2000

The Effects of Balance Training in Normal Young Adults as Assessed by the Neurocom Balance Master

Steve Dingmann
University of North Dakota

Follow this and additional works at: https://commons.und.edu/pt-grad

Part of the Physical Therapy Commons

Recommended Citation
https://commons.und.edu/pt-grad/117

This Scholarly Project is brought to you for free and open access by the Department of Physical Therapy at UND Scholarly Commons. It has been accepted for inclusion in Physical Therapy Scholarly Projects by an authorized administrator of UND Scholarly Commons. For more information, please contact zeinebyousif@library.und.edu.
THE EFFECTS OF BALANCE TRAINING IN NORMAL YOUNG ADULTS AS 
ASSESSED BY THE NEUROCOM® BALANCE MASTER

By

Steve Dingmann
Bachelor of Science in Physical Therapy
University of North Dakota, 1999

An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy 
School of Medicine
University of North Dakota
in partial fulfillment for the requirements
for the degree of
Master of Physical Therapy

Grand Forks, North Dakota
May
2000
This Independent Study, submitted by Steve Dingmann in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Faculty Preceptor)

(Graduate School Advisor)

(Chairperson, Physical Therapy)
PERMISSION

Title The Effects of Balance Training in Normal Young Adults as Assessed by the Neurocom® Balance Master

Department Physical Therapy

Degree Master of Physical Therapy

In presenting this Independent Study Report in partial fulfillment of the requirements for a graduate degree from the University of North Dakota, I agree that the Department of Physical Therapy shall make it freely available for inspection. I further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised my work, or in her absence, by the Chairperson of the department. It is understood that any copying or publication or other use of this Independent Study Report or part thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and the University of North Dakota in any scholarly use which may be made of any material in my Independent Study Report.

Signature _______________________
Date 12-6-79
# TABLE OF CONTENTS

LIST OF FIGURES ................................................................. vi
LIST OF TABLES ............................................................... vii
ACKNOWLEDGMENTS ........................................................... viii
ABSTRACT .......................................................... ix

CHAPTER

I INTRODUCTION .................................................. 1
   Problem Statement ................................................. 2
   Purpose/Research Questions .................................... 3
   Hypothesis ........................................................... 4
   Significance ........................................................ 4

II LITERATURE REVIEW ........................................... 5
   Static Balance ...................................................... 7
   Dynamic Balance .................................................. 7
   Balance Assessment .............................................. 8
   Balance Training ................................................... 9

III METHODOLOGY .................................................. 11
   Subjects ............................................................. 11
   Instrumentation ................................................... 13
   Assessment Procedure .......................................... 18
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Eight directions of limits of stability</td>
<td>13</td>
</tr>
<tr>
<td>2. Neurocom® Balance Master version 6.1</td>
<td>14</td>
</tr>
<tr>
<td>3. Hymanson, Inc.® Bodyblade</td>
<td>21</td>
</tr>
<tr>
<td>4. Varilite® air cushion</td>
<td>22</td>
</tr>
<tr>
<td>5. Sissel® Sitfit</td>
<td>23</td>
</tr>
<tr>
<td>6. Unilateral stance with Bodyblade®, shown on left without Varilite® air cushion and on right with Varilite® air cushion</td>
<td>25</td>
</tr>
<tr>
<td>7. Limits of stability performed forward and back with Bodyblade®</td>
<td>26</td>
</tr>
<tr>
<td>8. Limits of stability to the side on a stable surface shown on left, and unstable surface in diagonal direction shown on right, both with Bodyblade®</td>
<td>26</td>
</tr>
<tr>
<td>9. Tandem walk with Bodyblade®</td>
<td>27</td>
</tr>
</tbody>
</table>
### LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Unilateral stance intrarater reliability using ICCs</td>
<td>16</td>
</tr>
<tr>
<td>2. Unilateral stance interrater reliability using ICCs</td>
<td>17</td>
</tr>
<tr>
<td>3. Limits of stability interrater reliability using ICCs</td>
<td>17</td>
</tr>
<tr>
<td>4. ICC interpretations</td>
<td>18</td>
</tr>
<tr>
<td>5. Week one and two training program</td>
<td>24</td>
</tr>
<tr>
<td>6. Limits of stability descriptives for initial assessment</td>
<td>32</td>
</tr>
<tr>
<td>7. Unilateral stance descriptives for initial assessment</td>
<td>32</td>
</tr>
<tr>
<td>8. Male-vs-female descriptives for initial assessment: limits of stability</td>
<td>34</td>
</tr>
<tr>
<td>9. Male-vs-female descriptives for initial assessment: unilateral stance</td>
<td>34</td>
</tr>
<tr>
<td>10. Paired t-tests for LOS variables demonstrating significance: endpoint excursion (% LOS)</td>
<td>36</td>
</tr>
<tr>
<td>11. Paired t-tests for unilateral stance variables demonstrating significance: eyes open sway velocity (degrees/second)</td>
<td>36</td>
</tr>
<tr>
<td>12. One-way ANOVA for LOS variables demonstrating a significant difference in mean gain scores between groups: endpoint excursion (%LOS)</td>
<td>37</td>
</tr>
<tr>
<td>13. One-way ANOVA for unilateral stance variables demonstrating a significant difference in mean gain scores between groups: eyes open sway velocity (degrees/second)</td>
<td>38</td>
</tr>
</tbody>
</table>
ACKNOWLEDGMENTS

First of all, I would like to thank my family for all the support they have given me throughout my life, especially while pursuing my degree in physical therapy. In addition, I would like to thank the University of North Dakota Physical Therapy faculty, especially Meridee Danks, Renee Mabey, Tom Mohr, and Dave Relling. Without these people, this research project would not have been possible. I would especially like to acknowledge Meridee Danks for her guidance throughout this project and Renee Mabey for her long hours spent helping with the statistical analysis. Lastly, I would like to thank my research partners, Anna Burchill and Josh Woods, for contributing their hard work and dedication to this project. The road had a lot of hills and valleys, but with hard work and the support of many people, the destination has finally been reached. Thank you all.
ABSTRACT

Balance is a skill that is essential for most activities of daily living (ADL) including participation in any athletic activity, whether competitive or recreational. When assessing balance, it is very important to have normal balance baselines in order to serve as a guideline for comparison, especially when returning an athlete to competition. Additionally, given the importance of balance in athletics, it would seem important to determine if people with normal balance can improve their balance in order to enhance performance and decrease the risk of injury during sports.

The purpose of this study was to establish balance baselines on the Neurocom® Balance Master (NBM®) for relatively active young adults with normal balance and determine if these individuals could improve their balance with a five-week balance training program. The study consisted of 17 young adults who met the criteria established for “normal” including no history of injury or disease known to affect balance. All subjects were tested for unilateral stance and limits of stability (LOS) on the NBM® twice with a five-week interval between assessments. The study consisted of two balance training groups and one control group. Between assessments, one training group participated in traditional balance training exercises (N=7), while another group performed the same exercises utilizing the Bodyblade® (N=4) in order to challenge balance. The control group (N=6) was asked not to start any new strengthening or balance training exercises between assessments.
When compared to previous studies that developed normal balance baselines for young adults on the NBM®, subjects in this study showed a significantly greater sway velocity during unilateral stance with eyes open, while there was no significant difference in sway velocity during unilateral stance with eyes closed. The baselines established for LOS in this study demonstrated a significantly faster movement velocity backwards, but there was no significant difference between any of the other four components of LOS in any direction.

After training, the Bodyblade® training group improved significantly more than the control group in unilateral stance with eyes open, while the traditional balance training group improved significantly more than the Bodyblade® group in LOS endpoint excursion. After close examination, it was determined that these results could be misleading since the difference between groups appeared to come from one group getting significantly better and another group getting moderately, but not significantly, worse.
CHAPTER I
INTRODUCTION

Balance is the process of maintaining the center of gravity (COG) within the body's base of support (BOS).\textsuperscript{1-5} This process is a vital skill needed to carry out most activities of daily living (ADL) efficiently and independently without falling.\textsuperscript{6-9} Although balance is often assumed to be a simple task, it is really a "complex process involving sensory detection of body motions, integration of sensorimotor information within the central nervous system (CNS), and execution of appropriate musculoskeletal responses".\textsuperscript{2 (p5)}

Given the complexity, balance deficits can occur for a wide variety of reasons. In the older adult, balance difficulties often occur as a result of CNS problems (stroke, Parkinson's disease, etc.), vestibular disorders, or as a process of normal aging.\textsuperscript{10-12} In the young adult or adolescent, balance deficits are likely to occur as a result of athletic injury including head injuries, ankle sprains, and knee ligament injuries.\textsuperscript{1,5,13-15}

Balance has been called the most important aspect in determining effective movement strategies within the closed kinetic chain and is, therefore, essential for athletic performance.\textsuperscript{1} If an athlete does not have adequate movement strategies to maintain balance, a fall will result.\textsuperscript{13} In addition, inadequate balance can lead to poor athletic performance and an increased risk for injuries during sports.
In returning an athlete to competition following an injury, it is extremely important to assess balance and address any deficits to ensure a safe and successful return to the playing field.\textsuperscript{3-5} In the past, balance assessment has been mostly subjective and insensitive to subtle, yet significant, changes in balance, especially in athletes with normal balance or balance that is only slightly impaired due to injury.\textsuperscript{1,3-5} Many athletes could have balance impairments that could not be picked up with these relatively simple tests such as the Romberg test. With recent advancement in technology using sophisticated force plates such as the Balance Master (Neurocom\textsuperscript{®} International, Inc., Clackamas, OR) to measure the body's COG, balance assessment has become quantitative allowing for precise analysis of postural sway in patients with normal or only slightly impaired balance in addition to patients with obvious balance deficits.

Balance training programs to enhance balance skills have been very effective following lower extremity sports injuries.\textsuperscript{5,13,15,16} Given the fact that many athletes demonstrate extraordinary balance skills compared to the normal population, it would seem likely that the average person could improve balance above normal even without any balance deficit to improve.\textsuperscript{17-20} Improving balance above normal would lead to enhanced athletic performance and decreased risk of injury just like that which occurs with improved strength, flexibility, and endurance above normal.\textsuperscript{13}

Problem Statement

Although balance is extremely important for safety and performance during sports, little research has been done to establish normal balance baselines for comparison during assessment on the Neurocom\textsuperscript{®} Balance Master (NBM\textsuperscript{®}). Normal balance baselines would aid physical therapists and athletic trainers in determining when a patient
is ready to return to the playing field by comparing their patient with the normal values established. Additionally, although balance training and improvement has been well documented in patients with obvious balance deficits, there is a lack of research in regard to balance improvement in people with normal balance without a history of injury or disease known to affect balance. Athletes tend to focus on strength, flexibility, and endurance training to improve performance, but balance training tends to get neglected. Given the importance of balance for athletic performance, it would seem important to determine if people with normal balance can improve their balance in order to increase their athletic abilities and decrease their risk of injury.

