THE EFFECTS OF FUNCTIONAL KNEE BRACING ON THE BALANCE AND PROPRIOCEPTION, VELOCITY, AND AGILITY OF UNINJURED FEMALE ATHLETES

THESIS

Submitted to the Faculty of the School of Graduate Studies and Research of California University of Pennsylvania in partial fulfillment of the requirements for the degree of Master of Science

By
Amy M. Morocco

Chairperson, Dr. Bruce Barnhart
California, Pennsylvania
2005
CALIFORNIA UNIVERSITY OF PENNSYLVANIA
California, Pennsylvania

THESIS APPROVAL

Athletic Training

We hereby approve the Thesis of

Amy Marie Morocco
Candidate for the degree of Master of Science

<table>
<thead>
<tr>
<th>Date</th>
<th>Faculty</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-27-05</td>
<td>Dr. Bruce Barnhart - Research Advisor</td>
</tr>
<tr>
<td>4-27-05</td>
<td>Dr. Rebecca Hess - Committee Member</td>
</tr>
<tr>
<td>4-27-05</td>
<td>Dr. Benjamin Reuter - Committee Member</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

My parents have always taught me that I could do anything I wanted, and I always believed it to be true. They have raised me to discover what inspires me and dedicate myself to the pursuit of that inspiration. My parents have taught me that there is no limit to what I can achieve, and they have believed in my dreams and offered their constant faith and support. As I grow older, I realize that my mother has been my most loyal friend and my father has been the most proud and avid believer in my abilities. My step-parents have always been a constant source of strength and comfort in my life, and they have been instrumental in all of my successes. Mom, Dad, Al, and Sue... thank you for your faith, pride, inspiration, support, and understanding throughout the years. I would not be the person I am today without all of you, and I appreciate everything you have done for me throughout my life.

To my family and my closest friends... I want to thank you for understanding my lack of communication with the outside world for the past year. You have been there for me all along even though we haven’t been able to talk or visit as often as we may have liked.

I would like to thank Dr. Bruce Barnhart, Dr. Rebecca Hess, and Dr. Benjamin Reuter for their time and efforts. I would also like to thank Matt Gallo and DonJoy™ for their donations, which made this study possible. Thanks are also due to Dr. Tom West for his help with my poster and to Ellen West for keeping me sane this year.

The Cal U crew... Laura, my little research assistant, you have been a great friend and stress-reliever! Kevin and Nick, I wouldn’t have made it through the past 10 months without you. As much as we all love it here, it’s time to take this party back to New England!

... and I saved the best for last. Bob, finding you this year has made grad school the most amazing experience of my life. I never could have imagined finding someone like you to be my best friend and my true love. They say the best things happen when you least expect it, and now I know that is true. You have been the best support and encouragement for me throughout this year. I love you more than the most meaningful words could ever say. I look forward to making many more memories with you in the future. For everything you are and everything I have become because you are in my life... thank you!
## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGNATURE PAGE</td>
<td>ii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>iii</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vii</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>METHODS</td>
<td>7</td>
</tr>
<tr>
<td>Research Design</td>
<td>7</td>
</tr>
<tr>
<td>Subjects</td>
<td>8</td>
</tr>
<tr>
<td>Pilot Research</td>
<td>9</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>9</td>
</tr>
<tr>
<td>Procedures</td>
<td>12</td>
</tr>
<tr>
<td>Hypotheses</td>
<td>18</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>19</td>
</tr>
<tr>
<td>RESULTS</td>
<td>20</td>
</tr>
<tr>
<td>Demographic Data</td>
<td>20</td>
</tr>
<tr>
<td>Hypotheses Testing</td>
<td>21</td>
</tr>
<tr>
<td>Additional Findings</td>
<td>23</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>24</td>
</tr>
<tr>
<td>Discussion of Results</td>
<td>24</td>
</tr>
<tr>
<td>Conclusions</td>
<td>28</td>
</tr>
<tr>
<td>Recommendations</td>
<td>28</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>29</td>
</tr>
</tbody>
</table>
APPENDICES

A. Review of the Literature

- Rehabilitation of the Knee Joint
- Bracing the Knee Joint
- Form and Function of the Knee
- Injury Prevention and Protection
- The Effects of Bracing on Athletic Performance
- Muscle Function
- Balance and Proprioception
- Velocity and Agility
- Summary

B. The Problem

- Statement of the Problem
- Definition of Terms
- Basic Assumptions
- Limitations of the Study
- Significance of the Study

C. Additional Methods

- Informed Consent Form (C1)
- Demographic Information Sheet (C2)
- IRB Form (C3)
- Data Collection Sheets (C4)
- Instruments (C5)
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Descriptive Statistics OBI, Velocity, and Agility</td>
<td>22</td>
</tr>
<tr>
<td>2</td>
<td>Paired Samples T-Test for OBI, Velocity, and Agility with and without a Knee Brace</td>
<td>23</td>
</tr>
</tbody>
</table>
INTRODUCTION

The knee is an extraordinary construction of living tissue structure. The kinematics and mechanics, along with the tissue’s cellular capacities and physiologic possibilities, comprise the form and function of the unit called the knee.\(^1\) A comprehensive understanding of the anatomy and biomechanical function of the knee joint is imperative for practitioners to make accurate diagnoses and, in turn, make decisions regarding treatment, rehabilitation, and bracing of that joint based on the diagnosis.\(^2\)

The knee is the largest and most complex joint of the body. The knee bears the majority of body weight and is stimulated by the synergistic relationships among soft tissue restraints, such as ligaments and tendons, the musculature, and the bony architecture.\(^3\)

Stability of the knee tends to vary with the direction, mechanical loading, rotary forces, and angle of flexion. The knee is in an exposed position with long lever arm attachments, making it the joint most vulnerable to injury, especially during contact sports.\(^3\)

Knee braces have been used in sports for years to prevent injuries, rehabilitate injuries, or to provide
support and protection to the unstable knee. Knee bracing has increased tremendously during the past ten years. There are several reasons for this increase in bracing, including a greater interest in preventing knee injuries, desire for early return to play of injured athletes after operative or non-operative treatment, desire of athletes to return to their original intensity level during play, and documented reports of the benefits of bracing. There are three major types of knee braces: rehabilitative, prophylactic, and functional.  

Braces provide support and compression to the injured knee, as well as helping to limit the range of motion of the joint. Bracing reduces knee joint motion and allows proper healing to occur within the joint capsule. It is important to strictly adhere to the range of motion guidelines for the specific injury in order to prevent unsafe forces to the healing tissue. Bracing also provides proprioceptive feedback to the athlete and acts as a reminder to avoid overexertion and unnecessary motion. Functional knee braces are often used when the athlete is ready to return to play. Functional knee braces are devices that are designed to restore normal or near-normal motion to a knee with ligamentous damage or chronic instability.
An optimally designed functional knee brace strongly matches the kinematics of a normal knee. In order to facilitate a strong match, rigidity, tightness of fit, and placement of the brace are important. The axis of rotation of the brace should match that of the knee in order to avoid discomfort from the shearing of soft tissue beneath the brace.³

Physicians tend to recommend that a knee brace of some type be used after injury for any type of strenuous exercise or athletic competition. The length of time a brace may be worn is dependent upon the severity of the injury and the rate of progression during rehabilitation. These braces are usually given to help the athlete regain proprioception within limited ranges of motion. The return of the “delicate feeling” of the position of the knee while walking, running, or cutting is very gradual, but it is very important for the athlete to regain joint position sense.⁸

There are some perceived benefits for those with an unstable knee to wear a functional knee brace. It has been reported that, with a functional knee brace, patients have less complaints of the knee “giving out”, there is less pain with activity, and they are able to participate at a higher level of activity. Also reported are higher levels
of confidence in the knee’s ability to perform in a normal manner.\textsuperscript{3,9-13}

Proprioception is the body’s early and intrinsic feedback from the joint, muscle, and skin receptors about limb position and muscle tension. The effects of functional knee bracing on proprioception cannot be supported or refuted on the basis of current evidence.\textsuperscript{14}

Literature based on previous studies does not provide a general theory regarding the effects of bracing on running velocity and agility. Velocity and agility scores seem to differ depending on the type of brace being tested. Previous studies have recommended further research and testing of the effect of functional knee bracing on velocity and agility.\textsuperscript{13}

Maintaining a comprehensive understanding of the form and function of the knee joint increases the practitioner’s awareness of functional anatomy, improves their ability to make specific diagnoses, helps them choose the best treatment, and aides in the better design of rehabilitation programs and training methods. All of the structures within the knee joint are able to work to their fullest capacity for athletic performance when visual, auditory, and proprioceptive skills are optimally developed and executed simultaneously.\textsuperscript{1}
Athletic trainers should always educate their athletes about how to properly apply and align their brace. It is important to also teach athletes how to maintain proper brace alignment during physical activity and athletic competition. Functional knee bracing should always be used in conjunction with an extensive rehabilitation program focused on quadriceps and hamstring strength, coordination, and proprioception. Proper rehabilitation increases muscle tone and provides a solid base for brace application, and this should enhance the benefits that might be provided by the functional knee brace.12

Functional knee braces provide valuable support to athletes with unstable knees. They also act as an important rehabilitative tool following invasive surgical procedures. The adverse effects of knee bracing, however, include rapid muscle fatigue and increased energy expenditure. This is due to impaired blood flow resulting from the external compression of the brace. It has been demonstrated that functional knee braces do not improve athletic performance and may even hinder an athlete’s ability to perform optimally.14
This study answered the following research questions:

1) Does wearing a knee brace effect balance and proprioception?  
2) Does wearing a knee brace effect speed?  
3) Does wearing a knee brace effect agility?
METHODS

The purpose of this study was to determine the effects of functional knee bracing on the balance and proprioception, running velocity, and agility of uninjured female athletes. This section includes the following subsections: Research Design, Subjects, Pilot Research, Instrumentation, Procedures, Hypotheses, and Data Analysis.

