Comparison of the Wii Balance Board and the BESS Tool Measuring Postural Stability in Collegiate Athletes

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Abstract

Proper evaluation of postural stability is an integral part of the comprehensive management of concussed athletes. Clinicians are in need of a cost-effective and objective tool to assist them in their assessments performed in a variety of health care settings. This non-experimental design compared the Wii Balance Board (WBB), a recreational gaming system, to the Balance Error Scoring System (BESS), a tool developed for sports medicine clinicians for the assessment of postural stability in concussed athletes. The WBB has been proven to be used in various settings for rehabilitation but has not yet been used for the assessment of postural stability (Butler et al., 2010). This study hypothesized whether the WBB, when compared to the BESS, is an objective tool that can be used as an acceptable measurement of postural stability in college athletes. Ninety-one male collegiate football players participated in the study and were measured for postural stability both with the WBB and the BESS tool. Findings revealed that there was a direct and positive correlation between these two instruments. The WBB when compared to the BESS is found to valid tool in assessing postural stability. These results lay the foundation for future research on the WBB and its’ usefulness in measuring postural stability. The portable and cost effective WBB potentially could be used in various settings to aid in the concussion management of athletes. It is imperative that nursing becomes more actively involved in the research, prevention and education of concussions. Nursing plays an integral role in the management of concussions and future research on concussions should be conducted by nurse scholars.
# Table of Contents

**Chapter I: Background**  ......................................................... 7-17  
- Background ................................................................. 7  
- Purpose/Research Question  .............................................. 12  
- Hypothesis ................................................................. 12  
- Variables ................................................................. 12  
- Theoretical Framework  ............................................... 12-13  
- Importance to Nursing ................................................. 13-15

**Chapter II: Literature Review**  ........................................... 16-32  
- Concussions ............................................................... 16  
- Second Impact Syndrome .............................................. 20  
- Postural Stability ........................................................ 22  
- Balance Error Scoring System ........................................ 25  
- Wii Balance Board ........................................................ 29  
- Conclusion ................................................................. 30

**Chapter III: Methods** .......................................................... 31-35  
- Design/ Sample ............................................................. 31  
- Recruitment ............................................................... 31  
- Test-Retest ............................................................... 32  
- Quality Control .......................................................... 32  
- Data Collection .......................................................... 32-33  
- Setting ................................................................. 33  
- Procedures ............................................................... 33  
- Measures ............................................................... 34  
- Risk ................................................................. 35
Human Subjects Protection..........................................................................................35
Proposed Data Analysis............................................................................................35

Chapter IV- Results..................................................................................................36-44
Test/ Retest Pilot of the Wii Balance Board.........................................................36
Sample/ Demographics............................................................................................37
BESS / Wii Balance Scores......................................................................................40
Inter-rater Reliability of the BESS........................................................................44

Chapter V- Discussion and Conclusion..................................................................45-52
Summary of Results..................................................................................................45
Discussion..................................................................................................................46
Conclusion..................................................................................................................47
Essentials to DNP.......................................................................................................47
Implications of Results.............................................................................................49
Theoretical Framework..............................................................................................50
Limitations..................................................................................................................51
Recommendations for Future Research.................................................................51-52

References.................................................................................................................53-57

Appendix A – ..............................................................................................................Recruitment Letter
Appendix B-..............................................................................................................Script for BESS Collection
Appendix C...............................................................................................................IRB Proposal/Consent
Appendix D...............................................................................................................Wii Balance User Guide
Appendix E...............................................................................................................Data Score Card
Appendix F...............................................................................................................CITI Certification
Appendix G...............................................................................................................Demographic Data Sheet
CHAPTER I

Introduction

Concussions are a major health concern for athletes given the potential for these injuries in a wide range of sport activities. The leading concern for clinicians is that athletes are at risk for devastating consequences if they are not evaluated properly and cleared too early to return to play or competition. The evaluation of postural stability has been identified as an important aspect to the comprehensive management of such injuries. Clinicians are in need of a portable tool they can use in various settings to aid in decision making and health care delivery for concussed athletes. The Nintendo Wii Balance Board (Nintendo of America Inc., Redmond, Washington) is a tool that has the potential to aid in the evaluation of postural stability in concussed individuals.

Background

The Center for Disease Control and Prevention (2007) estimates that approximately 1.6 million to 3.8 million, treated and untreated, sports-induced concussions occur annually in the United States. The process of a concussion is defined as a complex physiological process due to biomechanical forces causing a brain injury (McCrory, Meeuwisse, Aubry, Cantu, Dvorak, & Echemendia, 2013). This can occur with or without loss of consciousness and disrupts the normal neurological functioning causing neurological, sleep, behavioral, cognitive, physical and emotional symptoms (McCrory et al., 2009). It is reported that 90% of sports related concussions recover from symptoms in one week (McCrea, Guskiewicz, Randolph, Barr, Hammeke, & Marshall, 2013). One of the greatest challenges for clinicians, however, is how to manage the athletes that do not recover from their injury in the “normal” one to two week range (McCrea et al., 2013).
The definition of concussion was revised at the 4th International Conference on Concussion in Sports in Zurich in 2012. The Zurich Consensus statement is a document that was devised by experts in the area of concussions to further address the assessment and management issues related to concussions in sports. It provided principles to enhance the treatment guidelines for providers.

The first International Conference on Concussions first took place in 2001 in Vienna (McCrory et al, 2009) and continues to convene in different parts of the world every four years. They are often referred to as the “Vienna Guidelines”. This conference gathered experts from all around the world to evaluate prevention, assessment and management issues related to sports induced concussions. This conference consists of a non-governmental, expert panel, designed to give a balanced and objective view of the topic. The panel presents current data about concussions in an open public forum. After the public hearing, the panel meets privately to develop a consensus statement. This consensus statement gives an overview of the current issues related to concussion injuries. This consensus statement is not intended to be the standard of care practice guidelines but a document to guide the development of practice guidelines and future research. The document stresses that treatment guidelines should be personalized and based upon the facts and circumstances of each individual case.

Concussions are one of the most serious injuries in college athletics (Gessel, Fields, Collins, Dick, & Comstock, 2007). Studies have revealed that there can be a cumulative neurologic effect in individuals who have sustained three or more concussions (Gessel et al., 2007). Proper concussion management can reduce the risk of a rare, but potentially life-threatening condition known as second impact syndrome (Cobb & Battin, 2004). This second impact syndrome is believed to consist of cerebral swelling and is the result of a second brain injury which occurs before the first injury has resolved (Halstead & Walters, 2010). There are
some experts who still question the existence of second impact syndrome and whether it is a valid diagnosis. It is believed that second impact syndrome, although rare, can have serious consequences such as cerebral hemorrhage or death (Byard & Vink, 2009). While most athletes recover from their concussion within the one to two week time, there is some evidence that a small percentage of athletes have prolonged post-concussion symptoms. In McCrea, Guskiewicz, Randolph, Barr, Hammeke, Marshall & Powell et al (2013) it was found that approximately 10% of athletes experience post-concussive symptoms outside the normal 7 day range. These recent findings suggest that recovery can be prolonged in many young athletes in which they can have symptoms for 6-12 weeks post injury (McCrea, 2013). Research, education and awareness about concussions continue to evolve, highlighting the importance of this issue. Studies have revealed that a comprehensive approach to concussion management can help providers to identify symptoms that are not normally seen in a routine exam (Guskiewicz, Ross & Marshall, 2001).

Concussions are difficult to recognize and medically manage. Clinicians find it challenging to diagnose concussions because it is, often, based subjectively from the patients’ report of symptoms (Frommer et al., 2011). It is known that athletes under report their symptoms to accelerate their return to play (Broglio & Puetz, 2008). Currently, the evaluation of concussions lacks a simple objective test to determine the severity of a closed head injury, which would help clinicians to better establish return-to-play guidelines (Notebaert & Guskiewicz, 2005).

A comprehensive approach is now recommended for the management of sports-related concussions, which includes symptom review, postural stability and a neuropsychological evaluation (Guskiewicz, 2001). A symptom review for the evaluation of a concussion is a quick and easy tool which allows athletes to self-report their symptoms. This tool is helpful but
cannot be used solely as the only diagnostic criteria because symptoms can be delayed and or may not be reported by the athlete (Scorza, Raleigh and O’Connor, 2012). Neuropsychological testing was developed to help to identify cognitive changes in a concussed athlete (Scorza et al., 2012). Even though they are widely used throughout the sports medicine industry, it should be used in conjunction with other assessments (McCrory, Meeuwisse, Aubry, Cantu, Dvorak, & Echmendia, 2013). Postural stability and balance are terms that are used interchangeably in concussion management. For the purposes of this study, the term postural stability will be used and is defined as the ability to maintain balance in a gravitational field by returning to the center of mass over its base of support (Horak, 1987).

The National Athletic Trainers’ Association position statement recommends that all athletes at risk for concussions should engage in postural stability baseline testing (Guskiewicz et al., 2001). Studies have concluded that deficits in postural control can be seen approximately within 72 hours post-concussion (McCrory et al., 2009). Postural control deficits are seen in concussed athletes as result of the lack of sensory integration of the balance mechanism in the brain (Broglio et al., 2008). Most postural deficits will return to baseline within a few days after a concussion, but some may experience symptoms for a more extended period of time (Beaumont, Mongeon, Thremblay & Messier, 2011). Baseline measurements should be used as a benchmark for comparison in the event the athlete sustains a head injury.

The ability of clinicians to assess and diagnose concussions and the change in postural stability directly impacts care and future sport engagement. There can be tragic results if an athlete is cleared too early to return-to-play (Guskiewicz et al., 2001). In the past, return-to-play guidelines have been very uncertain and are based upon self-reporting of symptoms. It is recommended, therefore, baseline balance testing should be conducted so as to serve as a more objective measure for comprehensive concussion management (McCrory et al, 2009). The
baseline measurements give normalized characteristics on athletes, which will help in the
determination of the post-injury impact and brain’s function. Obtaining baseline postural
stability scores is essential and should be used for comparison when a concussion occurs (Oliaro,
Anderson, & Hooker, 2001). Beumont et al. (2011) propose that postural stability assessment is
integrated into clinical practice to give clinicians a better guideline of when concussed athletes
who are experiencing balance symptoms can safely return to play.

