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# Effects of Knee Braces on Strength and Range of Motion

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Hanover College  
Winter 2017

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# Abstract

Following knee injury, it's common to use a knee brace for security and support. Studies investigating the effects of knee braces on performance have been very controversial. Some studies have found that a brace decreases performance while others have found improved performance when it comes to range of motion and strength. The purpose of the present study was to investigate the effects of two different types of popular knee braces.

**Methods:** Eight relatively active college aged females participated in three experimental sessions wearing (A) A Don Joy Defiance III brace, (B) A Don Joy Performer Sleeve, or (C) A control session with no brace. Strength was tested during knee extensions performed on a Cybex Isokinetic Analysis Machine to determine peak torque. Range of motion was determined with a goniometer.

**Results and discussion:** Results reveal that the Don Joy Defiance III brace and the Don Joy Performer Sleeve both decrease range of motion when compared to the absence of a brace. The Don Joy Defiance III appears to have the greatest impact on strength, with the Performer Sleeve also slightly decreasing strength. These findings suggest that the Don Joy Defiance III brace may be less beneficial than the sleeve as well as the absence of the brace all together when it comes to promoting strength. Both braces compromise range of motion.

## Chapter 1

### Introduction:

Knee injuries are the second most common injury in sports (12). A common fix to many knee problems is to wear some type of knee brace. A knee brace acts as a support for an injured or painful knee. Many knee braces are not only employed after an injury but often times are utilized as a preventative measure. Prophylactic knee braces, braces that prevent injury, are known to help an athlete with stabilization but there are still questions as to how the athlete's performance is affected.

There have been many studies and disagreements regarding the effects of knee braces on athletic performance. Many research studies have been done trying to examine the effects of multiple different variations of knee braces and whether or not the effects on performance outweigh protection afforded from the brace. Studies have studied examined range of motion, power, speed, and vertical jump.

One study examined the use two different types of prophylactic knee braces on peak torque and speed. The results of this study showed that there was a significant decrease in peak

torque and speed when the individual was wearing one of the prophylactic braces versus when they were not. It was concluded that wearing a knee brace can inhibit muscular and functional performance of an athlete (5). Conversely, there have been studies that contradict this. These studies state that wearing the brace had little to no impact on strength, speed, or power (11).

Research has shown that with various prophylactic knee braces the performance of an athlete, such as their strength, power, and range of motion has been impacted in both positive in negative ways. Often times this variation in research results are dependent upon the population and the current health of the subjects. For example, during one study it was found that the peak torque of the non-injured knee versus the injured knee was on average 5-10 N/m greater (9). The health of the knee of the subject can strongly influence the results found. Though these results appear to be beneficial, further research needs to be done to test the effects that specific knee braces such as the Don Joy Defiance III and the Don Joy Performer sleeve have on performance aspects such as strength and range of motion.

#### **Statement of Purpose:**

The purpose of this study was to determine the effects of knee braces on strength and range of motion.

#### **Significance of Study:**

##### ***Professional significance:***

Females are almost six times more likely to injure their knee and more specifically their ACL than males are due to their hormones and body structure (15). Knee braces are everywhere but majority are seen on the sports field. There has been a lot of controversy surrounding knee braces and whether or not bracing is doing more harm than good. There have been many conflicting findings about whether or not knee braces do have a significant impact on performance.

##### ***Personal significance:***

The reasoning behind this study holds a personal significance. As a female soccer player not only have I experienced several knee injuries but I have also seen my fair share as well. For me personally, after my ACL reconstructive surgery I was told I was not allowed to wear a brace what so ever. This is completely contrary to most other people I have seen who have had this surgery. This sparked my curiosity as to why my doctor did not want me wearing a knee brace. Would it decrease my strength or affect my performance? These questions drove me to do research on some of the different effects of knee braces.

### **Delimitations:**

This study was a relatively small study done at Hanover College. All materials were provided by the institution.

There were 8 subjects who participated in the study. Two types of knee braces were employed in the study. Those two braces were the Don Joy Defiance III Brace and the Don Joy Performer Knee Sleeve. Strength (peak torque) and Range of Motion were tested.

### ***Applying Control:***

In order to confirm consistency when taking measurements of range of motion and other variables, control was needed in the study.

- To ensure the range of motion measured with the goniometer was consistent, the same individual took the measurements for all subjects.
- The non-dominant knee was tested in all sessions for all subjects.
- All subjects performed a warmup at the exact same resistance and speed.
- The same questions and encouragement were given to all subjects.