Research Design

The research design used for this study was a quasi-experimental, within subject design. The research was conducted in a one-group pre-posttest design. The independent variable for this study was the condition of the knee brace vs no knee brace. The dependent variables for this study were: 1) balance and proprioception, as measured by the Biodex Balance System™ (Shirley, NY), 2) running velocity, as measured by the Wireless Sprint System™ (Brower Timing Systems, Inc., Draper, UT), and 3) agility, as measured by the T-test. In order to control for error, the researcher was the only person fitting the brace, measuring results, and collecting data. Strengths of the study include using valid and reliable instruments for testing, and testing female athletes from different
athletic backgrounds. Results of the study may be limited to only college-aged females in a Division II setting.

Subjects

The participants (N=17) in this research study were uninjured female athletes from California University of Pennsylvania. These participants were athletes involved in softball, soccer, tennis, track and field, and volleyball. The participants were a sample of convenience based on voluntary participation and eligibility for participation. The subjects all maintained the characteristic of having no previous or current injury to the lower extremity. Any lower extremity injury within the previous six-month period was considered grounds for elimination. It is assumed that athletes were healthy if they were currently participating in their sport. Subjects with previous reconstruction to any knee ligaments and/or chronically unstable ankles were also eliminated. Demographic information (age, sport, height, weight, etc.) was collected from each participant. Each participant completed an Informed Consent (Appendix C1) before taking part in the study. No names were included in the research study.
Pilot Research

The purpose of the pilot research was to determine the amount of time necessary for proper brace fitting and testing procedures. Also, the pilot research was used to determine that there were no foreseeable problems with the tests or equipment being used in the study. The pilot study allowed the researcher to become familiar with the bracing techniques and the equipment being used.

The pilot research was done using three college-aged subjects. Each subject was properly fitted for the brace. Each subject then participated in one 40-yard dash, one T-test, and one test protocol on the Biodex Balance System™ (BBS) with the knee brace. The same procedure was then followed without the brace.

Instrumentation

Five instruments were used in this study; the Biodex Balance System™, the 40-yard dash, the T-test for agility, the Wireless Sprint System™, and the Donjoy (Vista, CA) Drytex Wraparound Playmaker™ functional knee brace. To ensure test-retest reliability, the same researcher administered and supervised all tests and applied all bracing techniques. A Demographic Information Sheet
(Appendix C2) was used to document the subject’s age, height, weight, sport, position, preferred leg, any past injury, any past experience with knee bracing, and any past knee surgeries.

The BBS is a valid and reliable tool used to measure dynamic balance and proprioception of the uninjured knee using a single leg stance. The BBS provides eight levels of instability ranging from Level 1 (very stable) to Level 8 (very unstable). Measurements of sway amplitude (in degrees) were recorded from Level 4 (moderately stable). Measurements were taken in the anterior-posterior (AP) and medial-lateral (ML) directions. An overall balance index (OBI) was also measured, which is a combined score of anterior, posterior, medial, and lateral sway amplitude. Scores of higher amplitude or sway indicated a greater degree of movement and, therefore, decreased balance and proprioception.

A 40-yard dash is a valid and reliable tool, which was used to measure running velocity in this study. This test was done in the gymnasium at Hamer Hall at California University of Pennsylvania. Running velocity, which is the rate or speed of motion, was measured with the Wireless Sprint System™. Athletes’ velocity was measured with and without a properly applied functional knee brace.
The Wireless Sprint System™ by Brower Timing Systems, Inc. was used to evaluate linear sprint velocity. Infrared sensors were used to accurately measure both start and finish times. The Wireless Sprint System™ is more accurate than the traditional handheld timing devices. Handheld timing does not allow for simultaneous measurement of various splits and only provides an absolute finish time. There is also a timing discrepancy of 0.22 seconds between handheld devices and electronic devices, making electronic devices the more accurate tool for time measurement.17

The T-test for agility is a valid and reliable tool for measuring agility.16,18 This test was used to measure lateral running velocity in uninjured athletes, both with and without a properly applied functional knee brace. The T-test required a ten-yard forward sprint, followed by a five yard side shuffle to the right, a ten-yard side shuffle to the left, a five-yard side shuffle to the center, and a ten-yard backpedal sprint. Agility scores were based upon the time it takes the athlete to complete the agility drill. Time measurements were taken with the Wireless Sprint System™.

The Donjoy Drytex Wraparound Playmaker™ functional knee brace was used during this study. The Drytex Wraparound Playmaker is suitable for mild to moderate ACL,
PCL, MCL, and LCL instabilities. This brace also features a four-point dynamic design with ACL/PCL and Collateral Instability strapping options, and is designed to be used during exercise and competition. The brace was applied to each athlete by the researcher to ensure a proper application.

Procedures

The researcher applied for approval from the Institutional Review Board for the Protection of Human Subjects at California University of Pennsylvania (IRB) (Appendix C3). Subjects volunteered for participation in the study. The population was determined based on a sample of convenience. After reading and signing the Informed Consent Form (Appendix C1), each participant completed a Demographic Information Sheet (Appendix C2). Once subjects qualified for participation based on the Demographic Information Sheet, the researcher reviewed the athlete’s medical records to ensure no previous injury to the lower extremity.

The subjects’ preferred leg was determined. This was done by completing the push test. During the push test, the subjects stood erect and were gently pushed from behind. The leg that the subject moved forward to regain
stability was identified as the preferred leg. Participants were fitted for a functional knee brace to fit their preferred leg, according to the instructions that accompany the brace.

Once fitted for a brace, subjects each drew from two different groups of papers. Subjects were randomly assigned to treatments by drawing pieces of paper indicating the order in which they would participate in different tests for balance and proprioception (B), velocity (V), and agility (A). Each subject chose one paper at a time indicating which test they would complete at that time. Subjects then drew a piece of paper from a different group indicating whether they would be tested with the brace (WB) or without the brace (NB). In the case that a duplicate paper was drawn, subjects drew again until a new test or condition had been chosen. Each piece of paper was the same size, shape, color, and texture, and was folded in the same manner.

The researcher met with each subject a total of three times. The first meeting was an orientation and familiarization meeting. Subjects were asked to complete the Informed Consent (Appendix C1), Demographic Information Sheet (Appendix C2), push test, and were fitted for a knee brace. During this first meeting, subjects were also
introduced to the types of tests they would complete. The tests were demonstrated and then subjects performed a trial run of each test in each of the bracing conditions.

During the second meeting, subjects drew three pieces of paper stating the tests they would complete. The order in which they drew the papers was the order in which they completed the tests. They then drew another piece of paper stating the bracing condition in which they would complete the tests. The third meeting tested subjects in the opposite bracing condition. Selection of the order of tests followed the same protocol as the previous meeting. A 24-hour period was allotted between test days.

Subjects completed three trials of each test under each of the specified bracing conditions. All three trials of a particular test were conducted on the same day. Subjects were allowed a one-minute rest period between trials and five minutes rest between tests. The best score for each test was used for data analysis.

Before any testing occurred, each subject participated in a standard warm-up. The warm-up consisted of pedaling 5 minutes on a stationary bike, with the subject maintaining a velocity of 90-100 rpm, followed by a dynamic warm-up with cariocas, high knees, butt flicks, and quick step-ups. Two sets of the dynamic warm-up exercises were performed
for 30 seconds each, with 15 seconds rest between sets. All warm-ups were completed in the Hamer Hall gymnasium. A research assistant was properly instructed and supervised all warm-up sessions. Participants were sent for testing individually, so as not to have an unfair advantage of viewing the performance of their peers.

In order to familiarize participants with the BBS and the testing procedures, a practice trial was performed using the preferred leg. To test for balance and proprioception, all participants were tested on the BBS with and without a functional knee brace. Each participant was instructed to step up onto the platform system without shoes and assume a single leg stance on her dominant leg while maintaining her other leg in a comfortable position off the ground. Each subject was instructed to keep her arms down at her side to eliminate the possibility of unnoticed use of the stabilizers to regain balance during testing. A blindfold was used to ensure that visual feedback was eliminated. Industrial quality earplugs were used to ensure that auditory feedback was also eliminated. A one-minute rest period was allotted between trials.

