria used for published research addressing FAI. Percent agreement of eleven broad inclusion criteria, proportion of agreement and kappa scores, and the prevalence of FAI were calculated based upon the 25 authors' inclusion criteria.

Percent agreement suggested low overall agreement in eleven broad inclusion criteria authors used to select participants with FAI. Only three broad inclusion criteria, including history of ankle sprain, sprain frequency, and self-reported instability, were incorporated by at least 21 of the 25 authors, whereas eight of the categories were incorporated by less than 12 of the authors. The results also indicated low agreement

and kappa scores for the 2 x 2 contingency tables (m=85.8%; k=.10) and the 3 x 3 contingency tables (m=55.1%; k=.15). Prevalence ranged from zero to 31 percent.

Overall these results indicate that FAI research inclusion criteria is inconsistent, has potentially led to the study of participants with different characteristics, and cast doubt on the appropriateness of comparing previous FAI research.

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CHAPTER 1

INTRODUCTION

Seventy-three percent of individuals who have experienced at least one ankle sprain have experienced recurring ankle sprains (Yeung, Chan, So, & Yuan, 1994). Recurring sprains can lead to a condition known as chronic ankle instability. Chronic ankle instability (CAI) is a general term described as the "occurrence of repetitive bouts of lateral ankle instability, resulting in numerous ankle sprains" (Hertel, 2002, p. 364). Functional and mechanical deficiencies of the ankle are thought to contribute to the condition of CAI. While mechanical ankle instability (MAI) is the actual anatomical laxity within the ankle joint, functional ankle instability (FAI) is subjective and characterized as a feeling of ankle instability or weakness.

The concept of FAI was introduced in 1965 when Freeman first reported patients describing feelings of "giving way" following prior ankle injuries. This feeling of "giving way" was reported in approximately 40 percent of Freeman's general clinic population (Freeman, 1965). In fact, while many patients developed this tendency for their foot to "give way", Freeman stated that some surgeons could not find any defects or anomalies that contributed to these residual ankle sprain symptoms (Wiles as cited in Freeman, 1965).

An ankle sprain has been understood as the "gold standard" for researchers selecting FAI participants. Freeman reported that the tendency for residual symptoms, such as "giving way", occurred after an individual experienced an ankle sprain. More specifically, ankle instability has been reported in individuals with a history of repetitive

sprains. In fact, athletes obtaining five or more ankle injuries experienced ankle instability four times more often than athletes with no prior ankle problems (Yeung et al., 1994). In addition, Braun (1999) reported 72.6 percent of patients in a general clinic population had residual symptoms 6-18 months after suffering an ankle sprain with 40.3 percent of them reporting ankle weakness. Athletes have also reported ankle weakness (16.5%) in addition to pain, (30.2%), sense of instability (20.4%), and crepitus after experiencing an ankle sprain (18.2%; Yeung et al., 1994). These results have given credence to the concept of FAI and have perpetuated the interest in FAI research.

Researchers have examined many different risk factors in trying to conclusively identify those that cause FAI; however they have had limited success. Recent literature reviews by Richie (2001) and Hertel (2002) collectively agreed that the mechanisms thought responsible for FAI symptoms have not been soundly identified. Initial work by Freeman suggested insufficient proprioception caused by nerve damage during an ankle sprain could be implicated as the reason individuals suffer from FAI (Freeman, Dean, & Hanham, 1965). Generalized joint laxity, anatomical foot type, and gender were also examined, but not suggested, as possible risk factors for FAI (Beynnon, Murphy, & Alosa, 2002).

While FAI research has continued over the past 40 years, its definition has changed and evolved. Functional ankle instability has been recently defined as more than just a feeling of ankle weakness caused by proprioceptive deficits (Freeman, 1965). Tropp (2002) defined FAI as "the subjective feeling of ankle instability or recurrent, symptomatic ankle sprains (or both) due to proprioceptive and neuromuscular deficits."

(Tropp, 2002, p. 512) Hertel suggested that FAI "may be caused by insufficiencies in proprioception, neuromuscular control, postural control, and strength" (Hertel, 2002, p. 365) and are considered more frequently examined components of FAI.

Increased peroneal reaction times regarding injured individuals have been reported in participants with functional ankle instability (Bullock-Saxton, Janda, & Bullock, 1994; Hertel, 2002; Karlsson & Andreasson, 1992; Konradsen & Ravn, 1990; Konradsen & Ravn, 1991; Myo-Hla, Ishii, Sakane, & Hayashi, 1999; Vaes, Gheluwe, & Duquet, 2001). However, Vaes, Duquet, and Gheluwe, (2002) along with others disagree with these findings (Ebig, Lephart, Burdett, Miller, and Pincivero, 1986; Fernandes, Allison, & Hopper, 2000).

In addition, muscle strength, specifically peroneal weakness, has also been suggested as a contributing factor in FAI (Bernier, Perrin, & Rijke, 1997; Kaminski, Perrin, & Gansneder, 1999; Lentell, Katzman & Walters, 1990; Lentell et al., 1995; Ryan, 1994) however, other researchers have disagreed (Willems, Witvrouw, Verstuyft, Vaes, & Clercq, 2002).

Researchers have also implicated decreased kinesthesia (Forkin, Koczur, Battle & Newton 1996; Garn & Newton, 1988; Lentell, et al., 1995) and increased error in ankle joint position sense (Konradsen & Magnusson, 2000) in some studies of participants identified with chronic ankle instability. However, no significant differences in joint position sense have been found in functionally unstable ankles by other researchers (Bernier & Perrin, 1998; Brown, Ross, Mynark, & Guskiesicz, 2004). Individuals have reported better detection in sense of joint movement in their uninjured side compared to

their injured side (Forkin et al., 1996). Active position sense, due to afferent information from the mechanoreceptors, is suggested as being more critical than passive position sense in maintaining dynamic postural control (Konradsen, Ravn, & Sorensen, 1993). In addition, passive motion is diminished and more difficult for the individuals with injured ankles to detect (Garn & Newton, 1988; Lentell et al., 1995). However, it has been reported that individuals with FAI demonstrated less accuracy during active position sense (Willems et al., 2002) though this phenomenon was not thought to alter passive position sense (Hubbard & Kaminski, 2002; Willems et al., 2002).

Finally, impaired balance or postural control was consistently found in individuals with functional ankle instability and identified in the literature (Forkin et al., 1996; Garn and Newton, 1988; Gauffin, Tropp, & Odenrick, 1988; Hertel, 2002; Hiller, Refshauge, & Beard, 2004; Konradsen & Ravn, 1991; Matsusaka, Yokoyama, Tsurusaki, Inokuchi, & Okita, 2001; McGuine, Greene, Best, & Leverson, 2000; Olmstead, Carcia, Hertel, & Shultz, 2002; Perrin, Bene, Perrin, & Durupt, 1997; Rozzi, Lephart, Sterner, & Kuligowski, 1999; Tropp, 1986). However, Bernier et al. (1997) and Bernier and Perrin (1998) found no changes in postural control in participants with functional ankle instability.

These often conflicting research results highlight the differences and contradictions surrounding the deficiencies of FAI. Possible reasons for conflicting FAI research include: (1) statistical component (p-value too large or sample size too small to consistently identify the problem); (2) unidentified methodological issues; and (3) different FAI participant selection criteria for choosing participants. The lack of

consistency of FAI participant selection criteria is one issue that has gained momentum and interest among researchers (Demeritt, Shultz, Docherty, Gansneder, & Perrin, 2002; Hubbard & Kaminski, 2002; Kaminski & Hartsell, 2002; Riemann, 2002; Vaes et al., 2002).

As an example, in studies that focused on kinesthesia by Bernier and Perrin (Bernier & Perrin, 1998) and Garn and Newton (Garn & Newton, 1988), it is apparent that both used different broad criteria categories in selecting FAI participants. Both inclusion criteria included "history of ankle sprain," "sprain frequency," and "pain" however, Bernier and Perrin (1998) also included "subjective instability," "sprain severity," and "pain," while Garn and Newton (1988) included "edema," "functional activity," and "neurological and vestibular disorders." Thus these differences in broad criteria categories could contribute to selecting inconsistent individuals.

In another example, Konradsen and Ravn (1990) and Vaes et al. (2002) two authors who found different results regarding peroneal reaction times, included different broad categories in selecting FAI participants. Konradsen (1990) included broad selection criteria categories such as "history of ankle sprain," "sprain frequency," and "self-reported instability" in selecting FAI participants. Vaes (2002), also included "history of ankle sprain," "sprain frequency," and "self-reported instability" however, this author also included "sprain severity," "rehabilitation," "pain," and "edema" in selecting FAI individuals making the criteria more strict and less likely for the participants to qualify.

Unfortunately, this somewhat random and inconsistent pattern of selection criteria used by the FAI researchers seems to be repeated in most FAI research publications, making potential comparisons of these published results inappropriate. It is possible that although these studies have focused on population samples of participants with or without FAI, the inconsistencies in the selection criteria have led to the study of completely different participant groups. These differences in selection criteria could be one explanation for the conflicting FAI research results and may overshadow the true nature of FAI research.

Ultimately, it appears that researchers may have been examining characteristics of FAI without first defining widely accepted, standard criteria for FAI participant selection. However, it is uncertain exactly if, and to what magnitude, these selection criteria differed.

Statement of Purpose

The purpose of this study was to examine group agreement regarding selection criteria among authors who recruit participants with self-reported functional ankle instability. In addition, the prevalence of functional ankle instability will be identified.

Specific Aims

1. To determine the rate of agreement on broad inclusion criteria for authors selecting participants for functional ankle instability.
2. To determine the proportion of agreement between authors who have classified participants with functional ankle instability.

3. To determine the prevalence of participants classified as functionally unstable according to previous authors' classifications.

Hypothesis

1. This study will find limited agreement on broad inclusion criteria among authors who have classified participants with functional ankle instability.
2. This study will find limited agreement on specific inclusion criteria among authors selecting participants for functional ankle instability.
3. This study will find the prevalence of FAI to vary greatly based upon the inclusion criteria of previous authors.

Significance of the Study

Determining group agreement among the previous selection criteria for FAI participants will identify the consistency of the participants in previous FAI research. Ultimately, this study will help determine the appropriateness of directly comparing and contrasting the results of past and future FAI research. Without consistent criteria to select participants, it is difficult to reach a consensus regarding the insufficiencies or risk factors of FAI or to compare previous studies.

Delimitations

The delimitations for this study are as follows:

1. Volunteers include participants in a Division I University.
2. Volunteers include high school participants from a metropolitan high school
3. Volunteers include males and females.
4. Volunteers will answer a questionnaire created by the investigator.

Limitations

The limitations for this study were identified as follows:

1. Subjects were limited to high school aged participants.
2. Subjects were limited to college-aged participants.
3. Groups were selected based on participation in their high school physical education class.
4. Groups were selected based on having class within the Health, Physical Education, or Leisure Services department at the University of Northern Iowa.

Assumptions

The following are assumptions for this study:

1. The subjects reported ankle problems accurately.
2. The subjects were able to understand the questions.
3. The subjects were able to answer the questions to the best of their ability.
4. The subjects were able to answer the questions consistently.
5. The subjects didn't have any psychological or social problems to interfere with their ability to answer the questionnaire.
6. The subjects were able to recollect history of ankle sprain events correctly.

Definitions of Terms

Definitions of terms used in this study are as follows:

1. Chronic ankle instability (CAI) is the "occurrence of repetitive bouts of lateral ankle instability, resulting in numerous ankle sprains" (Hertel, 2002, p. 364).

2. Functional ankle instability (FAI) is characterized as a "feeling of giving way" (Freeman, 1965) in the ankle joint, "driven by insufficiencies in proprioception, neuromuscular control, postural control, and strength" (Hertel, 2002, p. 369).
3. Lateral ankle instability is "the existence of an unstable ankle due to lateral ligamentous damage caused by excessive supination or inversion of the rear foot" (Hertel, 2002, p. 364).
4. Mechanical instability is "a result of anatomic changes …including pathologic laxity, impaired arthrokinematics, synovial changes, and degenerative joint disease…which lead to insufficiencies that predispose the ankle to further episodes of instability" (Hertel, 2002, p. 369).
5. Neuromuscular Control is "an unconscious activation of dynamic restraints occurring in preparation for and in response to joint motion and loading for the purpose of maintaining and restoring functional joint stability (Riemann & Lephart, 2002, p. 72)
6. Proprioception is described as "afferent information arising from internal peripheral areas of the body that contribute to postural control, joint stability, and several conscious sensations" (Riemann & Lephart, 2002, p. 73).
7. Proportion of Agreement is a "popular method of estimating reliability from a contingency table…where scores are summed up and converted to proportions" (Safrit, 1990, p. 149).

8. Postural control system (PCS) is the system that "maintains postural equilibrium during all motor activities of the body" (Riemann, 2002, p. 386).
9. Sensorimotor system is the system that "incorporates all the afferent, efferent, and central integration and processing components involved in maintaining functional joint stability" (Riemann & Lephart, 2002, p. 72)

CHAPTER 2

A REVIEW OF RELATED LITERATURE

The concept of functional ankle instability (FAI) was originally introduced by Freeman nearly 40 years ago as he described it as a "feeling of giving way" found in an individual's ankle after an ankle injury (Freeman, 1965). Initially, he suggested that FAI was caused by proprioceptive deficits (Freeman et al., 1965). However, more recently FAI theories have focused on its association with lateral ankle sprains and include multiple factors such as "insufficiencies in proprioception, neuromuscular control, postural control, or strength" (Hertel, 2002, p.365).

Typically, individuals are chosen for FAI research participation based on criteria that has corresponded with common signs, symptoms, and dysfunction associated with FAI. For example, athletes with a high number of ankle injuries have complained of symptoms of FAI (Yeung, et al, 1994); therefore making ankle sprains a selection criterion when including FAI participants for research. Individuals with FAI have also reported difficulties including pain, (30.2%), a sense of instability (20.4%), crepitus (18.2%), and weakness (16.5%) following an initial ankle injury (Yeung et al., 1994).

In literature reviews, Richie (2001) and Hertel (2002) agreed that mechanisms thought responsible for FAI symptoms have not been soundly identified. When comparing and sorting the results of FAI research, it appears that authors selected participants using different inclusion criteria. If the selection methods for choosing FAI participants are actually different, the results of these publications will not be comparable. In fact, the lack of consistency in the selection criteria among authors for

choosing FAI participants has gained momentum and interest among researchers (Demeritt et al., 2002; Hubbard & Kaminski, 2002; Kaminski & Hartsell, 2002; Riemann, 2002; Vaes et al., 2002). Differences in selection criteria of FAI participants could be one reason why results have been conflicting and may overshadow the true nature of FAI.

Therefore, the purpose of this study was to examine group agreement regarding selection criteria among authors who recruit participants with self-reported functional ankle instability. In addition, the prevalence of functional ankle instability will be identified.

The following review of literature will address the following topics: the epidemiology of ankle injuries; chronic ankle instability; the foundation of FAI; and a historical perspective of FAI research, as well as a potential research model for addressing the inconsistencies in FAI participant selection.