Purpose/Research Questions

The purpose of this study is to establish balance baselines on the NBM® for relatively active young adults with normal balance and determine if these individuals can improve balance with a five-week balance training program. In reaching this purpose, this study will attempt to answer the following research questions:

1. Will balance baselines established on the NBM® in this study be consisted with the limited previous studies available on normal young adults?
2. Will the balance baselines established on the NBM® in this study show a significant difference between males and females?
3. Can individuals with normal balance, without a history of injury or disease known to affect balance, show significant improvement in balance following a five-week balance training program?
4. Will the two balance training programs used in this study show differing outcomes in regard to balance improvement?
Hypothesis

It is hypothesized that the normal balance baselines established on the NBM® in this study will be consistent with that of limited previous research on normal young adults, and that there will be no significant difference between males and females. Additionally, it is believed that both balance training groups will show a significant improvement in balance after a five-week balance training program, while the control group will not demonstrate any improvement. Lastly, it is expected that the balance training group utilizing the Bodyblade® (Hymanson®, Inc., Los Angeles, CA) will demonstrate greater improvement compared to the traditional balance training group.

Significance

The results of this study will aid physical therapists and athletic trainers by establishing balance baselines for subjects with normal balance, which will help them determine when an injured athlete is ready to return to athletics. Additionally, these results will help athletes and athletic trainers by providing research on whether young adults with normal balance can increase balance. Athletic trainers and athletes may be able to use these results to help form a well rounded training program including strength, flexibility, endurance, and balance training, which will improve performance and decrease the risk of injury. Lastly, this study will hopefully help stimulate research on different balance programs that may improve athletic performance and decrease the risk of injury during sports.
CHAPTER II
LITERATURE REVIEW

There are many different viewpoints about how the process of maintaining balance is exactly accomplished, but the general consensus is that the CNS controls balance by receiving information from three sensory systems including visual, somatosensory (proprioceptive), and vestibular.\textsuperscript{1,2,10,21,22} The CNS then has the difficult task of interpreting and integrating this information on balance and informing the musculoskeletal system of the appropriate response to maintain balance. In addition to the job of interpreting a wealth of information provided by these three sensory systems, the CNS must also decide which information is correct when presented with conflicting information from the sensory systems. This process is called sensory organization.

The CNS generally relies on only one sensory system at a time.\textsuperscript{1,2,21} In most people, the CNS relies on the visual system for information most of the time.\textsuperscript{18} The visual system supplies information regarding the position and motion of the head in relation to surrounding objects.\textsuperscript{1,2,21} Vision also provides an environmental vertical reference for maintaining balance. Although most people rely on this system, it is not the preferred method of maintaining balance since vision does not always provide accurate information, especially when the body is in motion.\textsuperscript{1,21}

The preferred method of maintaining balance is the somatosensory system.\textsuperscript{1} This is the system that is utilized by most athletes.\textsuperscript{18} The somatosensory system provides
information regarding the position and motion of the body in space with reference to supporting structures or the rest of the body.\textsuperscript{1,2,21} This information is obtained mainly by joint and muscle proprioceptors in addition to other cutaneous and pressure receptors throughout the body.

When sudden perturbations are induced to challenge balance, the vestibular system must take over the task of providing information to the CNS.\textsuperscript{1,2,21} These perturbations include obstructing the visual system, moving the base of support on which the subject is standing, or displacing the COG. All of these perturbations cause the visual and somatosensory systems to give inaccurate information to the CNS, thus the information from these systems is ignored. The vestibular system provides information regarding the position and movement of the head in relation to gravity. Although the vestibular system cannot act on its own, it is particularly effective in responding to perturbations in COG.

In responding to perturbations or just moving the COG to the limits of stability (LOS), a person can respond with several different postural strategies to help maintain balance.\textsuperscript{1,2,10,21,23} The main three strategies to move the COG include the ankle, hip, and stepping strategies. Other strategies might include bending the back or knees or even extending the arms. The ankle strategy produces large, slow movements in the COG, and is effective in adjusting the COG when encountered with small disturbances within the LOS. If the ankle strategy is not capable of maintaining the COG within the BOS, the hip strategy is initiated. The hip strategy produces small, rapid movements in the COG, and is effective when responding to a faster or stronger disturbances at the LOS.
Lastly, the stepping strategy is used when the COG is displaced beyond the LOS in order to regain balance.

**Static Balance**

Static balance refers to the ability to maintain the center of gravity over a fixed base of support while standing on a stable surface.\(^1,^3\) In assessing static balance, static steadiness is usually the main consideration. Static steadiness is the ability to keep the body as motionless as possible. There are many assessments to measure static balance, but perhaps the most common method of assessment is single leg stance, especially in an athletic population. Frandin et al\(^2^4\) reported that unilateral stance ability was significantly correlated to isometric knee extensor strength, walking speed, and stair climbing capacity. Studies have also shown that unilateral stance ability decreases with musculoskeletal injury such as an ankle or ACL sprain.\(^1^5,^2^5\)

**Dynamic Balance**

While most researchers agree on the definition of static balance, there are varying definitions of dynamic balance in literature.\(^1,^3\) In the past, dynamic balance referred to the ability to maintain the COG within the LOS with a moving BOS (locomotion). With the development of force plate technology, dynamic balance has been reclassified to include using an unstable surface, transferring the COG around a stationary supporting base such as with the LOS test, or even obstructing vision while trying to maintain balance.

Since the development of force plate assessment systems, one common measure of dynamic stability has been LOS.\(^1,^3,^2^3,^2^6-^2^8\) Limits of stability is defined as the
maximum angle at which a person can lean from vertical without a loss of balance or stepping.\textsuperscript{2,10} In normal adults, the angle is approximately 12 degrees anteroposterior and 16 degrees side to side.\textsuperscript{2} Dettman et al\textsuperscript{29} found that LOS ability is significantly correlated with walking ability, since a person tends to reach the LOS in several directions during various phases of gait. Limits of stability has also shown to be significantly correlated to ADL performance and moderately correlated to the Berg balance scale.\textsuperscript{30,31}

**Balance Assessment**

In the past, balance assessment has been mostly subjective and insensitive to subtle, yet significant, changes in balance.\textsuperscript{1,3-5} Some of these traditional assessments including the Romberg, single leg stance, or functional agility tests. Although tests such as the Romberg may show gross balance deficits, the tests cannot show the degree to which balance is affected by an injury. With the recent development in technology, the use of sophisticated force plates such as the NBM® has made balance assessment quantitative allowing for the precise analysis of postural sway. These quantitative values can help to determine the degree to which balance is affected by an injury.

Other computerized balance assessment systems such as the Biodex, the Breg K.A.T. 2000, or the Cybex Fastex all measure the movement occurring beneath the subject's feet in order to determine stability.\textsuperscript{4} They do not measure COG, and thus are not true assessments of balance. Unlike these other assessments, the NBM® uses height and weight in it's calculations to determine COG, which is the basis for the definition of balance. This allows for a true representation of balance. In addition, the NBM® can be used for a wide variety of patients including orthopedic, geriatric, and neurological.
There are a wide variety of balance training programs that are used to enhance balance.\textsuperscript{1,7,9,13,32,33} There is also a wide variation on the length of balance training programs. Effective programs in literature have ranged from one week to sixteen weeks with the average being around five to six weeks. Although there is this wide variety, there is always one similarity between balance training programs. They all work under the premise of moving the subject's COG within the BOS or to the LOS in order to challenge balance. Studies on balance training have not shown a significant preference for one training technique over another. Most balance training studies use an eclectic approach, so it is difficult to determine the effect of certain components of the training program.\textsuperscript{9} Common balance training exercises that have been effective include wobble board exercises, unilateral stance exercises, weight shifting exercises (LOS), and tai chi exercises.\textsuperscript{1,7,9,13,32,33}

Very little research is available that shows people with normal balance can improve above normal with a balance training program. One study conducted by France et al\textsuperscript{34} did determine that healthy, uninjured individuals could improve balance with a six-week balance training program. This study, however, was very small and did not mention the subjects' ages, which could be very important since many older adults demonstrate balance deficits simply due to the process of aging.\textsuperscript{1,12} Although there are a lack of studies in this area, there have been several studies that have shown that athletes demonstrate significantly better balance than the normal population, thus leading most
researchers to the conclusion that people can improve balance above normal whether with a balance training program or simply practicing a sport that challenges balance.¹⁷-²⁰
CHAPTER III

METHODOLOGY

Prior to the start of this study, approval for the use of human subjects was obtained from the University of North Dakota and Altru Health Systems' Institutional Review Boards. A copy of the Human Subjects Review Form and the approval letters from both UND and Altru Health Systems are located in Appendix A. During recruitment of subjects, all individuals were informed that their participation in this study was strictly voluntary. The components of the study were explained to those interested in participating, with each subject giving their informed consent. A copy of this consent form is located in Appendix B. To identify possible safety or health concerns, a health background questionnaire was given to each individual before inclusion. This questionnaire obtained information that could have an affect on balance: medications, current/past medical diagnoses, symptoms associated with balance disorders, visual acuity, and exercise level. A copy of this questionnaire is located in Appendix C for further reference.

Subjects

In order to test the hypotheses associated with this study, 36 subjects (8 males, 28 females) within the age range of 20-34 years were recruited from a physical therapy class within the University of North Dakota student population. It was determined that no subjects would be excluded from partaking in this study unless the health questionnaire
identified a safety or health concern that would possibly put them at risk for injury. The researchers determined that all 36 applicants were considered "safe" in addition to meeting the predetermined criteria for all testing/training procedures. A summary of the criteria that each applicant met for inclusion into this study was as follows:

1. An understanding that inclusion is strictly voluntary
2. A verbal understanding and signed agreement to all terms and conditions presented by the consent form
3. Considered "safe" for testing/training procedures as determined by the researchers
4. Age within the range of 20-39 years
5. Able to attend all training/assessment sessions.

Once all components of the above criteria were met, the 36 subjects were randomly assigned to one of three groups. Group 0 (N=12) served as a control and was asked not to start any new strengthening or balance activities during the five weeks between assessments. Group 1 (N=12) and Group 2 (N=12) served as experimental groups and participated in separate five-week balance training programs. Group 1 participated in a traditional balance training (TBT) program, while Group 2 participated in the same balance training program utilizing the Bodyblade® (BBT). Initially, each group was comprised of twelve individuals, however it was necessary to release one female from the TBT group during week four of training due to an injury requiring surgical intervention. It should be noted that this injury was not related to any procedures involved with this study.
Instrumentation

The NBM® was used to assess unilateral stance and LOS. Unilateral stance measures COG sway velocity in degrees per second. This was assessed on each leg with eyes open (EO) and eyes closed (EC). Limits of stability measures five components of balance: reaction time (RT), movement velocity (MV), endpoint excursion (EE), maximal excursion (ME), and directional control (DC). This test requires the subject to lean as far as possible in eight directions, one trial each, without losing their balance or stepping. See Figure 1 for a picture of the eight directions associated with LOS. A detailed description of both tests and their components is located in Appendix D or the NBM® Operator’s Manual.35

Figure 1. Eight directions of limits of stability
The NBM® is a clinically acceptable machine commonly used in physical therapy to assess balance in all types of individuals.\textsuperscript{36} It consists of two 9"x60" forceplates on which the subject stands to measure the force under each foot.\textsuperscript{35} These forceplates rest on four load cells and communicate with a computerized system integrated with a software program that interprets various data obtained during a balance assessment. This data is quantitative and allows the researcher or therapist to measure balance in an objective manner. Furthermore, this instrument is unique due to its ability to provide continuous visual feedback via a computer screen to the subject and researcher regarding the location of the subject's COG. See Figure 2 for a picture of the NBM®.