The measurements for each trial were recorded on the data collection sheet for balance and proprioception (Appendix C4). Scores for all three trials were calculated
and recorded on this data sheet. The best score was used for data analysis. The testing protocol remained constant for tests done with and without the functional knee brace.

Participants were introduced to the 40-yard dash and were asked to run, at a moderate pace, one trial of the measured distance. The participant then returned to the starting line, while the researcher waited at the finish line. To eliminate reaction time, the subject started when she was ready and sprinted from the starting line completely through the finish line. Running velocity was evaluated using infrared sensors via the Wireless Sprint System™. Timing was started when the laser at the starting line was broken and completed when the laser at the finish line was broken.

Three trials of this test were completed, with one-minute rest between trials. The results were recorded on the data collection sheet for velocity (Appendix C4). Velocity scores for all three trials were recorded and the best score was used for data analysis. The testing protocol remained constant for tests done with and without the functional knee brace.

The researcher demonstrated proper technique for completing the T-test. Each participant then jogged through one trial to familiarize herself with the test. To
eliminate reaction time, the subject began the test when she felt ready. The Wireless Sprint System™ was used to measure the time it took each subject to complete the T-test. Time was measured from the start of the test, when the laser was first broken, to completion of the test, when the subjects’ feet had passed the last cone and the laser was broken again.

Three trials of this test were completed, with one-minute rest between trials. The results were recorded on the data collection sheet for agility (Appendix C4). Agility scores for all three trials were recorded and the best score was used for data analysis. The testing protocol remained constant for tests done with and without the functional knee brace.
Hypotheses

The following hypotheses were based on the literature reviewed when developing this research study and the insight of the researcher. The null hypothesis is listed for the following research hypotheses.

1. Balance and proprioception scores will not be different for athletes wearing a knee brace as compared to the scores for athletes not wearing a knee brace.

2. Velocity scores for athletes wearing a knee brace will show no difference as compared to scores for athletes not wearing a knee brace.

3. Agility scores for athletes wearing a knee brace will show no difference as compared to scores for athletes not wearing a knee brace.
Data Analysis

The level of significance for this study was set at $\leq 0.05$ for all statistical tests in order to test the hypotheses. All hypotheses were analyzed using a Paired Samples T-Test (WB or NB) and the variables (B, V, A).

Statistical analysis was conducted using SPSS version 12.0 for Windows.
RESULTS

The results section explains the data collected during the course of this study. This section contains the following subsections: Demographic Data, Hypotheses Testing, and Additional Findings.

Demographic Data

The demographic data collected from this study gave the researcher a better understanding of the subjects who participated.

Each volunteer was required to complete a demographic information sheet prior to participation in the study. This questionnaire required the participant to provide information regarding age, height, weight, sport, position, previous surgeries, previous experience with knee braces, etc.

The total number of participants in this study was 17. All participants were college-aged female athletes from California University of Pennsylvania. The population of participants consisted of two volleyball players, four softball players, one tennis player, and 5 athletes each from the soccer and tennis teams. Athlete’s ages ranged
from 18 to 23 years (M=19.41; SD=1.62). The subjects
ranged in height from 162.56 cm to 177.8 cm (M=170.48;
SD=4.57), and they weighed between 58.97 kg and 95.25 kg
(M=67.69; SD=10.27).

Of the 17 subjects, one had prior experience
participating in sports while wearing a knee brace. None
of the subjects had ever undergone knee ligament
reconstruction or other invasive surgical procedure, nor
did any of the subjects report having a chronically
unstable ankle. No subjects had any lower extremity
injuries within the past six months.

Hypotheses Testing

**Hypothesis 1**: Balance and proprioception scores will
not be different for athletes wearing a knee brace as
compared to the scores for athletes not wearing a knee
brace.

**Hypothesis 2**: Velocity scores for athletes wearing a
knee brace will show no difference as compared to scores
for athletes not wearing a knee brace.

**Hypothesis 3**: Agility scores for athletes wearing a
knee brace will show no difference as compared to scores
for athletes not wearing a knee brace.
Conclusion: Hypotheses 1, 2, and 3 were supported. A paired samples T-Test was calculated to compare the mean braced scores to the mean unbraced scores for balance and proprioception, velocity, and agility. The mean for the braced score for balance and proprioception was 6.93 ± 2.23 and the mean for the unbraced score was 6.99 ± 2.24. No significant difference between the braced and unbraced condition was found ($t(16) = -0.140, P > 0.05$) for balance and proprioception. The mean for the braced score for velocity was 6.33 ± 0.44 and the mean for the unbraced score was 6.24 ± 0.43. No significant difference between the braced and unbraced condition was found ($t(16) = 1.87, P > 0.05$) for velocity. The mean for the braced score for agility was 9.43 ± 0.69 and the mean for the unbraced score was 9.32 ± 0.60. No significant difference between the braced and unbraced condition was found ($t(16) = 0.915, P > 0.05$).

Table 1. Descriptive Statistics OBI, Velocity, and Agility

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>OBI with brace</td>
<td>6.93</td>
<td>2.23</td>
<td>17</td>
</tr>
<tr>
<td>OBI without brace</td>
<td>6.99</td>
<td>2.24</td>
<td>17</td>
</tr>
<tr>
<td>Velocity with brace</td>
<td>6.33</td>
<td>0.44</td>
<td>17</td>
</tr>
<tr>
<td>Velocity without brace</td>
<td>6.24</td>
<td>0.43</td>
<td>17</td>
</tr>
<tr>
<td>Agility with brace</td>
<td>9.43</td>
<td>0.69</td>
<td>17</td>
</tr>
<tr>
<td>Agility without brace</td>
<td>9.32</td>
<td>0.60</td>
<td>17</td>
</tr>
</tbody>
</table>
Table 2. Paired Samples T-Test for OBI, Velocity, and Agility with and without a Knee Brace

<table>
<thead>
<tr>
<th>Effect</th>
<th>Variable</th>
<th>df</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paired Samples T-Test</td>
<td>OBI</td>
<td>16</td>
<td>-0.140</td>
<td>0.890</td>
</tr>
<tr>
<td>Paired Samples T-Test</td>
<td>Velocity</td>
<td>16</td>
<td>1.87</td>
<td>0.081</td>
</tr>
<tr>
<td>Paired Samples T-Test</td>
<td>Agility</td>
<td>16</td>
<td>0.915</td>
<td>0.374</td>
</tr>
</tbody>
</table>

Additional Findings

Tests were completed to determine if additional findings were present. A multiple linear regression was calculated to predict subjects’ OBI based on their anterior/posterior (AP) and medial/lateral (ML) sway amplitude. A significant regression equation was found ($F(2,14)= 143.367, P < 0.001$) with an $r^2$ of 0.953. Subjects’ predicted OBI is equal to $0.796 + 1.0(\text{AP}) – 0.028(\text{ML})$ where AP is anterior/posterior sway amplitude and ML is medial/lateral sway amplitude. Subjects increased linearly 1.0 OBI for each AP, and subjects decreased 0.028 OBI for each ML. AP sway amplitude is the best predictor of OBI, while both AP and ML were significant predictors of OBI. There was no significant difference in the OBI based on brace condition.
DISCUSSION

This section contains the following subsections:
Summary, Discussion of Results, Conclusions, and Recommendations.

Discussion of Results

This study was conducted to investigate whether wearing a functional knee brace would negatively affect an athlete’s balance and proprioception, running velocity, and agility. The researcher hypothesized that there would be no change in athletic performance when subjects wore a knee brace as compared to their performance without a knee brace.

The experiment conducted in this research study involved 17 female subjects. Two subjects were eliminated from the study due to the parameters set by the Informed Consent (Appendix C1). These subjects volunteered to perform three trials each of a 40-yard dash, a T-test, and a test protocol for dynamic stability on the BBS. Subjects completed each test wearing a Donjoy Drytex Wraparound Playmaker™ functional knee brace and again without a knee brace (control). Subjects were timed in the 40-yard dash and T-test, and sway amplitude was measured for the BBS.
Once all data was collected, it was analyzed using Paired Samples T-Tests. A regression of the OBI for balance and proprioception was also done. Statistical analysis was conducted using SPSS version 12.0 for Windows.

According to the data collected in this study, the researcher concluded that the Donjoy Drytex Wraparound Playmaker™ did not negatively affect a subject’s balance and proprioception, running velocity, or agility. This data supports the researcher’s hypotheses that no significant difference would be found when comparing activities completed wearing a knee brace to those same activities completed not wearing a knee brace.