There are several postural stability tests that can be used by clinicians to aid in
assessment of a concussion (Guskiewicz et al, 2001) such as technologically advanced force
plate measurement tools. They include sophisticated and costly force plate instruments
developed for postural stability. These highly advanced and technological tools are cost
prohibitive in most settings which limits the accessibility for most patients (Broglio et al., 2008).

Another instrument, The Balance Error Scoring System (BESS), a cost effective tool, was
developed solely for the assessment of balance deficits in concussed athletes and is widely used
(Broglio, Zhu, Sopiarz, & Park, 2009). The BESS tool was designed to evaluate postural control
objectively without having to use costly equipment and can be implemented without extensive
training (Broglio et al., 2009). Sports clinicians used the BESS tool by directly observing an
individual in various stances and subjectively determine a score based upon how many errors
they visualize. Despite the overall acceptance of the BESS in the sports medicine industry, it
lacks the test-retest stability (Broglio et al., 2009).

The Nintendo Wii Balance Board (WBB), a recreational gaming system, was first
introduced in 2008 and gave the video gaming industry a healthier aspect to recreational gaming
by incorporating exercise utilizing real life simulation experiences. The WBB has the capability
to measure the center of pressure which is used for the evaluation of balance. This mechanism is
similar to the costly force plates that are developed to measure postural instability. Recently,
health care facilities and athletic centers are starting to use the cost effective, Nintendo Wii Balance board for balance testing in the areas of geriatrics, physical therapy and rehabilitation indicating a general acceptance of this approach in the health field (Wikstrom, 2012).

Purpose/Research Question

The purpose of this study was to evaluate the Wii Balance Board as an objective, user-friendly, cost effective, valid alternative tool for the measurement of postural stability in college athletes. This study questioned whether the Wii Balance Board, when compared to the BESS testing, is an objective tool that can be used as an acceptable measurement of postural stability in college athletes.

Hypothesis

It is expected that Wii Balance Board can be used as valid and reliable tool for the measurement of postural stability in college athletes when compared to the BESS. The null hypothesis is that the Wii balance board is not a reliable and valid tool for measurement of postural stability in college athletes. The independent variables for this study are Wii Balance Board and Balance Error Scoring System. The dependent variable for this study is postural stability.

Theoretical Framework

A new framework has been identified over the past decade associated with injury prevention in sports (Finch, 2006). Translating Research into Injury Prevention Practice (TRIPP) framework suggests that research should be focused on building an evidence base for the efficacy and effectiveness of injury prevention measures (Table 1). This six step approach was developed to enhance research efforts for sports injury prevention (Finch, 2006).
Table 1

<table>
<thead>
<tr>
<th>Stage</th>
<th>Name</th>
<th>Framework</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1:</td>
<td>Injury Surveillance</td>
<td>Identify injury causes, incidences and outcomes.</td>
</tr>
<tr>
<td>Stage 2:</td>
<td>Mechanism of Injury</td>
<td>Understand and evaluate the mechanism of injury</td>
</tr>
<tr>
<td>Stage 3:</td>
<td>Prevention</td>
<td>Development of prevention measures</td>
</tr>
<tr>
<td>Stage 4:</td>
<td>Efficacy of Prevention</td>
<td>Evaluate the efficacy of prevention measures.</td>
</tr>
<tr>
<td>Stage 5:</td>
<td>Translate into Practice</td>
<td>Identify how outcomes can translate into practice</td>
</tr>
<tr>
<td>Stage 6:</td>
<td>Implementation</td>
<td>Full implementation of prevention measures and evaluation of effectiveness.</td>
</tr>
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*(Finch, 2006)*

Identifying a valid and easy to use tool to assist with the measurement of postural stability will help clinicians with return-to-play decisions. This study seeks to evaluate the reliability and validity of the Wii Balance Board. By indentifying an alternative and valid objective tool to measure balance, it could increase the reliability of an evaluation of an athlete’s ability to return to play, focusing on step four. A concussed athlete returning too soon to play can have devastating consequences including, the life-threatening, second impact syndrome (Guskiewicz et al., 2001). This theoretical framework served as a guide for the current study to ensure that it is purposeful and can help future clinicians prevent complications associated with concussions.

Importance for Nursing

Nursing professionals play an essential role in the treatment and management of concussion in athletes (Peibes, Gourley, McLeod, 2009). The Nurse Practitioner has a major role in the detection of concussions and this comprehensive assessment requires tools that help to
identify such injuries (Valente & Fischer, 2011). The Bess tool was developed for sideline assessment and is used by athletic trainers and others in the field of sports medicine. Even though the sports medicine industry widely uses the BESS tool, it lacks reliability and objectivity. Nurse Practitioners and others members of a multidisciplinary health care team require a method to measure postural stability that is inexpensive and simple to implement, and also provides valid and accurate data upon which to make evidence based decisions.

A gap in the literature has been identified indicating a lack of nursing scholars engaged in studies on concussions and postural stability. Most of the research that has been completed and published on concussions has been by athletic trainers, sports medicine physicians and neurologists. Yim-Chiplis and Talbot (2000) report that despite the fact that balance is important in multiple populations, there are very limited studies conducted by nurses. If nurses have a cost effective and easy to use tool, they can proficiently measure postural stability in primary care, schools, and in sports medicine. If nurses had a reliable assessment tool, it could lead to further studies conducted in this discipline. Nurses are already important in the management of concussions and having a tool that was researched for their intended use, will enhance their expertise in concussions. If the Wii balance board is found valid and reliable, it could also be used to measure postural stability in other neurological disorders. The significance of this study could lay the foundation for future research on concussions and other uses for the Wii Balance Board in the nursing field and related disciplines.

The Essentials of Doctoral Education for Advanced Nursing (DNP) practice have guided this project. Nursing practice is guided by evidence. The Doctor of Nursing Practice degree was developed to prepare experts in specialized advance nursing practice (AACN, 2006). This practice focused doctoral degree has been guided by The Essentials to the Doctor of Nursing Practice (AACN, 2006). These essentials or foundational competencies are designed to prepare
the DNP to have more specialized practice skills to meet the demands of the increasingly complex healthcare system. This project’s goal was to identify, test, and validate a new method of postural stability testing and compare it to the established normative tool, BESS. If this method is found to be reliable, it will be demonstrated that through research, nursing science will contribute to the enhancement of health care delivery for patients, DNP Essential I, Scientific Underpinnings for Practice. This project also encompasses Essential 2, Evaluating Health Care Delivery approaches based on Evidence and scientific findings. Having a valid objective tool which clinicians can use to in various settings, will aid in decision making and health care delivery for concussed athletes. This project also has the potential to reach other disciplines outside of nursing, which fulfills the goal of Essential VI, Interprofessional Collaboration for Improving Patient and Population Health Outcomes. Another Essential that this project encompasses is Essential IV, Patient Care Technology for Improvement and Transformation of Health Care. Overall, the WBB shows promise in meeting the goals of the DNP and is currently an acceptable tool for the healthcare delivery system. Conducting research on this tool to enhance healthcare delivery is an innovative approach that may have the potential to improve patient outcomes.
CHAPTER II

Review of Literature

This Review of Literature was conducted using various search engines. They include such as: Cumulative Index to Nursing and Allied Health (CINAHL), Proquest, Pubmed, Cochrane Library, Medline and Google Scholar. Only pertinent studies related to this research will be reviewed in this chapter as determined by an extensive review of literature. This review is organized into themes; Concussion, Second Impact Syndrome, Postural Stability, Balance Error Scoring System, and Wii Balance Board.

Concussion

Concussion research, assessment and management is continually evolving and changing better technology and having a better understanding of the impact of these types of injuries. The term concussion has been used interchangeably with the term of mild traumatic brain injury in the literature (Scorza, Raleigh, & O’Connor, 2012). For the purpose of this paper, however, the term concussion will be used throughout. Definitions have also evolved and changed over the years and there has been more than one definition used for the term concussion. The most universal definition for concussion, currently, is that it consists of a complex physiological process caused by biomechanical forces that cause disruption in brain functioning (McCrory, Meeuwisse, Johnston, Aubry, Mollowy & Cantu, 2009).

A concussion causes a disruption in normal neurological functioning (McCrory et al., 2009). As a result, these individuals can have neurological, sleep, behavioral, cognitive, physical and emotional symptoms (McCrory et al., 2009). The Zurich Consensus statement states that if an athlete presents with any of these types of symptoms after an injury, then a concussion should
be suspected (McCrory et al., 2013). Making diagnoses more challenging is the fact that there is no set pattern or physical presentation of concussion symptoms. Symptoms are highly variable depending on which part of the brain is injured and the severity of the injury (Valente & Fischer, 2011). However, initially a headache is one of the most common symptoms associated with concussions (Scorza et al., 2012; McCrea, Perrine, Niogi, & Hartl, 2012). A loss of consciousness is no longer a hallmark sign needed to diagnose concussions and does not correlate to severity (McCrea et al., 2012; Scorza et al., 2012). A common sign of concussions, more recently recognized, is retrograde and posttraumatic amnesia, and depending on the severity of the injury, can be prolonged for up to months to years (McCrea et al, 2012). McCrea et al (2012) defines retrograde amnesia as the inability to remember events just prior to the injury and posttraumatic amnesia as the inability to recall new information or memories that occur immediately post injury.