\textbf{Figure 2.} Neurocom® Balance Master version 6.1
Validity

As discussed previously, the NBM® is a clinically valid machine commonly used in physical therapy.\textsuperscript{36} Limits of stability has been shown to be significantly correlated with walking and ADL performance, along with a modest correlation to the Berg Balance Scale.\textsuperscript{29-31} Unilateral stance has shown a significant correlation with knee extensor strength, walking speed, and stair climbing capacity, along with a modest correlation to ADL performance.\textsuperscript{24}

Reliability

Many researchers have studied the reliability of the NBM®, specifically the LOS test. All published and unpublished research has shown that the LOS test has good to excellent reliability in a wide variety of patients.\textsuperscript{26-28,35-37} On the other hand, published studies on the reliability of the unilateral stance test were not found. The appendix of the NBM® does have a unpublished reliability study on unilateral stance which showed moderate reliability.\textsuperscript{35}

After the researchers in this study received instruction and significant practice on the NBM®, a pilot study was performed in order to establish intrarater (test-retest) and interrater (between testers) reliability for the three raters in this study. Ten subjects ranging from 18 to 24 years old were assessed on unilateral stance and LOS in the same manner as described in assessment procedures, including the amount of practice and rest each individual was given. Although no testing script was used in the pilot study, the NBM® Operator’s Manual was followed, and all three testers were present during the assessment of the subjects. In order to establish interrater reliability, each subject completed both tests for each of the three testers. To establish intrarater reliability, the
same procedure was followed a second time, approximately one to two weeks later. The
order that the testers assessed each subject remained the same as the first assessment.
One subject was released from the pilot study due to lack of effort during the second
assessment, leaving a total of nine subjects. The SPSS Version 6.01 (SPSS, Inc.,
Chicago, IL) was used to calculate interrater and intrarater reliability.

Intrarater Reliability

Intraclass correlation coefficients (ICC) were calculated from a repeated measures
analysis of variance (ANOVA) in order to assess test-retest reliability for each rater,
testing the subject on different days. The ICC formula (3,k) was used, as suggested for
intrarater reliability.\textsuperscript{38} Since there was a lack of variance or no significant difference
between many of the subjects’ scores, ICCs could not be calculated on many of the tests
because the ICC would not be considered valid.

Intrarater reliability ICCs could not be calculated for RT, EE, ME, and DC
composite components of the LOS test due to the lack of variance between the subjects’
scores. Limits of stability MV composite yielded an ICC value of .75 for Rater 1 and .90
for Rater 2, while an ICC value for Rater 3 could not be calculated due to the variance
issue. Intraclass correlation coefficients for the unilateral stance test could be calculated
for all conditions except EO COG sway velocity composite for Rater 1 and Rater 3. The
rest of the intrarater reliability results for unilateral stance are reported in Table 1.

Table 1. Unilateral stance intrarater reliability using ICCs

<table>
<thead>
<tr>
<th>Variable</th>
<th>Rater 1</th>
<th>Rater 2</th>
<th>Rater 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>EO COG Sway Velocity Composite</td>
<td>X</td>
<td>.73</td>
<td>X</td>
</tr>
<tr>
<td>EC COG Sway Velocity Composite</td>
<td>.82</td>
<td>.82</td>
<td>.87</td>
</tr>
<tr>
<td>EO and EC COG Sway Velocity Composite</td>
<td>.84</td>
<td>.75</td>
<td>.83</td>
</tr>
</tbody>
</table>

KEY: X = ICC could not be calculated due to lack of variance between subjects’ scores
Interrater Reliability

Intraclass correlation coefficients were calculated from a repeated measures ANOVA to determine interrater reliability. The ICC formula (2,k) was used, as suggested for interrater reliability. A significant difference in variance between subjects' scores was found, and all ICCs could be reported. Interrater reliability results from both initial and final assessments are reported in Table 2 and Table 3.

Table 2. Unilateral stance interrater reliability using ICCs

<table>
<thead>
<tr>
<th>Variable</th>
<th>1st Assessment</th>
<th>2nd Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>EO COG Sway Velocity Composite</td>
<td>.90</td>
<td>.85</td>
</tr>
<tr>
<td>EC COG Sway Velocity Composite</td>
<td>.95</td>
<td>.88</td>
</tr>
<tr>
<td>EO and EC COG Sway Velocity Composite</td>
<td>.95</td>
<td>.93</td>
</tr>
</tbody>
</table>

Table 3. Limits of stability interrater reliability using ICCs

<table>
<thead>
<tr>
<th>Variable</th>
<th>1st Assessment</th>
<th>2nd Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT Composite</td>
<td>.87*</td>
<td>.88*</td>
</tr>
<tr>
<td>MV Composite</td>
<td>.91</td>
<td>.91</td>
</tr>
<tr>
<td>EE Composite</td>
<td>.85</td>
<td>.92</td>
</tr>
<tr>
<td>ME Composite</td>
<td>.75**</td>
<td>.88</td>
</tr>
<tr>
<td>DC Composite</td>
<td>.72</td>
<td>.76</td>
</tr>
</tbody>
</table>

KEY: *Skewed and Kurtosed distribution ** Kurtosed distribution

ICC Interpretation

There are no standard values set for acceptable reliability when calculating the ICC. Values range between 0.00 and 1.00, with numbers falling closer to 1.00 representing stronger reliability scores. Table 4 describes two common ICC interpretations found in literature. Using the ICC Interpretation A shown in Table 4, the ICC values that were able to be calculated for both unilateral stance and LOS showed
high intrarater reliability, while values obtained for interrater reliability showed high to very high reliability.

**Table 4. ICC interpretations**

<table>
<thead>
<tr>
<th>ICC Value</th>
<th>Interpretation A&lt;sup&gt;39-40&lt;/sup&gt;</th>
<th>Interpretation B&lt;sup&gt;38&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>.90-1.00</td>
<td>Very High</td>
<td>Clinically Valid</td>
</tr>
<tr>
<td>.70-.89</td>
<td>High</td>
<td>Good</td>
</tr>
<tr>
<td>.50-.69</td>
<td>Moderate</td>
<td>Poor to Moderate</td>
</tr>
<tr>
<td>.26-.49</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>0.00-.25</td>
<td>Little, If Any</td>
<td></td>
</tr>
</tbody>
</table>

**Assessment Procedure**

Subjects reported to Altru Health Institute Outpatient Physical Therapy Department for assessment on the NBM®. Prior to testing, each individual was randomly assigned to a tester, and an identification number, date of birth, and self-reported height were entered into the subject’s file. All individuals were subject to testing procedures measuring both static and dynamic components of balance. Unilateral stance was used to measure static steadiness, while LOS was used to measure dynamic balance. Both tests required the subject to be either barefoot or wearing socks, based on their preference. This was recorded so identical conditions could be duplicated for the second assessment. All tests were administered at the subject’s pace in order to provide adequate rest between trials. The following is a summary of the procedures used for each test. Refer to the NBM® Operator’s Manual for further reference.<sup>35</sup>
General Assessment Set-up

To ensure reliability, a general set of guidelines were used for all testing procedures. First of all, subjects' feet were positioned on the NBM® forceplates using the recommended foot placement. They were allowed to toe in or out with their feet to a comfortable position. The subject was then instructed in proper procedures for completion of the test. To ensure that consistency was achieved between testers, a script was composed to address all commands given throughout the assessment. This script is located in Appendix E for further reference.

After receiving proper instruction, each subject was given adequate practice to ensure that improvement would not come from a learning curve. Clark et al noted significant differences in scores on the NBM® LOS test from assessment one to assessment two but no difference between assessment two, three, and four. Other studies on force platforms have also shown that there is a significant improvement from trial one to trial two, but no improvement from trial two to trial three. Additionally, the studies also found that greater learning curve improvement occurs on dynamic tests than static tests. Because of these findings, subjects were given one trial to practice unilateral stance (static test) and two trials to practice LOS (dynamic test). Once the practice sessions for both unilateral stance and LOS were completed, the individuals were notified that further performance of the tests would be recorded for analysis by the researchers.

Unilateral Stance Test

For testing of unilateral stance, each subject was given one trial in which to practice for each of the four conditions: eyes open left (EOL), eyes closed left (ECL), eyes open right (EOR), and eyes closed right (ECR). This was done secondary to the
high learning curve described above. After practice, the test was performed in the same fashion as the practice session except that three trials were completed for each condition. A spotter was provided for subject safety and tallied unsuccessful attempts at completing the trial. If a subject was unable to complete one trial six consecutive times, the researchers determined that this would be recorded as “unable to perform” and proceeded to the next condition.

**Limits of Stability Test**

For testing LOS, subjects performed the test in all eight directions two times during the practice session to increase their familiarity with the test. The test was then performed in a manner consistent with the two practice sessions. During movement for each of the eight directions of LOS, a spotter was present to prevent falls. The subject was allowed to repeat that particular trial/direction if they lost their balance and took a step.

**Second Assessment**

Six weeks following the initial assessment, the subjects were again tested on the NBM®. The same testing conditions were used, including tester and whether the subject was barefoot or wearing socks. The subject was again required to fill out a health background questionnaire in order to identify any changes that may have occurred over the course of the study.

**Training Equipment**

A variety of training equipment was used during the training sessions to challenge the subjects’ balance. The Bodyblade® was used by the BBT group throughout the training. This piece of equipment is used frequently in physical therapy to increase body
awareness, joint mobility, flexibility, and strength.\textsuperscript{41} Bodyblade® Model 400 is a four-foot long by 1.75 inch wide rod composed of graphite weighing 1.5 pounds while the Pro Model is five feet long by two inches wide weighing 2.25 pounds, thus providing more resistance and a greater challenge. The Bodyblade® oscillates as it is held in the middle and a force is applied by the person using it. The oscillations of the Bodyblade® require a stabilizing force by the subject, which can be utilized during both static and dynamic activities to challenge balance. For this study, females in the BBT group used the Model 400 while males in the BBT group used the Pro Model. See Figure 3 for a picture of Bodyblade® Model 400.

\textbf{Figure 3.} Hymanson, Inc.® Bodyblade
The Varilite® air cushion (Cascade Designs, Inc. Seattle, WA) was used during weeks three through five of training to create a less stable surface on which to perform unilateral stance activities, creating a greater level of difficulty for the subjects. See Figure 4.
The Sissel® SitFit (JELA, Bad Durkheim, Germany) is similar to a Swiss ball except that it is in the shape of a disc. This was used during weeks four through five of training to create a less stable surface on which the subjects stood while moving in the eight directions associated with the LOS. See Figure 5.