In this study, the data showed that the scores in the 40-yard dash and T-test while wearing the functional knee brace and in the control situation were not significantly different from one another. Literature based on previous studies supports these results. A study involving collegiate basketball players showed that bracing had no significant effect on running velocity. Functional knee braces contact a wearer’s knee, which may increase proprioception and improve gait biomechanics. These two factors may have compensated for any effects provided by the brace. Therefore, the difference in velocity and
agility scores for braced and unbraced conditions was insignificant.\textsuperscript{19}

Running velocity and agility scores from some other previous studies show differing results based on the type of brace being tested. The study by Greene et al,\textsuperscript{13} which studied six different functional knee braces, showed that the effect on speed and agility differed from brace to brace. Four out of the six braces tested significantly decreased running speed as measured by the 40-yard dash. Agility, however, as tested by the four-cone drill, was only significantly decreased (as compared to the control) with one of the six braces.\textsuperscript{13}

None of the reviewed literature had previously tested the DonJoy Drytex Wraparound Playmaker\textsuperscript{™}. Some researchers have found, when testing other braces, that there is a decrease in forward speed and agility in athletes wearing a functional knee brace as compared to unbraced control groups or healthy subjects.\textsuperscript{21-21} These researchers attributed the significant differences in sprint speed to the added weight of the brace on the lower limb.\textsuperscript{21}

The data collected from balance and proprioception tests does not demonstrate any significant difference between scores achieved while wearing the knee brace and not wearing a knee brace. A study by Risberg et al\textsuperscript{22} found no
significant differences in proprioception between the ACL-reconstructed and contralateral uninvolved knees. There was also no difference found between the ACL-reconstructed group and the healthy control group. Furthermore, there were no significant differences found in proprioception between braced and unbraced individuals for the ACL-reconstructed group or the healthy control group. Since current evidence does not provide any support or refusal for the effects of functional knee bracing on balance and proprioception, previous research does not conflict with the results of this study.

All testing was completed in a laboratory setting. The gymnasium provided a smooth, flat surface for testing and also removed the subject from any distracting circumstances. Had the testing been done in an athletic atmosphere, on an uneven or grassy surface with noise and commotion, the results may have been different.

Another limitation to this study is that all subjects were female athletes. The researcher assumed that each of these subjects was at a different phase of her menstrual cycle. Female bodies enter a state of decreased ligamentous integrity during the menstrual cycle. The menstrual cycle may have also affected subjects' balance, proprioception, velocity, and agility. The researcher
should have required information regarding menstruation on
the demographic information form.

Conclusions

The results of this study revealed that functional knee
bracing has no effect on athletic performance in uninjured
people. Because this study was conducted on uninjured
subjects, the knee brace was tested independent of injury.
Any performance differences in athletes wearing knee braces
are due to the injury and not to the knee brace.

Recommendations

Implications, with respect to the results of this study,
warrant the following research recommendations:

1) Consider testing both male and female athletes.

2) Consider testing the same protocol in a controlled
environment, such as the gymnasium, and an
uncontrolled environment, such as an outdoor field
and comparing the results.

3) Incorporate questions regarding menstruation on the
Demographic Information form.
REFERENCES


APPENDIX A

Review of the Literature
This literature review discusses the previous literature written regarding the development of this study: The effects of knee bracing on balance and proprioception, speed, and agility of uninjured female collegiate athletes. Knee bracing tends to decrease range of motion, therefore impeding performance. This literature review is divided into three sections: 1) Rehabilitation, 2) Bracing, and 3) Athletic Performance. Within the Bracing section, there are two subsections which include: 1) Form and Function of the Knee and 2) Injury Prevention and Protection. Within the Athletic Performance section, there are three subsections, which include: 1) Muscle Function, 2) Balance and Proprioception, and 3) Speed and Agility. A summary of the literature will be provided at the end of the literature review.

Rehabilitation of the Knee Joint

Functional rehabilitation of the knee following injury or surgical tissue repair incorporates many different facets of exercise. The goal of the particular arrangement of exercises is to return the athlete to the same state or condition they were in before the injury occurred. Providing rehabilitation services also allows the athletic
trainer to determine any underlying conditions or predisposing factors that may have caused the injury.¹

Bracing is a particularly important factor in the proper rehabilitation of knee injuries. Used appropriately, braces provide support and compression to the injured area. They also limit the range of motion of the joint, which helps to avoid harmful positions and allow proper healing to occur. Mullin¹ states that strict adherence to the range of motion restrictions for the specific injury is very important to prevent deleterious forces to the healing tissue. Bracing also provides proprioceptive feedback to the athlete and acts as a reminder to avoid overexertion and unnecessary motion.¹

The core is the foundation for all movement patterns of the body. The core is comprised of the hip, pelvis, and trunk and serves to connect the upper and lower extremities. Insufficient strength in the core can be detrimental to the extremities, especially in athletes. Weakness in the core may cause the pelvis to be tilted anteriorly, which could lead to hip adduction and internal rotation of the femur. Tibial external rotation is the subsequent result of this pattern. This postural position puts the athlete at an extreme risk for non-contact shearing and torsional injuries at the knee joint.¹
In a case study by Edward Leech, bracing is discussed in regards to reconstruction and rehabilitation of the anterior cruciate ligament of the knee. After ACL reconstruction, range of motion is limited and all precautions should be taken to avoid excessive stress to the knee joint. Bracing provides this kind of support. ACL reconstructed patients can expect to wear a knee brace when participating in all kinds of activities and may need to modify their competitive level in high risk sports.

Physicians often use functional braces in the treatment and rehabilitation of ACL grafted knees. It is necessary to protect the graft site, and a brace does this by limiting motion and preventing excessive loading of the graft site. It has not yet been determined how long the brace should be worn. It is suggested that after three months of bracing, quadriceps and hamstring atrophy occurs along with a significant decrease in the strength of these muscle groups. Functional bracing does not reduce further injury to the meniscus or hasten the return of proprioceptive sense. Bracing does, on the other hand, increase the athlete’s confidence in the ability of the injured area to perform.

In regards to early rehabilitation, many physicians are moving towards an accelerated type of therapy where the
knee brace is only used for stability without crutches, and only for a limited amount of time. The emphasis is on early return of active range of motion and early active weight bearing.²

Bracing the Knee Joint

Form and Function of the Knee

The knee is an extraordinary construction of living tissue structure. The kinematics and mechanics, along with the tissue’s cellular capacities and physiologic possibilities, comprise the form and function of the unit called the knee.³ A comprehensive understanding of the anatomy and biomechanical function of the knee joint is imperative for practitioners to make accurate diagnoses and, in turn, make decisions regarding treatment, rehabilitation, and bracing of that joint based on the diagnosis.⁴

The knee joint, comprised of the femorotibial joint and the patellofemoral joint, has very specific mechanics, kinematics, and function. The bony structure of the femur, tibia, and patella contribute to the overall stability of the knee joint, assisted by the restraining ligaments, capsule, and musculature surrounding the joint.⁵
The patellofemoral articulation is a joint between the patella and the femoral trochlea. This joint is most important when referring to the extensor mechanism of the knee and overall knee stability. By transmitting the extensor force across the knee joint at a greater distance from the axis of rotation, the patella increases the mechanical advantage of the quadriceps muscles.\footnote{5}

The tibiofemoral joint is the largest joint in the body, and is comprised of two condyloid articulations.\footnote{4} The knee joint is very incongruent when just analyzing the femur-tibia articulation. There are only two contact points between the femur and the tibia, yet the knee remains stable and functional for heavy load transmission.\footnote{3} The medial and lateral femoral condyles articulate with the medial and lateral tibial plateaus, while the medial and lateral menisci intervene to enhance the conformity of the joint.\footnote{4}

The medial side of the knee is divided into three layers.\footnote{6,7} The most superficial layer is the crural fascia, also known as the sartorial fascia. Layer one of the medial knee joint covers the popliteal fossa and its associated neurovascular structures. Layer two is represented by the superficial medial collateral ligament and contributes to the anterior retinaculum. The third,
and deepest, layer includes the deep medial collateral ligament and the joint capsule. The superficial medial collateral ligament originates at the medial femoral epicondyle and inserts into the flare of the tibia. The deep medial collateral ligament, in layer three, originates from an area proximal to the articular surface of the femur and inserts into the outer margin of the medial meniscus and then into the tibia. The medial collateral ligament is a primary restraint to external tibial rotation and a secondary restraint to anterior translation of the medial tibial plateau. Variations exist between individuals in the size or integrity of the medial collateral ligament. This appears to correlate with the strength and development of the musculature surrounding the knee joint.