Epidemiology of Ankle Sprains

Ankle Sprain Frequency

The ankle is one of the most frequently injured joints during athletic activity. In fact, it was suggested that athletics are responsible for 64 percent of all ankle sprains (Hintermann, Boss, & Schafer, 2002). Lateral ankle sprains occur more frequently than other types of ankle sprains in athletics accounting for approximately 85-95 percent of all ankle sprain injuries (Garrick, 1977; Garrick & Requa, 1988; Messina, Farney, & DeLee, 1999). Research indicated high school basketball athletes injure their ankles more frequently than athletes in other sports, causing about 46 percent of high school

basketball players to miss one week or more of competition (McKay, Goldie, Payne, & Oakes, 2001).

Individuals with a history of an ankle sprain have a higher incidence of re-injury and residual symptoms (Surve, Schwellnus, Noakes, & Lombard, 1994). Approximately 30 percent (Baumhauer, Alosa, Renstrom, Trevino, & Beynnon, 1995; Powell & Barber-Foss, 1999) to 85 percent (Watson, 1999) of athletes had incurred a previous ankle sprain prior to suffering an ankle injury during their sports season. Recurrent ankle injuries occurred in approximately 73 percent of athletes (Yeung et al., 1994) where 59 percent suffered from considerable residual symptoms including pain, (30.2%), sense of instability (20.4%), crepitus (18.2%), and weakness (16.5%). Athletes were five times more likely to re-injure their ankle after experiencing a prior ankle injury (McKay et al., 2001). In fact, 35 percent of healthy athletes experienced a previous ankle injury and 27 percent of these athletes sustained a recurrent injury to the same ankle (Baumhauer et al., 1995).

Participants have reported symptoms including greater pain and instability on their injured ankle that were admittedly due to past injuries of their ankles (Hintermann et al., 2002). In addition, 72 percent of participants with a history of an ankle sprain had residual symptoms 6-18 months after the initial injury with approximately 40 percent of these individuals reporting at least one symptom of ankle instability, weakness, pain and/or swelling in the injured ankle (Braun, 1999). Clearly, lateral ankle sprains are problematic, with residual symptoms and a high recurrent rate in many following initial injury.

Ankle Sprain Risk Factors

Researchers have attempted to establish the risk factors that are associated with initial ankle sprains and recurring ankle sprains in an effort to prevent them. Research has indicated that a previous ankle injury is the most broadly accepted risk factor for recurring ankle injuries (Thacker et al., 1999).

Collectively, researchers have reported that generalized joint laxity, anatomical foot type, and gender are not considered risk factors; however literature regarding muscle strength, reaction time, proprioception, and postural sway offers conflicting results (Beynnon, Renstrom, Alosa, Baumhauer, & Vacek, 2001). Nonetheless, different potential risk factors have been reported in women including increased rotation of the tibia and increased motion of the calcaneus during eversion (Beynnon et al., 2001).

Interestingly, females have shown a 25 percent greater risk of sustaining a grade I ankle sprain (Hosea, Carey, & Harrer, 2000), however, the exact origin of why this happens is unknown. Researchers have reported that women have a greater lateral ligamentous laxity in their ankles then men; however this has not been reported as a cause of increased lateral ankle sprains (Wilkerson & Mason, 2000). On the contrary, predisposing factors such as increased talar tilt in men have been shown to increase ankle ligament injuries (Beynnon et al., 2001).

Individuals with decreased postural sway scores experienced approximately 7 times as many ankle sprains as those with good balance scores (McGuine et al., 2000). Greater height, lower body mass index, postural defects, and decreased proprioception all contributed to an increased ankle re-injury rates in athletes playing both Gaelic football

and hurling suggesting that these risk factors may be important in preventing ankle injuries (Watson 1999). Other risk factors included wearing shoes with air cells in the heel, and proper stretching before the game (McKay, Goldie, Payne, & Oakes, 2001).

Individuals who included stretching and proper warm up prior to activity lowered the incidence of ankle injuries (Baumhauer et al., 1995). In fact, individuals who eliminated stretching and proper warm up nearly tripled ankle injury rates (McKay et al., 2001). Players with air cells in the heel of their shoes experienced 4.3 times greater chance of injuring their ankle (McKay et al., 2001). In addition, individuals with previous varus tilt of the tibial plafond (Sugimoto, Samoto, Takakura, & Tamai, 1997), history of surgery of the ankle, and participants who regularly used ankle braces or tape (Baumhauer et al., 1995) were also considered risk factors for ankle injuries.

Higher levels of competition, such as collegiate play, doubled the risks for incurring an ankle injury compared with lower levels of competition, such as recreational collegiate athletes (Hosea et al., 2000). However, Yeung et al. (1994) reported that the national team athletes experienced a lower incidence of ankle injuries than the recreational and competitive athletes, indicating that these teams may already participate in an appropriate warm up and stretching routine.

Ankle sprain reoccurrences have been shown to significantly decrease when individuals wore ankle braces (Surve et al., 1994) without adversely affecting athletic or functional performance (Thacker et al., 1999). In fact, ankle supports were reported to reduce the incidence and lessen the severity of ankle sprains, while proprioceptive training reduced the number of sprains to the level of a healthy individual (Verhagen,

Mechelen, and de Vente, 2000). In addition, training programs including ankle balance training activities increased static balance and were suggested to help decrease future ankle sprains (Madras and Barr, 2003). Although the risk factors have not been consistently identified, lateral ankle sprains remain a common injury during athletics and pose a high risk of re-injury.

Ankle Function and Stability

Ankle Anatomy

Prior to discussing ankle stability and potential causes of instability, it is important to establish an understanding of ankle anatomy and ankle function, including the collaborating efforts of appropriate soft tissue and bony structures. The foot and ankle are the two initial contacts the body has to the ground; therefore they contribute to absorption and transmission of direct and indirect forces.

Hertel (2002) clarified the three functional units of ankle motion the distal tibiofibular joint, the subtalar joint, and the talocrural joint. Together, these joints provide coordinated movements of the ankle and help accommodate the lower extremity to uneven surfaces. The ankle's stabilization is provided by ligaments and muscles surrounding the ankle. Ligaments are strong, static structures significant to talocrural ankle joint stabilization during inversion/eversion motions but also allow dorsiflexion/plantar flexion to occur (Hertel, 2002).

Three major lateral ligaments collaborate to stabilize the lateral side of the ankle and help limit inversion motions. The anterior talofibular ligament (ATF) originates from the lateral malleolus and inserts on the lateral malleolar surface of the talus

(Stephens & Sammarco, 1992). This ligament, while under constant stress, contributes to stability of the subtalar joint when the ankle is in a plantarflexed position (Stephens & Sammarco, 1992). The calcaneofibular ligament (CF) begins at the lower anterior border of the lateral malleolus, inserts on the posterior aspect of the lateral surface of the calcaneus (Stephens & Sammarco, 1992), and reaches deep through the peroneal tendon sheath to attach distally to these structures (Burks & Morgan, 1994). During constant stress, the CF ligament provides stability to all positions of the subtalar joint, as does the posterior talofibular ligament (Stephens & Sammarco, 1992). The posterior talofibular ligament (PTF) originates at the medial surface of the lateral malleolus and inserts into the posterior talar surface (Stephens & Sammarco, 1992).

The peroneal muscles are lateral, dynamic soft tissue structures that support ankle joint stability and concentrically or eccentrically prevent excessive inversion motions (Beckman & Buchanan, 1995; Garrick & Requa, 1988). The peroneal muscles must be active to resist talar tilting of the ankle joint, thereby creating a less prone environment for ankle injuries. Other muscles, including the extensor hallicus longus, extensor digitorum longus, peroneus tertius (also an evertor), and tibialis anterior (also an invertor), perform as main dorsiflexors of the ankle joint and eccentrically contract while decelerating plantarflexion motions.

Ankle Stability and Motion

Ultimate protection for the ankle and entire body involves joint congruity, ligament strength and stability, and proprioception from the muscles surrounding the ankle joint (Hertel, 2002). Proper alignment and fit of the ankle joint generates stability

and reduces torque generated from ground reaction forces. The ankle's subtalar joint reduces excessive rotation and malalignment during weight bearing activities (Hertel, 2002). During weight bearing activities, joint congruity and ankle ligaments provide primary stabilization and vital stability.

When major ankle ligaments or neuromuscular components are compromised, for example stretching or tearing the lateral stabilizing ligaments or muscles during an inversion ankle sprain, the ankle will become less stable and at risk for re-injury. An injured ATF, whether it is torn or stretched, allows subtalar joint laxity during plantarflexion motions (Hollis, Blasier, & Flahiff, 1995) however, the CF ligament shows the most laxity with the ankle in a predominately dorsiflexed position (Hollis et al., 1995). The PTF is not a frequently injured ligament in the lateral ligament complex; however, the most significant laxity occurs when both the ATF and CF are torn (Hollis et al., 1995). In fact, 69 percent of patients injured both the ATF and CF while suffering chronic ankle instability (Hintermann et al., 2002). Biomechanically, the CF ligament plays a considerable part in lateral subtalar instability (Karlsson, Eriksson, & Renstrom, 1997).

Malalignment is produced when the ankle is forced past a particular point of rotation. Therefore, during the heel-strike phase of gait, this shift provokes the subtalar joint to invert (Konradsen & Voigt, 2002) and possibly cause an ankle injury. Thus, an individual's awareness of the subtalar joint prior to striking the ground has been suggested as the missing link to functional ankle instability (Konradsen & Voigt, 2002).

Chronic Ankle Instability

Initial or repeated injury to the supporting structures of the ankle can lead to chronic ankle instability. Chronic ankle instability (CAI) is a general term described as the "occurrence of repetitive bouts of lateral ankle instability, resulting in numerous ankle sprains" (Hertel, 2002, p. 364) and is thought to encompass both functional and mechanical deficiencies. Participants with repeated episodes of ankle sprains have a tendency to develop symptoms of chronic ankle instability (Braun, 1999; Yeung et al., 1994).

Mechanical ankle instability (MAI) is the actual anatomical laxity within the ankle joint where conversely, functional ankle instability (FAI) is characterized as a feeling of "giving way" (Freeman, 1965), and is thought to be "driven by insufficiencies in proprioception, neuromuscular control, postural control, and strength" (Hertel, 2002, p.365). Injuries associated with chronic ankle instability were documented and included peroneal tenosynovitis in 77 percent of patients, impingement lesions, attenuated peroneal retinaculum, ankle synovitis, cartilage loose body, peroneus brevis tear, osteochondral lesion of the talus, and anterior talofibular ligament avulsion (DiGiovanni, Fraga, Cohen, & Shereff, 2000). In addition, recurrent inversion injuries and self-reported pain, tenderness, and "giving way", all correlated with findings of rupture or elongation of the anterior talofibular ligament (86%), calcaneofibular ligament (64%), deltoid ligaments (40%), and cartilage damage (66%) in individuals with chronic ankle instability. Interestingly, individuals complaining of symptoms of functional ankle

instability were four times higher in athletes with five or more sprains (Yeung et al., 1994).

While both mechanical and functional aspects were documented, it is interesting that functional ankle instability and mechanical ankle instability are both considered an element of chronic ankle instability but also described as independent of one another. For example, individuals showing symptoms of functional instability don't always show signs of mechanical instability or conversely, shows signs of mechanical instability without self-reported feelings of functional ankle instability (Ryan, 1994; Specchiulli & Cofano, 2001).

Approximately 50 percent of patients with functional instability did not show any signs of mechanical instability (Specchiulli & Cofano, 2001). However, a recent study has reported greater mechanical laxity in individuals with FAI (Hubbard, Kaminski, Vander Griend, & Kovaleski, 2004). Specchiulli and Cofano (2001) disagreed with Hubbard et al. (2004) regarding mechanical laxity attributing to FAI. These authors used different people in their sample population, which could attribute to the conflicting results. Specchiulli and Cofano (2001) examined patients with grade III ankle sprains and recruited them by the dates they were treated in the clinic; whereas Hubbard et al. (2004) examined participants with self-reported FAI determined by a questionnaire.

Although these conflicting reports could have several explanations, it becomes apparent that the selection criteria for participants in FAI research appears inconsistent. The subjective nature of selecting participants with FAI may have influenced the type of individuals being chosen with FAI. Ultimately, these studies may have examined two

very different groups of participants with different qualifications for involvement, therefore making them impossible to compare. This concept will be explored in greater details throughout this review.

Functional Ankle Instability

The Foundation

As early as the 1930's, physicians and researchers were perplexed by encounters among patients complaining of ankle instability that generated no concrete evidence of any physical disabilities (Freeman, 1965). In 1965, Freeman pioneered research in this field by searching for causes of this bewildering phenomenon. Freeman (1965) was the first to describe functional ankle instability, a phrase given to patients who had a feeling of the foot or ankle "giving way."

Patients in Freeman's clinic suffering from symptoms of FAI had all previously incurred an ankle sprain. Freeman became interested in determining if a problem actually existed. His study included asymptomatic, healthy participants with no prior history of ankle injuries. Talar tilt, considered in healthy participants with no prior history of ankle injury, was measured by radiography prior to experiencing an ankle injury. A one-year post injury follow up examination found approximately 40 percent of patients, with no prior complaints of instability before their ankle injury, reported symptoms of their ankle giving way , suggesting that a prior ankle sprain correlated with functional ankle instability.

After Freeman discovered the problem he called functional ankle instability, his determination to find a reason for these complaints lead to another study. Later in 1965

Freeman, Dean, & Hanham (1965) suggested FAI might occur because of damage to the nerve fibers following injury to the ankle joint muscles after an ankle sprain, thereby impairing ankle stabilization. Freeman and his colleagues reported that individuals experienced decreased symptoms of functional ankle instability with ankle proprioception training, which suggested that FAI might be caused by impaired proprioception.

Over the years, researchers have acknowledged Freeman's pioneering definition, and have encouraged others to elaborate on his original research and hypothesis. As research evolved, examiners have discovered many different insufficiencies in participants with functional ankle instability. Many are still being debated today and have contributed to the confusion of which definitions should be used to define individuals with FAI.

Recently, Hertel (2002) explained functional ankle instability as a multi-symptom disorder including a loss of sensation and proprioceptive deficits, neuromuscular control, impaired postural control, and diminished strength. However, literature reviews by Richie (2001) and Hertel (2002) collectively agreed that these insufficiencies thought responsible for FAI symptoms have not been soundly identified. With the lack of agreement on these insufficiencies, finding and accepting reliable criteria to select participants for research is difficult. This may offer one explanation for the often conflicting results found in FAI research. In the following section, these discrepancies in FAI research will be addressed.

FAI Research Timeline

Following the Discovery of FAI

After FAI was introduced in 1965, there was limited research on the topic in the 1970's. In the 1980's, FAI gained attention and momentum as a research topic. The aim seemed to focus on uncovering the risk factors of FAI. Tropp and his colleagues began a string of research on FAI beginning in the mid 1980's, adding to the original information in which Freeman began almost 20 years prior.