Concussions are a common and serious injury in college athletics (Gessel, Fields, Collins Dick, & Comstock, 2007). It is estimated that approximately 1.6 million to 3.8 million treated and untreated concussions occur related to sports annually in the United States (Center for Disease Control and Prevention, 2007). This number is somewhat uncertain due to the underreporting of injuries as well as the fact that many individuals may not seek medical attention (Scorza et al, 2012, Daneshvar et al., 2011 & Langlois, Rutland-Brown, & Wald, 2006). In addition to athletes, concussions are common in the general population as they affect 128 people out of 100,000 in the United States (Bey & Ostick, 2008). There are approximately 1.365 million emergency room visits annually for brain injuries (Daneshvar et al., 2011) and approximately seventy-five percent of these cases are considered concussions (Valente & Fisher, 2011).
The National Collegiate Athletic Association uses an Injury Surveillance System (ISS) to attempt to track the rate of concussion among college athletes (Gessel, Fields, Collins, Dick, & Comstock, 2007). This surveillance system is not mandatory but the goal of this surveillance is to get at least ten percent of colleges to participate in order to better understand the phenomenon. Gessel et al. (2007) evaluated the NCAA ISS and revealed that 180 schools took part in the surveillance, which included 16 different sports. This study compared college and high school concussion rates and discerned that the overall concussion rates were higher than previously reported (Gessel et al., 2007). The study also found that the concussion rates among collegiate athletes were higher when compared to high school athletes, which is contrary to reports from previous studies (Guskiewicz, Weaver, Padua, & Garret, 2000 & Mueller, 2004). The researchers found that collegiate athletes play with a higher intensity than high school athletes and were, therefore, more susceptible to concussions (Gessel, 2007)

Daneshevar et al., (2011) evaluated the NCAA ISS to closely examine the concussion rates and trends of high school and college athletes from the years 1988-2004. The results revealed that 5% of all injuries sustained were concussions. The injury rate per 1000 athletic exposures (individual participation in one or more practice or competition) increased during this longitudinal study from .17 in1989 to .34 in 2004. This review showed an annual increase in the concussion rate of 7% (p<.01). Daneshevar et al. (2011) suggested that the increase rate of concussions is related to proper identification of such injuries (Daneshevar, 2011) rather than an actual increase in concussions. This study also revealed, however, that there has been a steady increase of concussion rate over the past 20 years. Both Gessel et al. (2007) and Daneshevar et al (2011) concluded that the increase in collegiate athletes sustaining concussions is related to the fact that athletes are bigger, faster and more forceful than in previous decades.
Concussions can have long term neurological consequences that affect the brain’s ability to function (Langlois et al., 2006), McCrea, Guskiewicz, Randolph, Barr, Hammeke, & Marshall (2013). Many studies have indicated that most athletes have a complete recovery from symptoms within the one to two week range (Broglio et al., 2008, Guskiewicz et al., 2003 Belanger and Vanderploeg, 2005). McCrea et al. (2013) conducted a large study, over a ten year period, investigating the long-term consequences of concussions. The data collection was from 1998-2008 and evaluated both high school and college athletes who sustained a concussion while participating in a sport. The sample of 570 athletes in this prospective study was comprised of 88.9% male and 11.1% female participants. A control group of approximately 166 non-concussed athletes were matched to the concussion group based upon demographic data and the results of their baseline evaluation. All individuals were measured in a pre-season assessment during the initial enrollment of the study. Injured students were then re-evaluated using the same procedures. Athletes were evaluated immediately post injury, again in 2-3 hours, and periodically over 90 day period. Participants were assessed using several instruments including the Balance Error Scoring System (BESS) to assess post concussive symptoms, postural control and cognitive functioning. The results concluded that 90% of all athletes recovered from their concussion within 7 days (n=513) and 10% (n=57) had prolonged recovery of up to 45-90 days. The prolonged recovery also showed a greater increase in severity of cognitive symptoms (95% CI, P<.001). Both the prolonged recovery and typical recovery groups had changes in postural stability measured by the BESS immediately post-injury (95% CI, P<.001). In addition, both the typical and prolonged group had statistically similar findings. There was no statistical difference in postural stability for either group found after 3 hours of injury. Approximately 25% of athletes that were categorized as prolonged recovery still had post concussive symptoms 6-12 weeks after the injury occurred. This study indicated that the longer a player was held from competition and remained symptom-free, the lower the risk the individual had of a prolonged
recovery. This research is the largest sample-size, prospective study on incidence and course of recovery in the area of concussion research to date. This study has laid the groundwork for other studies to further examine return to play guidelines. The researchers concluded that the self-reporting of symptoms is only one piece of an evaluation and recommend a more objective means of both cognitive and postural stability testing.

Second Impact Syndrome

Proper concussion management can reduce the risk of the potentially life threatening conditions such as second impact syndrome (SIS). This syndrome is believed to consist of cerebral swelling and is the result of a second brain injury which occurs before the first injury has resolved (Halstead & Walters, 2010). It is believed that second impact syndrome, although rare, can have serious consequences such as cerebral hemorrhage or death (Byard & Vink, 2009).

SIS has been found mostly in children and adolescents less than 20 years of age (Herring, Bergfeld, Boland, Boyajian- O’Neill, Cantu & Hershman (2005), who have sustained a second mild head injury which, in turn, caused cerebral swelling (Bey & Ostick, 2008). There is not much data on SIS, but health care providers take this syndrome seriously due to the potential of the consequences (Bey et al., 2008). Bey et al. (2008) describe in detail how SIS occurs after an initial concussion. During an initial concussion there is limited cerebral blood flow and an altered blood flow causes an increase in potassium concentration in the brain that can last for up to 10 days. Subsequently, this influx of potassium makes the brain more vulnerable to re-injury and susceptible to death (Bey et al., 2006). The SIS prevents the brain from self-regulating cerebral and intracranial pressures after a second injury. This then causes brain herniation and death. It is reported that death can occur within 3-5 minutes after an injury. It is strongly recommended by these authors that an athlete should not return to play while showing signs of a concussion in order to avoid these dire outcomes altogether.
The National Football League (NFL) has conducted studies evaluating concussions and the long term consequences (Pellman & Viano, 2006). In 1994, the NFL devised a commission called The NFL’s committee on Mild Traumatic Brain Injury. This committee is comprised of experts that work for the NFL and outside of the organization to evaluate these types of injury and to devise prevention strategies. The NFL has participated in a study as a part of the committee’s work examining concussions and has gathered clinical data from 1996-2001 (Pellman & Viano, 2006). The study collected data on 650 injured athletes with a total of 887 concussions. Out of this sample, 160 of the players had a repeated injury and 51 of the players had three or more concussions, all during the study period. They study was multifaceted and evaluated equipment, biomechanics, and player techniques in hitting. This prospective study collected data on incidence and symptoms of concussions. The most common symptoms that were seen with these players were headaches, dizziness, memory loss, cognitive and other somatic symptoms. Headaches were reported as the most common complaint (55%, 95% CI). It was noted that 56.5% of all players return to competition on the day of the injury and 97.1% returned to play by day 9 post injury (Pellman et al., 2006). There were no cases of second impact syndrome reported in the NFL during this 6 year time frame. Due to the lack of second impact cases in the NFL, the authors suggest that strict return to play guidelines are too conservative for the NFL. This study conducted by the NFL was contrary to other research findings and the method of data collection and reporting has been questionable. This research has been highly controversial and as a result Dr. Elliot Pellman, a rheumatologist, was asked to step down as the Chair of the NFL’s Concussion Research Committee.
Postural Stability and Concussions

The National Athletic Trainers’ Association position statement recommends that all athletes at risk for concussions should engage in postural stability baseline testing (Guskiewicz, 2001). It has been highly documented that changes in postural control are another symptom present with concussions (Guskiewicz, Perrin, & Gansnede, 1996, McCrory et al., 2009). Research shows that areas of the brain most susceptible to injury are responsible for maintaining postural control (Guskiewicz, Ross, & Marshall, 2001) and that balance deficits can take place approximately within 72 hours after a concussion (Broglio et al., 2008). Postural control deficits are seen in concussed athletes as a result of the lack of sensory integration of balance mechanism in the brain (Broglio et al., 2008).

Extensive research has been conducted on postural stability and concussions suggesting that it is an essential part of the clinical management of concussions treatment and management (Broglio, Zhu, Sopiarz, & Park, 2009). Guskiewicz, Perrin, & Gansneder (1996) conducted a study on the effects of postural control in concussions of both college and high school athletes. Baseline measurements were taken during preseason and then used for comparison should athletes later sustain an injury. This study also used matched controls in their sample which included 19 individuals sustaining a concussion and 19 matched controls with no injury. The postural control was measured by evaluating postural sway and center of balance using Chattecx Balance System (Chattanooga Group, Inc. Chattanooga, TN). This tool used foot transducers to measure any sway in the distribution of weight. This study revealed that a postural sway was present in concussed athletes up to three days post injury (F=3.36, p<.05) even when other symptoms were not present (Guskiewicz et al., 1996).

In a subsequent study, Guskiewicz, Ross, & Marshall (2001) also concluded that postural sway was present in concussions up to 3 days post injury. This study examined collegiate
athletes that sustained a concussion and compared them to the control sample of non-concussed athletes. All athletes were given a baseline postural control tests at the beginning of season. The injured athletes participated in post injury assessments of postural control on day one, three and five. The matched control subjects were similar in age, height and weight. These subjects also participated in the same amount of competition and playing time. Each of the subjects was measured using the NeuroCom Smart Balance Master system (NeuroCom International, Inc. Clackamas, Oregon), a force plate mechanism and the Balance Error Scoring System (BESS) (Guskiewicz, et al., 2001). The sample size was 72 athletes; 36 of them were concussed and 36 were in the non injured control group. The scores of the Smart Balance System revealed a decrease in postural stability on days one, three and five both in comparison to their baseline readings and to the control subjects (F=10.17, p<.01) (Guskiewicz et al., 2001). The BESS also revealed a decrease in postural control on day one, three, and five (F=2.68 p < .05). This study concluded that most concussions have postural control deficits and are usually seen within three days. The researchers stated this was the result of a sensory integration problem as a result of the injury. This type of injury prevents the athlete from properly exchanging information from their sensory systems causing problems with balance (Guskiewicz, 2001).

In a related study, Broglio and Puetz (2008) conducted a meta-analysis examining the effects of sports-induced concussions on neurocognitive function, self-report of symptoms and postural control. The authors examined 39 studies which were conducted on high school and collegiate athletes that met all inclusion criteria of an immediate post- injury assessment and a 14 day post-injury evaluation. However, only six of the studies examined postural control. The dates of the analysis ranged from 1970-2006. Even though there were limited numbers of studies examining postural control, the results revealed that postural control deficits were present immediately post injury and up to 14 days. Broglio et al. (2008) examined both force plate...
systems and the BESS. This study concluded that further tests need to be conducted on postural control and concussions because there is still a lack of evidence about the extent of the postural deficits. The researchers also suggest that the use of postural control tests should be used to evaluate patients for complete recovery from injury (Broglio et al, 2008).