The lateral aspect of the knee joint is divided into superficial and deep layers. The most superficial layer is made up of aponeurotic tissue, which wraps around the anterior aspect of the knee to connect with the sartorius on the medial side. In the deep layer of the lateral knee, the fascia lata runs longitudinally and inserts into Gerdy’s tubercle on the lateral tibia. More proximally, the fascia lata is connected to the lateral intermuscular septum.
The lateral collateral ligament and the lateral joint capsule contribute to the third and deepest layer. The lateral collateral ligament originates on the flare of the lateral epicondyle of the femur and inserts into the head of the fibula. The lateral collateral ligament is primarily responsible for resisting varus rotation in all positions of knee flexion.\textsuperscript{9}

The collateral ligaments, the medial collateral ligament and the lateral collateral ligament, are myotendinous structures that receive direct input from the muscle fibers. Dynamic balance occurs because of this myotendinous relationship. Balance of intrinsic and extrinsic forces also contribute to dynamic balance via the quadriceps muscle group (as a decelerator) and the hamstring muscle group by coordinating forces.\textsuperscript{3}

The medial and lateral menisci play an important role in transmission of forces through the knee joint. The menisci act on the knee joint by distributing the pressure and absorbing the shock. They precisely follow the roll-glide motion of the femoral condyle and increase the congruency of the joint surfaces.\textsuperscript{3} Overall, the menisci are thick and convex on the peripheral edges and taper off to a thin, free edge more centrally.\textsuperscript{4}
The medial meniscus is semicircular with a posterior horn wider than the anterior horn. The lateral meniscus is more circular in shape and covers a larger portion of the tibial plateau than the medial meniscus. The lateral meniscus is approximately the same width when measured anterior to posterior. The meniscal surfaces conform to the surfaces of the femur and tibia.\(^4\) With knee flexion from 0° to 120°, both menisci move posteriorly. The motion between the anterior and posterior horns of each meniscus allows the menisci to maintain optimal conformity to the bony surfaces of the tibia and femur during flexion.\(^4,10,11\)

The two cruciate ligaments, the anterior cruciate ligament and the posterior cruciate ligament, form the central pivot point of the knee joint. The crossed four-bar linkage of these two ligaments allows the knee joint six degrees of freedom. Three degrees of freedom allow for types of rotation: extension–flexion, external rotation–internal rotation, and varus–valgus rotation. The other three degrees of freedom allow for types of translation: anteroposterior, mediolateral, and compression–distraction.\(^3\)

The cruciate ligaments direct movement at the knee joint while stabilizing the joint and absorbing peak force stress.
The complex structure of the anterior cruciate ligament implies its importance in the function of the knee joint. The femoral attachment of the anterior cruciate ligament is the posterior-medial surface of the lateral femoral condyle. The tibial attachment of the ligament is a wide depression found anterior and lateral to the intercondylar eminence of the tibia. The anterior cruciate ligament is usually oriented directly in line with the midline of the femur when the knee is fully extended.\textsuperscript{4,12,13}

The anterior cruciate ligament plays a key role in maintaining controlled, fluid, and stable flexion and rotation of the knee joint. This ligament acts as a primary restraint to anterior translation of the tibia on the femur. Secondarily, the anterior cruciate ligament resists internal rotation, varus and valgus forces, and hyperextension.\textsuperscript{4,11-14} The anterior cruciate ligament does not resist posterior translation of the tibia on the femur.\textsuperscript{4,14}

The study by Girgis\textsuperscript{13} that provided much insight regarding the anterior cruciate ligament also presents valuable information about the posterior cruciate ligament. The femoral attachment of the posterior cruciate ligament is the lateral surface of the medial condyle. The ligament
runs vertically and posteriorly to attach into a depression between the two plateaus of the tibia. 4

The posterior cruciate ligament acts primarily to resist posterior translation of the tibia on the femur. This ligament acts as a secondary restraint to varus and valgus forces, and external rotation. 4,11,13-15 According to Gollehon et al, 15 the PCL is the only ligament able to provide a primary restraint to posterior translation of the tibia on the femur at all angles of flexion, but does not resist any anterior translation of the tibia on the femur. 4,14

Injury Prevention and Protection

The knee is the largest and most complex joint of the body. The knee bears the majority of body weight and is stimulated by the synergistic relationships among soft tissue restraints, such as ligaments and tendons, the musculature, and the bony architecture. 16

Stability of the knee tends to vary with the direction, mechanical loading, rotary forces, and angle of flexion. The knee is in an exposed position with long lever arm attachments, making it the joint most vulnerable to injury, especially during contact sports. 16
Knee braces have been used in sports for years to prevent injuries, rehabilitate injuries, or to provide support and protection to the unstable knee. Knee bracing has increased tremendously during the past ten years. There are several reasons for this increase in bracing, including a greater interest in preventing knee injuries, desire for early return to play of injured athletes after operative or non-operative treatment, desire of athletes to return to their original intensity level during play, and documented reports of the benefits of bracing. There are three major types of knee braces: rehabilitative, prophylactic, and functional. Functional knee bracing is most pertinent to this research study and will be the focus of this subsection.

Functional knee braces are devices that are designed to restore normal or near-normal motion to a knee that has ligamentous disruptions or chronic instability. Their primary biomechanical role is to reduce the amount of anterior translation and rotational forces that occur. Functional knee braces are now indicated to prevent further injury and are applied earlier in the course of rehabilitation to provide greater range-of-motion control.

Functional knee braces may be prefabricated or custom fitted. Custom fitted braces are more comfortable, but may
not be as effective due to the fact that limb girth and contour change dramatically as rehabilitation progresses and strength gains are made.\textsuperscript{16,19} Vandertuin and Grant\textsuperscript{17}, however, state that, although they are more expensive, custom fitted braces may be more effective than off-the-shelf braces because they are fabricated to match the exact contours of the athlete’s extremity.

An optimally designed functional knee brace strongly matches the kinematics of a normal knee. In order to facilitate a strong match, rigidity, tightness of fit, and placement of the brace are important. The axis of rotation of the brace should match that of the knee in order to avoid discomfort from the shearing of soft tissue beneath the brace.\textsuperscript{16}

Hinge position and hinge design are both important in matching knee kinematics, but hinge position is of greater relevance. In order to prevent abnormal knee kinematics, the connections between the brace and the soft tissue of the lower limb should be as rigid as possible to most closely match normal knee joint motion.\textsuperscript{16-18} Improper hinge placement limits the functional capability of the knee brace by increasing axial and anterior-posterior forces. If the hinge is improperly placed, strain may occur in the
cruciate ligaments. This may lead to suboptimal performance and result in ligamentous damage.\textsuperscript{20-22}

The two most common types of functional knee braces available are the shell-type brace and the strap-type brace. The shell-type brace uses a rigid, stiff, conforming outer shell to provide greater stability than the strap-type brace. The strap-type brace, however, uses flexible straps around the knee and medial and lateral metal stays to keep the brace in place.\textsuperscript{16,17}

Independent of the type or style of brace, functional knee braces are meant to decrease the amount of rotation and torque generated by the anterior-cruciate deficient knee. They usually have a biomechanical constraining effect that acts to prevent the leg from generating high forces, which the limb is capable of without the brace.\textsuperscript{16,17,23,24}

There are some perceived benefits for those with an unstable knee to wear a functional knee brace. It has been reported that, with a functional knee brace, patients have less complaints of the knee “giving out”, there is less pain with activity, and they are able to participate at a higher level of activity. Also reported are higher levels of confidence in the knee’s ability to perform normally.\textsuperscript{16,17,23,25-27}
A practitioner should choose a brace according to the individual needs of the athlete, the severity of the injury, the potential for rehabilitation, and the requirements for treatment. Several variables should be considered in the prescription of a knee brace, including laxity, pain, degree of stability of the knee, and the level of athletic competition the patient wants to maintain. An athlete with a greater degree of functional instability is the best candidate for a custom fitted, rigid brace. However, an athlete with an anterior-cruciate deficient knee but minimal laxity should show improved function with an off-the-shelf strap brace.\textsuperscript{16}

By opposing external forces, functional knee braces operate to maintain the knee joint in its proper alignment. Theoretically, functional knee braces redistribute force and minimize abnormal or excessive movement of the knee joint. An ideal functional knee brace would allow for movement in all planes of motion, while restricting any motion beyond the athlete’s physiological range. An athlete should be able to take part in aggressive competition without experiencing any subluxation.\textsuperscript{17,20,28,29}

A study by Brandsson et al\textsuperscript{30} investigated whether a knee brace was advantageous after ACL reconstruction. The principal finding in this study was that, following an ACL
reconstruction, the overall function of the knee was not influenced by the use of a brace during the early rehabilitation period. However, the patients who incorporated a brace into their rehabilitation had less pain and had a decreased tendency towards complications during the first two post-operative weeks. In an article by Mallory et al, it is stated that knee bracing does not significantly protect against injury during recovery following ACL reconstruction. The use of a knee brace following ACL reconstruction does not improve stability or speed up the rehabilitation process. Athletes wearing a knee brace after ACL reconstruction might report subjective enhanced performance, but measured performance is better without the brace.

The Effects of Bracing on Athletic Performance

Muscle Function

Deficiency of the ACL can result in an overall functional instability of the knee joint. The ACL contains mechanoreceptors that are sensitive to knee joint movements and are important in the control of muscle reflex actions.