The original research of Freeman (Freeman et al., 1965) leads others to investigate the role proprioception played in individuals with FAI in the 1980s. Reduced postural control was found in participants with FAI, but not in participants with mechanical ankle instability (Tropp, Odenrick, & Gillquist, 1985), suggesting that functional and mechanical instabilities may actually be two different problems.

Balance training seemed to provide significant improvements in postural sway in participants with FAI (Tropp, Ekstrand, & Gillquist, 1984); however individuals still reported feelings of "giving way". In 1986, Tropp completed another study on postural control and found impaired postural control in participants with injured ankles (Tropp, 1986). Interestingly, Tropp reported a bilateral deficit in postural control in individuals with only one injured ankle (Tropp, 1986). It seems that participants in Tropp's 1986 study with a prior ankle sprain experienced increased postural sway scores on their non-injured ankle, indicating that using the participant's non-injured side during research may influence the results.

Two years later, a 1988 publication by Tropp and Odenrick suggested FAI participants were using a different type of balancing strategy in which they named the "hip strategy of balance" (Tropp & Odenrick, 1988). This alternate balancing strategy was thought to contribute to slower response times of the peroneal muscles thereby increasing the chance for ankle injuries (Tropp & Odenrick, 1988). Gauffin, Tropp, and Odenrick (1988) found that an 8-week ankle disk-training program significantly improved postural control in participants with functional ankle instability.

It appears that the 1980s touched on a few important research concepts of FAI and provided others a good starting point. The mid 1990s picked up where Tropp left off in 1988 with Bullock-Saxton (1994) examining the "hip strategy of balance" (Tropp & Odenrick, 1988).

Bullock-Saxton was interested in the effects of sensory changes in proximal muscle groups in participants with severe lateral ankle sprains. Significant delays were found in the proximal hip muscle group recruitment patterns of the injured group compared with the uninjured group during hip extension. In addition, Bullock-Saxton, Janda, & Bullock (1994) investigated muscle patterns of participants with severe ankle sprains. In fact, changes were found in activation of the gluteus maximum, hamstrings, and erector spinae in injured participants and more importantly, bilaterally. In agreement, Beckman & Buchanan (1995) indicated hip muscle recruitment patterns changed in participants with unstable ankles. These researchers all found decreased muscle latency times in the hip muscles of individuals with hypermobile ankles.

These early publications were important in leading researchers towards specific directions of the participant selection process. An important suggestion included using a separate control group instead of the participant's "healthy" contralateral ankle when examining individuals with an ankle sprain. However, these findings lead to the notion that the original definition by Freeman needed enhanced.

Re-establishing a Definition of FAI in the 1990s

A re-established definition of FAI by Lentell and colleagues surfaced twenty-five years after Freeman first described the phenomenon and was used in the inclusion criteria for FAI research (Lentell et al., 1990). This new definition and inclusion criteria included a past history of a unilateral ankle sprain requiring crutches and/or immobilization; no fractures to either ankle or lower leg; the injured ankle was weaker, more painful, and less functional than the contralateral side; and the complaints were secondary to the history of a lateral ankle sprain (Lentell et al., 1990).

Additional criteria in Lentell's definitions included no significant trauma in the past three months; full weight bearing without a limp at least 3 weeks before testing; no current formal or informal rehabilitation program; and functional use of the ankle was not better since the original injury. Lentell's publication was significant in redefining FAI since Freeman's definition in 1965 (Lentell et al., 1990). Lentell's definition of FAI could be dubbed historically fundamental, however; the researchers used participant's contralateral ankle as a control in their 1990 and 1995 publications (Lentell et al., 1995; Lentell et al., 1990). This use of the opposite ankle as the control makes comparison to

Tropp's earlier work problematic, as Tropp employed a separate group for a control comparison (Tropp, 1986).

FAI Research Results and Participant Selection in the 1990s

Muscle reaction times. Konradsen and Ravn (1990) began a quest of finding causes and effects of the debilitating syndrome of functional ankle instability. Konradsen and Ravn (1990) defined FAI as recurrent sprains and/or a feeling of the ankle "giving way", often seen as a lingering disability after an ankle sprain. No significant differences were found in center of pressure or joint motion patterns with stable and unstable participants however; prolonged reaction times were noted in unstable ankles.

In agreement, Konradsen and Ravn (1991) found increased peroneal reaction times in participants with functional ankle instability and increased postural sway. Both selected FAI participants based on self-reported, severe complaints of FAI in one or both ankles. However, Konradsen and Ravn (1991) also chose participants who experienced no generalized joint laxity, although it some participants had ankle joint mechanical instability tested by anterior drawer or talar tilt.

Tape had a positive effect on prolonged reaction times in participants with FAI (Karlsson & Andreasson, 1992). In fact, the highest degree of mechanical instability seemed to produce greatest improvements in reaction time among FAI participants (Karlsson & Andreasson, 1992). Later research indicated that applying mechanical stability, such as an ankle brace, significantly slows down inversion speeds in participants with functional ankle instability, thus potentially decreasing injury risk (Vaes, Duquet, Casteleyn, Handelberg, & Opdecam, 1998). Interestingly, ankle braces were also found

to improve functional skills in athletes with FAI however, the authors did not state how they selected participants (Jerosch, Thorwesten, Frebel, & Linnenbecker, 1997).

Delayed peroneal reaction times were also found during an ankle inversion stress test on participants with chronic ankle instability (Lofvenberg, Karrholm, Sundelin, & Ahlgren, 1995). The peroneal and tibialis anterior reaction times were significantly longer in individuals with chronic ankle instability. Conversely, Ebig et al. (1997) concluded that no differences existed in peroneal and tibialis anterior muscle response times in participants with self-reported functional ankle instability. The only requirement for participant selection in Lofvenberg's study was a history of unilateral or bilateral chronic ankle instability for at least twelve months (Lofvenberg et al., 1995). Ebig et al. (1997) required participants filled out a questionnaire of self-perception of chronic functional ankle instability, however the information from the survey was not provided. In addition, they included active individuals with a history of unilateral inversion ankle sprain, individuals with previous protective devices and/or immobilization, full weight bearing at testing, and no trauma at least two months prior to testing. These authors used completely different selection criteria, making it inappropriate to compare these results.

Myo-Hla, Ishii, Sakane, and Hayashi (1999) also found peroneal reaction times were significantly increased in participants with functional ankle instability prior to injection however, significantly decreased after being injected in the sinus tarsi area with anesthetic (Myo-Hla, Ishii, Sakane, & Hayashi, 1999). Importantly, participants felt they improved their instability while actually performing better on the balance board. Participants with FAI were selected if they experienced three or more lateral ankle

sprains accompanying complaints of the ankle "giving way" and had no neurological diseases, spinal disorders, or other lower leg injuries. These results indicated that participants could correlate the "feeling" of FAI when they actually experienced symptoms of FAI. The work of Myo-Hla and colleagues was an important step in establishing the use of self-reported symptoms of FAI research participant inclusion.

Conversely, Johnson and Johnson (1993) found no significant differences in peroneal muscle reaction times in neither participants with injured ligaments nor others with surgically repaired ankles. Participants in the injured group reported a grade II or above lateral ankle sprain at least three months before the study and the surgical group had repairs of their lateral ligaments after experiencing a grade II or III unilateral sprain six months or more prior to the study. In addition, bilateral comparisons were completed with the contralateral ankle however, no differences were noted. Bilateral comparisons were noted in Tropp's publication in 1986 however, the designs used different selection criteria. These studies also are not comparable due to the wide range in participant selection criteria.

Isakov and Mizrahi (1997) found no significant differences in proprioception between injured and uninjured participants in testing however, both groups demonstrated significantly higher reaction times with their eyes open. Injured participants were included if they had reported recurrent ankle injuries requiring a protective device, mechanically unstable, pain free, full functional use of the ankle, and fully weight bearing four months prior to testing.

Importantly, the previous publications on peroneal reaction times in participants with FAI could be affected by including different participants. Some chose participants with excessive mechanical laxity in the ankle and others did not. In addition, some authors chose participants according to how many ankle sprains they experienced and required a time frame in which they were injured. Unfortunately, many of the selection criteria were different and may have contributed to the difference in results.

Ankle muscle strength. An earlier study by Isakov and colleagues found no differences in strength of the peroneal muscles of participants with FAI (Isakov, Mizrahi, Solzi, Susak, & Lotem, 1986). A later study by Ryan (1994) agreed with these findings. In addition, Kaminski, Perrin, and Gansneder (1999) found no differences in isometric and isokinetic eversion muscle strength of the ankle in participants with FAI. However, Hartsell and Spaulding (1999) later determined there were differences in inversion and eversion muscle strength ratios in participants with chronic ankle instability. Results demonstrated chronically unstable ankles had significantly weaker eccentric and concentric muscle velocities during inversion and eversion movements (Hartsell & Spaulding, 1999). Nonetheless, researchers found that specific ankle strengthening exercises had significant positive effects on joint position sense and strength in FAI participants (Docherty, Moore, & Arnold, 1998).

Looking at participant selection, Ryan selected FAI participants if they had a history of unilateral functional ankle instability, at least 6 episodes of the ankle "giving way" with or without pain within the past 12 months, and 3 or more inversion sprains including 2 or more within the past 18 months with at least one in the past 6 months.

Kaminski et al. (1999) chose FAI participants including one significant unilateral ankle sprain where they were unable to bear weight, no history of bilateral fracture, at least one repeated LAS or had the feeling of "giving way" in one ankle (not within 6 weeks of testing), and were pain free and full weightbearing without a limp at the time of the study. In addition, participants were excluded if they participated in formal rehabilitation or had a positive anterior drawer test by a physician. Hartsell and Spaulding (1999) selected participants differently by choosing participants with at least two moderate ankle sprains requiring medical intervention, self-reported repeated episodes of "giving way," but no injury within six months of testing, no formal rehabilitation at the time of testing, no pain, swelling, or functional limitations, and normal range of motion. Obviously, participant selection criteria among the authors were extremely broad and could be a reason for the differences in results. Potentially the authors had selected very different participants for their research.

Postural control. Contradictory results involving postural control were found in individuals suffering from FAI and may exist because of inconsistent participant selection.

In 1997, Bernier, Perrin, and Rijke found no significant changes in FAI participants regarding postural control or strength. Within the same year, however, participants with FAI who experienced the largest number of ankle sprains reported larger postural control scores (Perrin, P., Bene, Perrin, C. & Durupt, 1997). For example, basketball players with long histories of ankle injuries showed more difficulty in

maintaining balance that directly reflected players with greater numbers of injuries (Perrin et al., 1997).

Larger postural control scores suggested their balance or postural control was not as good as individuals with healthy ankles, possible contributing to FAI. However, differences in participant selection were broad. Bernier et al. (1997) selected injured participants if they had self-reported histories of unilateral inversion ankle sprain resulting in crutches or diminished activity; repeated episodes of "giving way"; and no history of other lower extremity injuries. Bilateral mechanical ankle instability, determined by radiographs, was part of the exclusion criteria. Contrary to these stringent inclusion guidelines by Bernier (1997), Perrin only required FAI participants to have experienced ten to fifteen episodes of sprained ankles (Perrin et al., 1997).

Nevertheless, balance training was found to improve poor postural control (Bernier & Perrin, 1998; Rozzi et al., 1999) and significant decreases were found in mediolateral sway velocities in FAI participants after the application of an ankle brace (Baier & Hopf, 1998). In addition, Rozzi et al. (1999) found significant improvements in both the healthy and FAI groups after just 4 weeks of a balance training program. Interestingly, improvement in balance correlated with an improvement in the participants' perceived functional stability measured by a questionnaire (Rozzi et al., 1999).

Ankle proprioception. In Lentell's 1990 investigation of muscle strength and balance problems in participants with ankle instability, there was supportive evidence regarding deficits in proprioception in FAI participants (Lentell et al., 1990). Again, in

1995, Lentell and colleagues (Lentell et al., 1995) measured proprioception and muscle weakness in participants with functional ankle instability. The same participant selection was used as Lentell's definition in 1990 in both of Lentell's 1990 and 1995 publications. Lentell's 1995 publication reported significantly larger replication error during passive joint position sense (proprioception) with participants exhibiting increased talar tilt, which also agreed with a later study by Boyle and Negus (1998).

Boyle and Negus (1998) selected injured participants with a history of at least two repeated ankle sprains but none within the last three months and any pain or swelling at the time of testing. However, participants were excluded from both groups if they had a history of bone or joint injury, major medical or neurological problems, and unable to reach 42 degrees range of motion in plantarflexion. Complaints of "giving way" were present in some of Boyle's participants but not part of the selection criteria contributing even more to the already confusing FAI selection process. These criteria were somewhat similar but slightly different from Lentell's definition which included a past history of a unilateral ankle sprain requiring crutches and/or immobilization; no fractures to either ankle or lower leg; the injured ankle was weaker, more painful, and less functional than the contralateral side; and the complaints were secondary to the history of a lateral ankle sprain (Lentell et al., 1990).

Forkin and colleagues concur with Lentell that functionally unstable participants (gymnasts) reported having decreased balance and proprioception in their injured ankles (Forkin et al., 1996). In fact, Mattacola and Lloyd (1997) found FAI participants experienced better balance scores following a six week balance training program. Again,

participant selection between the two authors (Boyle & Negus, 1998; Forkin et al., 1996) may determine why the results are conflicting. Forkin et al. (1996) selected participants with a prior lateral ankle sprain to one ankle at least two years prior to testing; no pain or effusion at time of study; no neurological or vestibular disease; or no current history of musculoskeletal injuries to the back or opposite side lower extremity.

Comprehensive approaches in FAI participant selection in the 1990's

By the mid to late 1990's, some authors undertook a more comprehensive approach of selecting and separating individuals with FAI. A few authors began separating FAI participants into "groups" that were different from the normal "stable" and "unstable" groups.

While examining muscle relationships and postural control variables of single leg stance, Pintsaar, Brynhildsen, and Tropp (1996) categorized participants into not two but three groups. For example, Group A consisted of participants with healthy ankles and no previous ankle injuries; Group B consisted of participants with FAI defined as recurrent ankle injuries and subjective "giving way" of the injured ankle; and Group C represented participants with MAI only by means of a positive anterior drawer or talar tilt. Grouping research participants in this way excluded some individuals from participating. Ultimately, Pintsaar et al. (1996) found no muscle latency effects between the groups, however, an initial hip strategy of balance was found between FAI and healthy participants.

Furthermore, Vaes et al. (1998) categorized participants with FAI into two groups: compensated ankle instability or non-compensated ankle instability.

Compensated ankle instability was defined as "ankles frequently sprained without further complaint" (Vaes et al., 1998). For example, participants with a history of traumatic ankle sprains and a positive score on the following question: "Do you sprain your ankle regularly?" and "How often does this happen?" would qualify as a compensated FAI participant (Vaes et al., 1998). Non-compensated ankle instability included ankle swelling for at least five days and a continual feeling of ankle instability. Vaes et al., (1998) proposed that compensated ankles were more efficient in making corrections, thus prevented further injury, and better classified participants with repeated ankle sprains (Vaes et al., 1998). These similar groupings of FAI participants were used in two other studies (Vaes et al., 2002; Vaes et al., 2001).