Postural control may continue to be present in concussions even after the resolution of an injury (Sosnoff, Broglio, Shin & Ferrara, 2011). Sosnoff et al. (2011) evaluated postural control and cognitive function after a concussion and to determine whether postural control deficits persist beyond the acute stage of an injury. This retrospective study consisted of 224 collegiate athletes, of which, 64 of them had been previously diagnosed with one concussion. Postural control was evaluated by detection of postural sway and center of balance. Baseline data was collected during preseason assessment to gather information on concussion related symptoms, neurocognitive functioning, and postural control. This study used the NeuroCom Sensory Organization Test (NeuroCom International Inc. Clackamas, OR), a force plate mechanism that measures the center of balance. This study compared the patients that never sustained a concussion to patients with a previously medically diagnosed concussion. The time frame of the reported concussions was between 6.4 months to 150.9 months. A significance difference was found in postural sway among these groups when the postural task became more demanding. This study suggests that concussions should no longer be considered a transient injury (Sosnoff et al., 2011). The use of a technologically advanced and expensive tool, such as the Neurocom Sensory Organization Test was able to detect subtle balance differences which may not have been seen using other tools. The researchers suggest that further studies are needed to evaluate the long-term postural deficits found with concussions and its’ role in determining return to play guidelines.
There are several postural stability tests used by clinicians to aid in identifying balance deficits and assessing the effects of a concussion (Guskiewicz et al., 2001). There are sophisticated and costly force plate instruments developed to measure postural stability. These highly-advanced and technological tools are cost prohibitive in most settings (Broglio et al., 2008). Beumont et al. (2011) propose that postural stability assessment is integrated into clinical practice to give clinicians a better guideline of when concussed athletes who are experiencing balance symptoms can safely return to play. Therefore, finding a more cost effective and accurate measurement of postural stability appears a priority in this field.

BESS Tool

Kevin Guskiewicz, PhD developed the Balance Error Scoring System (BESS) as a cost effective tool for the assessment of concussion in athletes (Broglio, Zhu, Sopiarz, & Park, 2009). Despite the overall acceptance of the BESS in the sports medicine industry, it lacks the test-retest reliability (Broglio et al., 2009). It was found that repeat exposure to the test may lead to improved balance, which can hide balance deficits found in concussions. Sports clinicians used the BESS tool by directly observing an individual in various stances and subjectively determine a score based upon how many errors they visualize.

Iverson, Kaarto and Koehle (2008) conducted a study to evaluate the BESS tool and to determine normative data on healthy populations. This tool lacked the backing of studies that determine the normal standard of errors found in an uninjured population. These researchers conducted their study to determine the normative results of the BESS across a lifespan for men and women. The sample for this study consisted of adults (n=589) that ranged from 20-69 years of age. Anyone that had balance, neurological or lower extremity deficits were excluded from the study. The sample consisted of 63.5% men and 36.5% women. The individuals were measured using the BESS by a trained exercise physiologist. A small correlation was found
between the BESS and age ($r=.36$, $p<.0001$) and there was no differences found in gender in the sample ($t=.44$, $P<.067$). The mean errors found in the ages from 20-49 ranged from 10.97-11.88 errors. The changes of the normative data remained consistent until after the age of 55 and in which it revealed a dramatic worsening of errors. The authors recommended that additional research needs to be conducted on the BESS and its’ clinical usefulness (Iverson et al., 2008).

Bell, Guskiewicz, Clark & Padua (2011) conducted a systematic review of the BESS. The goal of this review was to provide an objective summary of the reliability and validity of the BESS. It consisted of a literature search of 29 studies during 1999-2010 that were conducted on the reliability and validity of this tool.

The BESS consists of different stances performed on a firm and foam surface with the eyes closed. The stances include: double leg stance, single leg stance, and tandem stance. Each of them is held for 20 seconds and errors counted by the administrator of the test. These types of errors include; opening eyes, lifting hands off of the hips, falling out of position or stepping out of position, swaying of hip, and failing to return to position after 5 seconds (Bell et al., 2011). Reliability was defined by the authors as retest-test reliability, inter-rater or intra-rater reliability. Validity was considered criterion-related validity or if two tests are correlated. This review looked at studies that examined the BESS tool and compared it to force plate balance testing and revealed a wide span of results for reliability. The results ranged from poor, moderate to good level of reliability.

The average errors on a BESS score after a concussion was 17 (Bell et al., 2011). The average errors on a BESS score of a healthy youth population was 10.93 (Bell et al, 2011). The authors suggest that individuals need to be properly trained in the BESS tool to increase reliability. It was reported in this review that the BESS had moderate to high validity but it was somewhat variable depending on the stance and surface. The BESS had moderate to high
criterion-related validity when compared to more advanced instruments using a correlation coefficient. The more difficult stance of standing on foam (single foam $r=.79$ & tandem foam, $r=.64$, $p < .01$) the more it correlated with the advance instruments. The easier stances in which individuals standing on firm surface, (single leg firm $r=.42$ & double leg firm $r=.31$, $p < .01$) the less it correlated to the advance instruments.

Valovich, Perrin and Gansneder (2003) conducted an analysis of the BESS and Standardized Assessment of Concussion (SAC) to determine whether a practice effect exists when using these tools. The SAC test is a mental-status test that is performed usually on the field or immediately following an injury. There are various components to this test which include: mechanism of injury, mental status orientation, immediate and delayed memory, neurological examination, and clinical evaluation of symptoms (Valovich et al., 2003). It is a rapid tests and takes approximately 5-7 minutes to administer. The sample consisted of thirty two uninjured high school athletes who were assigned to a control or practice group. The control group was assessed twice at approximately 30 days apart. The practice group was evaluated during 5 evaluations where the first four measurements were each separated by a week and the last one was conducted 30 days after the previous assessment. The researchers were interested in the practice effect of using the BESS because it is very common for concussed athletes to be given several BESS test while under the care of athletic trainers. There were no significant differences on day 1 and day 30 between the control and practice group for the SAC ($F=2.217$, $p=.147$ and $\beta = .302$). The level of significance was set prior to analysis ($p<.05$). A repeated ANOVA was conducted to analyze the within group practice effect and found a significant main effect for test days ($F=4.934$, $p=.005$, $\beta=.243$). For the BESS test there was not a significant effect between the control and practice group when compared from day 1 and day thirty ($F=.078$, $p=.782 \beta=.058$). The post hoc analysis revealed that the practice group had fewer errors on day
30 than the control group. A post hoc analysis revealed on days 5 and 7 there was a significantly lower number of errors than at the baseline. The results of this study did indeed reveal a practice effect which was most significant on day 5 and 7 with the total number of errors decreased during each testing session. Interestingly, the researchers pointed out that the practice effect did decrease if a subject was not exposed to the BESS tool for three weeks. These results reveal important information for clinicians that evaluate concussions, because they are evaluating injured athletes at various times within a short time frame to establish return to play recommendations. Keeping the practice effect in mind could be important to factor in to the overall assessment and recommendations.

Broglio, Zhu, Sopiarz & Park (2009) conducted a study to investigate the BESS test-retest reliability and to provide recommendations to account for the practice effect found when using the BESS tool. It also investigated gender differences. The sample for this study consisted of 48 of individuals that were not injured or ill. The participants of the study were evaluated using the BESS tool with 5 consecutive measurements. All participants had never had postural control measured using the BESS tool and had to be free of any balance problems. The baseline was measured on each individual and again during a post test in 50 days. The five measurements on each of these days were separated between 2-3 minutes. The interrater reliability of the investigators was determined during a pilot (.92) and was comparable to other studies (Broglio et al., 2009). They were analyzed in two groups based upon gender. The results of the study found that despite the wide acceptance in the sports medicine industry, it lacks the test-retest stability (Broglio et al, 2009). The study showed that the reliability increased as the number of tests increased, both in females and males. It was also revealed using a post hoc analysis (p<.05) that the participants performance on baseline test number one was greater than any other test. A
learning effect is present in various tools of baseline assessment (Broglio et al., 2009), it is important for clinicians to find an objective tool to assist in the management of concussions.

Nintendo Wii Balance Board

The Nintendo Wii balance board, Nintendo of America Inc. (Redmond, Washington), a recreational gaming system, was first introduced in 2008 and gave the video gaming industry a healthier aspect to recreational gaming. Recently, health care facilities and athletic centers are starting to use the, cost effective, Nintendo Wii Balance Board for balance testing (Wilkstrom, 2012). The Wii Balance Board has similar characteristics as the instrumental force plates and transducers, which are highly technological and costly for many clinicians (Wilkstrom, 2012). Similarly to the force plates, the Wii Balance Board measures center of balance (COB). The Wii Balance Board uses this technology to provide recreational gaming and fitness activities.

Clark, Bryant, Pua, McCrory, Bennell, and Hunt (2010) conducted a study on the validity and reliability of the Nintendo Wii Balance Board (WBB) for the measurement of standing balance. The need for clinicians to find an objective tool that is portable and inexpensive was the motivation for these researchers to explore the clinical use of the WBB. The goal of the study was to evaluate the WBB and compare it to the highly specialized laboratory force plate.

The sample for this study consisted of thirty young female and male participants with mean age of 23.7. Subjects were tested on two occasions on the force plate AMTI Model OR6-5 (Advance Mechanical Technology Inc., Watertown, MA.) and WBB. Each test measured center of pressure (COP). Correlation coefficients were used to assess reliability. The standard error of measurement was used to calculate the concurrent validity between the force plate and WBB. Both devices revealed consistent and test-retest reliability during various stances. The concurrent validity was found to be consistent among both instruments. This study provides the
groundwork for future research on the WBB. Clark et al., (2010) conclude that further studies are warranted to further investigate the WBB in other populations. Clark et al., (2010) state that the Nintendo Wii Balance board gaming system has an internal balance test and since the overall instrument was found to be valid and reliable, it can be used clinically to measure balance. The WBB has the potential to “bridge the gap” between the expensive and non-portable force plate tools and the subjective standing balance tools, such as the BESS (Clark et al, 2010). The WBB could provide providers with an objective alternative tool that accurately measures balance in an array of healthcare settings (Clark et al., 2010).