### ***Methods Preview:***

1. 3 sessions over the course of the study. A control session, Don Joy Defiance III Brace session, and Don Joy Performer Sleeve session.
2. Each subject acted as their own control. 8 subjects total were utilized.
3. A 5 minute warm up on the cycle ergometer was performed before each session.
4. Two knee extension strength tests using the Cybex and two range of motion tests using the goniometer were performed during each session.
5. Each session took roughly 30 minutes.
6. A measurement for comfortability was also taken throughout each session.

### ***Independent Variables:***

- Don Joy Defiance III Brace
- Don Joy Performer Sleeve



Figure 1 Don Joy Defiance III Brace



Figure 2 Don Joy Performer Sleeve

***Dependent Variables:***

- Range of Motion
- Peak Torque

***Equipment Used:***

- Cyclergometer – Utilized for a 5 minute warm up before strength tests were performed.
- Cybex – Utilized to measure knee extension peak torque during 60°/s and 180°/s tests.
- Goniometer- Utilized to measure flexion and extension range of motion.

**Limitations:**

One major limitation of this study was the reliability of range of motion measurements. The goniometer is the instrument employed to test ROM, though; the goniometer can often be misused which can cause the results to be unreliable.

Another limitation to this study is the subjects utilized. All of my subjects were college aged females thus my research may not be generalized to other populations.

**Assumptions:**

- All subjects will follow pre-test protocol.

- All subjects will give their best effort on all tests.
- The knee brace was the proper size for each subject.
- Range of motion was accurately measured with the goniometer.
- Each subject went through the same warmup and test protocol.

### Hypotheses:

*It was hypothesized that...*

- The Don Joy Defiance III Knee Brace will...
  1. decrease flexion.
  2. decrease extension.
  3. decrease strength.
- The Don Joy Performer Sleeve will...
  4. decrease flexion.
  5. decrease extension.
  6. decrease strength.

### Definition of Terms:

- **Goniometer:** Instrument utilized for the precise measurement of angles of a particular joint.
- **Cybex isokinetic machine:** A machine powered through software that measures peak torque through programmed exercises.
- **Range of motion:** Measurement of movement around a specific joint.
- **Peak Torque:** The force rotating about an axis. A term that indicates muscle strength.
- **Foot-Pounds:** A unit of energy equal to the amount required to raise 1 lb. a distance of 1 foot.
- **Knee extension:** When the angle between the thigh bone and the shin bone is 0 degrees.
- **Knee flexion:** A bending movement around the knee joint that decreases the angle between the thigh and shin bone.
- **Don Joy Defiance III Brace:** A hinged brace made with aluminum that provides support for ACL, PCL, MCL, and LCL instabilities.
- **Don Joy Performer Sleeve:** A brace designed to provide enhanced performance through compression, improved heat retention, and increased circulation.
- **Knee injury:** Accidents, impacts, sudden or awkward movements, or gradual wear and tear on the knee joint.
- **Vertical Jump:** The act of raising one's center of gravity higher in the vertical plane.



## Chapter 2

### Background:

#### **Knee structure:**

In order to understand how a knee brace can affect performance it is first important to understand how the structure and function of the knee.

#### ***Bones, Ligaments, Tendons***

The knee joint is composed of three main bones, the femur, tibia (shin bone), and patella. The ends of the femur, tibia and the back of the patella are covered in articular cartilage. The articular cartilage is somewhat of a slippery substance that helps the bones of the knee to move smoothly across each other when the knee is being bent or straightened. In addition to the articular cartilage there is also meniscus which acts as a shock absorber and sits between the femur and tibia. The meniscus though a type of cartilage, is different from articular cartilage. The meniscus is both tough and rubbery in order to help stabilize and cushion the knee joint (8).

The bones of the knee joint are connected by four main ligaments that help to keep the knee stable. The ligaments are broken up into two groups, the collateral and cruciate ligaments. The collateral ligaments are found on the sides of the knee. The medial collateral ligament is found on the inside of the knee and the lateral collateral ligament is on the outside of the knee. The purpose of these two ligaments is to control the sideways motion of the knee. Unlike the collateral ligaments the cruciate ligaments are found on the inside of the knee joint. These two ligaments are the anterior and posterior cruciate ligaments. The cruciate ligaments form an “X” in the joint and help to control the forward and backward translation of the tibia on the femur (8).

The last major component of the knee joint is the tendons. Tendons connect the muscles needed to move the knee, to the bones. The major tendons of the knee are the quadriceps tendon which connects the quadriceps muscles to the patella. The second major tendon is the patella tendon that goes from the patella to the tibia (8).