Rozzi et al. (1999) redesigned a functional knee questionnaire to measure ankle function called the "Ankle Joint Functional Assessment Tool." This questionnaire consisted of 12 questions, each with a possible maximum point value of 4 and a maximum total score of 48. The total score signified the subject's perceived level of functional ability. The higher scores indicated a greater perceived ankle function by the subject. Questions consisted of describing the level of pain, swelling, strength, and overall stability of the subject's ankle. Also participants were to describe their feelings of their ability to walk on uneven surfaces, descend stairs, jog, and change direction when running. Finally, participants described their capability to sense and react to their ankle rolling over and time required to return to activity after an ankle injury episode. In conclusion, the authors stated it was necessary to design this tool due to the lack of a

written ankle joint functional performance evaluation instrument, however, no studies on the tool's validity and reliability were found (Rozzi et al., 1999).

Re-establishing a Definition of FAI in the 2000s

The new millennium not only brought forth a new decade, but also established new and updated definitions by two leading researchers on FAI. In 2002, Hertel described the multi-symptom disorder as a loss of sensation and proprioceptive deficits and neuromuscular control, impaired postural control, and diminished strength. Hertel referred to FAI as a "pathologic contribution to CAI" (chronic ankle instability; Hertel, 2002, p. 368).

Hertel suggested that the insufficiencies contributing to CAI stemmed from recurrent sprains leading to mechanical and functional instabilities (Hertel, 2002). These two main components of CAI are fueled by many other changes that occur including "pathologic laxity; degenerative and synovial changes; arthrokinematic restrictions; impaired proprioception, impaired postural control, strength deficits, and impaired neuromuscular control" (Hertel, 2002, p. 369). Furthermore, in 2002, Tropp defined this phenomenon as "the subjective feeling of ankle instability or recurrent, symptomatic ankle sprains (or both) due to proprioceptive and neuromuscular deficits" (Tropp, 2002, p. 512).

Results on FAI Research and Different Participant Selection in the 2000s

Ankle muscle reaction times. Recent evidence on muscle reaction times was just as contradicting as it was during the 1990s. In agreement with earlier reports, Fernandes, Allison, and Hopper (2000) also found no differences in peroneal reaction time.

However, others disagreed and reported that individuals with FAI had longer peroneal reaction times. In fact, Vaes et al. (2001) reported that participants with non-compensated functional ankle instability showed a lack of control with ankle supination and significantly longer peroneal muscle reaction times. In addition, one year later, Vaes et al. (2002) found significantly slower first deceleration times in FAI participants, which are thought responsible for ankle injury protection. Other authors, Isabelle, Sylvie, and Chantal (2003), also found delayed peroneal muscle reaction times in a one and two-legged stance in FAI participants. Longer peroneal reaction times were also found in earlier studies (Lofvenberg et al., 1995).

Again, the lack of similar FAI participant selection could be one possible reason for the conflicting evidence. For example, Fernandes et al. (2000) divided FAI participants into two groups by frequency and severity of their sprains. Vaes et al. (2001) chose participants by using the same participant selection criteria as the 1998 study by Vaes et al. (1998). Both Vaes' studies grouped participants with FAI as being compensated or non-compensated, however excluded participants that had ankle inflammation at the time of the study. Isabelle et al. (2003) selected participants for the unstable group if they had a history of self-reported lateral ankle sprains more than 3 months ago with ankle swelling; required immobilization, loss of practice time or used an external support and limited performance secondary the ankle injury; and had no fracture of their lower extremity. Obviously, the FAI participants were selected by using different criteria making them broadly identified among these publications.

Peroneal reaction times have been reported to improve in individuals with injured ankles after participating in balance training programs. Osborne, Chou, Laskowski, Smith, and Kaufman (2001) found both injured and non-injured legs had quicker initial reaction times in the tibialis anterior after an 8-week balance training program. In addition, Eils and Rosenbaum (2001) reported significant improvements in peroneal and anterior tibialis muscle reaction times, postural control, and passive joint position sense after a 6 week balance training program.

Even though the results of these two studies agreed, participants were still selected differently. Eils and Rosenbaum (2001) selected participants based on repeated ankle inversion sprains that were pain free at the time of the study and self-reported feelings of ankle instability or "giving way." Osborne et al., 2001 selected FAI participants if a physician diagnosed a lateral ankle sprain within 6-18 months of the study; participants had a negative fracture x-ray and no other significant muscular injury. Exclusions included a history of lateral ankle sprain on the contralateral ankle, formal physical therapy, any lower extremity surgery, balance or vestibular disorder or any pathological conditions.

Ankle muscle strength.

Essentially, ankle muscle strength was not insufficient in participants with FAI in the 2000s. Porter, Kaminski, Hatzel, Powers, and Horodyski (2002) showed no differences in total peak torque and strength during concentric muscle contractions in either group using a stretch-shortening protocol. In addition, Munn, Beard, Refshauge, and Lee (2003) found no significant differences in muscle strength however; there was a

trend toward deficits in eccentric invertor muscle strength. In fact, this trend of deficits was thought to contribute to the feelings of ankle instability due to possibly causing a decrease in lateral foot displacement (Munn et al., 2003).

Nonetheless, Kaminski, Buckley, Powers, Hubbard, and Ortiz (2003) also found no significant differences in any versions of the strength and proprioception training in participants with self-reported FAI. One year later, Powers, Buckley, Kaminski, Hubbard, and Ortiz also reported that six weeks of proprioception and strength training did not affect proprioception or strength in FAI participants (Powers, Buckley, Kaminski, Hubbard, & Ortiz, 2004).

However, in 2002, Willems et al. (2002) did find significant decreases in concentric and eccentric ankle eversion muscle strength relative to body weight in FAI participants.

The selection of FAI participants was exactly the same for three of the publications that agreed in finding no significant differences in strength. Porter et al. (2002), Kaminski et al. (2003), and Powers et al. (2004) all chose FAI participants by using the same questionnaire regarding criteria for functional ankle instability previously described by Hubbard and Kaminski (2002). Munn et al. (2003) used a questionnaire previously described by De Bie et al. (1997), which included one unilateral inversion ankle sprain within the last year but not the last 4 weeks; self-reported symptoms of ankle weakness; reduced function at the time of study; no past surgery or fracture on either ankle, no ankle pain at rest, and no history of any neurological conditions. Even though

these criteria are not exactly the same, the criteria categories are very similar which may have lead to the selection of similar participants.

Postural control. Hertel (2002) defined postural control as dynamic structures of the foot and ankle keeping the body's center of gravity over its support base. In addition, Hertel (2002) stated that weakness might be related to damaged nerves and muscles causing individuals to develop irregular muscle-firing patterns during dynamic postural control.

Improved postural control scores were reported in FAI participants in late 1990's by training the individuals' balance. These improvements were explained by a compensatory mechanism (a hip strategy) of balance in individuals with injured ankles (Bullock-Saxton, 1994; Pintsaar et al., 1996). However, this type of balancing strategy is less efficient thereby, producing an increased postural sway (Bullock-Saxton, 1994; Pintsaar et al., 1996).

Recently, postural sway values were reported as improved in participants using tape on the ankle tape after 4 weeks of training (Matsusaka et al., 2001). In fact, postural sway values were within normal limits in 6 weeks or less of training compared to the group with no tape (Matsusaka et al., 2001), suggesting that the stimulation of the sensory receptors in the ankle muscles were responsible for the improvements.

In 2002, a specific and objective balance test, the Star Excursion Balance Test, was used to check participants with unilateral chronic ankle instability. Olmstead, Carcia, Hertel, and Shultz (2002) confirmed that participants with chronic ankle instability performed significant decreases in their reach ability on their injured foot and compared

with the controls (Olmstead et al., 2002). The results suggested that participants with FAI have deficits in postural control on their involved limbs.

Nonetheless, dancers with injured ankles showed increased postural sway for flat foot stance but, smaller measures for baseline measures on demi-pointe (Hiller, Refshauge, & Beard, 2004). Even though the injured dancers complained of feelings of ankle instability, the authors stated they did not feel it hindered any functional performance (Hiller et al., 2004).

Participant selection was very different and confusing among the recent publications regarding postural control in participants with FAI. Olmstead, et al. (2002) chose FAI participants with at least one episode of a lateral ankle sprain but not within the last 6 weeks; multiple episodes of "giving way" within the past 12 months; no prior balance training; no cerebral concussions or vestibular disorders; no lower extremity injuries 3 months prior to testing; and no ear or upper respiratory infection. Many differences were noted in the participant selection by Olmstead et al. (2002) compared to Matsusaka et al. (2001). Matsusaka selected FAI participants with one unilateral inversion ankle sprain; unable to weight bear and used crutches; reported repeated sprains and/or "giving way" episodes at least two times within a six month period; no pain or stiffness at the time of the study; had no history of a fracture or any impairments of lower extremity, trunk or central nervous system. Different and less stringent on requirements, Hiller et al. (2004) selected injured dancers with a past history of ankle injury requiring some type of immobilization, but without fracture, neurological deficit, or ankle surgery.

Proprioception. Hertel's (2002) review included proprioceptive deficits, as well as components that he called "kinesthesia (movement threshold)" and "joint position sense" (Hertel, 2002). Hubbard and Kaminski (2002) found no differences in "threshold to detection of passive motion" in either the healthy or FAI groups however, after applying an ankle brace, there was a decreased ability to perceive passive motions in both groups.

In addition, Konradsen & Magnusson (2000) found greater replication error in FAI participants however; this error was not significant and was reduced after a warm-up in healthy individuals. Later, Brown, Ross, Mynark, and Guskiesicz (2004) did not find any significant differences in joint position sense in individuals with functionally unstable ankles (Brown et al., 2004), which agreed with an earlier study (Bernier & Perrin, 1998). However, the authors did find significant deficits in anterior/posterior time to stabilization measures and soleus muscle activity that the authors thought may be an adaptative mechanism following an ankle injury (Brown et al., 2004).

On the contrary, a recent study reported individuals with functionally unstable ankles demonstrated less accuracy during active position sense (Willems et al., 2002), which agreed with an earlier report that participants were better able to detect joint movement in their uninjured side compared to their injured side (Forkin et al., 1996)

Interestingly, Caulfield and Garrett (2002) found FAI participants experienced greater knee flexion and dorsiflexion upon landing, which the authors believe may be a result of defects at the central processing level responsible for motor control. In fact, lower extremity muscle responses to single leg-landing performance were slower in FAI

participants. Selected participants included a self-reported history of at least 2 lateral ankle sprains; a feeling of the ankle "giving way"; and recently released from a rehabilitation program. Neither group reported any neurological or vestibular impairments and the healthy group had no history of lateral ankle sprain to either ankle or fracture.

Jerosch & Schoppe (2000) found improvements in sport specific activities in FAI participants while wearing an ankle brace (Jerosch & Schoppe, 2000). Unfortunately, no selection criteria were available in the publication. Moreover, Eils and colleagues reported that passive support of ankle braces on restricting ankle motion is appropriate. However, the function is not as appropriate during rapid motions similar to ankle sprain motions (Eils et al., 2002).

Results regarding proprioception have been contradictory. Again however, there were differences in the criteria required for participant selection. Hubbard et al. (2002) chose subjects with the "The Functional Ankle Instability Questionnaire." Participants were considered functionally unstable if their initial injury required crutches and/or immobilization, injured ankle felt more painful, weaker, and less functional, had episodes of "giving way" within the past 3 months, hadn't participated in any formal rehabilitation program, and attributed current instability to past injuries of the ankle. In addition, participants exhibiting mechanical instability by means of anterior drawer and talar tilt tests were excluded.

On the other hand, Konradsen & Magnusson (2000) chose participants if they had at least seven self-reported repeated ankle sprains within the previous year experienced

on a flat surface; recreationally active no more than twice a week; and mechanically unstable.

Brown, Ross, Mynark, and Guskiesicz (2004) chose participants differently than the first two authors and described FAI participants as recreational athletes with at least two recurrent sprains in the last year; feelings of the ankle giving way with activity; and a scored of 20 or less on the Ankle Joint Functional Assessment Test (AJFAT). The healthy group contained participants with no history of lateral ankle sprain, lower extremity (including surgery) injury or feelings of "giving way." Again, obvious differences in FAI participant selection could be one reason conflicting research results.

Comprehensive Approaches in FAI Selection Criteria in the 2000s

In 2002, many researchers started questioning the lack of consistency of selecting FAI participants (Demeritt et al., 2002; Hubbard & Kaminski, 2002; Kaminski & Hartsell, 2002; Riemann, 2002; Vaes, Duquet, & Gheluwe, 2002). During this year, two studies were published showing others how they could complete this selection process.

Hubbard and Kaminski (2002) was a benchmark study in constructing a survey of criteria specifically for FAI called "Criteria Functional Ankle Instability" (Hubbard & Kaminski, 2002). The survey has appeared in many other studies to qualify participants with FAI (Kaminski et al., 2003; Hubbard & Kaminski, 2002; Porter et al., 2002).

Participants were considered functionally unstable if their initial injury required crutches and/or immobilization, injured ankle felt more painful, weaker, and less functional, had episodes of "giving way" within the past three months, hadn't participated in any formal rehabilitation program, and attributed current instability to past injuries of

the ankle. The survey qualified FAI participants when they answered questions 3, 5, 6, 7, and 9 as "yes," however they must have also answer questions 4, 8, and 10 as "no" (Hubbard et al., 2004, p. 483). However, this survey excluded any participants with signs of mechanical instability found by the talar tilt and anterior drawer tests. Even though this questionnaire is comprehensive, no validity or reliability data for this questionnaire was found in the literature.

Willems et al. (2002) separated participants into four groups. Group one consisted of healthy individuals with no prior history of ankle injury. Group two consisted of the instability group defined as more than three lateral ankle sprains of the same ankle but not within the last three months. In addition, unstable participants complained of "giving way" and pain during extreme activity. Group three consisted of participants with only one to three lateral ankle sprains in the last two years, but didn't complain of ankle instability or pain. Group four consisted of unstable participants exactly such as group three however; the participants' ankle injuries were experienced three to five years prior to testing. Mechanical instability was not considered a factor or measured in this study. Interestingly, the amount of time passed after the last ankle sprain did not affect the outcomes. Nonetheless, different criteria applied to FAI participant selection may account for the different outcomes.

Functional Performance and Gait Patterns

In addition to the four main FAI insufficiencies described by Hertel (2002), researchers also looked at a few other characteristics affected by FAI. It appears that functional performance tests were not affected in FAI participants (Demeritt et al., 2002).