Functional knee braces are often used by people with ACL deficiency or after a surgical reconstruction of the ACL. Studies on the mechanical efficacy of knee braces
reveal that the braces can provide mechanical protection to the knee under low-loading conditions like walking, but not under high-loading conditions like sport activities.\textsuperscript{26,32,33}

Some researchers suggest that when an athlete wears a knee brace, the threshold of movement detection is lowered in the knee and muscle activities can be better integrated so that body sway is decreased.\textsuperscript{34,35} Wu et al\textsuperscript{36} compared the efficacy of a DonJoy\textsuperscript{TM} functional knee brace, a placebo brace, and no brace in subjects with ACL reconstruction during running, jumping, knee joint repositioning, and isokinetic testing. Subjects demonstrated slower running times in both bracing conditions than without a brace. They attributed these differences to the extra weight of the brace on the lower limb.\textsuperscript{36}

Beynnon et al\textsuperscript{28} studied the strain in the ACL with and without the use of a brace using an in vivo Hall transducer. They found that the braced group had lower strain values when the subjects rose from a seated position to a standing position. They concluded that the brace had a protective effect on the ACL in both weight-bearing and non-weight-bearing conditions.\textsuperscript{28}

DeVita and Hortobagyi\textsuperscript{37} found that a functional brace protected the ACL during the stance phase of walking. They found that a functional knee brace may help to develop
neuromuscular adaptation during walking after ACL reconstruction.\textsuperscript{37}

Recent reports have emphasized the potential detriment that may be caused by knee braces when it comes to athletic performance. Braces have been reported to compromise knee flexion and extension and, therefore, the strength of the quadriceps and hamstrings muscle groups. This has been demonstrated in healthy athletes and in individuals with knee pathology.\textsuperscript{36,38–41}

It has been concluded that knee braces provide external compression on the leg and thigh muscles, and this results in an increase in intramuscular pressure at rest and in muscle relaxation pressure during exercise.\textsuperscript{39} Muscle contraction pressure is a measure of the force output from a muscle, and is increased in braced legs. The increased pressure is not a measure of increased force generation. It is a measurable result of the external compression put forth by the brace. Force generation during knee extension was found to be decreased by 30\% in the braced leg.\textsuperscript{41}

Muscle function is important to prevent injury. Individuals have demonstrated that it is difficult to contract the leg musculature fast enough to provide a significant protective effect. Voluntary reaction times have also been shown to be too slow to protect the knee
from injury. The muscles and ligaments are unable to absorb enough energy to prevent injury when the leg is braced.\textsuperscript{42,43} Functional knee braces also increase the energy expenditure of runners and, therefore, muscle fatigue is elicited significantly faster in braced legs as compared to unbraced legs.\textsuperscript{44}

Neuromuscular function in the leg seems to be altered by the external compression of the brace. Most braces appear to consistently slow hamstring muscle reaction times during voluntary contractions. The slowed muscle reaction time caused by functional knee braces is a cause for concern, according to Wojtys et al.\textsuperscript{45}

Balance and Proprioception

When evaluating the effectiveness of functional knee braces, the possible proprioceptive effects of brace wear must be considered. There are afferent nerve endings in the ACL, which means that ACL deficient athletes and ACL reconstructed athletes are lacking a certain amount of proprioceptive input to the central nervous system. Afferent feedback plays a critical role in maintaining dynamic closed kinetic chain knee stability, both in sport and in activities of daily living. Functional knee braces
are not thought to be effective during open kinetic chain activities.\(^{20}\)

Afferent feedback from a number of receptors located in the skin, muscles, ligaments, and joint capsule contribute to the overall proprioceptive mechanism of the knee joint.\(^{46-48}\) Most of the cutaneous receptors respond to changes in movement and adapt rapidly.\(^{48,49}\) It has been suggested that knee bracing augments afferent input by providing increased cutaneous stimulation.\(^{48,50}\)

A study by Risberg et al\(^{51}\) found no significant differences in proprioception between the ACL-reconstructed and contralateral uninvolved knees. There was also no difference found between the ACL-reconstructed group and the healthy control group. Furthermore, there were no significant differences found in proprioception between braced and unbraced individuals for the ACL-reconstructed group or the healthy control group.\(^{51}\)

**Velocity and Agility**

A study involving collegiate basketball players showed that bracing had no significant effect on running speed. Functional knee braces contact a wearer’s knee, which may increase proprioception and improve gait biomechanics. These two factors may have compensated for any effects
provided by the brace. Therefore, the difference in velocity and agility scores for braced and unbraced conditions was insignificant.\textsuperscript{52}

A decrease in forward speed and agility has been found in athletes wearing a functional knee brace as compared to unbraced control groups. Greene et al\textsuperscript{53} found that those braces which provided the most subjective stability were the ones that hindered performance times in healthy athletes. It is possible that increased stability may come at the expense of impaired performance capabilities.

The study by Greene et al\textsuperscript{53}, which studied six different functional knee braces, also showed that the effect on speed and agility differed from brace to brace. Four out of the six braces tested significantly decreased running speed as tested by the 40-yard dash. Agility, however, as tested by the four-cone drill, was only significantly decreased (as compared to the control) with one of the six braces.\textsuperscript{53}

A study has revealed that knee bracing does inhibit specific performance parameters in subjects unaccustomed to wearing knee braces. This inhibition may result in subsequent decreases in athletic performance. Forward sprint speed in the 40-yard dash was found to be
significantly inhibited while wearing the knee brace as compared to healthy subjects. \textsuperscript{54}

Summary

Some physicians recommend that a knee brace of some type be used after injury for any type of strenuous exercise to help the athlete regain proprioception. The delicate feeling of the position of the knee while walking, running, or cutting is very gradual, but it is very important for the athlete to regain this joint position sense. \textsuperscript{2}

As of now, there is no general definition of proprioception, much less a generally accepted method of assessing this quality. The enhancement of proprioception by functional knee bracing cannot be supported or refuted on the basis of current evidence. \textsuperscript{20}

There was no general consensus provided among the literature regarding speed and agility. Speed and agility seem to differ depending on the type of brace being tested. Recommendations have been made in the literature regarding further research and testing of the effect of knee bracing on speed and agility. \textsuperscript{53}

All of the structures within the knee joint are able to work to their fullest capacity for athletic performance
when visual, auditory, and proprioceptive sensorimotor skills are optimally developed and perform in a simultaneous manner. Understanding the form and function of the knee joint increases the practitioner’s comprehension of functional anatomy, improves specific diagnoses, helps them to choose the best treatment, and aides in the better design of rehabilitation programs and training methods. ³

Athletic trainers and therapists should always educate their athletes regarding techniques for proper brace application and alignment. It is important to also teach athletes how to maintain this proper alignment during physical activity. Functional knee bracing should always be used in conjunction with a rehabilitation program focused on quadriceps and hamstring strength, coordination, and proprioception. Proper training increases muscle tone and provides a solid base for bracing, and this should enhance any benefits that might be provided by the functional knee brace. ²⁰

Functional knee braces give valuable support to athletes with unstable knees. They also act as a valuable rehabilitative tool following invasive surgical procedures. However, the adverse effects of knee bracing include premature muscle fatigue and increased energy expenditure.
This is due to impaired blood flow to the local musculature resulting from the external compression of the brace. It is concluded that functional knee braces do not improve athletic performance and may even inhibit performance.
APPENDIX B

The Problem
The Problem

Statement of the Problem

The primary purpose of this study was to investigate the effect of knee bracing on balance and proprioception, velocity, and agility in healthy college-aged subjects. The study used the Biodex™ Balance System to test balance and proprioception, a timed T-test for agility, and a timed 40 yard dash for running velocity. Each subject served as her own control, being tested with and without a knee brace on the subject’s preferred leg. Scores with bracing were compared to the scores obtained without bracing. The purpose of this research was to determine whether knee bracing impedes the athlete’s range of motion so much that their performance is also affected. An athlete with a decreased range of motion may also have a decrease in balance, agility, and velocity. Therefore, these athletes may be at a greater risk for obtaining further injury.

Definition of Terms

The following definitions of terms are operationally defined throughout this study:

1) Agility: Agility is lateral running velocity. It is the ability to decelerate, stabilize, accelerate and change
direction without the loss of proper posture, speed, strength, balance, or body control. Agility requires optimum neuromuscular control and efficiency because the athlete is consistently regaining their center of gravity over their constantly changing base of support.  

2) Functional knee brace: Functional knee braces are designed to provide stability to an unstable knee during a return to stability-challenging rehabilitation or sports activities. A functional knee brace may be custom-fitted or off-the-shelf, and are usually prescribed for ACL-deficient and ACL-reconstructed individuals.

3) Proprioception: Proprioception is the ability to acknowledge input from various mechanoreceptors in muscles, tendons, and joints. Information from the mechanoreceptors is processed by the central nervous system. The central nervous system ultimately communicates by indicating where the limb is in space. Proprioception is assessed by measuring kinesthesia (perception of movement) and joint position sense (perception of joint position).