![Figure 5. Sissel® SitFit](image)

Training Procedure and Progression

The TBT and BBT groups both participated in a five-week balance training program that met for 30 minute sessions two times per week. The BBT group participated in all of the activities while using the Bodyblade® while the TBT group
performed the same activities but without the Bodyblade®. A summary of the activities performed during week one and two of training is provided in Table 5.

**Table 5.** Week one and two training program.

<table>
<thead>
<tr>
<th><strong>Unilateral Stance (firm surface)</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Eyes open Left**</td>
<td>20 sec x 3 reps</td>
</tr>
<tr>
<td>2. Eyes closed Left**</td>
<td>20 sec x 3 reps</td>
</tr>
<tr>
<td>3. Eyes open Right***</td>
<td>20 sec x 3 reps</td>
</tr>
<tr>
<td>4. Eyes closed Right***</td>
<td>20 sec x 3 reps</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Limits of Stability (firm surface)</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. LOS- Forward*</td>
<td>5 sec hold x 3 reps</td>
</tr>
<tr>
<td>2. LOS- Diagonal forward and right*</td>
<td>5 sec hold x 3 reps</td>
</tr>
<tr>
<td>3. LOS- Right**</td>
<td>5 sec hold x 3 reps</td>
</tr>
<tr>
<td>4. LOS- Diagonal back and right*</td>
<td>5 sec hold x 3 reps</td>
</tr>
<tr>
<td>5. LOS- Back*</td>
<td>5 sec hold x 3 reps</td>
</tr>
<tr>
<td>6. LOS- Diagonal back and left*</td>
<td>5 sec hold x 3 reps</td>
</tr>
<tr>
<td>7. LOS- Left***</td>
<td>5 sec hold x 3 reps</td>
</tr>
<tr>
<td>8. LOS- Diagonal forward and left*</td>
<td>5 sec hold x 3 reps</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Miscellaneous (firm surface)</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tiptoes*</td>
<td>(3 sets) 5 sec hold x 3 reps</td>
</tr>
<tr>
<td>2. Heels*</td>
<td>(3 sets) 5 sec hold x 3 reps</td>
</tr>
<tr>
<td>3. Tandem Walk*</td>
<td>30 ft x 3 reps</td>
</tr>
</tbody>
</table>

*Bodyblade® held in front, with anterior/posterior force applied  
**Bodyblade® held on the right  
***Bodyblade® held on the left

**Unilateral Stance Training Procedure**

Subjects stood on one leg at a time with hands on their hips and either EO or EC. The BBT group performed the same activity, however the Bodyblade® was incorporated. It was held vertically in the upper extremity that was contralateral to the lower extremity on which the subject was standing. The hand not holding the Bodyblade® was placed on the hip. An oscillatory force was applied to the Bodyblade® in the frontal plane. See Figure 6.
Figure 6. Unilateral stance with Bodyblade®, shown on left without Varilite® air cushion and on right with Varilite® air cushion.

Limits of Stability Training Procedure

The subjects stood with their feet approximately shoulder width apart. As in the testing procedure, the subject shifted their weight in one of eight directions: forward, forward-right, right, back-right, back, back-left, left, and forward-left. See Figure 1. During these weight shifts, the subject was asked to lean as far as possible without losing their balance or removing one foot entirely from the weight-bearing surface. The BBT group performed this activity while holding the Bodyblade® with bilateral upper extremities in a horizontal position, applying an oscillatory force parallel to the direction they were leaning. See Figure 7 and Figure 8.
Figure 7. Limits of stability performed forward and back with Bodyblade®

Figure 8. Limits of stability to the side on a stable surface shown on left, and unstable surface in diagonal direction shown on right, both with the Bodyblade®
Miscellaneous Training Procedures

A variety of other balance training activities were incorporated into the program to help increase overall balance skills. These activities included standing on tiptoes/heels and tandem walking. During the tiptoe activity, the subject plantarflexed up to a tiptoe position and held for five seconds. During the heels activity, the subject dorsiflexed and shifted all weight to their heels, once again holding this position for five seconds. The BBT group performed these activities in a similar fashion with the addition of the Bodyblade® being held in bilateral upper extremities, with an oscillatory force applied in the sagittal plane. This force was applied throughout the entire motion including the five seconds in the tiptoe or heel position.

During tandem walking, subjects walked in a heel to toe fashion for a distance of 30 feet. The TBT group performed this activity with hands on hips. The BBT group performed the activity while holding the Bodyblade® in a vertical position with bilateral upper extremities and applying an oscillatory force in the frontal plane. See Figure 9.

Figure 9. Tandem walk with Bodyblade®
Training Progression

During week three of training, activities were the same for both the TBT and BBT groups with the exception of the following differences:

1. Subjects performed unilateral stance activities while on the Varilite® air cushion
2. Limits of stability activities were performed while subjects stood in a tandem position
3. Tandem walking was eliminated from the program.

Week four and five activities were the same as those performed during week three with the exception of LOS, which was performed with subjects standing on the Sissel® SitFit with feet together.

Data Analysis

The SPSS Version 6.01 with an alpha level of .05 was used throughout all statistical analysis. First of all, descriptive statistics for both the first and second assessments were run in order to establish norms such as means, standard deviations, medians, ranges, skewness, and kurtosis. These descriptive statistics were also run according to group (0, 1, 2) and sex (male, female). Gain scores between the first and second assessments were then calculated. Next, paired samples t-tests were run for each group to identify any significant improvements between the first and second assessment. From there, an one-way ANOVA design with post hoc analysis of the gain scores was used to determine if there was a significant difference in improvement between groups. The dependant variable was the subjects’ score. The independent variable was the group assignment (0, 1, 2). The assessment time (first, second) could have also been an
independent variable, but this was eliminated by using gain scores rather than scores from both the first and second assessment. Lastly, it was determined that the one-way ANOVA was indeed appropriate by checking for a normal distribution through skewness/kurtosis descriptives and homogeneity of variance through Levine’s test.

Reporting of Results

Upon completion of this study, a copy of the results of this independent study were given to Altru Health Institute and the University of North Dakota Department of Physical Therapy. This study was completed to fulfill the requirements for the University of North Dakota School of Medicine and Health Sciences Physical Therapy Program.
CHAPTER IV
RESULTS/DISCUSSION

This study was divided into three separate studies for the purpose of data analysis. In order to see additional results from this study, please refer to *The Effect of a Five Week Balance Training Program on Individuals with Previous Ankle Sprains* by Burchill\(^42\) and/or *The Effect of Balance Training in Healthy Subjects as Assessed by the Neurocom® Balance Master* by Woods.\(^43\) In order to answer the research questions regarding “normals” in this study, it was first necessary to define “normals”. According to a study published in the NBM® Operator’s Manual, “normals” are defined as clinically asymptomatic subjects who meet the following criteria:\(^35\)

1. No current or past medical diagnosis or injury affecting balance
2. No medications affecting the CNS or known to affect balance/coordination
3. No symptoms of dizziness or lightheadedness
4. No symptoms suggestive of vestibular or neurologic disorders
5. No psychological disorders including depression
6. No history of two or more unexplained falls within the past six months
7. Normal vision with or without glasses.

After releasing subjects who did not meet the criteria for “normal”, there were 17 subjects left for data analysis from the original 36 subjects that were recruited. The
subject population consisted of five males and twelve females. The control group consisted of six subjects, while the TBT group had seven subjects, and the BBT group was left with four subjects.

Descriptive Statistics

Descriptive statistics including mean, standard deviation, median, range, skewness, and kurtosis were calculated for the 17 “normal” subjects during the initial assessment. The results are displayed in Table 6 and Table 7 for reference. These results were then compared to the study published in the NBM® Operator’s Manual, which also established baselines for young adults. In answer to research question #1, all means were within a standard deviation with a few exceptions. The NBM® study unilateral stance with EO had a mean sway velocity of .70 degrees/second for both right and left which was significantly lower (better) than 1.18 degrees/second found in this study. As a result of this discrepancy, the composite values for unilateral stance (EO and EO/EC) were both significantly different. The only other value that was not within a standard deviation was LOS MV backwards. The NBM® study had a mean of 2.7 degrees/second while the subjects in this study were much faster with a mean of 4.0 degrees/second. With these exceptions, there seems to be no significant difference between these two studies in regard to the normal balance baselines established for young adults. There was no significant difference in baselines for unilateral stance with eyes closed or any of the other four components of LOS in any direction.

It should be noted that several subjects (N=3) were not able to complete the unilateral stance test with EC. If a subject could not perform a ten second trial six consecutive times, it was recorded as “unable to perform”.

31
### Table 6. Limits of stability descriptives for initial assessment

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT: Forward*</td>
<td>17</td>
<td>.53</td>
<td>.17</td>
<td>.47</td>
<td>.34-.90</td>
</tr>
<tr>
<td>RT: Back</td>
<td>17</td>
<td>.41</td>
<td>.17</td>
<td>.38</td>
<td>.14-.75</td>
</tr>
<tr>
<td>RT: Right*</td>
<td>17</td>
<td>.56</td>
<td>.17</td>
<td>.51</td>
<td>.37-.93</td>
</tr>
<tr>
<td>RT: Left*</td>
<td>17</td>
<td>.59</td>
<td>.17</td>
<td>.51</td>
<td>.42-1.00</td>
</tr>
<tr>
<td>RT: Composite*</td>
<td>17</td>
<td>.52</td>
<td>.15</td>
<td>.48</td>
<td>.36-.85</td>
</tr>
<tr>
<td>MV: Forward</td>
<td>17</td>
<td>8.1</td>
<td>2.4</td>
<td>8.3</td>
<td>4.6-12.1</td>
</tr>
<tr>
<td>MV: Back</td>
<td>17</td>
<td>4.0</td>
<td>1.3</td>
<td>3.7</td>
<td>1.4-6.4</td>
</tr>
<tr>
<td>MV: Right</td>
<td>17</td>
<td>8.1</td>
<td>2.6</td>
<td>8.1</td>
<td>4.2-11.7</td>
</tr>
<tr>
<td>MV: Left</td>
<td>17</td>
<td>9.9</td>
<td>2.9</td>
<td>9.8</td>
<td>4.9-14.4</td>
</tr>
<tr>
<td>MV: Composite</td>
<td>17</td>
<td>7.5</td>
<td>2.0</td>
<td>7.4</td>
<td>3.9-10.4</td>
</tr>
<tr>
<td>EE: Forward</td>
<td>17</td>
<td>99.9</td>
<td>15.1</td>
<td>102</td>
<td>72-118</td>
</tr>
<tr>
<td>EE: Back</td>
<td>17</td>
<td>54.5</td>
<td>16.6</td>
<td>59</td>
<td>24-79</td>
</tr>
<tr>
<td>EE: Right</td>
<td>17</td>
<td>86.5</td>
<td>11.2</td>
<td>92</td>
<td>67-102</td>
</tr>
<tr>
<td>EE: Left</td>
<td>17</td>
<td>105.2</td>
<td>9.5</td>
<td>103</td>
<td>87-125</td>
</tr>
<tr>
<td>EE: Composite</td>
<td>17</td>
<td>86.7</td>
<td>7.6</td>
<td>87</td>
<td>73-99</td>
</tr>
<tr>
<td>ME: Forward</td>
<td>17</td>
<td>107.7</td>
<td>11.6</td>
<td>111</td>
<td>80-127</td>
</tr>
<tr>
<td>ME: Back</td>
<td>17</td>
<td>67.1</td>
<td>17.6</td>
<td>68</td>
<td>31-96</td>
</tr>
<tr>
<td>ME: Right</td>
<td>17</td>
<td>101.8</td>
<td>8.9</td>
<td>103</td>
<td>88-118</td>
</tr>
<tr>
<td>ME: Left**</td>
<td>17</td>
<td>112.5</td>
<td>8.5</td>
<td>112</td>
<td>103-135</td>
</tr>
<tr>
<td>ME: Composite**</td>
<td>17</td>
<td>97.3</td>
<td>4.4</td>
<td>98</td>
<td>85-105</td>
</tr>
<tr>
<td>DC: Forward</td>
<td>17</td>
<td>86.4</td>
<td>7.7</td>
<td>88</td>
<td>66-98</td>
</tr>
<tr>
<td>DC: Back</td>
<td>17</td>
<td>49.4</td>
<td>18.3</td>
<td>51</td>
<td>9-75</td>
</tr>
<tr>
<td>DC: Right</td>
<td>17</td>
<td>75.2</td>
<td>9.9</td>
<td>76</td>
<td>49-91</td>
</tr>
<tr>
<td>DC: Left</td>
<td>17</td>
<td>83.1</td>
<td>7.3</td>
<td>83</td>
<td>65-92</td>
</tr>
<tr>
<td>DC: Composite</td>
<td>17</td>
<td>73.5</td>
<td>7.5</td>
<td>75</td>
<td>59-84</td>
</tr>
</tbody>
</table>