Selected participants experienced at least one lateral ankle sprain with the inability to weightbear; one repeated lateral ankle sprain or an episode of the ankle "giving way;" and were not participating in a formal rehabilitation program. However, general gait patterns in chronically unstable participants were actually different between participants with injured and healthy ankles (Spaulding, Livingston, & Hartsell, 2003). In fact, an ankle brace did not further affect the gait characteristics. Even though it is common for clinicians use ankle braces for individuals with symptoms of ankle instability, it is interesting that the ankle brace did not enhance gait characteristics similar to the unaffected ankle.

Mechanical Instability

Mechanical instability has been included as a criterion for participant selection in many of the research publications found on functional ankle instability. Back in 1985, Tropp, Odenrick, and Gillquist (1985) found reduced postural control was found in participants with FAI, but not in participants with mechanical ankle instability. In fact, the highest degree of mechanical instability seemed to produce greatest improvements in reaction time among FAI participants (Karlsson & Andreasson, 1992). However, while both are considered part of the problem in individuals with chronic ankle instability, Specchiulli and Cofano (2001) found approximately 50 percent of patients with functional instability did not show any signs of mechanical instability. However, Hubbard et al. (2004) determined that participants with FAI actually measured greater mechanical laxity on their injured side when compared with their opposite ankle.

Contradictions in the results of these two studies could be attributed to a different sample population. Specchiulli and Cofano (2001) selected participants that were patients treated for grade III ankle injuries, closed epiphyseal growth plates, and ligament rupture was diagnosed. Participants in Hubbard's study (2004) were selected based on a questionnaire targeting individuals with self-reported FAI and did not measure any objective diagnosis of ankle instability. Even though it is the most comprehensive FAI participant selection questionnaire to date, it has not been a widely used and there is lack of agreement on the use of mechanical instability in FAI selection criteria.

Proportion of Agreement

Characteristics such as neuromuscular control, postural control, and strength have been inconsistently identified as insufficiencies of FAI. One approach in identifying an explanation for these inconsistencies is to evaluate differences in the research methods used by the authors. The methods that were used in the FAI research clearly indicate that broad ranges of FAI participant inclusion criteria have been used. However, it is uncertain if these criteria could have lead to the selection of different population samples, and the ultimate study of different groups.

One method to evaluate these inconsistencies is to determine the level of agreement between past authors' inclusion criteria. Specifically, methods include calculating the proportion of agreement by applying the multiple selection criteria to a common sample of participants. Proportion of agreement is a "popular method of estimating reliability from a contingency table…where scores are summed up and converted to proportions" (Safrit, 1990, p.149). Therefore, the purpose of this study was

to examine group agreement regarding selection criteria among authors who recruit participants with self-reported functional ankle instability. In addition, the prevalence of functional ankle instability will be identified.

The specific aims of this study are as follows:

1. To determine the rate of agreement on broad inclusion criteria for authors selecting participants for functional ankle instability.
2. To determine the proportion of agreement between authors who have classified participants with functional ankle instability.
3. To determine the prevalence of participants classified as functionally unstable according to previous authors' classifications.

CHAPTER 3

METHODS

The purpose of this study was to examine group agreement regarding selection criteria among authors who recruit participants with self-reported functional ankle instability. In addition, the prevalence of functional ankle instability will be identified. The organization of this chapter is as follows: participants; design; instrumentation; procedures; and statistical analysis.

Participants

One hundred ninety physically active high school and college-aged participants, (74 men, 19.0 yrs $\pm$ 2.49, 180.37 cm $\pm$7.57, 78.31 kg $\pm$14.55; 115 women, 18.5 yrs $\pm$ 2.13, 166.82 cm $\pm$6.72, 62.45 kg $\pm$12.34) were included in this project. One participant was excluded due to incomplete data reporting. Approval by the University of Northern Iowa's Institutional Review Board (IRB) was obtained. All participants provided consent and assent in accordance with the university's IRB (Appendix A).

Design

This study utilized a non-experimental, observational design. There was no experimental condition or intervention imposed. Participants were asked to respond to 113 criteria items that represented a culmination of 25 authors' inclusion criteria used for published research addressing functional ankle instability.

Instrumentation

Functional ankle instability (FAI) was assessed by means of a survey comprised of a collection of questions from multiple authors' inclusion criteria. An author's research participation inclusion criteria qualified for this study by meeting all of the following criteria: (a) Focus of the research was functional ankle instability, (b) Participants were categorized by their potential of having different possible outcomes including "stable" or "unstable," or just "unstable," (c) No objective testing techniques, such as a drawer test or device, were used to determine mechanical instability, and (d) The publication did not utilize the participant's contralateral ankle as the control group. Seventy-five peer-reviewed publications addressing ankle instability were reviewed for potential inclusion. To find potential FAI publications, the Pub Med data base was searched using the following terms: "functional ankle instability," "ankle instability," "unstable ankle" and "ankle sprain." Twenty-five publications qualified for this study. To help sort and organize the criteria questions, eleven broad inclusion criteria categories were established from the publications addressing functional ankle instability and were labeled as follows: history of ankle sprain, sprain frequency, self-reported instability, sprain severity, lower extremity injury, rehabilitation, pain, edema, functional activity, neuromuscular/vestibular disorder, external support. Categorizing the inclusion criteria eliminate duplicated items.

Specific criteria items used on the instrument were derived from questions used to select FAI participants in the 25 publications. A broad criteria item such as one labeled "history of ankle sprain" included specific criteria items described as: "participants who

experienced an ankle sprain" or "history of a severe ankle sprain." These are a few examples of the numerous specific criteria items described by the 25 authors. Specific criteria items that appeared as questions in their published form were taken directly from the article and used word for word. However, specific criteria items that did not appear as questions were converted into dichotomous questions to match the original criteria as close as possible. For example, if an author stated a specific criteria item was "history of a previous ankle sprain," then the question on the instrument stated "Have you ever experienced an ankle sprain?" Based upon the specific inclusion criteria questions derived from the 25 publications, a decision was made for each participant whether they were "stable," "unstable," or "excluded" according to each of the 25 authors. A participant qualified as "excluded" if they did not meet the qualifications set forth by that particular author to be "stable" or "unstable."

Procedures

Participants met in a predetermined, quiet classroom for administration of the questionnaire. All participants completed the instrument within 20 minutes.

Data Analysis

Raw data were reduced to provide a score of "stable," "unstable," or "excluded" for each participant under each of the 25 criteria. Data for each subject were entered into the SPSS 12.0 Statistical Package (SPSS Inc., Chicago, IL) for analysis. Nine authors used two categories to classify participants as "stable" or "unstable". Sixteen authors used three categories to classify participants as "stable," "unstable," or "excluded" therefore 36 two-by-two and 105 three-by-three contingency tables were calculated.

Specific Aim 1: To determine the rate of agreement on broad inclusion criteria for authors selecting participants for functional ankle instability.

The rate of agreement on broad inclusion criteria for authors selecting subjects for functional ankle instability was calculated. The 11 broad inclusion criteria categories included history of ankle sprain, sprain frequency, self-reported instability, sprain severity, LE injury, rehabilitation, pain, edema, functional activity, neuromuscular/vestibular disorder, external support. Agreement was calculated for each broad category by totaling the number of authors that incorporated each category into their inclusion criteria and dividing by the total number of authors.

Specific Aim 2: To determine the proportion of agreement between authors who have classified participants with functional ankle instability.

The level of agreement of participants' groups assignment between the author's criteria were examined using three statistics, proportion of agreement, kappa coefficient, and pairwise agreement.

Proportion of Agreement. To examine the level of agreement of participant group assignment among the authors criteria proportion of agreement coefficients were calculated. The proportion of agreement represents the percentage of participants assigned to the same group using two authors' criteria. The proportions of agreements were separated by the number of possible classifications used.

Kappa Coefficient. To true agreement, between author's criteria that classify participants with functional ankle instability, the Kappa coefficient was used. Kappa coefficient is more powerful than proportion of agreement because it represents the

amount of agreement between the two criteria after chance has been removed (Kraemer, Periyakoil, & Noda, 2004). One disadvantage of the kappa coefficient is it can only handle two raters (criteria) at one time.

Pairwise Agreement. Fleiss (1971) developed an approach to examine agreement between more than two raters (criteria) called pairwise agreement. Pairwise agreement is a kappa-like statistic that represents the average kappa among all the raters (Fleiss, 1971).

Specific Aim 3: To determine the prevalence in participants classified as functionally unstable according to authors' classifications.

This study also considered the percent of occurrence in subjects that were classified as functionally unstable according to each author. This figure was calculated by adding the number of participants that were found as "unstable" according to how they answered the survey tool according to the criteria specified by each author. This number was divided by the total number of participants (N=189) that completed the survey.

CHAPTER 4

RESULTS

The results of the statistical analyses are presented in the following chapter. The analyses include: (a) Rate of agreement regarding broad categories of inclusion criteria past authors had used, (b) Proportion of agreement in responses to questions regarding inclusion criteria for participants in functional ankle instability research, and (c) Prevalence of functional ankle instability based upon the past authors' inclusion criteria.

Specific Aim 1: To determine the rate of agreement on broad inclusion criteria for authors selecting participants for functional ankle instability.

Agreement was calculated for each broad category by totaling the number of authors that incorporated each category into their inclusion criteria and dividing by the total number of authors. The percent agreement for each category is presented in Table 1. Each author (100%) incorporated history of at least one ankle sprain into their inclusion criteria for functional ankle instability. Ankle sprain frequency (88%) and self-reported instability (84%) were the next two most commonly incorporated criteria categories. Edema (20%), functional activity (20%), and the use of external support (8%) were the least frequently incorporated criteria.

Table 1:
Author Agreement for the Eleven Broad Inclusion Criteria Categories Used in FAI Participant Selection

Authors	History of Ankle Sprain	Sprain Frequency	Self-Reported Instability	Sprain Severity	Pain	Lower Extremity Injury	Rehabilitation	Neurologic/ Vestibular Disorders	Edema	Functional Activity	External Support
Bernier et al 1998	X	X	X	X	X						
Caulfield et al 2002	X	X	X			X	X	X			
Demerritt et al 2002	X		X	X			X				
Docherty et al 1998	X	X	X							X	
Eils et al 2002	X	X	X								
Eils et al 2001	X	X	X								
Forkin et al 1996	X	X			X	X		X	X		
Garn et al 1988	X	X			X			X	X	X	
Gribble et al 2004	X	X	X	X		X					
Hubbard et al 2004	X	X	X	X	X		X			X	
Isabelle et al 2003	X	X		X		X	X	X			X
Konradsen et al 1990	X	X	X								X
Lofvenberg et al 1995	X		X			X					
Matsusaka et al 2001	X	X	X	X	X	X					
Myo-Hla et al 1999	X	X	X			X		X			
Olmstead et al 2002	X	X	X			X	X	X			
Robinson et al 1986	X									X	
Ryan et al 1994	X	X	X	X	X					X	
Spaulding et al 2003	X	X	X	X	X	X	X		X		
Tropp 1986	X	X	X	X							
Tropp et al 1988	X	X	X					X			
Vaes et al 1998	X	X	X	X	X	X					
Vaes et al 2002	X	X	X	X	X		X		X		
Vaes et al 2001	X	X	X	X	X		X		X		
Willems et al 2002	X	X	X		X						
TOTAL and %	25/25=100%	22/25=88%	21/25=84%	12/25=48%	11/25=44%	10/25=40%	8/25=32%	7/25=28%	5/25=20%	5/25=20%	2/25=8%

The eleven criteria are presented in descending order of agreement from left to right.

Specific Aim 2: To determine the proportion of agreement between authors who have classified participants with functional ankle instability.

To establish criterion referenced standard reliability, both 2 x 2 and 3 x 3 contingency tables determined the proportion of agreement between authors who rated participants with functional ankle instability. To establish nominal scale agreement, or true agreement, between authors who rate participants with functional ankle instability, kappa coefficients were calculated. The results indicate that the proportion of agreement and kappa scores for the 2 x 2 contingency tables (m=85.8%; k=.10) and the 3 x 3 contingency tables (m=55.1%; k=.15) were very low. Proportional agreement and kappa scores are presented in Tables 2-5.

Table 2:

Proportional Agreement for Authors Categorizing Participants by Stable or Unstable (2 x 2)

	Bernier 98	Demeritt 02	Docherty 98	Eils 02	Eils 01	Hubbard 04	Matsusaka 01	Ryan 94	Tropp 86
Bernier 98									
Demeritt 02	83.6								
Docherty 98	92.1	87.3							
Eils 02	74.6	77.2	78.3						
Eils 01	77.8	80.4	81.5	96.8					
Hubbard 04	93.1	80.0	87.3	76.2	79.4				
Matsusaka 01	98.9	82.5	92.5	74.6	77.8	93.1			
Ryan 94	98.4	84.1	93.7	75.1	78.3	92.6	98.4		
Tropp 86	96.3	81.0	89.4	75.1	78.3	90.5	96.3	95.8	

Note: The total number of proportional agreement scores=36, scores total=3088.30, and mean = 85.8%.

Table 3:
Kappa Scores for Authors Categorizing Participants by Stable or Unstable (2 x 2)

	Bernier 98	Demeritt 02	Docherty 98	Eils 02	Eils 01	Hubbard 04	Matsusaka 01	Ryan 94	Tropp 86
Bernier 98									
Demeritt 02	.05								
Docherty 98	-.01	.42							
Eils 02	.03	.33	.26						
Eils 01	.04	.39	.31	.91					
Hubbard 04	-.01	.05	.01	.18	.21				
Matsusaka 01	-.01	-.01	-.01	.03	.04	-.01			
Ryan 94	-.01	.10	.24	.06	.07	-.02	-.01		
Tropp 86	-.01	-.00	-.05	.09	.11	-.04	-.01	-.02	

Note: The total number of kappa scores=36, scores total=3.7 and mean=.10.

Table 4:
Proportional Agreement for Authors Categorizing Participants by Stable, Unstable, or Excluded (3 x 3)

	Caulfield 02	Forkin 96	Garn 88	Gribble 04	Isabelle 03	Konradsen 90	Lofvenberg 95	Myo-Hla 99	Olmstead 02	Robinson 86	Spaulding 03	Tropp 88	Vaes 98	Vaes 01	Vaes 02	Willems 02
Caulfield 02																
Forkin 96	54.5															
Garn 88	51.9	65.6														
Gribble 04	59.8	65.1	50.1													
Isabelle 03	56.1	67.2	50.0	79.4												
Konradsen 90	54.5	57.7	53.0	64.0	62.4											
Lofvenberg 95	35.4	50.3	40.7	60.3	66.1	56.6										
Myo-Hla 99	---	---	---	---	---	---	---									
Olmstead 02	48.7	63.0	55.6	71.4	70.4	54.0	55.0	---								
Robinson 86	41.3	43.4	43.4	39.5	39.7	51.3	49.7	---	34.9							
Spaulding 03	43.4	51.3	53.4	51.9	50.8	45.5	52.4	---	48.1	51.9						
Tropp 88	56.6	46.6	41.8	60.3	62.0	62.4	61.9	---	47.1	38.6	33.4					
Vaes 98	37.0	47.1	33.9	60.3	70.9	49.2	66.7	---	59.8	37.6	34.9	59.3				
Vaes 01	37.0	46.0	33.9	61.9	71.4	47.6	68.3	---	59.8	36.0	36.5	60.8	94.2			
Vaes 02	37.0	46.0	33.9	61.9	71.4	47.6	68.3	---	59.8	36.0	36.5	60.8	94.2	100		
Willems 02	42.9	60.0	45.0	72.5	79.4	66.1	77.8	---	67.2	41.8	43.4	75.7	75.7	76.2	76.2	

Note: The total number of proportional agreement scores =105, scores total = 5784.80, and mean = 55.1%. The dash (--) represents scores that would not compute because no participants qualified as being unstable. When computing these scores, all three possibilities were needed to be compared to other similar studies.