#### ***Summary:***

The knee joint is a complex structure that is made up of three major bones. The knee joint itself is unstable but with the support of four ligaments and two tendons it is well supported and stable. If one of the individual structures of the knee joint is injured the stability of the knee will be compromised.

### ***Movements and muscles associated with the knee***

The knee joint is considered to be a synovial hinge joint allowing for extension, flexion, and little internal and external rotation. The structure of the knee is crucial to everyday functions such as walking, running, kicking and jumping.

The knee joint is moved by three major muscle groups. These two muscle groups are the quadriceps and the hamstrings. The quadriceps group is made up of four muscles. The vastus lateralis, vastus medialis, vastus intermedius and the rectus femoris are located on the front of the thigh and assist in the extension of the knee. The hamstrings group, composed of the bicep femoris, semitendinosus, and semimembranosus, are on located on the back of the thigh and aid in the flexion of the knee. A third muscle group, the gastrocnemius, which attaches on the tibia also assists in the flexion of the knee joint (8).

#### ***Summary:***

The quadriceps muscles are responsible for the extension of the knee while the hamstring muscles and the gastrocnemius are responsible to the flexion the knee. The strengthening or weakening of either of these large muscle groups could greatly impact the function of the knee. The quadriceps with be the main focus of this study as knee extension peak torque is being tested.

### ***Production of knee strength***

Knee strength refers to the joints ability to exert a maximal amount of force for a short period of time. Strength is measured by peak torque through isokinetic testing. Fiber type of the muscles plays a large role in one's peak torque and duration of isokinetic contractions (2).

#### ***Types of muscle fibers***

##### ***Slow-twitch***

Slow-twitch fibers are also known as type I fibers. These muscle fibers are surrounded by capillaries and have a high concentration of mitochondria and myoglobin. This composition allows for the fibers to have a good capacity for aerobic metabolism and fatigue resistance. Type I fibers have lower myosin ATPase activity but they maintain longer contractions and are key for stabilization (6, 11). Type one fibers are often targeted for endurance training and low resistance exercise.

##### ***Fast-twitch***

Fast-twitch muscle fibers are also referred to as type II fibers. These fibers have a low concentration of mitochondria, myoglobin and capillaries. Type II fibers are larger in size and

help to produce a greater force than type I fibers. Fast-twitch fibers are often used for power activities (6, 12). Type II fibers are often recruited for strength and resistance training exercises. Fast-twitch fibers can also be broken down into two different types, Type IIx and Type IIa.

Type IIx fibers have a low oxidative capacity and thus rely heavily on anaerobic metabolism. While these fibers produce the most force they are very inefficient. Type IIa fibers are often times also referred to as the intermediate fibers because they are a mix of both type I and type IIx fibers. These fibers are able to use aerobic and anaerobic energy systems. Type IIa fibers, unlike type IIx fibers have a higher oxidative capacity and do not fatigue as quickly (6, 12).

#### *Summary:*

For individuals who have a higher percentage of fast-twitch fibers more torque is produced but become more fatigued than those with lower percentages of fast-twitched fibers (2). During an isokinetic knee extension test for peak torque the main muscle fibers that will be utilized will be type II muscle fibers.

### ***Knee Injuries***

Knee injuries cause pain to the knee. Most knee injuries are caused by accidents, impact, sudden or awkward movements, and gradual wear and tear of the knee joint. The most common types of knee injuries are fractures around the knee, dislocation, as well sprains and tears of soft tissues such as ligaments (8).

Ligament injuries are the most common injuries in high impact sports such as soccer, basketball, and football. Ligament injuries include damage to the anterior cruciate ligament, posterior cruciate ligament, lateral collateral ligament, and medial collateral ligament.

#### *Collateral ligament injuries*

Collateral ligament injuries are often caused by a force that pushes the knee sideways. These injuries often occur due to contact. A medial collateral (MCL) injury often occurs when the knee is directly hit on the outside of the knee forcing the knee inward. MCL injuries are the more common injury of the two collateral ligaments. Though rare, lateral collateral ligament injuries occur when the knee is directly hit on the inside, causing the knee to be forced outward. . Symptoms of a collateral ligament knee injury include swelling, pain on the side of the knee, and instability of giving way of the knee joint (8).