Key: *Skewed distribution  **Skewed & kurtosed distribution

### Table 7. Unilateral stance descriptives for initial assessment

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>EOL</td>
<td>17</td>
<td>1.18</td>
<td>.14</td>
<td>1.20</td>
<td>.90-1.40</td>
</tr>
<tr>
<td>EOR</td>
<td>17</td>
<td>1.18</td>
<td>.12</td>
<td>1.20</td>
<td>1.00-1.40</td>
</tr>
<tr>
<td>EO: Composite</td>
<td>17</td>
<td>1.18</td>
<td>.12</td>
<td>1.20</td>
<td>.95-1.40</td>
</tr>
<tr>
<td>ECL</td>
<td>16</td>
<td>2.13</td>
<td>.31</td>
<td>2.15</td>
<td>1.70-2.90</td>
</tr>
<tr>
<td>ECR</td>
<td>14</td>
<td>2.07</td>
<td>.30</td>
<td>2.10</td>
<td>1.70-2.70</td>
</tr>
<tr>
<td>EC: Composite</td>
<td>14</td>
<td>2.08</td>
<td>.22</td>
<td>2.05</td>
<td>1.70-2.50</td>
</tr>
<tr>
<td>EO and EC: Composite</td>
<td>14</td>
<td>1.62</td>
<td>.16</td>
<td>1.61</td>
<td>1.33-1.90</td>
</tr>
</tbody>
</table>
**Age**

One major difference between the two studies was that the NBM® study had 74 subjects within the age range of 20-39, while this study had 17 subjects within the age range of 20-28 (Mean=22.7). It was thought that a younger age range would do significantly better, but this was obviously not the case. The older age range did much better on unilateral stance with EO. The only test that the younger age range did better on was LOS MV backwards. With these exceptions, there seems to be no significant difference in regard to balance between these two age ranges.

The fact that these different age ranges did not appear to have much of an affect on balance is consistent with that found in other literature. The NBM® study grouped subjects within the age range of 20-39 because there was no significant differences found within this age range.\(^{35}\) Additionally, in examining the normal baselines established in the NBM® study, there also seems to be no significant difference in any of the components of unilateral stance or LOS between groups 20-39 years and 40-59 years. Colledge et al\(^{44}\) also found no significant difference in balance skills between groups 20-39 years and 40-59 years. Elliot et al\(^{45}\) found no significant difference in balance skills between groups 15-29 years and 30-64 years.

Although there seems to be no significant difference in balance skills between adults of different ages, the elderly and children under age 15 both have decreased balance skills in comparison.\(^{12,35,46-50}\) In examining the normal baselines established in the NBM® study, there seems to be a significant difference in unilateral stance and most components of LOS between groups 20-39 years and 70-79 years, with the younger group doing much better than the older group.\(^{35}\) Maki et al\(^{11}\) and Hageman et al\(^{12}\) both
conducted studies in agreement with this fact that younger adults have significantly better balance than the elderly.

**Gender**

The only other difference between the two studies was that the NBM® study had a higher percentage of males in their study. The NBM® study had 31 males and 43 females (42% males), while this study had only five males and twelve females (29% males). To investigate the difference between males and females in regard to performance, descriptive statistics were calculated for males and females during the initial assessment. See Table 8 and Table 9 for reference. In answer to **research question #2**, all baseline values were within a standard deviation between males and females except for LOS RT and MV. The females in this study were significantly faster than the males in these two components of LOS.

**Table 8. Male-vs-female descriptives for initial assessment: limits of stability**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>RT: Composite</td>
<td>5</td>
<td>.68</td>
</tr>
<tr>
<td>MV: Composite</td>
<td>5</td>
<td>6.0</td>
</tr>
<tr>
<td>EE: Composite</td>
<td>5</td>
<td>82.2</td>
</tr>
<tr>
<td>ME: Composite</td>
<td>5</td>
<td>95.2</td>
</tr>
<tr>
<td>DC: Composite</td>
<td>5</td>
<td>76.0</td>
</tr>
</tbody>
</table>

**Table 9. Male-vs-female descriptives for initial assessment: unilateral stance**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>EO: Composite</td>
<td>5</td>
<td>1.12</td>
</tr>
<tr>
<td>EC: Composite</td>
<td>4</td>
<td>1.98</td>
</tr>
<tr>
<td>EO and EC: Composite</td>
<td>4</td>
<td>1.55</td>
</tr>
</tbody>
</table>

Most researchers have found that there is no significant difference between males and females in regard to balance.11,12,22,51-55 Although most researchers have not found
any difference between male and female balance, there are some researchers who have reported that men show greater balance skills than women, while very few studies have shown that women have better balance than men.

The fact that women in this study had significantly faster reactions times and movement velocities than men may be explained by the instructions given during the LOS test. Subjects were instructed to move to the target as fast and as accurate as possible. The faster a subject travels, the less accurate the subject will be when traveling toward a target. Hamman et al observed that subjects in their study tended to interpret “improved performance” as increasing accuracy. Given the competitive nature of males, they may have sacrificed speed for accuracy, even though it did not result in a significant improvement in accuracy when compared to females.

Analytical Statistics

For the next portion of the study, descriptive statistics for initial and final assessments were calculated for each of the three groups and t-tests were run to determine if any group had a significant improvement between assessments. These results are shown in Table 10 and Table 11. In answer to research question #3, the BBT group showed a significant improvement in unilateral stance with EO (composite), while the TBT group showed a significant improvement in LOS EE (left, right, composite). Given these results, it appears that “normals” can improve at least some components of balance with a balance training program. It should be noted that the only results that are reported are variables that showed a significant improvement between assessments under a t-test and showed a significant difference between groups under a one-way ANOVA.
Table 10. Paired t-tests for LOS variables demonstrating significance: endpoint excursion (% LOS)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Initial Assessment</th>
<th>Final Assessment</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Right</td>
<td>0 (Control)</td>
<td>87.7</td>
<td>12.6</td>
<td>93.2</td>
<td>14.0</td>
</tr>
<tr>
<td></td>
<td>1 (TBT)</td>
<td>83.1</td>
<td>11.9</td>
<td>97.4</td>
<td>11.2</td>
</tr>
<tr>
<td></td>
<td>2 (BBT)</td>
<td>90.8</td>
<td>7.8</td>
<td>82.0</td>
<td>11.7</td>
</tr>
<tr>
<td>Left</td>
<td>0 (Control)</td>
<td>103.2</td>
<td>8.1</td>
<td>109.0</td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td>1 (TBT)</td>
<td>102.3</td>
<td>9.2</td>
<td>113.0</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td>2 (BBT)</td>
<td>113.5</td>
<td>9.3</td>
<td>104.3</td>
<td>3.8</td>
</tr>
<tr>
<td>Composite</td>
<td>0 (Control)</td>
<td>88.3</td>
<td>7.0</td>
<td>92.0</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>1 (TBT)</td>
<td>82.9</td>
<td>8.5</td>
<td>94.3</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>2 (BBT)</td>
<td>90.8</td>
<td>3.9</td>
<td>87.3</td>
<td>5.2</td>
</tr>
</tbody>
</table>

Key: * Significant improvement between assessments using alpha = .05

Table 11. Paired t-tests for unilateral stance variables demonstrating significance: eyes open sway velocity (degrees/second)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Initial Assessment</th>
<th>Final Assessment</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Composite</td>
<td>0 (Control)</td>
<td>1.26</td>
<td>.12</td>
<td>1.32</td>
<td>.11</td>
</tr>
<tr>
<td></td>
<td>1 (TBT)</td>
<td>1.11</td>
<td>.10</td>
<td>1.15</td>
<td>.07</td>
</tr>
<tr>
<td></td>
<td>2 (BBT)</td>
<td>1.16</td>
<td>.11</td>
<td>1.10</td>
<td>.09</td>
</tr>
</tbody>
</table>

Key: * Significant improvement between assessments using alpha = .05

One-way ANOVAs were then calculated using Scheffe’s Post-Hoc Analysis to determine if there was a significant difference in gain scores between groups. These results are shown in Table 12 and Table 13. In answer to research question #4, the BBT group did significantly better than the control group in unilateral stance with EO, while the TBT group did significantly better than the BBT group in LOS EE.

When examining the mean gain scores closer, it seems that the results could be misleading since the difference between groups appears to come from one group getting significantly better and another group getting moderately, but not significantly, worse.
Given this information, it would appear that the five-week balance training programs had
very little, if any, affect on balance.