TABLE 5:
Kappa Scores for Authors Categorizing Participants by Stable, Unstable, or Excluded (3 x 3)

	Caulfield 02	Forkin 96	Garn 88	Gribble 04	Isabelle 03	Konradsen 90	Lofven-berg 95	Myo-Hla 99	Olm-stead 02	Robinson 86	Spaulding 03	Tropp 88	Vaes 98	Vaes 01	Vaes 02	Willems 02
Caulfield 02																
Forkin 96	.31															
Garn 88	.38	.43														
Gribble 04	.38	.39	.22													
Isabelle 03	.31	.40	.21	.54												
Konradsen 90	.31	.28	.25	.37	.30											
Lofvenberg95	-.01	.11	.07	.14	.14	.21										
Myo-Hla 99	---	---	---	---	---	---	---									
Olmstead 02	.21	.35	.30	.45	.36	.19	.06	---								
Robinson 86	.12	.02	.06	.03	.02	.20	.20	---	-.05							
Spaulding 03	.15	.10	.20	.18	.14	.06	.18	---	.11	.12						
Tropp 88	.33	.13	.13	.24	.20	.37	.21	---	.01	.09	-.02					
Vaes 98	-.00	.02	-.01	-.04	-.04	.01	-.11	---	.01	.03	-.09	-.06				
Vaes 01	-.00	.01	-.01	.00	-.02	-.02	-.06	---	.01	.02	-.05	-.03	.53			
Vaes 02	-.00	.01	-.01	.00	-.02	-.02	-.06	---	.01	.02	-.05	-.03	.53	1.00		
Willems 02	.10	.26	.14	.34	.40	.36	.40	---	.26	.07	.02	.45	-.05	-.02	-.02	

Note: The total number of kappa scores =105, scores total =15.38, and mean =.15. The dash (--) represents scores that would not compute because no participants qualified as being unstable. When computing these scores, all three possibilities were needed to be compared to other similar studies.

Specific Aim 3: To determine the prevalence in participants classified as functionally unstable according to authors' classifications.

The number of participants that qualified as functionally unstable (Table 6) according to each author's inclusion criteria ranged widely from 0-59 participants (16.36 $\pm$ 17.08) or 0-32 percent (8.72 $\pm$ 8.98). Ten of the authors would have selected 4 or fewer participants as functionally unstable from the sample of 189 physically active participants whereas six authors would have classified thirty or more participants as functionally unstable.

TABLE 6
Number & Percent of Participants Identified as Unstable (N = 189)

Authors	Number identified as Unstable	Percent Identified as Unstable
Myo-Hla 99	0	0.0
Bernier 98	1	1.0
Matsusaka 01	1	1.0
Vaes 98	1	1.0
Ryan 94	2	1.1
Willems 02	2	1.1
Isabelle 03	3	1.6
Vaes 01	3	1.6
Vaes 02	3	1.6
Spaulding 03	4	2.1
Tropp 86	6	3.2
Lofvenberg 95	9	4.8
Hubbard 04	12	6.3
Forkin 96	13	6.9
Docherty 98	14	7.5
Gribble 04	17	9.0
Olmstead 02	17	9.0
Robinson 86	22	11.6
Konradsen 90	23	12.2
Demeritt 02	32	16.9
Garn 88	35	18.5
Tropp 88	38	20.1
Eils 01	43	22.8
Eils 02	49	25.9
Caulfield 02	59	31.2
Mean	16.36	8.72
SD	17.08	8.98
Range	0 – 59	0 – 31.2

N= 189

CHAPTER 5

DISCUSSION

Functional ankle instability has been commonly identified in the literature as a cause of ankle injury and dysfunction. However, FAI has not been consistently identified or described (Kaminski & Hartsell, 2002). Numerous criteria have been reported concerning FAI selection, leaving comparisons difficult. Establishing group agreement among FAI selection criteria is essential to future FAI research.

The results of this study indicated low agreement between authors who have classified research participants with FAI. This suggests that FAI participants have been selected inconsistently among different researchers. In addition, the results have identified three broad categories of inclusion criteria commonly used in FAI research. These categories may help clarify the criteria and bring consistency to the research in FAI.

Agreement on Broad Inclusion Criteria Categories in Selecting Participants for FAI

The results suggest low overall agreement in eleven broad inclusion criteria authors used to select participants with functional ankle instability. Every inclusion item implemented by each author fit into one of the eleven broad criteria categories (Table 1), but only one category was incorporated by every author. Although sprain frequency, self-reported instability, and sprain history were incorporated by at least 21 of the 25 authors, eight of the categories were incorporated by less than 12 of the authors.

Each of the 25 authors incorporated sprain history as a requirement into their inclusion criteria. Research supports that individuals who suffered recurrent ankle sprains also experienced symptoms of FAI suggesting that a previous sprain should be considered a criterion when selecting FAI participants (Yeung et al., 1994). In addition, ankle instability has been reported four times higher in athletes with five or more sprains suggesting that repetitive sprains should be considered a criterion when selecting FAI participants (Yeung et al., 1994). However, the sprains frequency and recentness was interpreted differently among the 25 authors.

Twenty-one different descriptions were used by 22 authors to address the category of "sprain frequency". For example, two authors required at least one lateral ankle sprain (Isabelle, et al., 2003; Olmstead et al., 2002) with different time limits required to be selected for FAI participation however, nine authors required repeated lateral ankle sprains with no time limit (Caulfield & Garret, 2002; Eils & Rosenbaum, 2001; Garn & Newton, 1988; Konradsen & Ravn., 1990; Myo-Hla et al., 1999; Tropp, 1988; Vaes et al., 1998; Vaes et al., 2001; Vaes et al., 2002). Eleven authors required repeated lateral ankle sprains with different time limits (Bernier & Perrin, 1998; Demerrit et al., 2002; Docherty et al., 1998; Eils et al., 2002; Forkin et al., 1996; Hubbard et al., 2004; Matsusaka et al., 2001; Ryan, 1994; Spaulding et al., 2003; Tropp, 1986; Willems et al., 2002) to be considered FAI.

In addition, the criteria category "self-reported instability" included individuals with symptoms of "giving way" or "weakness" and was incorporated by 84 percent (m=21/25) of the authors. However, the phrase "giving way" can be interpreted

differently. Freeman (1965) first described "giving way" when individuals explained their symptoms in his clinic. Quickly the phrase became the central identifier of FAI and was used by Freeman (1965) and others to diagnose and recruit individuals for research.

Functional ankle instability has evolved over the years, encouraging intriguing discussion of what individuals actually experience during episodes of FAI. "Giving way" may be interpreted as ankle weakness, recurring lateral ankle ligament sprains, an inversion ankle injury causing recurrent turning on the lateral border without severe injury, and/or recurrent feelings of ankle instability or weakness without spraining or injuring the ankle. For example, Vaes defined the phrase "giving way" as "unable to control the stability of the ankle or the sensation as if your ankle is going to sprain instantly." (Vaes et al., 2001, p. 742) However, Eils broadly defined "giving way" as a feeling of ankle instability, leaving much room for interpretation (Eils & Rosenbaum, 2001).

Concerns regarding the inclusion of individuals with either recurrent ankle sprains and/or those who reported symptoms of the ankle "giving way" for FAI participation have been expressed (Hubbard & Kaminski, 2002). Researchers should decide if they will use both or only one of the previous criteria. Nonetheless, the term "giving way" is an example of a subjective description in which functional ankle instability may be articulated. Without an accurate understanding of this phrase however, research participants may interpret the meaning differently, which may contribute to further inconsistencies of selecting FAI participants.

Three broad criteria categories demonstrated high percentages of incorporating authors using them in FAI participant selection including "history of ankle sprain," "ankle sprain frequency," and "self-reported instability." Even though many of the 25 authors used these three broad criteria categories, the specific criteria items within these broad categories were not consistent in language and invited numerous interpretations. This may have allowed participants to interpret the specific criteria questions differently. However, the high percentage of incorporation of these three broad criteria categories has highlighted the inclusion content deemed important by most authors and may in the future help narrow and refine inclusion criteria.

Agreement between Authors regarding Specific Selection Criteria In FAI Participant Selection

Collectively, the results showed very low agreement between the classifications of the 25 authors, illustrating inconsistencies of selecting FAI research participants. The classifications with high agreement were typically conducted by the same authors implementing exact or similar criteria during the FAI selection process. For example, perfect agreement (1.00) was reported between Vaes et al. (2001) and Vaes et al. (2002) and very high agreement (.91) between Eils & Rosenbaum (2001) and Eils et al. (2002).

One explanation for this low agreement among different authors is their use of different broad criteria categories in their selection criteria used to qualify FAI research participants. Hertel (2002) described conflicting results of FAI research regarding proprioception, postural sway, peroneal reaction times and muscle strength. Specifically, increased peroneal reaction times have been reported in individuals with FAI (Bullock-

Saxton et al., 1994; Hertel, 2002; Karlsson & Andreasson, 1992; Konradsen & Ravn, 1990; Konradsen & Ravn, 1991; Lofvenberg et al., 1995; Myo-Hla et al., 1999) however, others reported conflicting results (Ebig et al., 1997; Fernandes et al., 2000; Isakov et al., 1986; Vaes et al., 2002).

Not surprising, Konradsen and Ravn (1990) and Vaes et al. (2002), two authors that found conflicting results regarding peroneal reaction times, demonstrated very low agreement (-.02) in their participant selection (Table 5). For example, Konradsen and Ravn (1990), who reported peroneal muscle weakness with FAI, would have identified 23 of the 189 individuals with FAI. However, Vaes et al. (2002), who found no differences in muscle weakness, would have only identified three. In fact, Konradsen and Ravn (1990) incorporated only three of the eleven broad criteria categories whereas Vaes (2002) incorporated seven. Both authors included "history of ankle sprain," "sprain frequency," and "subjective instability" as broad criteria categories, however Vaes (2002) also included "sprain severity," "rehabilitation," "pain," and "edema" in his selection process making the criteria more strict and less likely for the participants to qualify.

Vaes et al. (2001) and Vaes et al. (2002) would have identified only three participants each for research participation whereas Eils and Rosenbaum (2001) and Eils et al. (2002) would have identified 43 and 49 participants respectively. The Eils' criteria were less strict and included only three out of the eleven different broad criteria categories for recruitment, whereas the Vaes' criteria were strict and included seven.

An additional explanation for the low agreement included the structure of the questions within each broad criteria category. Although "history of ankle sprain" was a

consistent broad criteria category, the structuring of the specific criteria items within the broad criteria categories were inconsistent and resulted in different specific criteria item questions. For example, within the broad criteria category "subjective instability," the specific criteria item was "frequent giving way" and developed in the following question: "Have you ever had a feeling of ankle instability or that your ankle feeling like it is giving way?" However, in the same broad criteria category of "subjective instability," the specific criteria item was "at least 6 episodes of the ankle giving way with or without pain within the past 12 months" and developed in the following question: "Have you had at lease six episodes of your ankle giving way into inversion with or without pain, within the past 12 months?" In addition, the broad criteria category "history of ankle sprain" used the specific criteria item "history of one ankle sprain," the specific criteria item question asked "Have you ever experienced an ankle sprain?" whereas another question asked "Have you ever had an ankle injury?" These questions could have been perceived differently and answered inconsistently.

Ryan (1994) and Willems et al. (2002) reported conflicting results in identifying peroneal muscle weakness as a contributing factor to FAI. Although they both would have qualified only two out of 189 participants with FAI in this study, the participants they would have qualified were four different individuals. Even though both authors used similar broad criteria categories, Ryan (1994) used six of the eleven broad criteria categories and Willems et al. (2002) used four, the structure of the specific criteria item questions contributed to inconsistent participant selection. Both authors included "sprain frequency" and "self-reported instability" in their broad criteria categories. Ryan (1994)

required FAI participants to have experienced at least 6 episodes of the ankle "giving way," whereas Willems (2002) required frequent episodes. Not only could the term "frequent" been interpreted differently by the participants, but Ryan (1994) also included participants as FAI if they had experienced either episodes of "giving way," or at least 3 inversion ankle sprains with 2 or more within the past 18 months, and one within the past 6 months. However, Willems required the unstable group to have experienced both "giving way" episodes and more than 3 inversion sprains, but none within 3 months of testing. This example demonstrates how the structure of the specific criteria items lead to questions that could have contributed to low agreement.

Another example of authors who used different structure of specific criteria items included the authors Bernier and Perrin (1998) and Tropp (1986). Bernier and Perrin (1998), who reported no significant changes in postural control, and Tropp (1986), who stated postural control was insufficient in FAI individuals, reported very low agreement (-.01) in regards to their selection criteria. However, they each would have qualified only 1 and 6 participants respectively for FAI participation. For participant selection, Bernier and Perrin (1998) required five out of the eleven broad criteria categories and Tropp (1986) chose four. In fact, these two authors also used very similar broad criteria categories for selection of FAI participants. Both authors thought important broad criteria categories included "history of ankle sprain," "sprain frequency," self-reported instability," "and "sprain severity," although Bernier and Perrin (1998) also included "pain." However, structure of the questions within the broad criteria category became an issue that could explain the low agreement between the two authors. For example, within

the broad criteria category "sprain frequency" both authors included the question "Have you experienced repeated episodes of a lateral ankle sprain or an ankle sprain to the outside of your ankle?" Within this category, Bernier and Perrin (1998) also asked the specific criteria question "Have you had at least two of these sprains within the past 12 months?" But Tropp (1986) asked the question "Have you had an ankle injury within the last 1.5 years?" The word "injury" could be widely interpreted such as a sprain, fracture, strain, or contusion, however Tropp (1986) stated "sprain" which narrows the interpretation. The two questions have different concepts due to the structure of the specific criteria items. Regarding "sprain severity," Bernier and Perrin (1998) stated research participants must have been non-weight bearing and used crutches. However, Tropp (1986) only required that FAI participants' ankle sprains were severe enough to have created limited performance.