4) T-test: The T-test is a measure of four-directional agility and body control. It measures the ability to change directions rapidly while maintaining balance and without decreased velocity.
Basic Assumptions

The following are the basic assumptions for this study:

1) Subjects will be honest in reporting no lower extremity injuries within the past six months.
2) All subjects will perform to the best of their ability.
3) The subjects will not perform any training program on their own.
4) Proper bracing application will be executed.
5) The Biodex™ Balance System is a valid and reliable \((r = 0.90 \text{ (OBI)}, r = 0.86 \text{ (AP)}, r = 0.76 \text{ (ML)})\) tool to measure balance and proprioception.\(^55\)
6) The 40-yard dash is a valid and reliable \((r = 0.53)\) tool to measure maximum speed exertion.\(^56\)
7) The timed T-test is a valid and reliable \((r = 0.96)\) test to measure maximum agility exertion.\(^56,57\)
8) The Wireless Sprint System™ is a valid and reliable \((r = 0.95)\) tool to accurately measure time, as compared to handheld timing devices.\(^59\)
Limitations of the Study

The following are the possible limitations of this study:

1) Some subjects may sustain an injury during the course of the study, which may cause them to be eliminated from the study.

2) Because testing will be done in a laboratory setting, the results may not be applicable in less controlled settings.

3) Because only one type of brace is being tested, the results may not be generalized for all types of knee braces.

4) The study did not control for the stage of the menstrual cycle in subjects. Subjects may have had decreased balance, proprioception, and running velocity due to these natural occurrences of the body.
Significance of the Study

Balance, proprioception, agility, and running velocity all have a huge impact on an athlete’s overall performance. Athletes often train to enhance these aspects of their performance. When they are injured, rehabilitation is necessary to regain these factors of their overall physical fitness and ability to compete.

Once the athlete is ready to return to play after knee injury, they are often provided with a bracing system to prevent re-injury. These braces limit range of motion and are sometimes heavy, which impedes the athlete’s ability to perform. Some studies suggest that bracing prevents re-injury, and that prophylactic bracing prevents the initial injury. However, without full ROM, full balance, proprioception, velocity, and agility cannot be obtained. This may cause the athlete to be more prone to injury during each exposure.

This study attempted to determine whether knee braces affect an athlete’s ability to perform to their full potential. The results of this study could assist certified athletic trainers and brace manufacturers in the production and prescription of braces in the future.
APPENDIX C

Additional Methods
APPENDIX C1

Informed Consent
Informed Consent Form

1. Amy Morocco, who is a Graduate-Assistant Certified Athletic Trainer, has requested my participation in a research study at California University of Pennsylvania. The title of the research is “The effects of functional knee bracing on the balance and proprioception, speed, and agility of uninjured female athletes.”

2. I have been informed that the purpose of the research is to determine whether knee braces impair an athlete’s ability to perform to their full potential. I understand that I have been asked to participate, along with 24 other participants, because I have reported no lower extremity injury within the past six months and because I am currently an athlete at California University of Pennsylvania.

3. My participation will involve the testing of my balance and proprioception, speed, and agility both with and without a properly applied knee brace. Reliable and valid tools such as the Biodex™ Balance System, 40-yard dash, and T-test for agility will be used to measure my performance. My participation in this study will consist of three meetings.

4. I understand there are foreseeable risks or discomforts to me if I agree to participate in the study. The possible risks and/or discomforts include injury from falling due to poor balance and proprioception, delayed onset muscle soreness due to physical activity, and lower extremity injury due to the nature of physical activity being performed. In order to minimize these risks and/or discomforts, the researcher will provide a spotter during balance and proprioception activities, along with treatment and/or stretching to offset muscle soreness due to testing.

5. I understand that, in case of injury, I can expect to receive treatment or care in Hamer Hall’s Athletic Training Facility. This treatment will be provided by the researcher, Amy Morocco, ATC, or another Certified Athletic Trainer, either of whom can administer emergency and rehabilitative care. Additional
services needed for prolonged care past three days will be referred to the attending physician at the Downey Garofola Health Center located on campus.

6. I understand that if I am or may become pregnant, the particular testing procedures may involve risk, foreseeable or currently unforeseeable, to me or to my embryo or fetus.

7. There are no feasible alternative procedures for this study.

8. I understand that the possible benefits of my participation in the research are enhancing the understanding of injury prevention and rehabilitation, contributing to the enhancement of existing research, and gaining knowledge of one’s own level of athletic performance.

9. I understand that the results of the research study may be published, but that my name or identity will not be revealed. In order to maintain confidentiality of my records, Amy Morocco, ATC, will maintain all documents in a secure location in which only the researcher and research advisor can access. Subjects will be assigned numbers and will only be referred to by those numbers during the testing process.

10. I understand that Amy Morocco, ATC, will inform me of any significant new findings that develop during the research that may affect me and influence my willingness to continue participation.

11. I have been informed that I will not be compensated for my participation.

12. I have been informed that any questions I have concerning the research study or my participation in this study, before or after my consent, will be answered by Amy Morocco, ATC, 947 Cross Street, Apt. 3, California, PA 15419, 724-938-2533, amy_morocco@hotmail.com, or by Dr. Bruce Barnhart (research advisor), Hamer Hall, California University, 724-938-4562, barnhart@cup.edu.
13. I understand that written responses may be used in quotations for publication, but my identity will remain anonymous.

14. I understand that my participation in this research study may be terminated by the researcher without my consent if I prove to be consistently tardy, uncooperative, or noncompliant.

15. I have read the above information. The nature, demands, risks, benefits, and technical terms associated with this project have been explained to me. I knowingly assume the risks involved, and understand that I may withdraw my consent and discontinue participation at any time without penalty or loss of benefit to myself. In signing this consent form, I am not waiving any legal claims, rights, or remedies. A copy of this consent form will be provided to me.

Subjects signature: ___________________________ Date: __________

Witness signature: ___________________________ Date: __________

16. I certify that I have explained to the above individual the nature and purpose, the potential benefits, and possible risks associated with participation in this research study, have answered any questions that have been raised, and have witnessed the above signature.

17. I have provided the participant a copy of this signed consent document.

Researcher’s signature: ______________________ Date: __________

Approved by the California University of Pennsylvania IRB.
APPENDIX C2

Demographic Information Sheet
Demographic Information

1. Age: ______
2. Height: ______
3. Weight: ______
4. Sport: _____________________________
5. Position: ___________________________
6. Have you had any lower extremity injury within the past six months? Yes No
7. Have you ever participated in sport while wearing a knee brace? Yes No
8. Have you ever undergone any knee ligament reconstruction or other invasive surgical procedure? Yes No
   If yes, explain:_____________________________________________________
9. Do you have a chronically unstable ankle (i.e. Does you often sprain or “roll” your ankle)? Yes No

Research use:

Push Test: R L
Brace size: S M L
APPENDIX C3

IRB Form
# California University of Pennsylvania

## PROTOCOL for Research Involving Human Subjects

Institutional Review Board (IRB) approval is required before beginning any research and/or data collection involving human subjects.

- [ ] Request for Exempt Review
- [x] Request for Expedited Review
- [ ] Request for Full Board Review

(Reference IRB Policies and Procedures for clarification)

<table>
<thead>
<tr>
<th>Project Title</th>
<th>The effects of functional knee bracing on the balance and proprioception, velocity, and agility of uninjured female athletes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researcher/Project Director</td>
<td>Amy Marie Morrocco</td>
</tr>
<tr>
<td>Phone #</td>
<td>(724) 938-2533</td>
</tr>
<tr>
<td>E-mail Address</td>
<td><a href="mailto:Amy_Morocco@hotmail.com">Amy_Morocco@hotmail.com</a></td>
</tr>
<tr>
<td>Faculty Sponsor (if you are a student)</td>
<td>Dr. Bruce Barnhart</td>
</tr>
<tr>
<td>Department</td>
<td>Health Science and Sport Studies</td>
</tr>
<tr>
<td>Project Dates</td>
<td>January 2005 to May 2005</td>
</tr>
<tr>
<td>Sponsoring Agent (if applicable)</td>
<td></td>
</tr>
<tr>
<td>Project to be Conducted at</td>
<td>California University of Pennsylvania</td>
</tr>
<tr>
<td>Purpose of the Project</td>
<td>[x] Thesis</td>
</tr>
<tr>
<td></td>
<td>[ ] Research</td>
</tr>
<tr>
<td></td>
<td>[ ] Class Project</td>
</tr>
<tr>
<td></td>
<td>[ ] Other</td>
</tr>
</tbody>
</table>

## Required IRB Training

The training requirement can be satisfied by completing the online training session at [http://cme.nci.nih.gov/](http://cme.nci.nih.gov/). A copy of your certification of training must be attached to this IRB Protocol. If you have completed the training at an earlier date and have already provided documentation to the California University of Pennsylvania Grants Office, please provide the following:

- [ ] Previous Project Title
- [ ] Date of Previous IRB Protocol
(All Proposals Must be Typed)

1. Give a brief overview of your project/proposal with research hypothesis.

   The purpose of this research study is to determine the effects of functional knee bracing on the athletic performance of uninjured athletes. It is hypothesized that balance and proprioception scores will not be different for athletes wearing a knee brace as compared to the scores for athletes not wearing a knee brace; velocity scores will not be different for athletes wearing a knee brace as compared to scores for athletes not wearing a knee brace; and agility scores will not be different for athletes wearing a knee brace as compared to scores for athletes not wearing a knee brace.