Injured collateral ligaments are often referred to as sprains and are separated into three grades. Grade one being a mild sprain, where the ligament is only slightly stretched, and still able to keep the knee joint stable. Grade two sprains are considered to be a partial tear of the ligament, the ligament as become loose. A grade three sprain often refers to a complete tear of the ligament

causing the knee joint to be unstable. During a grade one sprain an athlete may still participate in competition, but it is often advised that they wear a supportive brace. A brace is often recommended for any type of collateral ligament injury in order to help relieve the injured ligaments from stress as well as further protect the knee (8).

### *Cruciate ligament injuries*

The cruciate ligaments are found on the inside of the knee making an “X” controlling the back and forth motion of the knee. Like the collateral ligaments, the cruciate ligament injuries are divided into the same three grades. Grade one being a slight stretch, grade two, a partial tear and grade three being a complete tear. Often times the partial tear will only be found in the posterior cruciate ligament (PCL). Partial tears of the anterior cruciate ligament (ACL) are rare; most ACL injuries are complete tears.

ACL injuries can occur by changing direction, sudden stops, landing incorrectly after a jump, or through direct contact or collision. Symptoms of an ACL injury include pain, tenderness along joint line, swelling, loss of complete range of motion, and discomfort while walking. Surgery is needed in order to repair an ACL. Along with surgery a doctor may recommend a brace to protect the knee from instability (8).

Unlike ACL injuries, PCL injuries tend to be partial tears that have the ability to heal on their own. Often individuals who have injured their PCL have a hard time returning to sports without stability problems. PCL injuries are often caused by a direct blow to the front of the knee, a misstep, or hyperextension of the knee. Symptoms of PCL injuries include swelling, stiffness, difficulty walking, and giving way of the knee. For these types of injuries an immobilizing brace is often recommended to protect the knee and keep it from moving (8).

### *Summary:*

Knee injuries of any type can cause instabilities to the joint causing pain and discomfort. Depending on the severity of the injury surgery could be required but in most cases a knee brace is always recommended.

### **Knee Bracing:**

Knee braces made to prevent injury became popular in the 1970s when they were tested on NFL players. Because of this many studies have investigated the rate of injuries in athletes who wear prophylactic, or injury prevention braces. Evidence concerning the rate of injury associated with these braces is unclear, with only very small differences. The effectiveness of the knee braces is often dependent on the person and their size, the sport that is being played, as well as the position played in that sport (7).

Most knee braces are made with metal frames that restrict twisting of the knee as well as bending in the wrong direction. Along with metal frames many knee braces are made with elastic material known as neoprene that bends and flexes with the leg. This material helps to provide support while trying not to restrict range of motion (7).

### *Benefits of Bracing*

- Protection if an individual were to slip and fall
- Allows knee to rest
- Helps maintain extension of leg
- Keep knee warm
- Increase blood flow

### *Cons of Bracing*

- Uncomfortable
- Can make individual more likely to fall
- May prevent normal movements of the knee

Two different types of knee braces were utilized in this study, the Don Joy Defiance III and the Don Joy Performer Sleeve. In order to understand the purpose of the braces in the study, it is essential to first understand how they work.

### *Don Joy Defiance III*

The Don Joy Defiance III brace is utilized for ligament instabilities. The brace has an aluminum frame with a four point leverage system and fourpoint hinges.

#### Four Point Leverage system:

The four point leverage system has two anterior points and two posterior points. The first point is a cuff on the anterior side of the thigh and its purpose is to anchor the femur. The second point is a cuff on the posterior side behind the upper calf. This point acts to anchor the tibia. The third point is also on the posterior side and it is a strap that is applied to push the femur forward and thus push the hinges back on the knee. The fourth and final point is located on the anterior side of the tibia. This point brings the hinges back to the midline creating a posterior pre-load on the tibia which reduced the strain on the ACL. The metal points located across the front of the femur and back of the upper calf help to protect the ACL and PCL. The straps that go across the back of the thigh and the front of the shin bone serve to protect the MCL and PCL. The metal bars going down the side of the knee, connecting the hinges also help to support the MCL and PCL.

### Fourpoint Hinge:

The fourpoint hinge is a spring mechanism that gradually increases the resistance to the knee as the knee moves towards “at-risk” positions. This means that the hinge helps to slow down the acceleration of the knee during the last 25 degrees of extension which helps to reduce the athletes risk for injury. The purpose of this braces it to treat ACL, MCL, PCL, and LCL instabilities as well as prevent hyperextension (4).