On the other hand, Myo-Hla et al. (1999) and Lofvenberg et al. (1995) both agreed that peroneal reaction times were longer in FAI participants and it is not surprising that the broad criteria categories used by both authors were similar. Even though Myo-Hla (1999) chose only three of the eleven broad criteria categories, whereas Lofvenberg (1995) chose five; the authors used different specific criteria items within the broad criteria category. Both authors agreed on three broad categories including "history of ankle sprain," "self-reported instability," and "lower extremity injury." However, the specific criteria items were different and raise questions to the reliability of their participant selection process. For example, within the broad criteria category "self-reported instability" Lofvenberg used the specific criteria item "no history of chronic

ankle instability within 12 months of testing" whereas Myo-Hla required "complaints of the ankle giving way." Also, within the broad criteria category "history of ankle sprain" Lofvenberg used the specific criteria item "history of chronic ankle instability," whereas Myo-Hla required "experiencing an ankle sprain." Myo-Hla also required the broad criteria category "sprain frequency" and included the specific criteria category "at least 3 or more sprains" whereas Lofvenberg did not. Unfortunately, proportion of agreement could not be calculated between these authors because no participants from this population sample would have qualified for Myo-Hla's study, therefore questioning the participant selection process again.

Authors did not use similar requirements in the specific criteria items and in turn allowed research participants a broad interpretation of the specific criteria item questions. In addition, there were different number requirements and time allowances regarding the specific criteria items within the broad criteria categories that may have created inconsistencies in the participant selection process.

A third explanation for the low agreement may be attributed to the potentially different classification of participants by each author. Nine authors grouped research participants as either "stable" or "unstable" (Tables 2 & 3) however, sixteen authors grouped research participants as "stable," "unstable," or "excluded" (Tables 4 & 5). Ideally, individuals should be classified as functionally "stable" or "unstable" however, the "excluded" group did not qualify as one or the other. Individuals qualified as "excluded" when they did not meet the criteria of being functionally stable or unstable. However, it would seem logical that an individual who did not qualify as functionally

unstable should be considered functionally stable. This "floating" group called "excluded," which should not exist, seemed to contribute to more confusion of FAI participant selection.

Ultimately, agreement between authors regarding FAI participant selection was low due to the following reasons: (1) lack of consistency if the broad criteria categories incorporated into the selection criteria, (2) the structuring of the specific criteria items within the broad criteria categories were inconsistent and potentially resulted in different interpretations by the participants, and (3) the multiple classifications of participants by each author (stable, unstable, excluded). This lack of consistency in participant selection criteria makes comparing FAI research extremely confusing, problematic, and potentially inappropriate. Ideally, researchers would use consistent inclusion criteria for FAI research. Caution should be used when comparing previous FAI research by different authors due to these participant selection inconsistencies.

Prevalence of Participants Classified as Functionally Unstable

Finally, the results of this study indicate that, based on the 25 different inclusion criteria, an extremely wide range of percentages (0 -31) were identified as functionally unstable from the sample of 189 physically active participants (Table 6). Furthermore, ten of the authors' criteria resulted in 2.1 percent or less of the sample identified as unstable, while six of the authors' criteria led to the identification of 16.9 percent of the participants or greater as unstable.

The wide range of potential FAI participants being selected from this sample population may be due to the difference in sample populations being selected by the

authors. Myo-Hla et al. (1999) would have potentially qualified no FAI participants in this population sample however; Caulfield & Garret (2002) potentially would have qualified 59 FAI participants. In comparing the two authors, both included similar broad criteria categories, however the structure of one specific criteria item question changed the meaning. Specifically, Caulfield and Garret (2002) stated participants should have at least two ankle sprains with feelings of "giving way" during sporting activities however, Myo-Hla (1999) stated that participants should have three or more ankle sprains with feelings of "giving way". These two authors agreed "giving way" should be a criterion for FAI participant selection however, the meaning of these two sentences were obviously different.

Since there were no participants in this study that would have potentially qualified for FAI participation in Myo-Hla's study, the participants in this sample population, by the way they answered the author's questions, should have at least one of following characteristics: (1) Did not have 3 or more ankle sprains; (2) Did not have "feelings of giving way" if they actually sprained their ankles 3 or more times; or (3) Never had feelings of "giving way." The final characteristic raises questions of whether feelings of "giving way" are actually quantifiable or perhaps maybe more of a psychological issue.

Poor recollection of injuries could have also contributed to the wide range of potential FAI participants selected by the 25 authors. Junge and Dvorak (2000) stated that nearly two-thirds of injuries were not reported when participants completed a one year follow up questionnaire as well as participants reporting mild and moderate injuries less frequently than severe injuries. Since the authors included different levels of sprain

severity in this study, it is possible that only approximately 10 percent of the mild injuries were actually reported (Junge & Dvorak, 2000).

The sample population in this study was different than many previous authors. Previously, researchers have found that approximately 30 (Specchiulli & Cofano, 2001), 40 (Braun, 1999; Freeman, 1965) and up to 50 (Karlsson et al. as cited in Peters, Trevino, & Renstrom, 1991) percent of the general clinical population had residual pain and self-reported ankle instability following ankle injury. However, a general clinic population is very different from that used in this study. In this study, a population of physically active high school and college-aged participants were surveyed. The general clinic populations in publications by Braun (1999), Specchiulli and Cofano (2001), Karlsson et al. (as cited in Peters et al., 1991), and Freeman (1965) also included participants with mechanical instabilities which were excluded from this study due to the undecided role mechanical ankle instability plays in individuals with functional ankle instability.

The physically active population in this study was somewhat similar to the sample population in Yeung's study (Yeung et al., 1994). Approximately 59 percent of the athletic population participating in Yeung's research was functionally unstable and included participants from nationally competitive teams, various team sports and clubs, recreational athletes, and other physically active people (Yeung et al., 1994). However, physically active participants in the current study were defined by the National Athletic Trainers Association as "Physically active individuals engage in athletic, recreational or occupational activities that require physical skills and utilize strength, power, endurance, speed, flexibility and range of motion, or agility." The participants in this study were

physically active individuals found in high schools and colleges. Participants were not as highly trained as many of the athletes in Yeung's study.

The range of 0-31 percent for the prevalence of FAI in physically active individuals in this study offers further explanation why there have been such conflicting and inconsistent results of FAI research. Essentially, none of the 25 authors in this study would have selected the same participants. In fact, this study found one author who would have qualified no participants as unstable. Individuals being selected for FAI participation should be chosen in a consistent manner. Questions asked by either interview or survey should always convey the same exact meaning anytime a researcher selects FAI participants, which will create a reliable method of selecting these individuals.

Limitations

Although this study raises question to the selection process of FAI participants, potential limitations exist. First, the sample population included only participants in high school and college. Second, participants were all physically active individuals; therefore the results may not be generalizable to all previous research. Third, publications that included the assessment of mechanical instability were excluded. It is possible that inclusion criteria that incorporated mechanical instability would have demonstrated greater agreement. Finally, this study used only dichotomous questions. The original version of each item from previous authors' criteria was not always dichotomous and therefore could have been interpreted differently in the dichotomous form.

Recommendations

In light of these results, comparing and contrasting past studies of FAI is exceptionally confusing and problematical due to the differences in agreement regarding FAI participant selection. A consensus of FAI inclusion criteria should be established before researchers embark on any future ankle instability research. First, widely accepted definitions of functional ankle instability must be determined. Next, consistent inclusion criteria should be identified. Finally, researchers should develop valid and reliable inclusion items for widespread acceptance and use.

Summary

The purpose of this study was to examine group agreement regarding selection criteria among authors who recruit participants with self-reported functional ankle instability. First, agreement of broad inclusion criteria categories showed high percentages of only three out of the eleven categories used by the 25 authors, suggesting that the authors have not created widely accepted broad criteria categories to select FAI participants. Positively, however, three inclusion criteria (history of ankle sprain, sprain frequency, and self-reported instability) did demonstrate high consistency and two (sprain severity and pain) with moderate consistency among the 25 authors which could be beneficial in helping establish consistent broad inclusion criteria categories in future FAI research.

Second, this study found low agreement of the 25 authors classifying individuals with FAI, which may be an effect of different individuals being selected for participation in FAI research. Explanations for low agreement also included authors using different

broad criteria categories for FAI selection; individuals being qualified as "excluded" which is a "floating" group that should not exist; and specific criteria items structured differently within the broad criteria categories possibly contributing to a slightly different representation of that category.

Finally, the number of functionally unstable individuals that would have been qualified in this study according to criteria set forth by the 25 authors varied greatly between authors. Overall these results indicate that FAI research inclusion criteria is inconsistent, has potentially led to the study of participants with different characteristics, and cast doubt on the appropriateness of comparing previous FAI research.

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APPENDIX A

UNIVERSITY OF NORTHERN IOWA
HUMAN PARTICIPANTS REVIEW
INFORMED CONSENT
Adult Participants

Project Title: **Proportion of Agreement Between Various Inclusion Criteria For Classification of Functional Ankle Instability**

Name of Investigator(s): Shantelle Weichers, Todd Evans PhD, Brian Ragan PhD, Biff Williams PhD

Invitation to Participate: You are invited to participate in a research project conducted through the University of Northern Iowa. The University requires that you give your signed agreement to participate in this project. The following information is provided to help you make an informed decision about whether or not to participate.

Nature and Purpose: The purpose of this study is to examine some of the characteristics that are seen with repeated ankle sprains. You will be asked to complete a survey that includes questions about ankle injury history and factors that are often measured with ankle sprains (swelling, instability, etc.) The questionnaire will take approximately 10 minutes to complete. There are no right or wrong answers.

Explanation of Procedures: This section describes what you will be doing if you agree to participate in this study.
You will be asked to complete the survey at a predetermined time next week. After the surveys are collected, it will be kept confidential. Once the project is complete, all surveys and information from the surveys will be stored in a secure location until the results have been analyzed. The surveys will be destroyed thereafter. *Remember, you may withdraw from the project at any time. You will not be asked to put your name anywhere on the surveys. There will be no way to identify you from the survey.*

Discomfort and Risks: This study will involve no foreseeable risks to your physical or mental health beyond those similar in your every day life.

Benefits and Compensation: Your participation in this study may not directly benefit you, however it will potentially assist others who may experience similar circumstances. Results of this study may lead to future improvements in specific qualifications and prevention of such injuries. There will be no compensation for participating in this study.

Confidentiality: Information obtained during this study that could identify you will be kept confidential. Only the investigators will have access to your identity and information

associated with your identity. The summarized findings with no identifying information may be published in an academic journal or presented at a scholarly conference.

Right to Refuse or Withdraw: Your participation is completely voluntary. You are free to withdraw from participation at any time or to choose not to participate at all, and by doing so, you will not be penalized or lose benefits to which you are otherwise entitled.

Questions: If you have questions about the study you may contact or desire information in the future regarding your participation or the study generally, you can contact Shantelle Weichers at 319-239-2738 or (if appropriate) the project investigator's faculty advisor Dr. Todd Evans at the Department of HPELS, University of Northern Iowa 319-273-6152. You can also contact the office of the Human Participants Coordinator, University of Northern Iowa, at 319-273-2748, for answers to questions about rights of research participants and the participant review process.

Agreement:

> **I am fully aware of the nature and extent of my participation in this project as stated above and the possible risks arising from it. I hereby agree to participate in this project. I acknowledge that I have received a copy of this consent statement. I am 18 years of age or older.**

_____ _____
(Signature of participant) (Date)

_____
(Printed name of participant)

_____ _____
(Signature of investigator) (Date)

_____ _____
(Signature of instructor/advisor) (Date)

[NOTE THAT ONE COPY OF THE ENTIRE CONSENT DOCUMENT (NOT JUST THE AGREEMENT STATEMENT) MUST BE RETURNED TO THE PI AND ANOTHER PROVIDED TO THE PARTICIPANT. SIGNED CONSENT FORMS MUST BE MAINTAINED FOR INSPECTION FOR AT LEAST 3 YEARS]

University of Northern Iowa
Human Participants Review
Informed Assent
For older child approximately 11-17 years old

Project Title: **Proportion of Agreement Between Various Inclusion Criteria For Classification of Functional Ankle Instability**

Name of Principal Investigator(s): Shantelle Weichers, Todd Evans PhD, Brian Ragan PhD, Biff Williams PhD

I, _____, have been told that one of my parents/guardians has given his/her permission for me to participate in a project about specific ankle problems. I understand that I will be asked to complete a 10 minute questionnaire during physical education class regarding ankle injury history and factors that are often measured with ankle sprains (swelling, stability, etc.). I know there is no right or wrong answers to this questionnaire and that I will answer the questions to the best of my ability. I also understand that I am not to write my name on any paper other than this paper. My name should not appear on the ankle questionnaire.

I understand that my participation is voluntary. I have been told that I can stop participating in this project at any time. If I choose to stop or decide that I don't want to participate in this project at all, nothing bad will happen to me. My grade in my physical education class will not be affected in any way.

_____ _____
Name Date

UNIVERSITY OF NORTHERN IOWA
HUMAN PARTICIPANTS REVIEW
PARENTAL PERMISSION
Participant's Parents

Invitation to Participate: Your child has been invited to participate in a research project conducted through the University of Northern Iowa. The University requires that you give your signed agreement to allow your child to participate in this project. The following information is provided to help you made an informed decision whether or not to participate.

Nature and Purpose: The purpose of this study is to examine some of the characteristics that are seen with ankle sprains. Your child will be asked to complete a survey that includes questions about ankle injury history and factors that are often measured with repeated ankle sprains (swelling, stability, etc.)
With permission granted from your child's physical education teachers, your child will be asked to fill out a questionnaire during the end of their physical education period. The questionnaire will take approximately 10 minutes to complete. There are no right or wrong answers. We will collect the questionnaire after your child is finished answering all the questions. Names will not appear anywhere on the survey. The history section and sample questions are attached to this form.

Explanation of Procedures: Upon both you and your child's agreement to participate in this study, your child will be asked to fill out a questionnaire during a small portion of their physical education class time. Your child will only fill out the questionnaire once, and after completion your child will be finished with participation in this study.
All data collected will be kept confidential and will be stored in a secure location until the results can be analyzed. Once the project is complete, all data will be destroyed. *At any time, you or your child may decide to withdraw from the study. Names will not appear anywhere on the questionnaire. There will be no way to identify the completed answers as your child's answers once the questionnaire is completed.*

Discomfort and Risks: This study will involve no foreseeable risks to your physical or mental health beyond those similar in your every day life. This project is for educational research. If your child chooses not to participate in this study, they will be participating in regular physical education activities that are planned by their physical education teacher. Participation in this study is completely voluntary and will not have any effect on your child's academic progress or status in class.

Benefits: Your child's participation in this study may not directly benefit them, however it will potentially assist others who may experience similar circumstances of ankle problems. Results of this study may lead to future improvements in specific self-reported

qualifications and prevention of such ankle injuries. There will be no compensation for participating in this study.

Confidentiality: Information obtained during this study that could identify your child will be kept strictly confidential. However, we will not be collecting names on the questionnaires. The summarized findings with no identifying information may be published in an academic journal or presented at a scholarly conference.

Right to Refuse or Withdraw: Your child's participation is completely voluntary. He or she is free to withdraw from participation at any time or to choose not to participate at all, and by doing so, your child will not be penalized or lose benefits to which he/she is otherwise entitled.