2. Give a brief description of the subjects you plan to use, and check the appropriate box(es) below.

   - Adult Volunteers
   - Minor Volunteers
   - Children Under 18
   - CAL University Students
   - Minorities
   - Disadvantaged
   - Mentally Ill
   - Elderly
   - Mentally Retarded
   - Physically Handicapped
   - Prisoners
   - Pregnant Women

3. Is remuneration involved in your project? □ Yes or □ No
   If yes, Explain below.

4. How do you plan to select subjects? Did they volunteer? Is participation required?
   Explain below.

   Subjects will be selected based on convenience. Uninjured female athletes from California University of Pennsylvania will be asked to volunteer to participate in this study.

5. Does your project involve use of a consent form? □ Yes or □ No
   If yes, attach the form.

6. What instruments or devices will be used to gather data? Provide a copy of documentation pertaining to the data collection, such as but not limited to:
   Cover letter, questionnaire/survey, consent form, interview/focus group sheets.

   The BiodeX™ Balance System and Wireless Sprint System by Brower Timing Systems, Inc. will be used to gather data. All data will be recorded on the Data Collection Sheets. Athletes will also complete an Informed Consent form and a Demographic Information Sheet. Please see attached photographs and Appendices.

7. Is this project part of a grant? □ Yes or □ No
   If yes, provide the following information:

   Title of the Grant Proposal ____________________________________________

   Name of the Funding Agency ____________________________________________

   Dates of the Project Period ____________________________________________
8. **Does your project involve the debriefing of those who participated?** □ Yes or ☒ No
   If yes, explain the debriefing procedure.

9. **The Federal Regulations require that the protocol meet certain criteria before IRB approval can be obtained. Describe in detail how the following requirements will be satisfied:**

   **A. Ensure that the risks of the subject are minimized.**

   In order to minimize any risks and/or discomforts, the researcher will provide a spotter during balance and proprioception activities, along with treatment and/or stretching to offset muscle soreness due to testing.

   **B. Justify the degree of risk involved (if any) in relationship to the potential of the project to the subject matter.**

   There are foreseeable risks or discomforts to the participant if she agrees to participate in the study. The possible risks and/or discomforts include injury from falling due to poor balance and proprioception, delayed onset muscle soreness due to physical activity, lower extremity injury due to the nature of physical activity being performed.

   **C. Ensure that the selection of the subjects is equitable.**

   Subjects have been asked to participate because they have reported no lower extremity injury within the past six months and because they are currently a female athlete at California University of Pennsylvania.

   **D. Guarantee that informed consent will be obtained for each prospective subject or the subject’s legally authorized representative and that consent forms will be adequately documented.**

   Subjects will each be provided an informed consent form. Subjects will not be allowed to participate in the study without giving their informed consent. Forms will be kept on file and a copy will be provided to each participant.

   **E. Monitor the data collected to ensure the safety of the subject.**

   Data that has been collected will be recorded on the Data Collection Sheets found in Appendix C4.

   **F. Protect the privacy of subjects and maintain the confidentiality of data.**

   The results of the research study may be published, but the subjects’ name or identity will not be revealed. In order to maintain confidentiality of records, Amy Morocco, ATC, will maintain all documents in a secure location in which only the researcher and research advisor can access. Subjects will be assigned numbers and will only be referred to by those numbers during the testing process.

   **G. Provide for extra safeguards to protect the rights and welfare of “vulnerable” subjects (e.g., children, prisoners, pregnant women, mentally disabled persons or economically or educationally disadvantaged persons).**
The nature, demands, risks, benefits, and technical terms associated with this project will be explained to the participants. Each participant will knowingly assume the risks involved, and understand that she may withdraw her consent and discontinue participation at any time without penalty or loss of benefit to herself. If any participant is or may become pregnant, she will be eliminated from the study. Amy Morocco, ATC, will inform each participant of any significant new findings that develop during the research that may affect her and influence her willingness to continue participation.

Project Director’s Certification
Program Involving HUMAN SUBJECTS

The proposed investigation (research or training program) involves the use of human subjects and I am submitting the complete application form and description of the project to the Institutional Review Board for Research Involving Human Subjects.

If the Board grants approval of this application, I agree to:

1. Abide by any conditions or changes in the project required by the Board.
2. Report to the Board any change in the research plan that affects the method of using human subjects before such change is instituted.
3. Report to the Board any problems that arise in connection with the use of human subjects.
4. Seek advise of the Board whenever I believe such advice is necessary would be helpful.
5. Secure the informed, written consent of all human subjects participating in the project.
6. Cooperate with the Board designed in its effort to provide a continuing review after investigations have been initiated.

I have reviewed the Federal and State regulations concerning the use of human subjects in research and training programs and the guidelines. I agree to abide by the regulations and guidelines aforementioned and will adhere to policies and procedures described in my application. I understand that changes to the research must be approved by the IRB before they are implemented.

Professional Research

Signature of Project Director  

Signature of Department Chairperson

Student Research

Signature of Student Researcher

Signature of Faculty Member  

Signature of Department Chairperson
ACTION OF REVIEW BOARD

The Institutional Review Board for Research Involving Human Subjects has reviewed this application to ascertain whether or not the proposed project:

1. provides adequate safeguards of the rights and welfare of human subjects involved in the investigations;
2. uses appropriate methods to obtain informed, written consent;
3. indicates that the potential benefits of the investigation substantially outweigh the risk involved.
4. provides adequate debriefing of human participants.
5. provides adequate follow-up services to participants who may have incurred physical, mental, or emotional harm.

Chairperson, Institutional Review Board

Date 1/12/05
APPENDIX C4

Data Collection Sheets
## Data Collection

### Balance and Proprioception

<table>
<thead>
<tr>
<th>Subject Number</th>
<th>Without Brace</th>
<th>With Brace</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>T2</td>
<td>T3</td>
</tr>
<tr>
<td>a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p</td>
<td></td>
<td></td>
</tr>
<tr>
<td>m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p</td>
<td></td>
<td></td>
</tr>
<tr>
<td>m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p</td>
<td></td>
<td></td>
</tr>
<tr>
<td>m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Data Collection

Running Velocity

<table>
<thead>
<tr>
<th>Subject Number</th>
<th>Without Brace</th>
<th>With Brace</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>T2</td>
<td>T3</td>
</tr>
<tr>
<td>T1</td>
<td>T2</td>
<td>T3</td>
</tr>
<tr>
<td>T1</td>
<td>T2</td>
<td>T3</td>
</tr>
<tr>
<td>T1</td>
<td>T2</td>
<td>T3</td>
</tr>
<tr>
<td>T1</td>
<td>T2</td>
<td>T3</td>
</tr>
<tr>
<td>T1</td>
<td>T2</td>
<td>T3</td>
</tr>
<tr>
<td>T1</td>
<td>T2</td>
<td>T3</td>
</tr>
<tr>
<td>T1</td>
<td>T2</td>
<td>T3</td>
</tr>
<tr>
<td>T1</td>
<td>T2</td>
<td>T3</td>
</tr>
<tr>
<td>T1</td>
<td>T2</td>
<td>T3</td>
</tr>
<tr>
<td>T1</td>
<td>T2</td>
<td>T3</td>
</tr>
<tr>
<td>T1</td>
<td>T2</td>
<td>T3</td>
</tr>
</tbody>
</table>
Data Collection

Agility

<table>
<thead>
<tr>
<th>Subject</th>
<th>Without Brace</th>
<th>With Brace</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>T1</td>
<td>T2</td>
</tr>
</tbody>
</table>

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C5

Instruments
Biodex Balance System™

T-Test for Agility

5 yards

C B D

5 yards

10 yards

A
Donjoy Drytex Wraparound Playmaker™

http://www.djortho.com
Wireless Sprint System™
Brower Timing Systems, Inc.

http://www.browertiming.com
REFERENCES


ABSTRACT

Title: The effects of functional knee bracing on the balance and proprioception, velocity, and agility of uninjured female athletes.

Researcher: Amy Marie Morocco

Advisor: Dr. Bruce D. Barnhart

Purpose: The purpose of this study was to determine the effect of the DonJoy Drytex Wraparound Playmaker™ functional knee brace on the balance and proprioception, velocity, and agility of uninjured female athletes.

Methods: Subjects were required to perform a 40-yard dash, a T-test for agility, and a test protocol on the Biodex™ Balance System while wearing a DonJoy Drytex Wraparound Playmaker™ functional knee brace. The test was repeated in an unbraced condition to serve as a control. Tests were assigned in random order.

Conclusion: The results of this study showed no significant difference in athletic performance, as measured by balance and proprioception, velocity, and agility, while wearing a knee brace as compared to no knee brace. All data was analyzed at the 0.05 level. The researcher concluded that the DonJoy Drytex Wraparound Playmaker™ functional knee brace did not negatively affect athletic performance. This research suggests that altered performance in athletes wearing the DonJoy Drytex Wraparound Playmaker™ is due to the knee injury and is not due to the knee brace.