**Table 12.** One-way ANOVA for LOS variables demonstrating a significant difference
in mean gain scores between groups: endpoint excursion (%LOS)

<table>
<thead>
<tr>
<th>Variable: Right</th>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between Groups</td>
<td>1351.38</td>
<td>2</td>
<td>675.69</td>
<td>4.348</td>
<td>.033</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>2157.68</td>
<td>14</td>
<td>154.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3509.06</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 (Control)</td>
<td>6</td>
<td>5.50</td>
<td></td>
<td>12.39</td>
<td>.033*</td>
<td>TBT</td>
</tr>
<tr>
<td>1 (TBT)</td>
<td>7</td>
<td>14.29</td>
<td></td>
<td>10.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 (BBT)</td>
<td>4</td>
<td>-8.75</td>
<td></td>
<td>15.95</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable: Left</th>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between Groups</td>
<td>1036.52</td>
<td>2</td>
<td>518.26</td>
<td>5.847</td>
<td>.014</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>1241.01</td>
<td>14</td>
<td>88.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2277.53</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 (Control)</td>
<td>6</td>
<td>5.83</td>
<td></td>
<td>10.63</td>
<td>.015*</td>
<td>TBT</td>
</tr>
<tr>
<td>1 (TBT)</td>
<td>7</td>
<td>10.71</td>
<td></td>
<td>6.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 (BBT)</td>
<td>4</td>
<td>-9.25</td>
<td></td>
<td>11.90</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable: Composite</th>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between Groups</td>
<td>588.42</td>
<td>2</td>
<td>294.21</td>
<td>4.220</td>
<td>.037</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>976.05</td>
<td>14</td>
<td>69.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1564.47</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 (Control)</td>
<td>6</td>
<td>3.67</td>
<td></td>
<td>6.98</td>
<td>.040*</td>
<td>TBT</td>
</tr>
<tr>
<td>1 (TBT)</td>
<td>7</td>
<td>11.43</td>
<td></td>
<td>10.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 (BBT)</td>
<td>4</td>
<td>-3.50</td>
<td></td>
<td>6.25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Sig. difference between groups under Scheffe’s Post Hoc with alpha of .05
Table 13. One-way ANOVA for unilateral stance variables demonstrating a significant difference in mean gain scores between groups: eyes open sway velocity (degrees/second)

<table>
<thead>
<tr>
<th>Variable: Eyes Open Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source</strong></td>
</tr>
<tr>
<td>Between Groups</td>
</tr>
<tr>
<td>Within Groups</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Group</strong></th>
<th><strong>N</strong></th>
<th><strong>Mean Gain</strong></th>
<th><strong>SD</strong></th>
<th><strong>Post-Hoc</strong></th>
<th><strong>Group</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (Control)</td>
<td>6</td>
<td>.058</td>
<td>.07360</td>
<td><strong>.036</strong></td>
<td>Control</td>
</tr>
<tr>
<td>1 (TBT)</td>
<td>7</td>
<td>.036</td>
<td>.06901</td>
<td></td>
<td>&amp; BBT*</td>
</tr>
<tr>
<td>2 (BBT)</td>
<td>4</td>
<td>-.063</td>
<td>.02500</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Sig. difference between groups under Scheffe’s Post Hoc with alpha of .05

Although very little research is available that shows people with normal balance can improve above normal with a training program, this fact may not be important. Following the principles of motor learning, the best balance training program that may help improve performance during athletics could be simply practicing of the sport.¹⁰ During sports, participants are continually taking themselves to their LOS in order to perform better.¹³ As stated earlier, moving the COG to the LOS is a basic principle of many balance training programs.¹,⁹,¹³

Several studies have shown that athletes demonstrate significantly better balance than the normal population.¹⁷⁻²⁰ Additionally, De Witt¹⁸ demonstrated that athletes tend to use somatosensory cues more, rather than relying on vision as most of the normal population, which would make athletes less likely to fall when confronted with obscured or conflicting visual signals. Specifically, steeplejacks, gymnasts, water skiers, tight-rope artists, skaters, and dancers demonstrate extraordinary balance skills.¹⁷⁻²⁰ In a study of dancers, Shick et al¹⁹ demonstrated the fact that level of balance was significantly correlated with the level of dance (beginner, intermediate, or advanced) of each subject.
Singer\textsuperscript{17} also found a significant correlation between balance and success in sports. Although there is a correlation between balance and athletic success, the question still remains as to whether better balance leads to athletic success or participation in athletics leads to better balance. This is a question that may never be answered.

Limitations

As previous research on balance clearly indicates, athletes are capable of balance above and beyond normal, so balance clearly must be able to be enhanced.\textsuperscript{17-20} This study did not conclusively prove that normal balance can be improved by balance training. However, there are a number of reasons why this may have occurred.

The first limitation of this study was demonstrated by Brandt et al\textsuperscript{62} who showed that the percentage of improvement in balance is related to the amount of initial instability. Thus, a person with poor balance is more capable of improving balance. On the other hand, a gymnast, for example, may not be able to improve much more than they already have through participation in gymnastics. Even though the individuals in this study were all considered normal, France et al\textsuperscript{34} concluded that there is still a significant difference in balance skills throughout the normal population. With this significant difference in balance skills, there is also a significant difference in the capability to improve balance in the normal population.

A second limitation of this study was the environmental distractions during the balance assessments. The NBM® was located in a very lively physical therapy department. Although visual distractions were avoided by the use of a curtain, auditory distractions could not be controlled. Irrgang et al\textsuperscript{13} pointed out that noise can lead to distraction and falls when performing a difficult balance skill. Although balance is not
normally practiced in a silent environment, the reliability of the tests may have been affected since the noise/distractions were different each time the subject was assessed.

Internal distractions during the final assessment may have also affected the reliability of the tests. Due to time constraints, the subjects were assessed during final examination week. This could have led to increased distractions and lack of concentration on the balance tests. Several researchers have pointed out that decreased attention given to a balance test clearly leads to decreased balance. Specifically, Shumway-Cook et al demonstrated that performance of cognitive tasks lead to decreased balance. During final examination week, the subjects clearly had more important cognitive tests to think about, rather than a balance test.

Several obvious limitations in this study were the number of subjects and the training schedule/progression utilized. Due to the fact that many subjects were not able to meet the criteria for "normal", the number of subjects in each group was very small. Additionally, due to time constraints, balance training was only performed two times a week for five weeks. A longer training period may have yielded better results. Lastly, due to the fact that training occurred in groups, the program could not be advanced at each subject's individual pace.

There are several other limitations that will be addressed only briefly. First of all, strength and range of motion (ROM) were not tested. Several researchers have shown that ROM and strength, especially of the ankle, is extremely important in maintaining balance. Additionally, subjects were allowed to select their own balance strategy (ankle, knee, or hip) and this was not recorded between assessments. Dickstein et al reported that when a subject is allowed to choose from a variety of balance strategies,
reliability decreases. The last factors that could not be controlled were motivation and mental training. Several subjects in the training groups appeared to lack motivation during the second assessment after five weeks of balance training, while several subjects in the control group commented that they were thinking about how to improve. Feltz et al\textsuperscript{67} found that mental training improves performance and learning.

Future studies in this area may be necessary to determine if certain balance training techniques are effective in increasing normal balance or if sport specific training would be of greater benefit to increase balance and performance. Most studies on balance utilize an eclectic approach, utilizing many different techniques.\textsuperscript{9} This makes it difficult to determine which exact balance training techniques are most effective. Studies examining the most effective balance training techniques would be very helpful to physical therapists in treating their patients. Additionally, although the Bodyblade\textsuperscript{©} was not extremely effective in this study, it should be studied further into it's affect on balance in "normals" and people with balance deficits, especially in improving static stability. Lastly, similar studies utilizing a longer training period and larger groups of subjects may be helpful in the future. These studies could also look at a number of different functional tests available on the NBM\textsuperscript{©} including weight bearing/squat test, step up/over test, and forward lunge test.

Clinical Implications

Establishing baselines on the NBM\textsuperscript{©} for subjects with normal balance, will aid physical therapists and athletic trainers by helping them determine when balance is within normal limits, so their patient can return to the playing field after an injury. If these professionals utilize these baselines, many re-injuries due to a premature return to the
playing field may be able to be prevented. Additionally, although this study did not prove that this particular balance training program was effective for improving balance in "normals", it will hopefully lead to further research in regards to the affect of balance training on "normals" and improved athletic performance. With further research, balance training may need to be included in the typical athletic training program of strength, flexibility, and endurance. Lastly, the Bodyblade® would provide an interesting topic for further research in regards to static stability. Pending further research with a longer training program, the Bodyblade® may be a tool that can be utilized to improve balance and stability in various postures that are used throughout daily life.
Balance is a skill that is essential for most ADLs including participation in any competitive or recreational athletic activities. When assessing balance, it is very important to determine normal balance baselines in order to serve as a guideline for comparison, especially for returning an athlete to the playing field after an injury. Since this is vitally important, one purpose of this study was to establish balance baselines on the NBM® (unilateral stance and LOS tests) for young adults with normal balance. Additionally, given the importance of balance in athletics, the second purpose of this study was to determine if people with normal balance can improve their balance in order to enhance performance and decrease the risk of injury during sports.

In establishing normal balance baselines, subjects in this study showed significantly greater sway during unilateral stance with EO and demonstrated a significantly faster MV backwards with LOS when compared to previous studies that established balance baselines for normal young adults on the NBM®. In regard to improving normal balance with balance training, the BBT group improved significantly more than the control group in unilateral stance with EO, while the TBT group improved significantly more than the BBT group in LOS EE. In examining the results closer, it was determined that the results could be misleading since the difference between groups
appeared to come from one group getting significantly better and another group getting moderately, but not significantly, worse.

It appears that the five-week balance training programs utilized in this study had very little, if any, affect on balance. Although this study did not prove that balance training is effective in improving balance in "normals", it should help stimulate future research in regard to the effect of balance training on "normals" and improved athletic performance. Similar studies utilizing a longer training period and larger groups of subjects in addition to avoiding the other limitations stated earlier may be necessary to answer the question as to whether "normals" can improve their balance with a balance training program. Additionally, the use of the Bodyblade® for balance training should be studied further in "normals" and people with balance deficits, especially in regard to improving static stability. With future research in these areas, balance training may become included in the typical athletic training program of strength, flexibility, and endurance.
APPENDIX A
EXPEDITED REVIEW REQUESTED UNDER ITEM 3.7 (NUMBER(S)) OF HHS REGULATIONS
EXEMPT REVIEW REQUESTED UNDER ITEM _____ (NUMBER[S]) OF HHS REGULATIONS

UNIVERSITY OF NORTH DAKOTA HUMAN SUBJECTS REVIEW FORM
FOR NEW PROJECTS OR PROCEDURAL REVISIONS TO APPROVED
PROJECTS INVOLVING HUMAN SUBJECTS

PRINCIPAL INVESTIGATOR: Anna Burchill, Steve Dingmann, & Josh Woods
TELEPHONE: Anna-795-4987, Steve & Josh-772-3519
DATE: 05/13/99
ADDRESS TO WHICH NOTICE OF APPROVAL SHOULD BE SENT: UND Physical Therapy Department, P.O. Box 9037, Grand Forks, ND 58202

PROPOSED SCHOOL/COLLEGE: University of North Dakota
DEPARTMENT: Physical Therapy
PROJECT DATES: 05/17/99 to 7/20/99
PROJECT DATES: 05/17/99 (Month/Day/Year)

PROJECT TITLE: The Effects of a Balance Training Program Utilizing the Hymanson Inc.® Bodyblade as Compared to a Traditional Training Program

FUNDING AGENCIES (IF APPLICABLE):
TYPE OF PROJECT (Check ALL that apply):

X NEW PROJECT ______ CONTINUATION ______ RENEWAL ______ THESIS RESEARCH ______ STUDENT RESEARCH PROJECT

CHANGE IN PROCEDURE FOR A PREVIOUSLY APPROVED PROJECT

DISSERTATION/THESIS ADVISER, OR STUDENT ADVISER: Meridee Danks

PROPOSED PROJECT:

X COOPERATING INSTITUTION

INvolves non-approved __ INvolves new drugs (IND) USE OF DRUG

(Altru Health Systems)

IF ANY OF YOUR SUBJECTS FALL IN ANY OF THE FOLLOWING CLASSIFICATIONS, PLEASE INDICATE THE CLASSIFICATION(S):

__ MINORS (<18 YEARS) __ PREGNANT WOMEN __ MENTALLY DISABLED
__ ETTUSES __ MENTALLY RETARDED
__ PRISONERS __ ABORTUSES __ UND STUDENTS (>18 YEARS)

F YOUR PROJECT INVOLVES ANY HUMAN TISSUE, BODY FLUIDS, PATHOLOGICAL SPECIMENS, DONATED ORGANS, FETAL MATERIAL, OR PLACENTAL MATERIALS, CHECK HERE

F YOUR PROJECT HAS BEEN/WILL BE SUBMITTED TO ANOTHER INSTITUTIONAL REVIEW BOARD(S), PLEASE LIST NAME OF BOARD(S):

Status: ___ Submitted; Date ____________________ ___ Approved; Date ____________________ Pending

46
1. **ABSTRACT:** (LIMIT TO 200 WORDS OR LESS AND INCLUDE JUSTIFICATION OR NECESSITY FOR USING HUMAN SUBJECTS.)