Questions: If you have any questions about the study or desire information in the future regarding your child's participation, you can contact Shantelle Weichers at 319-239-2738 or (if appropriate) the project investigator's faculty advisor Dr. Todd Evans at the Department of HPELS, University of Northern Iowa 319-273-6152. You can also contact the office of the Human Participants Coordinator, University of Northern Iowa, at 319-273-2748, for answers to questions about rights of research participants and the participant review process.

Agreement:

> **I am fully aware of the nature and extent of my child's participation in this project as stated above and the possible risks arising from it. I hereby agree to allow my son/daughter to participate in this project. I have received a copy of this form.**

_____ _____

(Signature of parent/legal guardian) (Date)

_____

(Printed name of parent/legal guardian)

_____

(Printed name of child participant)

_____ _____

(Signature of investigator) (Date)

_____ _____

(Signature of instructor/advisor) (Date)

[NOTE THAT ONE COPY OF THE ENTIRE CONSENT DOCUMENT (NOT JUST THE AGREEMENT STATEMENT) MUST BE RETURNED TO THE PI AND ANOTHER PROVIDED TO THE PARTICIPANT. SIGNED CONSENT FORMS MUST BE MAINTAINED FOR INSPECTION FOR AT LEAST 3 YEARS]

APPENDIX B

INJURY HISTORY FORM
PLEASE DO NOT PUT YOUR NAME ON THIS PAPER

Ht. ____feet _____inches Wt. _____pounds Age: _____ Gender: M F

1. Do you participate in an organized sport? Y N If yes, please describe:_____

2. Have you ever injured either ankle (i.e. ankle sprain, fracture, strain) Y N

3. Are you currently experiencing any ankle pain or disability? Y N

3a. if so, please describe the injury type_____

3b. Location: Left Right

3c. Date of Injury: _____days/weeks/years ago (circle one)

3d. Date of Surgery: _____days/weeks/years ago (circle one)

4. Have you ever experienced your ankle feeling weak, or as if it is giving out from under you? Y N

5. Do you currently have any other injury or condition that limits your activity level? Y N

5a. If yes, what side is the other injury located? Left Right

6. Are you currently physically active usually exercising 30 minutes per day, 3-5 days per week? Y N

7. How would you rate your overall health status?

1 = excellent 2 3 4 5 = poor

8. How would you rate your general level of physical activity?

1 = not active at all 2 3 4 5 = extremely active

APPENDIX C

ANKLE INJURY QUESTIONNAIRE

Instructions: PLEASE DO NOT PUT YOUR NAME ON THIS PAPER. Fill out this survey to the best to your ability. Circle the appropriate answer to the questions. *Note:* During this survey, some questions may sound and look very similar. Some questions may not apply to you (Examples: pain, crutch use, injury frequency, etc.). However, please answer all the questions.

Do not put your name on this survey.

Criteria #1 (History of ankle sprain)

1.1 **Y** **N** Have you ever experienced a lateral ankle sprain or an ankle sprain to the outside of your ankle?

1.2 **Y** **N** Have you ever been diagnosed (told by a doctor) with a moderate lateral ankle sprain? (to the outside of your ankle)

1.3 **Y** **N** Have you ever experienced a lateral ankle sprain or a sprain to the outside of one, but not both of your ankles?

1.4 **Y** **N** Have you ever experienced an ankle sprain?

1.5 **Y** **N** Has your most recent ankle sprain occurred within the last 3 months?

1.6 **Y** **N** Has your most recent ankle sprain occurred within the last 6 months?

1.7 **Y** **N** Have you ever had an ankle injury?

1.8 **Y** **N** Do you have a history of chronic ankle instability?

1.9 **Y** **N** Do you have a history of a severe ankle sprain?

1.10 **Y** **N** Did this ankle injury occur to only one ankle?

1.11 **Y** **N** Has it been at least 2 months since the last injury?

1.12 **Y** **N** "Concerning your purported (reported) ankle instability, does this injury involve one ankle?"

Y **N** "If yes, did the initial episode involve your ankle "rolling inward"?"

1.13 **L** **R** "What ankle suffers the instability?"

1.14 **Y** **N** Have you ever had an ankle sprain followed by complaints lasting at least 3 weeks?"

Criteria #2 (Ankle sprain frequency)

2.0 **Y** **N** Have you experienced repeated episodes of a lateral ankle sprain or an ankle sprain to the outside of your ankle?

2.1 **Y** **N** Have you had at least 2 of these sprains within the past 12 months?

2.2 **Y** **N** Have you experienced at least 2 recurrent ankle sprains in the last year?

2.3 **Y** **N** Have you had a history of at least two lateral ankle sprains?

2.4 **Y** **N** Have you experienced a history of at least 3 or more lateral ankle sprains?

2.5 **Y** **N** Have these ankle sprains occurred in the last 5 years?

2.6 **Y** **N** Have these lateral ankle sprains occurred with in last 3 months?

2.7 **Y** **N** Did this sprain occur no more than 2 years ago?

2.8 **Y** **N** Have you experienced repeated moderate ankle sprains?

2.9 **Y** **N** Have you experienced at least 2 lateral ankle sprains within the last 6 months?

2.10 **Y** **N** Was the last episode of your previous ankle injury less than 1yr ago?

2.11 **Y** **N** Was the last episode of your previous ankle injury more than 4 wks ago?

2.12 **Y** **N** Has this experience of spraining your outside of your ankle occurred within the last 6 weeks?

2.14 **Y** **N** Have two or more of these lateral ankle sprains occurred within the past 18 months?

2.15 **Y** **N** Has at least one of these ankle sprains occurred within the last 6 months?

2.16 **Y** **N** Did these repeated sprains occur to the same ankle?

2.17 **Y** **N** Have you had an ankle injury within the last 1.5 years?

2.18 **Y** **N** Have you had repeated episodes of chronic ankle instability with more than 3 lateral ankle sprains of same ankle?

2.19 **Y** **N** "Have you had 1-3 lateral ankle sprains in the previous 2 years but not accompanied by instability or pain?"

2.20 **Y** **N** "Have you had 1-3 lateral ankle sprains within the last 3-5 years but have experienced no instability or pain?"

2.21 **Y** **N** "Do you sprain your ankle regularly? How often does this happen?"
_____R ankle _____L ankle

Criteria #3 (Feeling of ankle "giving way")

3.0 **Y** **N** Have you ever had a feeling of ankle instability or your ankle feels like it is "giving way"?

3.1 **Y** **N** Have you ever had a feeling of ankle instability or your ankle feels like it is "giving way" during activity?

3.2 **Y** **N** Have you ever had a feeling of ankle instability or feeling of your ankle "giving way" during sporting activities?

3.3 **Y** **N** Have you had at least one episode of ankle instability or feeling of your ankle "giving way" during last 12 months?

3.4 **Y** **N** Do you have a history of multiple episodes of your ankle giving way in past 6 months?

3.5 **Y** **N** Do you feel that one or both ankles are "giving way"?

3.6 **Y** **N** Has this feeling of your ankle "giving way" happened at least twice within the last 6 months?

3.7 **Y** **N** Do you feel like your ankle is weaker because of your ankle injuries?

3.8 **Y** **N** Have you had multiple episodes of your ankle "giving way" within past 12 months?

3.9 **Y** **N** Have you had at least six episodes of your ankle "giving way" in regards to the ankle turning inward, with or without pain, in the past 12 months?

3.10 Y N "Is the injured/unstable ankle chronically weaker, more painful, "looser," and less functional than your uninvolved ankle?"

3.11 Y N "Do you ever have episodes of your ankle "giving way" or "rolling over" during daily activity (athletic or otherwise?)"

3.12 Y N "Do you attribute your current instability to past injuries to the affected ankle?"

3.13 Y N "Do you have complaints of ankle instability, as if you are unable to control the stability of the ankle or a sensation as if your ankle is going to sprain instantly?"

Criteria #4 (Ankle sprain severity)

4.0 Y N Did your lateral ankle sprain require you to use crutches?

4.1 Y N Did your lateral ankle sprain require you to be non-weight bearing?

4.2 Y N Did your lateral ankle sprain require you to use any type of immobilization?

4.3 Y N Did your ankle sprain result in swelling?

4.4 Y N Did your ankle sprain result in pain?

4.5 Y N Did your ankle sprain result in temporary loss of function?

4.6 Y N Did your ankle sprain required medical attention?

4.7 Y N Did this injury involve any loss of practice time if you were involved in a sport?

4.8 Y N Do you feel that your ankle injury has contributed to limited performance?

4.9 Y N Does your ankle appear to be more painful and/or less functional than the other at this time?

4.10 Y N Do you feel your current ankle problems are due to the past history of your traumatic ankle sprain?

4.11 Y N Was your ankle sprain followed by more than two days of pain?

4.12 Y N "Did your initial injury to your ankle require crutches, immobilization, or both, or immobilization of any form (cast, brace, etc)?"

4.13 Y N "Have you had any fractures (breaks) in either of your ankles?"

4.14 Y N "Do you have an ankle sprain that needed immobilization, bandaging, and/or treatment over the last 3 months?"

Criteria #5 (History of other ankle injuries)

5.0 Y N Have you ever had any kind of a fracture in your leg, foot, or ankle?

5.1 Y N Do you have any current or history of injury to the back or other lower extremity (legs, feet, toes).

5.2 Y N Have you experienced any other injuries to your lower extremity other than your ankle injury in the last 6 months?

5.4 Y N Have you ever had a fracture of your foot, ankle or lower leg?

5.5 Y N Have you ever had any other injury to your lower leg, knee, ankle or foot?

5.6 Y N Do you have any impairments of your legs, trunk, or central nervous system?

5.7 Y N Have you had any past surgeries to either ankle?

5.8 Y N Have you experienced any other injuries to either of your lower legs other than an ankle injury in the last 3 months?

5.9 Y N Have you had any previous history of injury to either lower extremity (legs, feet, toes)?

5.10 Y N Have you experienced any other injuries to either of your lower extremities (legs, feet, toes) in the last 3 months?

5.11 Y N Have you ever had a history of an ankle fracture; documented cartilage lesion at the ankle joint; or knee or hip joint abnormalities?

5.12 Y N "Have you ever had any history of lower leg, knee, or hip dysfunctions that could impair this procedure?" (Procedure means balance tests)

5.13 **Y** **N** Have you ever had surgery to your foot, ankle, or lower leg?

Criteria #6 (History of rehabilitation)

6.0 **Y** **N** Are you currently enrolled in a formal rehabilitation session?

6.1 **Y** **N** Have you been involved in a rehabilitation program, but not in one within the last 3 months?

6.2 **Y** **N** Are you participating in any formal or informal rehabilitation program for your injured ankle?

6.3 **Y** **N** Have you ever been involved in a balance-training program?

6.4 **Y** **N** Are you currently participating or have participated in a formal rehabilitation program?

6.5 **Y** **N** "Are you currently involved in a "formal" rehabilitation program for the affected ankle?"

6.6 **Y** **N** "Can you describe a symptom(s) of your ankle "giving way"?

Criteria #7 (Pain)

7.0 **Y** **N** Do you have any pain in your ankle right now?

7.1 **Y** **N** Do you have any stiffness in your ankle right now?

7.2 **Y** **N** Do you have any ankle pain at rest?

7.3 **Y** **N** Do you experience ankle pain during heavy loading or activity?

7.4 **Y** **N** "Following the (repetitive) sprain, do you have complaints of pain and/or swelling during the hours that follow the sprain (>24hrs)?"

Criteria #8 (Swelling)

8.0 **Y** **N** Do you have any swelling in your ankle right now?

Criteria #9 (Activity Level)

9.0 **Y** **N** Are you physically active?

9.1 Y N Do you feel you have any functional limitations regarding your injury?

9.3 Y N Have you been full weight bearing, without a limp, for at least 3 weeks?

9.4 Y N Do you feel the functional use of your injured ankle has plateau or peaked since the original injury?

9.5 Y N Do you feel like your ankle has a reduced function right now?

9.6 Y N Are you currently full weight bearing on the previously injured ankle?

9.7 Y N Are you actively involved in sports?

9.8 Y N Have you been able to engage in activity fully for at least the last 2 weeks?

9.9 Y N Do you have any symptoms right now in regards to your previously injured ankle?

9.10 Y N "Have you been walking around unassisted without a "limp" for at least the past 3 months?"

Criteria #10 (History of eye, ear, and balance problems and head concussions)

10.0 Y N Have you had any cerebral (head) concussions or diseases that affect your balance?

10.1 Y N Do you have any neurological disorders?

10.2 Y N Have you had any otologic (ears) injury or disease?

10.3 Y N Do you have any current or history of any other musculoskeletal injuries?

10.4 Y N Do you have any neuromuscular (nerve or muscle) dysfunction or disease?

10.5 Y N Do you have a musculoskeletal (muscle, bone, joint) dysfunction or disease?

10.6 Y N Do you have any other problems that contribute to balance deficits?

10.7 Y N Do you have any spinal disorders?

10.8 **Y** **N** Have you ever been diagnosed with a cerebral (head) concussion?

10.9 **Y** **N** Have you ever been diagnosed with a vestibular (balance) disorder?

10.10 **Y** **N** Do you have an ear infection, upper respiratory infection or head cold right now?

10.11 **Y** **N** Do you have a history of vertigo (dizziness)?

10.12 **Y** **N** Do you have an uncorrected refraction error (vision problem)?

Criteria #11 (Use of braces, wraps, taping)

11.0 **Y** **N** Did you have to use any form of external support on your injured ankle?

You are now finished!

Thank you for participating.

APPENDIX D

Script for Recruitment
College-Aged Participants

Hi, my name is Shantelle Weichers and I am finishing my master's degree at the University of Northern Iowa. At this time, I am in the process of completing research for my thesis and need volunteers to participate in this study.

You are invited to participate in a research project conducted through the University of Northern Iowa. The purpose of this study is to examine the proportion of agreement between different common criteria found in subjects with functional ankle instability. The information I am handing out will help you make an informed decision about whether or not to participate.

If you wish to volunteer for this study, please sign the consent form and bring it to the testing session on DATE at TIME in PLACE. Remember, participating in this study has no effect on your status or grade for any class. If you agree to participate in this project, you may discontinue your participation in this project at any time with no negative affect on your class status or grade.

Thank you for your time.

Script for Recruitment
High School Aged Participants

Hello, my name is Shantelle Weichers and I am completing my master's degree at the University of Northern Iowa. I am looking for people to participate in a study that I am conducting to complete my degree.

My project involves the completion of an ankle injury survey that I estimate will take you 10 minutes to complete. The papers I am handing out are consent forms for anybody to volunteer for participation in this project. Please read and give these forms to your parent(s) or guardian(s) to read with you. If you wish to participate in this study, please bring back these forms signed by you and your parent(s) or guardian(s) on _____(DATE).

If you agree to participate, on this date you will be asked to fill out the questionnaire during your physical education class time. This task will involve approximately 10 minutes of your physical education class time. Remember, participating in this study has no effect on your grade for this class. If you agree to participate in this project, you may discontinue your participation in this project at any time with no negative affect on your class status or grade. I will ask you not to include your name on the survey.

Thank you for your time.