Conclusion

This review supports that concussions are a complex problem among collegiate athletes. The studies presented here strongly indicate that balance deficits take place after a concussion and should be part of the assessment and management of such injuries. In addition, there is an identified need for a cost effective, user friendly and objective tool to assist clinicians in the measurement of balance in this population. A gap in the literature was found to be that no studies have been conducted to date evaluating the Wii Balance Board in comparison to the BESS tool. The significance of this is that Wii Balance Board may have a future role in the measurement of postural stability as an effective and cost-effective means to enhance the clinical management of concussions.
CHAPTER III

METHODS

Design

This study uses non-experimental comparison design to compare two methods of postural stability. College athletes’ postural stability was evaluated utilizing the BESS tool and the Wii Balance Board. Each participant in the study was evaluated using both methods, and a correlation was conducted on the data. The independent variables for the study are the WBB and the BESS tool. The dependent variable is postural stability.

Sample

The population for this study is collegiate football players over the age of 18. A sample of convenience was recruited from a northeast Division III intercollegiate football team from a public four year institution during summer football camp. All participants were healthy and medically cleared to participate in football. All participants could read and understand English which is important because all instructions were given in English. Exclusion criteria included any athletes that were not medically cleared to participate in Football, minors, and non-English speaking.

Recruitment

Permission from the Athletic Department had been granted for the researcher to conduct this study with all participating athletes during the football summer camp. The Principal Investigator met with the athletic team to explain the study during an initial football camp meeting. In this meeting, a letter explaining the study was distributed (Appendix A). It was explained to them that if athletes chose not participate in the study, it would have no
consequence on their participation in the football program or have any influence on their medical clearance. They were also informed that no identifying information will be used in the reporting of data and all information will be kept confidential. Athletes indicated their willingness and interest in participating by signing consent and asking questions about the study.

Test/Retest

A test/retest for reliability of the Wii Balance Board was conducted with a sample size of 12 volunteer convenience subjects. Employees of the University were measured for postural stability using the Wii Balance Board. All participants had two consecutive measurements taken and results were compared. Each subject was measured on the WBB, which included height, weight, center of balance and a single-legged balance test. This measurement was done again following a 5 minute rest.

Quality Control

In order to ensure that proper procedures are being following, each of the research assistants gathered the data in the same manner, the head athletic trainer, who is trained in both methods, observed the assistants in their collection methods. Each of the research assistants used a script for the BESS to instruct the subjects on how to change positions and how they would be measured (Appendix B). The head athletic trainer also independently scored 20 subjects during the data collection on the BESS during the same time each of the research assistants were measuring them. This was conducted to evaluate for inter-rater reliability.

Data Collection

Data on the BESS and Wii Balance Board was collected. All data was collected by two undergraduate research assistants and were trained by an experienced athletic trainer using an
instructional video on the method of BESS testing. Scores were given for each tool. The Wii balance board determined a score by the computerized software which measures center of balance and balance stability. The scores are calculated based upon the subject’s age and the performance on the center of balance test and the single-legged balance test. Each test takes approximately 20-30 seconds. The height is entered in the beginning screen and weight is also measured. The BESS tool had an error score given by the research assistant. Confidentiality is maintained. Data was stored in a locked cabinet in the primary investigator’s office.

Setting

All data were collected on campus during summer football camp, 2013. There were two stations set up in the advance. One station contained the Wii balance board plugged into a television screen. Equipment was not required for the second station, only room for the research assistants and participants to stand in various predetermined poses using the BESS tool.

Procedures

Institutional Review Board permission was received and informed consent was obtained for all participants (Appendix C). Demographics were collected (Appendix G). The software for balance testing included in the WBB was utilized. The research assistants followed the user guidelines from the manufacturer for set up and implementation (Appendix D). Using this Wii training software, the participant was measured in a two legged stance and a single leg stance to evaluate balance. A total score, Wii age, was determined by the software and recorded by the research assistants on their score card (Appendix E). Their form was given to the participant to take to the next station. At the next station, postural stability was measured using the BESS tool. The participants participated in a modified BESS measurement (Table 2). They were measured on a firm surface only. Then an appropriate comparison can be made from the BESS to the firm
surface of the Wii balance Board. Data collection continued until an adequate sample which was determined to be 75 subjects was obtained. The procedure for this study was counterbalanced and participants alternated which instrument on which they were first measured.

Measures

Scores were calculated by the WBB for the measure of balance. This numerical score was a Wii “age” for balance with an estimated range of 17-55. The BESS was measured in errors given by the research assistants during observation in the three stances (Table 2). For each error observed, 1 point was given. The errors were then added and a final number was recorded.

Demographics were collected on all participants. They included; age, height, weight, position in football, history of concussions and when did they occur, and history of limb disorders.

Table 2

*Modified BESS Procedure

1) Research Assistants will follow the written script for each participant (Appendix B).

2) Participants will be measured on firm surface (floor) only.

3) Participants will remove all socks and ankle taping.

4) They will be measured in three different stances for 20 seconds with eyes closed. (The stances include; Double leg stance, Single-leg stance and tandem stance.)

5) Research assistants will give instructions before each stance.

6) Errors will be counted by research assistants. 1 point will be given for each error.

Errors:
A) Eyes opening
B) Lifting hands off of hips
C) Falling or stepping out of position
D) Swaying of hip
E) Failing to return to position within 5 seconds.

7) Scores will be calculated on Score Card (Appendix E).

*(Bell, Guskiewicz, Clark & Padua, 2011).
Risks

This study contained minimal risk to this population, which was outlined in the consent (Appendix A). There were risks of falling off of the Wii or during the BESS measurement, but due to the athletic nature of these individuals this was unlikely. If a patient was identified as having a severe problem with balance during this data collection, they would have been referred to the head athletic trainer, who was onsite to make assessments as needed. This athletic trainer was present in the event that there was an injury and was capable of providing emergency medical care.

Human Subjects Protection

Confidentiality of subjects will continue to be maintained. The consents along with any identifying information are kept separate from the data collection sheet.

Proposed Data Analysis

This correlation study was analyzed using SPSS version 19. Statistical procedures include using a Pearson Correlation coefficient to compare the readings from the two instruments and an independent T-Test to evaluate the history of concussions and limb disorders to the postural stability scores. There were other ancillary and exploratory analysis to evaluate the demographic data that were collected.
Chapter IV

Results

This non-experimental comparison design compared two methods of postural stability testing. College athletes were evaluated utilizing the Balance Error Scoring System (BESS) tool and the Wii Balance Board (WBB). The independent variables for this study are the Wii Balance Board and the BESS tool. The dependant variable is postural stability. This study was a test in measures study to evaluate criterion-validity of the Wii Balance Board to an already established and widely used measure, the BESS. All data were analyzed using SPSS version 19.

Test/ Retest  WBB Pilot

A test/retest pilot was conducted to evaluate within-person reliability on the WBB prior to the study’s data collection. A convenience sample of 12 volunteer subjects had two consecutive measurements for postural stability using the Wii Balance Board. The results were analyzed using a Cronbach’s Alpha to test for internal consistency. The reliability coefficient was strongly reliable at .955 (Table 1).

Table 1

Test/ Retest Reliability

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
<th>Cronbach's Alpha Based on Standardized Items</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach's Alpha</td>
<td>.955</td>
<td>.958</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
Sample

This study had a sample size of 91 of volunteer male athletes from a Division III Collegiate football team. The total number of male subjects that were eligible to participate was 95 which was a 96% participation rate. All participants were medically cleared to participate in football prior to the data collection. Age, height and weight were collected for each subject. The age range of the subjects was from 18-25. Demographic data such as medical history of concussions and limb disorders were also collected.

The age range of the subjects was from 18-25.

Table 2

Age, Height & Weight Demographics

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>age</td>
<td>91</td>
<td>18.00</td>
<td>25.00</td>
<td>20.2088</td>
<td>1.64328</td>
</tr>
<tr>
<td>weight</td>
<td>91</td>
<td>160.00</td>
<td>320.00</td>
<td>211.2527</td>
<td>38.35408</td>
</tr>
<tr>
<td>Height in inches</td>
<td>91</td>
<td>66.00</td>
<td>77.00</td>
<td>71.3407</td>
<td>2.53955</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>91</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Of the 91 subjects 34 (37.4%) individuals had a history of concussion diagnosed by a medical provider (Table 3). Seventy-three percent of the individuals that stated they had a history of a concussion only had one (Table 4). Two athletes reported that they had a history of four concussions.
Table 3

History of Concussions

<table>
<thead>
<tr>
<th>History of Concussions</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid yes</td>
<td>34</td>
<td>37.4</td>
<td>37.4</td>
<td>37.4</td>
</tr>
<tr>
<td>no</td>
<td>57</td>
<td>62.6</td>
<td>62.6</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>91</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Table 4

Number of Concussions Sustained by Subjects

<table>
<thead>
<tr>
<th>Number of Concussions</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid 1.00</td>
<td>25</td>
<td>27.5</td>
<td>73.5</td>
<td>73.5</td>
</tr>
<tr>
<td>2.00</td>
<td>6</td>
<td>6.6</td>
<td>17.6</td>
<td>91.2</td>
</tr>
<tr>
<td>3.00</td>
<td>1</td>
<td>1.1</td>
<td>2.9</td>
<td>94.1</td>
</tr>
<tr>
<td>4.00</td>
<td>2</td>
<td>2.2</td>
<td>5.9</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
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<td>37.4</td>
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<tr>
<td>Missing System</td>
<td>57</td>
<td>62.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>91</td>
<td>100.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The majority of reported concussions occurred between one to three years ago (47.1%) (Table 5).
Table 5.

Timeframe of concussion occurrence

![Bar chart showing the frequency of concussions occurring at different timeframes.](chart.png)

Fifty-two percent the athletes reported a history of limb disorders (Table 6).

Table 6.