Balance is critical to maintain optimal function in daily activities and is a skill that is frequently affected in individuals who have experienced some type of neurological, vestibular, orthopedic or musculoskeletal injuries/surgeries/alterations. A successful balance training program that can be used to improve such a person’s balance can be of great use and importance to a patient and therapist. Through the performance of this study, two different types of balance training programs will be used, with subjects’ balance being tested before and after the training. This will give information regarding any changes that may occur in their dynamic and/or static balance skills because of their participation in the balance training. The purpose of this study is to determine if a 6 week balance training program consisting of static and dynamic exercises utilizing the Hymanson Inc.® Bodyblade increases static and/or dynamic balance, as assessed by the NeuroCom® Balance Master. There are a variety of balance training tools on the market, but this study proposes that the Hymanson Inc.® Bodyblade will provide a unique training program that can be used to improve balance, enabling people to perform higher level balance activities required in certain sports & activities.

**PLEASE NOTE:** Only information pertinent to your request to utilize human subjects in your project or activity should be included on this form. Where appropriate attach sections from your proposal (if seeking outside funding)

2. **PROTOCOL:** (Describe procedures to which humans will be subjected. Use additional pages if necessary.)

**Subjects:** Subjects will consist of approximately 30-45 volunteers from the UND student population which will be recruited by word of mouth. They will be randomly assigned to one of three groups, each consisting of approximately ten to fifteen subjects. Each subject will be within the age range of 20-39 years of age. No volunteers in this age group will be excluded from this study unless there is a safety or health concern. A questionnaire administered before and after participation will be used to determine health information that may influence the subject’s balance or ability to participate in the training program. Informed consent for this study will be obtained via a signed consent form (attached) before any testing or training procedures are performed.

**Assessment Procedure:** The NeuroCom® Balance Master is a clinically acceptable machine commonly used in physical therapy to assess balance. It consists of a force platform on which the subject stands. This platform communicates with a software program that interprets various data obtained during a balance assessment. Standardized testing procedures will be followed by the researchers for the following tests:

1) Unilateral Stance with eyes open and closed (an indicator of static balance skills)
This testing procedure requires the subject to stand on one foot at a time, tested first with their eyes open and then again with their eyes closed.

2) Limits of Stability (an indicator of dynamic balance skills)
This test requires the subject to shift their weight and lean in all directions including: forward, backward, sideways, and diagonally. During this the subject will be required to maintain their balance while leaving their feet planted on the force platform. Testing will be done at Altru Health Institute before and after a 6 week balance training program.
A brief objective physical assessment of the subjects will also be performed by the researchers prior to the start of the training program.

**Training Procedure:** Subjects will be divided randomly into 3 groups (1 control and 2 experimental). All groups will be assessed on the NeuroCom® Balance Master before and after the training program. The control group will not participate in the 6 week balance training. Experimental group #1 will perform various traditional dynamic and static balance activities. Experimental group #2 will consist of individuals trained by an identical
program as group #1 with the addition of the Hymanson Inc.® Bodyblade during all balance activities. Subjects in the experimental groups will attend training sessions conducted by the researchers two times per week for 6 weeks. These training sessions will consist of activities similar to those used during the assessment. These include but are not limited to: 1) standing on a firm surface using one leg at a time, either with eyes open or eyes closed 2) shifting weight and leaning in all directions while maintaining standing balance. Again as stated previously, these activities will be done with or without the addition of the Hymanson Inc.® Bodyblade.

The Hymanson Inc.® Bodyblade is a piece of equipment that is used in physical therapy to increase body awareness, joint mobility, flexibility, and strength. It is a four-foot long by 1.75 inch wide rod composed of graphite weighing 1.5 pounds. It oscillates as it is held in the middle and an oscillatory force is applied by the person using it. The oscillations of the Hymanson Inc.® Bodyblade require a stabilizing force by the subject, which can be utilized during both static and dynamic activities. This may allow for a unique training program for balance.

Data Analysis and Reporting: Statistical analysis consisting of descriptive and analytical statistics will be used to compile the data. We will be using an alpha level of .05 in determining significance of the results. The individual subjects' results will remain confidential, and the data will be identified by a number known only by the investigators. Data will be reported in a manner that maintains subject confidentiality. To ensure maximum confidentiality, data will be kept in a locked confidential file in the Physical Therapy office. Data will also be kept for three years following the completion of the study, at the end of which the documents will be shredded.

3. BENEFITS: (Describe the benefits to the individual or society.)

The primary aim of this study is to determine if these methods of balance training are effective/efficient. If this is the case, physical therapists may be able to provide a more cost-efficient balance training alternative to their patients. Additionally, the study will determine if balance skills can be improved in normal individuals. If it is found that their balance skills can be improved through training, this will be beneficial to individuals wishing to attain a higher level of performance in sports or activities requiring balance skills.

The individuals participating in the study will benefit from exposure to the research process and the knowledge that they are involved in improving the field of physical therapy and the patients they serve. The subjects will also benefit from exercise and the potential for improved balance.

1. RISKS: (Describe the risks to the subject and precautions that will be taken to minimize them. The concept of risk goes beyond physical risk and includes risks to the subject's dignity and self-respect, as well as psycho-logical, emotional or behavioral risk. If data are collected which could prove harmful or embarrassing to the subject if associated with him or her, then describe the methods to be used to insure the confidentiality of data obtained, including plans for final disposition or destruction, debriefing procedures, etc.)

Although the NeuroCom® Balance Master is a clinically acceptable machine commonly used in physical therapy to assess balance, there is still a slight risk of falls. Prevention of falls will be prevented by the use of a second person (a spotter) in addition to the researcher performing the assessment. Also, verbal instructions will be given to the subject prior to the balance assessment.

As with any exercise program, there is a risk of some muscle soreness and a potential for injury. In order to combat this risk, each training session will include a brief warm-up and cool-down period, including adequate stretching. Close supervision and proper instruction will also be provided by the researchers during all exercises sessions to ensure safety.
Respect for the individual will be controlled by informing the subjects that all information will be kept confidential, and results will be disclosed using a number known only to the investigators. No names will be used. Subjects' balance will be assessed individually to promote privacy. Subjects will be informed on the consent form prior to beginning participation that they can withdraw from the study at any time.

5. CONSENT FORM: A copy of the CONSENT FORM to be signed by the subject (if applicable) and/or any statement to be read to the subject should be attached to this form. If no CONSENT FORM is to be used, document the procedures to be used to assure that infringement upon the subject's rights will not occur.

Describe where signed consent forms will be kept and for what period of time.

Informed consent will be obtained through the attached consent form. Each subject will be required to sign the form if they agree with the terms that are presented. Upon agreement they will be included into the study and given a copy of their consent form for future reference.

All consent forms, questionnaires, and data reports will be kept in a locked confidential file located in the Physical Therapy Office (Room 1518) of the UND School of Medicine and Health Sciences. Data and information obtained from the study will be kept for three years following the completion of this study. At the end of this three year period the documents containing this information will be disposed of with the use of a shredder. Please see attached consent form.

References


5. For FULL IRB REVIEW forward a signed original and thirteen (13) copies of this completed form, and where applicable, thirteen (13) copies of the proposed consent form, questionnaires, etc. and any supporting documentation to:

Office of Research & Program Development
University of North Dakota
Grand Forks, North Dakota 58202-7134

On campus, mail to: Office of Research & Program Development, Box 7134, or drop it off at Room 105 Twamley Hall.

For EXEMPT or EXPEDITED REVIEW forward a signed original and a copy of the consent form, questionnaires, etc. and any supporting documentation to one of the addresses above.

The policies and procedures on Use of Human Subjects of the University of North Dakota apply to all activities involving use of Human Subjects performed by personnel conducting such activities under the auspices of the University. No activities are to be
initiated without prior review and approval as prescribed by the University's policies and procedures governing the use of human subjects.

SIGNATURES:

________________________________________  Date
Principal Investigator

________________________________________  Date
Project Director or Student Adviser

________________________________________  Date
Training or Center Grant Director

(Revised 3/1996)
STUDENT RESEARCHERS: As of June 4, 1997 (based on the recommendation of UND Legal Counsel) the University of North Dakota IRB is unable to approve your project unless the following "Student Consent to Release of Educational Record" is signed and included with your "Human Subjects Review Form."

STUDENT CONSENT TO RELEASE OF EDUCATIONAL RECORD

Pursuant to the Family Educational Rights and Privacy Act of 1974, I hereby consent to the Institutional Review Board's access to those portions of my educational record which involve research that I wish to conduct under the Board's auspices. I understand that the Board may need to review my study data based on a question from a participant or under a random audit. The study to which this release pertains is:

The Effects of a Balance Training Program Utilizing the Hymanson Inc.® Bodyblade as Compared to a Traditional Training Program

I understand that such information concerning my educational record will not be released except on the condition that the Institutional Review Board will not permit any other party to have access to such information without my written consent. I also understand that his policy will be explained to those persons requesting any educational information and that this release will be kept with the study documentation.

______________________________
Date

______________________________
Signature of Student Researcher

Consent required by 20 U.S.C. 1232g.
REPORT OF ACTION: EXEMPT/EXPEDITED REVIEW
University of North Dakota Institutional Review Board

DATE: May 13, 1999

PROJECT NUMBER: IRB-9905-242

NAME: Anna Burchill, Steve Dingman, Josh Woods

DEPARTMENT/COLLEGE: Physical Therapy

PROJECT TITLE: The Effects of a Balance Training Program Utilizing the Hymanson Inc. Bodyblade as Compared to a Traditional Training Program

The above referenced project was reviewed by a designated member for the University's Institutional Review Board on May 19, 1999 and the following action was taken:

☑ Project approved. EXPEDITED REVIEW NO. 