<table>
<thead>
<tr>
<th>History of Limb Disorders</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid yes</td>
<td>52</td>
<td>57.1</td>
<td>57.1</td>
<td>57.1</td>
</tr>
<tr>
<td>no</td>
<td>39</td>
<td>42.9</td>
<td>42.9</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>91</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>
Wii and BESS Scores

The BESS scores ranged from 0 to 14 errors. The mean error for the sample was 4.27 with a median of 4 (Table 7). The BESS scores ranged from 0-14 (Table 8).

Table 7
Mean BESS Error Scores

<table>
<thead>
<tr>
<th>Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>BESS Score</td>
</tr>
<tr>
<td>N</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>Std. Deviation</td>
</tr>
<tr>
<td>Range</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>Maximum</td>
</tr>
</tbody>
</table>

Table 8
BESS Score Frequency

The WBB scores ranged from 18-52 (Table 9) with a mean score of 22.98 and a standard deviation of 5.846 (Table 10).
The Wii and Bess scores were computed to Z-scores for analysis because of the different scales of measurement and to operate on the same means. A Pearson correlation coefficient was conducted to determine the strength of the relationship between the two tools. Both variables
were measured on an interval scale. A correlation is considered significant at the .01 level. The analysis revealed a significant direct relationship between the two variables ($r = .347$) (Table 11).

**Table 11**

**Pearson Correlation Coefficient of the BESS and WBB**

<table>
<thead>
<tr>
<th></th>
<th>Zscore(BESS)</th>
<th>Zscore(WBB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zscore(BESS)</td>
<td>Pearson Correlation</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>91</td>
</tr>
<tr>
<td>Zscore(WBB)</td>
<td>Pearson Correlation</td>
<td>.347**</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>91</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).**

Independent samples t-tests were performed to see if there is a difference in the scores of the individuals that had a history of a concussion versus the subjects that did not report a concussion. The independent samples t-tests compared the means of scores of concussed versus the non-concussed groups both on the Wii Balance Board and the BESS test. The confidence level was set at 95%. There were no significant difference found on the Wii in these two groups ($t = .456, p > .05$ (Table 12). The mean of the concussed group in Wii z-scores was ($m = -.1018, sd = .6868$) which were not significantly different from the non-concussed group in Z-scores ($m = .0607771, sd = 1.1485$). There were no significant difference found on the scores of BESS in these two groups ($t = .099, p > .05$) (Table 12). The mean of the concussed group in the BESS z-scores ($m = -.2240883, sd = .9299$) were not significantly different from the concussed group in z-scores ($m = .1336667, sd = 1.0241$).
Table 12
Independent Samples T-Test for Concussed Individuals versus Non-Concussed

<table>
<thead>
<tr>
<th>T-test for Equality of Means</th>
<th>95% Confidence Interval of the Difference</th>
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<tbody>
<tr>
<td></td>
<td>t</td>
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<tr>
<td>Zscore(wiiscore)</td>
<td></td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>-.749</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>-.845</td>
</tr>
<tr>
<td>Zscore(BESS)</td>
<td></td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>-1.667</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>-1.709</td>
</tr>
</tbody>
</table>

Independent samples t-tests were also performed to see if there was a difference of mean scores on individuals that had a history of limb disorders compared to individuals with no limb disorders on both the Wii Balance Board and the BESS test. The confidence level was set at 95%. There were no significant difference found on the WBB in the two groups \((t=.332, P > .05)\) (Table 13). The mean of the group that identified with a history of limb disorder \((m = -.0945, sd = .9299)\) was not significantly different from the group denied any history of limb disorders \((m = .11302, sd = 1.0899)\). There was also, no significant difference found on the BESS tool in the two groups \((t = .277, p > .05)\) (Table 13). The mean Z-score of the BESS of the individuals with limb disorders was \((m = .1060, sd =1.0595 )\) not statistically significantly different from the group that denied a history of limb disorders \((m = -.1302393, sd = .94228)\).
Inter-rater reliability was conducted on the research assistants for the BESS tool to evaluate the subjective tool of the data collection. The head athletic trainer, who trained each research assistant on the BESS method, rated subjects at the same time during the data collection for 20 subjects. A Chronbach’s Alpha was determined for reliability on research assistant 1 (RA1) and research assistant 2 (RA2). For RA 1 (n=10) the reliability coefficient was strongly reliable at .782. RA 2 (n=10) was also strongly reliable at .977.
Chapter V

Discussion

Summary of Results

This study compared readings from the WBB to the BESS tool. A pilot using a test-retest design was conducted to evaluate within-person reliability on the WBB prior to the study’s data collection. A total of 12 volunteer subjects’ postural stability was measured on the WBB and was found to be a strongly reliable tool \( r = 0.955 \). This is consistent with other studies that also have revealed test-retest reliability (Butler & Willet, 2010; Clark et al., 2010). The strong within-device reliability revealed in this pilot warrant further investigation in future studies with a larger sample size.

Demographics were collected on all subjects. Ninety-one male collegiate football players participated in the study. The age range for the sample was 18 to 25 with a mean age of 20. The weight ranged for individuals was 160 to 320 pounds, with a mean weight of 211. The height range was 66 to 77 inches with a mean height of 71 inches. In this sample, 37.4% reported having a history of concussions. The majority of subjects reported a history of one concussion (73.5%). The most concussions reported was four (n=2). The majority (47.1%) of concussions that these individuals sustained were approximately 1-3 years ago. None of the subjects reported having a concussion 1-3 months prior to data collection. Fifty-two percent of subjects reported a history of limb disorders.

The WBB scores were revealed as a Wii fit age and ranged from 18-52. The mean for WBB was 22.9. The BESS was scored in errors and ranged from 0-14. The mean error score for
the sample was 4.27. The WBB and BESS scores indicated that there was a positive and direct correlation between the two instruments supporting the hypothesis of this study. The strength of the relationship between the two scores was strong between the two variables ($r=.347$). The WBB, when compared to the BESS, is found to valid tool in assessing postural stability. These findings are similar to another study in which WBB was compared to a laboratory grade force plate mechanisms for the measurement of balance (Clark et al. 2010). The laboratory grade force plate mechanism is similar to the WBB because they both measure postural stability using the center of balance. In Clark et al. (2010), it was found that there was a strong correlation between measurements of both instruments (Interclass Correlation = .77-.89). No other previous studies compared the WBB to the BESS tool.

**Discussion**

Proper assessment is essential in the care of concussed athletes. It has been documented through research that postural deficits can be present approximately 72 hours post concussion (Broglio et al., 2009). Most of these deficits resolve within few days, but some may have prolonged symptoms which extend for a longer period (Beaumont et al., 2011). It is recommended that postural stability testing needs to be an integral part of the assessment of concussions in order to give clinicians a better guideline of when athletes can safely return to play (Beaumont et al., 2011). Clinicians should use objective tools to aid in making return to play decisions in concussed athletes. If an athlete is not properly evaluated and returned to play too soon, it can have devastating consequences (Bey et al., 2009).

There are highly advanced systems developed to measure postural stability, but in most settings they are cost prohibited (Broglio, 2008). Therefore, clinicians are in need of an objective and cost effective tool to assess postural stability and one that can be used across healthcare disciplines. In the field of sports medicine, the gold standard is to use the BESS, as it
is most cost-effective. This is controversial in the literature as studies have revealed that it lacks the retest-test reliability and contains a practice effect (Bell et al., 2011, Broglio et al., 2009 & Valvovich et al., 2003). Recently healthcare facilities and athletic centers are starting to use the WBB for postural stability testing (Wilkstrom, 2012). However, there are limited studies previously conducted on the WBB (Clark et al., 2010 & Butler et al., 2010).

The significance of this study was to provide evidence that WBB has the potential to improve the management of concussions. The WBB was found to be a statistically valid tool when compared to the BESS. These findings support results reported by Clark et al. (2010) which found the WBB reliable and valid when compared to the highly specialized and technologically advanced force plate instruments. The results of this study revealed that the WBB is a reliable and valid tool when compared to the BESS and has the possibility to aid in the diagnosis and management of concussions.

Conclusions

Essentials to the Doctor of Nursing Practice. Nursing practice is guided by evidence. The Doctor of Nursing Practice degree was developed to prepare experts in specialized advance nursing practice (AACN, 2006). This practice focused doctoral degree has been guided by The Essentials to the Doctor of Nursing Practice (AACN, 2006). These essentials or foundational competencies are designed to prepare the DNP to have more specialized practice skills to meet the demands of the increasingly complex healthcare system. There are eight Essentials defined by the AACN that a DNP student should experience during their doctoral education in order to be successful candidate for a DNP degree. There are several Essentials that have guided this study.
Essential I, Scientific Underpinnings of Practice, stresses’ the importance of nursing science to enhance the delivery of healthcare to patients (AACN, 2006). Conducting this study on the WBB should lead to future research to further enhance the diagnosis and management of concussions. This study has the potential to change the way nurses evaluate concussions. This project contributes to evidence-base practice by evaluating different methods of postural stability testing. This study, which was conducted by an advance practice nurse, enhances the scientific underpinnings of the evaluation of concussions. Nursing scholars should actively be involved in future research to aid in the prevention of such serious injuries. The dynamic role of nurses in the community offers an opportunity to have an impact in the comprehensive approach of concussion management.

Essential VI, Interprofessional Collaboration for Improving Patient and Population Health Outcomes, is an additional essential guiding this project (AACN, 2006). This project has evaluated a tool that is used for concussion management outside of nursing. The BESS was developed for sports medicine clinicians. Proper concussion management of concussed athletes encompasses interprofessional collaboration. This study was conducted in collaboration with athletic trainers. All data collection and training of research assistants were supervised by an Athletic Trainer experienced with using the BESS tool. Working in collaboration on this study to collect data for the evaluation of postural stability in athletes contributed to the continual interprofessional collaboration for the comprehensive management of concussed athletes in this setting.

Essential VII, Clinical Prevention and Population Health for Improving the Nation’s Health, also guided this study. It is imperative that concussion management continues to evolve to improve the safety of athletes. Identifying a valid and reliable tool, such as the WBB, that can be used in various settings has the potential to prevent serious complications of concussions.
The long term and serious consequences are devastating and sometimes irreversible. This study’s goal was to determine whether the WBB is reliable and valid well compared to an already established tool. Having a reliable and valid tool to detect postural instability in concussed athletes will aid in the decision making process to determine when an athlete can safely return to play, therefore, reducing the risk of second-impact syndrome or post-concussion syndrome. Second impact syndrome is a complication of concussions if a re-injury to the brain occurs and can cause brain herniation or death (Bey et al., 2008). Proper clinical assessment is essential in decreasing the risk of this serious complication.

Essential IV, Patient Care Technology for Improvement and Transformation of Healthcare (AACN, 2006), was the fourth and final essential to frame this project. Utilizing a modern technology gaming system, the WBB, to enhance patient care delivery is an innovative approach that potentially will improve patient outcomes. This project evaluated a non-medical device for the assessment of postural stability. Evaluating a system that was not designed for postural stability testing is a resourceful and modern approach to improving healthcare for this population.

**Implications of the Results.** It is imperative that nursing become more actively involved in the research, prevention and education of concussions. Nursing plays an integral role in the management of concussions and future research on concussions should be conducted by nurse scholars.

In this study the WBB was found to be a reliable and valid tool when compared to the BESS. The WBB could change the way clinicians evaluate postural stability. The WBB, a gaming system has been proven to be used in various settings for rehabilitation, has not yet been used for the assessment of postural stability (Butler et al., 2010). These results lay the foundation for future research on the WBB and its’ usefulness in measuring postural stability.
The portable and cost effective WBB potentially could be used in various settings to aid in the concussion management of athletes.

**Theoretical Framework.** Translating Research into Injury Prevention Practice (TRIPP) framework suggests that research should consist on building an evidence base for efficacy and effectiveness of injury prevention measures (Finch, 2006). This theoretical framework encompasses a stepped approach in injury prevention (Gosling, Gabbe, & Forbes, 2008). The first step of this framework identifies injury surveillance as a key component. The serious injury identified for this project is concussions. In the review of literature, it was revealed that concussions are serious concern in sports today. The Center for Disease Control and Prevention (2007) estimate that approximately 1.6 to 3.8 million treated and untreated sports induced concussions occur annually in the United States.

The second step of the TRIPP framework includes understanding of the mechanism of injuries (Gosling et al., 2008). Concussions are a complex physiological process caused by biomechanical forces that cause disruption in brain functioning (McCrory et al., 2012). Clinicians need to have a clear understanding of the mechanism of injury in order to develop prevention strategies.

This study mostly encompasses step 3 of the TRIPP framework. This part of the framework identifies possible solutions to injuries and identifying prevention measures to reduce the risk of a second injury occurring (Gosling et al., 2008). Second Impact Syndrome consists of cerebral swelling and is the result of a second brain injury which occurs before the first injury has resolved (Halstead et al., 2010). This can lead to brain death or herniation within in three minutes of such an injury (Bey et al., 2006). Determining when an athlete is cleared to return to play encompasses various assessments including postural stability. Identifying a valid and easy
to use tool, such as the WBB, to assist with the measurement of postural stability will assist in the safer return to play decisions.

This framework identifies that an evaluation of the efficacy of prevention measures is needed in order to identify how outcomes can translate into practice (Finch, 2006). Evaluating the WBB as a valid alternative to the BESS, could increase the reliability of the evaluation of the athlete’s ability to return to play. A concussed athlete returning too soon to play can have devastating consequences, including second impact syndrome (Guskiewicz et al., 2001).

Identifying a serious injury such as concussions and the factors which contribute to the complications of such an injury is essential in identifying prevention measures. This framework provided guidance to support the relevance and organization of this study.

**Limitations.** The sample size of the pilot was small (n=12). A larger study needs to be conducted to further investigate the reliability of WBB. The study contained only male collegiate football players from ages 18-25. Other populations including females and athletes engaged in other sports at risk for concussions.

**Recommendations for Future Research.** These conclusions provide the foundation for future research to investigate the validity and reliability of the WBB and its’ usefulness in the management of concussions. Future research should continue to focus on postural stability and the WBB. Studies should be conducted to compare the WBB to other highly advanced force plate instruments, which also measure center of pressure and are designed to measure postural stability. Since this study began, there have been other devices that have come on the market to evaluate postural stability that include using and IPad (Apple Inc., Cuppertino, CA.) or other newer forms of technology. Future studies should evaluate other cost effective alternatives as well. Studies also need to evaluate concussed athletes with comparisons to baseline or prior to concussion scores to investigate whether it can be used for the detection of postural deficits in
these injuries. A practice effect or improvement in scores with repeat administration was not determined in this study and will need to be evaluated in future studies.

If the WBB continues to be proven to valid and reliable in various settings and populations, it could be used in primary care offices, sports medicine industry, schools, collegiate and in professional sports. The WBB could also be used to evaluate postural stability in other neurological disorders, such as Parkinson’s disease, vertigo and vestibular disorders.

The WBB is user-friendly and does not require advance technological skills. The company, Nintendo America Inc., as well as third-party software developers, should consider specialized software to focus primarily on postural stability testing. When the clinician utilizes the gaming system it forces them to navigate through various and unnecessary screens in order to complete a balance evaluation. The development of software specifically designed for postural stability testing will further enhance this dynamic gaming system.
References


Dear WPU Football Player,

This letter is to invite you to participate in a voluntary research study during your summer camp this year. I am a nursing doctoral student from William Paterson University and am conducting research on measuring balance in college football players. The purpose of this study is to measure balance by using two different tools to aid in the assessment of concussions. If you choose to participate in this study, your balance will be measured using two methods. Your participation in this study is strictly voluntary. If you choose not to participate, it will have no influence over your team participation or with your medical clearance.

If you have further questions, you can contact me directly. My contact information is below.

Thank you for your time.

Sincerely,

Jill Guzman, APN

973-720-3176

Guzmanj21@wpunj.edu.
Direction to participant:

I am now going to test your balance. Please take off your shoes. Roll up your pant leg (if applicable) and remove any ankle tapping (if applicable).

This test will consist of 3- twenty seconds tests using three different stances. I will describe the stances as we go along.

DOUBLE LEG STANCE:

Direction to the participant: The first stance is standing with your feet together like this (administrator will demonstrate the two-legged stance).

You will be standing with your hands on your hips with your eyes closed. You should try to maintain stability in that position for 20 seconds. I will be counting the number of times you move out of this position. If you lose your balance, you should try to get back into position as soon as possible.

Direction to participant:

Put your feet together, put your hands on your hips and when you close your eyes the testing will begin. (start timer when the person closes their eyes and time for 20 seconds).

SINGLE LEG STANCE:

Direction to participant:

If you were to kick a ball, which foot would you use? (this is the dominant foot).

(Instruct the person they will stand on the non-dominant foot.)

(Before starting test assess the position of the dominant leg. The dominant leg needs to have about 30 degree hip flexion and 45 degree knee flexion.)

You will need to stay in position for 20 seconds with your eyes closed. I will be counting how many times you move out of position. Place your hands on your hips. When you close your eyes the testing time will begin.

(Start timer when subject closes their eyes)

TANDEM STANCE

Directions to the participant:
Now stand heel to toe with your non-dominant foot in back. Your weight should be evenly distributed across both feet.

Again, you should try to maintain stability for 20 seconds with your eyes closed. I will be counting the number of times you move out of this position.

Place your hands on your hips. When you close your eyes the testing time will begin.

(Start timer when subject closes their eyes).

*This tool was developed by Kevin Guskiewicz, PhD at the University of North Carolina’s Sports Medicine Research Laboratory, Chapel Hill, NC.*
Comparison of the Wii Balance Board and the BESS tool for Measuring Postural Stability in Collegiate Athletes

IRB Proposal

Jill Guzman

William Paterson University – School of Nursing
Institutional Review Board for Human Subject Research

APPENDIX C2: PROTOCOL FACE SHEET
For use by WPUNJ Doctoral Students

Instructions: Submit one original protocol prior to the initiation of any work involving human subjects or human material to the IRB Administrator c/o the Office of Sponsored Programs, Raubinger Hall, Room 309. A complete protocol includes: (A) this form completed and signed, (B) a complete description of the research plan, (C) one copy of all test instruments, and (D) one copy of all draft informed consent statements. IRB Training Certification for the principal investigator and other investigators* must have been received by the IRB before this protocol is submitted. (*Certification of training is not required for WPU undergraduate or master’s degree students. A copy of certifications for investigators affiliated with other institutions should be attached.)

Doctoral Candidate(s) Jill Guzman

Program and Department Doctor of Nursing Practice
Contact Phone and Email 973-720-3176, guzmanj21@wpunj.edu
Home Address 206 Andover Drive Wayne NJ 07470

Other Investigators

Faculty Sponsor Dr. Nadine Aktan
Course NUR 8300, NUR 8301, NUR 8310, NUR 8311
Title of Research Comparison of the Wii Balance Board and the BESS tool for Measuring Postural Stability in Collegiate Athletes

Research Dates Beginning: June 2013 Ending: June 2014

PLEASE ANSWER THE FOLLOWING QUESTIONS:

1.  ____  _X_ Is this research part of or related to a previously approved protocol or is it associated with a sponsored project or activity of William Paterson University or another institution? If so, please identify:

2.  _X_  ____ Human subjects to be involved in the proposed activity include: (select all that apply)

<table>
<thead>
<tr>
<th></th>
<th>Children or minors</th>
<th>Mental or behavioral disorder</th>
<th>Limited English Proficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fetuses</td>
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<td>Developmental disability</td>
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<tr>
<td>Abortuses</td>
<td></td>
<td>Physical disorder or disability</td>
<td>Other:</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>x</td>
<td>WPUNJ students</td>
<td></td>
</tr>
</tbody>
</table>
3. ____ X__  Will subjects be videotaped or audiotaped?

5. ____ X__  Does the project involve in-person interviews?

6. ____ X__  Does the project involve the use of human blood, blood products, tissues or body fluids?

7. ____ X__  If Question #7 is yes, have you attended the Occupational Exposure to Blood-borne pathogens program offered by the WPU College of Science and Health?

   Does the project involve the use of electrical apparatus other than routine care equipment?

8. _X__ ____  Are all of the follow items attached to this form?