☐ Next scheduled review is on May 2000

☐ Project approved. EXEMPT CATEGORY No. 

☐ No periodic review scheduled unless so stated in the Remarks Section.

☐ Project approved PENDING receipt of corrections/additions. These corrections/additions should be submitted to ORPD for review and approval. This study may NOT be started until final IRB approval has been received. (See Remarks Section for further information.)

☐ Project approval deferred. This study may not be started until final IRB approval has been received. (See Remarks Section for further information.)

☐ Project denied. (See Remarks Section for further information.)

REMARKS: Any changes in protocol or adverse occurrences in the course of the research project must be reported immediately to the IRB Chairperson or ORPD.

PLEASE NOTE: Requested revisions for student proposals MUST include adviser's signature.

cc: M. Danks, Adviser

Signature of Designated IRB Member
UND's Institutional Review Board

Date

If the proposed project (clinical medical) is to be part of a research activity funded by a Federal Agency, a special assurance statement or a completed 310 Form may be required. Contact ORPD to obtain the required documents.

(1/98)
ALTRU HEALTH SYSTEM

APPROVAL TO CONDUCT RESEARCH STUDY AT ALTRU HEALTH SYSTEM

Name: Anna Burchill, Steve Dingmann, & Josh Woods Date: May 19, 1999

Address: UND Physical Therapy Department, P. O Box 9037, Grand Forks, ND 58202

Telephone Numbers: Work ___________________________________ Home 795-4987 & 772-3519

Department/College: UND School of Medicine & Health Sciences, Physical Therapy Dept.

Project Title: The Effects of a Balance Training Program Utilizing the Hymanson Inc. Bodyblade as Compared to a Traditional Training Program

Your request to conduct the above named study at an Altru Health System facility involving employees or patients as participants, and/or requiring facility resources has been reviewed. The following action has been taken:

☐ Permission to conduct the study is granted

☐ Permission to conduct the study will be granted upon completion of the following:

☐ Permission to conduct the study is denied for the following reason(s):

RECOMMENDATIONS/REMARKS:

Signature: Virginia During Date: 5/19/99

Title: 

wordresearchpapers
Title: The Effects of a Balance Training Program Utilizing the Hymanson Inc® Bodyblade as Compared to a Traditional Training Program

You are invited to participate in an independent study conducted by students of the UND physical therapy program (Anna Burchill, Steve Dingmann, & Josh Woods) in collaboration with faculty member Meridee Danks. Your participation in this study would be greatly appreciated and it should be noted that it is strictly voluntary.

The purpose of this study is to determine the effectiveness of two training programs in improving balance as measured by the NeuroCom® Balance Master. The NeuroCom® Balance Master is a clinically acceptable machine commonly used in physical therapy to assess balance. Subjects for this study must be healthy individuals between the ages of 20-39. No volunteers in this age group will be excluded from this study unless there is a safety or health concern. You will be asked to fill out a brief health questionnaire prior to the start of the study in order to protect you from injury & help us interpret our results.

We do ask that you wear loose, comfortable clothing & socks if you prefer not to be barefoot as shoes will not be allowed when participating in the study.

Prior to the study, you will be randomly assigned to one of the six week training program groups or the control group. Groups will consist of approximately 10-15 subjects (30-45 total). At the beginning of the study, you will be asked to report to the Physical Therapy Department at Altru Health Institute Rehabilitation Hospital where a training session & assessment on the NeuroCom® Balance Master lasting 20-30 minutes will be performed. Tests will include: 1) standing on one foot at a time, tested both with your eyes open and with your eyes closed. 2) leaning forward, backward, sideways, and diagonally without moving your feet. If you are selected to the control group, you will be assessed on the NeuroCom® Balance Master at the beginning of the study & also 6 weeks later without participating in any type of balance program. Those in the balance training groups will meet for 30-45 minutes 2x/week for 6 weeks at the University of North Dakota Physical Therapy Department in order to perform the balance training protocol. You will be asked to perform similar tasks to those used during the testing, these will include but are not limited to: 1) standing on one leg at a time, again with eyes open and eyes closed 2) leaning in all directions while standing on both feet. One group will perform these tasks with the Hymanson Inc® Bodyblade while the other group performs the same tasks without. At the end of the 6 weeks, you will also be re-tested on the NeuroCom® Balance Master to determine the effects of the balance program.

Although the process of balance testing & training involves some risk of falling & injury, the researchers of this study feel the risk of injury is minimal. In order to combat this risk of falling, an assistant will be provided to safeguard you from possible loss of balance during the assessment. In addition, all training programs will be supervised by the researchers. As with any new training program, there is also a risk of muscle soreness.
In order to minimize this effect, each training session will include a brief warm-up & cool-down period including adequate stretching. If you should choose to participate in this study you will benefit from exposure to the research process and the knowledge that you are involved in helping to improve the field of physical therapy. You may also benefit from the exercise involved and the potential for improving your balance.

The results of this study will remain confidential & your data will be identified by a number known only by the investigators. These results will be kept in a locked confidential file in the physical therapy department for three years following the completion of the study. After this period of time the results will be destroyed. If you decide to participate, you are free to discontinue participation at any time for any reason. You may stop the experiment at any time if you are experiencing pain, discomfort, fatigue, or any other symptoms that may be detrimental to your health. Your decision not to participate in this study will not effect your future relationship with the University of North Dakota or the Physical Therapy Department. If it is determined that you have health issues that put you at risk for injury, you may be excluded from the study. Again you will not be penalized in any way.

The investigators are available to answer any questions you might have concerning this study now or in the future. Questions may be answered by contacting Steve or Josh at (701) 772-3519 or Anna at (701) 795-4987. A copy of this consent form will be provided to you for future reference. If you would like to contact Meridee she can be reached at (701) 777-3861.

In the event that this research project results in physical injury or medical treatment including first-aid, emergency treatment, or any follow-up care, the investigators along with Altru Hospital & the University of North Dakota are not responsible for any such injury or treatment. The payment for any such treatment must be provided by you & your third party payer, if any.

I have read all the above, all my questions have been answered, & I willingly agree to participate in this study explained to me by Anna Burchill, Steve Dingmann, & Josh Woods.

Participant’s Signature Date

Witness(not Investigator) Date
Health Background Questionnaire

1. Are you currently taking any medications? (ex: allergy medications, cold medications, etc.) Please list all over-the-counter and prescription medications in order for us to determine if these may affect your balance.

2. Do you have any current or past medical diagnoses or injury that could affect balance or your participation in a moderate training program? If so, please list. (include fractures, orthopedic conditions, sprains, etc.)

3. Do you have symptoms of dizziness or lightheadedness?

4. Have you experienced any episodes of two or more unexplained falls within the past 6 months?

5. Do you have normal vision (either with or without glasses)?

6. What is your current exercise level? Please list type of exercise and frequency (# of times per week).
APPENDIX D
Description of Tests

Unilateral stance analyzes COG sway velocity. This is the ratio of the distance traveled by the COG (level of S1-S2) to the time of the trial (10 seconds), expressed in degrees per second. A mean of the COG sway velocity is calculated from data obtained during 3 trials for each of the four conditions: eyes open left, eyes open right, eyes closed left, and eyes closed right.

The other test, limits of stability (LOS), assesses reaction time (RT), movement velocity (MV), endpoint excursion (EE), maximum excursion (ME), and directional control (DC). This test requires the subject to lean in eight directions, one trial each, as far as possible without losing their balance or stepping. The directions include: forward, forward-right, right, right-back, back, back-left, left, and left-forward.

Scores from back, back-right, and back-left are combined in a weighted fashion to obtain an overall value for back. For example:

\[
\frac{(0.7)(\text{left-back}) + (0.7)(\text{right-back}) + (1)(\text{back})}{2.4}
\]

Calculations similar to this are also performed for forward, left, and right for each of the following five components:

1. Reaction Time—the time in seconds between the cue to move and the initiation of movement.

2. Movement Velocity—the average speed of COG movement, expressed in degrees per second, between five percent and 95 percent of the distance to the primary endpoint.
3. Endpoint Excursion—the distance traveled by the COG on a primary attempt to reach the target, expressed in %LOS. The endpoint is considered to be the point at which the initial movement toward the target ceases, and subsequent corrective movements begin.

4. Maximal Excursion—the furthest distance traveled by the COG during the trial.

5. Directional Control—a comparison of the amount of movement in the intended direction (toward the target) to the amount of extraneous movement (away from the target). This is calculated as follows:

\[
\frac{(\text{Amount of intended movement}) - (\text{Amount of extraneous movement})}{\text{Amount of intended movement}}
\]

This value is expressed as a percentage. For example, if a subject’s movement is directly toward the target (a straight line), then the amount of extraneous movement would equal zero, and the perfect directional control score is 100%.
Balance Master Testing Procedures

- Make sure to position screen directly in front of the subject during practice and testing
- Take off shoes

Unilateral Stance

1. Line up subject’s medial malleolus with wide blue line, and the lateral calcaneous with the T-line.
2. Instructions (At least one practice for each test, then actual testing when subject has demonstrated comfort with procedures)
   - put your hands on your hips
   - stand on your ____ leg
   - don’t allow legs to touch, and the nonstance foot should not touch the ground
   - “Look straight ahead and stand as steady as possible until the testing is completed, which will be 10 seconds.”
   - “Make sure to avoid any movements of your arms or nonstance leg that are not necessary to maintain balance”
   - EO: Say “go” when you feel that you are as steady as possible
   - EC: “When you feel that you are as steady as possible close your eyes and say “go” when you are ready to begin testing”
3. During eyes closed: notify subject when they have reached half way point
4. Have spotter tally failed attempts if applicable, and note in comments section

Limits of Stability

1. Line up subjects medial malleolus with the wide blue line, and the lateral calcaneous with the appropriate line (determined by computer: T, M, S)
2. Pre-test instructions (Give subject brief training in movement of cursor through weight shift demonstrating acceptable strategies; then run through at least two practice sessions)
   - Begin by centering entire cursor in middle target (box) and hold it there
   - Point out that the yellow box will be the target for that particular test
   - Explain that a blue circle will appear in this targeted box
   - “Once this circle appears you should move the cursor to the box with the circle as quickly and accurately as possible, moving the cursor in a straight path (point out on screen). Try to get as close to the circle as possible without taking a step or losing your balance. A portion of both feet should stay in contact with the ground at all times during the testing, however make sure to maintain positioning of the ankle and heel. Once you get to the circle try to stay as still as possible until the circle disappears.”
   - “You will follow these instructions for all the boxes”
   - When subject is ready begin practice/test
3. Test instructions
   - “Move to the center and hold it”
   - “Remember to move as straight and as quickly as possible” (repeat for every test)
   - Point out at first click of mouse: “get ready for the circle”
   - Run through the tests (8 total)
REFERENCES


42. Burchill A. *The effect of a five week balance training program on individuals with previous ankle sprains* (master’s independent study). Grand Forks, ND: University of North Dakota; 2000.


65. Maylor EA, Wing AM. Age differences in postural stability are increased by additional cognitive demands. *J Gerontol.* 1996;51B:P143-P154.