   - **Research plan**: Including
     a. Research Hypothesis
     b. Purpose and Background of the Research
     c. Methodology: (1) design of research, (2) information to be collected, (3) instruments to be used, (4) how data will be analyzed, (5) plan for storage and disposition of data and recordings, and (6) identification of research locations and whether those locations have agreed to participate in this research
     d. Human Subjects: (1) description of subjects, (2) identification and consideration of vulnerable populations or special classes of subjects, (3) recruitment and selection plan, (4) protection of anonymity and/or confidentiality of subjects, and (5) informed consent process
     e. Risks and Benefits: (1) potential risks, (2) potential benefits, and (3) risk/benefit analysis
   - Data collection instruments
   - Informed Consent Statements

---

Signatures:

Doctoral Candidate: ______________________________ Date: ________________

Doctoral Candidate: ______________________________ Date: ________________

Faculty Sponsor: ______________________________ Date: ________________

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For Completion by IRB Only

Training Certification Confirmation

<table>
<thead>
<tr>
<th>Name</th>
<th>Title/Role in Project</th>
<th>Federal Regulations</th>
<th>WPUNJ Policy &amp; Procedures</th>
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<tbody>
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</tbody>
</table>
Initial Review
Reviewers: __________________________ Type: _______________ Decision: _____________________ Date: ________

IRB Review
Date: ________________ Affirmed: Yes ___ No ___:

First Continuing Review Date: ________________
Research Hypothesis

The Nintendo Wii Balance Board can be used as a valid and reliable for the measurement of postural stability in college athletes.

Purpose

This study will compare the readings from the Wii Balance Board and the Balance Error Scoring System. The purpose of this study is to evaluate the Wii Balance Board as an objective, user friendly, cost effective, valid alternative tool for the measurement of postural stability in college athletes.

Background

Concussions are one of the most serious injuries in college athletics (Gessel, Fields, Collins, Dick, & Comstock, 2007). Studies have revealed that there can be a cumulative neurologic effect in individuals who have sustained three or more concussions (Gessel et al, 2007). Along with other neurological symptoms, balance deficits can take place approximately within 72 hours post concussion (McCrory, Meeuwisse, Johnston, Aubry, Molloy & Cantu, 2009). Beaumont, Mongeon, Thremblay, Messier & Prince (2011) propose that postural stability assessment is integrated into clinical practice to give clinicians a better guideline of when concussed athletes who are experiencing balance symptoms can safely return to play. In the past return-to-play guidelines have been very uncertain and based upon self-reporting of symptoms. The Balance Error Scoring System (BESS) was developed solely for the assessment of balance deficits in concussed athletes (Broglio, Zhu, Sopiarz, & Park, 2009). Despite the overall acceptance of the BESS in the sports medicine industry, it lacks the test-retest stability (Broglio et al, 2009). Even though this is a widely utilized tool in other health care disciplines, Nurse Practitioners are not trained using this method.

Methodology

This non experimental comparison study will compare the two methods of postural stability testing. College athletes’ postural stability will be evaluated utilizing the BESS tool and the Wii Balance Board. Each participant in the study will have both evaluations and results will be compared. Undergraduate research assistants, Wesley Ostrzycki and Carlye Bianco will be used for the data collection. The researcher assistants will be trained on how to use the Wii Balance Board and the BESS tool.

All subjects will be asked to sign consent to participate in the study. Subjects will be measured on a Wii Balance Board utilizing the gaming software that is part of the gaming system. The research assistants will follow the user guidelines from the manufacturer. All Data Collection will be monitored by the Head Athletic Trainer to ensure that proper procedures are being followed. Using this software the participant will be measured in a two legged stance to evaluate center of balance. This is done for 60 seconds and has three levels of measurement. A numerical score is given by the Wii after the three measurements are calculated by the software. This score will be recorded on their form. Their form will then be given to the participant to take to the next station. At the next station, they will be measured using the BESS tool. The participants will be participating in a modified BESS measurement. They will be measured on a
firm surface only. Then an appropriate comparison can be made from the BESS to the firm surface of the Wii balance Board. The modified BESS consists of different stances performed on a firm surface with the eyes closed. Each stance is held for 20 seconds and errors counted by the administrator of the test. These types of errors are opening eyes, lifting hands off of the hips, falling out of position or stepping out of position, swaying of hip, and failing to return to position after 5 seconds. The participant will be given one point for each error during their evaluation and a total score of errors will be reported. The research assistants will be trained by Robert Rehberg, PhD, Department of Kinesiology on how to use the BESS tool.

Test/Retest

A test/retest for reliability of the Wii Balance Board will be conducted with a sample size of 10 volunteer convenience subjects. Employees of the William Paterson University Counseling, Health and Wellness Center, will be measured for postural stability using the Wii Balance Board. All participants will have two measurements taken. The results will be compared and similar results should be obtained during this test/retest.

Analysis

This correlation study will be analyzed using SPSS version 19. All this study will compare the scores of each individual on the BESS to the Wii Balance Scores. A Pearson Correlation Coefficient and a paired T-Test will be used to compare the readings from the two instruments.

Storage of Data

All identifying information from this study will be kept in a locked cabinet in a locked office that only the Principal Investigator has access too.

Setting

All data will be collected in the athletic training room at WPU during summer football camp.

Human Subjects

A convenience sample will be recruited from William Paterson University’s (WPU) Intercollegiate Football Players, who are all medically cleared to participate in football camp. There are no subjects in this study that are of a vulnerable population.

Recruitment

The principal investigator will speak to the athletes during one of their football meetings to recruit participants. It will be made clear to all participants that if they choose not participate in the study that it will have no consequence on their participation in the football program or have any influence on their medical clearance. A letter will be given to potential subjects explaining the study and with the Principal Investigator’s contact information; in case they have concerns or questions. All students must be able to read and understand English.

Confidentiality of Subjects

Only the chief principal investigator will have access to the data collection of students. After the data is collected by the research assistants it will be given to the investigator and locked
in a file for no one else to have access too. The results will not be published identifying individuals but rather as aggregate data.

Consent

All individuals that agree to participate in the study will be asked to sign a consent form. This consent form will also include information about the confidentiality of this project. The consent forms will be coded so that they will match up with the data collected. They will have the same code that is on the data collection score card. No identifying information will be on the score card.

Risk/ Benefits

This study contains minimal risk to this population. There is a slight risk of falling off of the Wii or during the BESS measurement, but due to the athletic nature of these individuals it is minimal. The head athletic trainer, Alison Moquin, will be present in the event that there is an injury and will be capable of providing emergency medical care. The risk will be outlined in the consent (Appendix A). If the Wii balance board is found valid and reliable, it could also be used to measure postural stability in other neurological disorders. The significance of this study could lay the foundation for future research on concussions and other uses for the Wii balance board in the nursing field and related disciplines.
Appendix A

Consent

William Paterson University
Project Title: Comparison of the Wii Balance Board and the BESS Tool for Measuring Balance in Collegiate Athletes.
Principal Investigator: Jill Guzman, 973-720-3176
Other Investigators: 
Faculty Sponsor: Nadine Aktan, PhD
Contact Phone Number: 973-720-2527
Department: Department of Nursing
Course Name and Number: NUR 8300, NUR 8301, NUR 8310, NUR 8311
Date: August, 2013

I have been asked to participate in a research study on balance testing and college athletes. The purpose of this study will be to determine whether the Wii Balance Board is a valid tool to measure balance in college athletes. I understand that I will be asked to participate in balance testing using the Wii Balance Board and the Balance Error Scoring System (BESS). There are minimal physical risks in participating in this study. Although unlikely, they include falling and sustaining a physical injury.

I understand that my participation is entirely voluntary and I may end my participation in this research at any time. I understand that my identity will be protected at all times and that my name will not be used. I understand that the results of this study will not be reported in a way that would identify individual participants. The principal investigator will have access to your information. This information will be kept confidential and not shared with others.

I may call the investigators, Jill Guzman or Nadine Aktan, PhD. If I have any questions or concerns about this research and my participation, I may call the Associate Provost for Academic Affairs (973-720-2565) for information regarding my rights as a research subject.

By signing this consent form, I am agreeing to participate in this research study.

Name of Subject________________________Signature of Subject______________________________

Date: ________________________________

Name of Investigator___________________Signature of Investigator______________________________

Date: ________________________________
Scores

**Wii Balance Score**

---

**Balance Error Scoring System**

**Types of Errors**

1. Hands lifted off of iliac crest
2. Opening eyes
3. Step, stumble or fall
4. Moving hip into >30 degrees abduction
5. Lifting forefoot or heel
6. Remaining out of test position >5 seconds

The Bess is calculated by adding one error point for each error during the 3 20-second tests. Only firm surface will be tested.

**Which foot was tested:**  ○ Left ○ Right

(i.e. which is the non-dominant foot)

**Score for BESS**

<table>
<thead>
<tr>
<th># of Errors</th>
<th>Firm Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double leg stance (Feet together)</td>
<td></td>
</tr>
<tr>
<td>Single leg stance (Non-dominant Foot)</td>
<td></td>
</tr>
<tr>
<td>Tandem Stance (non-dominant foot in back)</td>
<td></td>
</tr>
<tr>
<td><strong>Total BESS Score</strong></td>
<td></td>
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</tbody>
</table>
Date_________________________

Please answer the following:

Age:________

Height: ____________

Approximate Weight___________

1. **What is the football position you have played the most?**___________________________

2. **Have you ever been diagnosed by a medical provider as having a concussion?**  
   ○Yes  ○No

   If yes, How many?_______________________________________________

   **Please list when these concussions occurred** (include the number of concussions for each time period):
   
   ___less than one month ago   ___1-3 months ago   ___3-6 months ago
   ___6-12 months ago   ___1-3 years ago   ___3-5 years ago   ___ over 5 years ago

3. **Do you have a history of any problems with your lower limbs** (For example, Fracture, Sprained ankle, Achilles tendon injury)?  ○Yes   ○No

   If yes, please check off all that apply.

   ○ right ankle  ○ right foot  ○right calf  ○right knee  ○Other ________

   ○left ankle  ○left foot  ○left calf  ○left knee  ○ Other ________

*Please remember all information is private and confidential.*