**Figure 3 Fourpoint Hinge**

### *Don Joy Performer Sleeve*

Knee sleeves are designed in order to prevent future injuries. The knee sleeves add compression and warmth to the knee to help increase blood flow. In addition to increasing blood flow, the knee sleeve limits patella movement and can increase proprioception, the capacity to feel the position of a joint in a space that is sensed by the central nervous system. A knee sleeve is different than a knee brace in the sense that the sleeve does not provide ligament support (4).

### *Summary:*

Though the Don Joy Defiance III brace and the Don Joy Performer sleeve are very different in their forms of support for the knee, they both still have either a positive or negative impact on performance that are being investigated in this study.

### *Background Summary:*

The structure of the knee is crucial to the function of the knee. An injury to any part of the knee can affect the function of the knee. Knee braces are commonly used to help support or protect individuals from knee injuries and help them to perform as normal as possible.

## Literature Review:

Knee bracing is a very conflicting matter with some studies stating that braces do more good than harm, while others say the opposite. Research is still being done to determine exactly how knee braces affect the performance of an athlete.

**Hypothesis 1: The Don Joy Defiance III Knee Brace will decrease extension.**

**Hypothesis 2: The Don Joy Defiance III Knee Brace will decrease flexion.**

**Hypothesis 4: The Don Joy Performer Sleeve will decrease extension.**

**Hypothesis 5: The Don Joy Performer Sleeve will decrease flexion.**

- 1.) Schmidt, Alexis P.; Hearon, Christopher M.; and Daniel, Michael (2013) "The Effect of Prophylactic Knee Braces on Balance and Uninjured Knee Range of Motion," *International Journal of Exercise Science: Conference Proceedings*: Vol. 2: Iss. 5, Article 67.
- 2.) Arnold, Lauren R.; Helbig, Casi; Newberry, Jim; and Kent, Tim (2015) "Walk This Way: The Effects of Wearing a Knee Brace on Gait," *International Journal of Exercise Science: Conference Proceedings*: Vol. 2: Iss. 7, Article 42.

These two articles support Hypotheses 1,2,4 & 5 in that each study gives evidence that knee braces and knee sleeves decrease range of motion. The study by Schmidt et al. was a study that took four different range of motion measurements using a goniometer. This study concluded that range of motion was decreased by the use of knee sleeves as well as hinged knee braces. Another study by Arnold et al. looked at the effects of knee bracing on gait patterns. This study concluded that gait pattern was changed when a knee brace was worn. With these conclusions, assumptions were able to be made that the range of motion of the knee was affected causing gait patterns to be altered.

**Hypothesis 3: The Don Joy Defiance III Knee Brace will decrease strength.**

- 1.) Kramer, J., D. Nusca, P. Fowler, and S. Webster-Bogaert. "Knee Flexor and Extensor Strength during Concentric and Eccentric Muscle Actions after Anterior Cruciate Ligament Reconstruction Using the Semitendinosus Tendon and Ligament Augmentation Device." *The American Journal of Sports Medicine* 21.2 (1993): 285-91. Web.
- 2.) Birmingham, Trevor B., John F. Kramer, and Alexandra Kirkley. "Effect of a Functional Knee Brace on Knee Flexion and Extension Strength after Anterior Cruciate Ligament Reconstruction." *Archives of Physical Medicine and Rehabilitation* 83.10 (2002): 1472-475. Web.

Both of these articles show a decrease in peak knee extension torque. In the study by Kramer et al. two prophylactic knee braces were used to perform two isokinetic cybex tests. The results revealed that there was a significant decrease in peak torque when both prophylactic knee braces were worn compared to the control when no brace was worn. In the study by

Birmingham et al. there was one braced session and one session where no brace was worn. An isokinetic cybex test was performed and it was found that peak torque decreased while wearing a knee brace, though only slightly.

**Hypothesis 3: The Don Joy Defiance III Brace will decrease strength.**

**Hypothesis 6: The Don Joy Performer Sleeve will decrease strength.**

- 1.) Mortaza N, Ebrahimi I, Jamshidi AA, Abdollah V, Kamali M, et al. (2012) The Effects of a Prophylactic Knee Brace and Two Neoprene Knee Sleeves on the Performance of Healthy Athletes: A Crossover Randomized Controlled Trial. PLoS ONE 7(11): e50110. doi:10.1371/journal.pone.0050110

This study used healthy individuals to test the effects of strength while wearing a knee braces. Mortaza et al. found that with a knee sleeve there is a slight reduction in knee extension strength, though it is not significant. This still allows me to assume that a knee sleeve can decrease range of motion. The study also found that when the subjects were wearing a brace with metal supports that their peak torque increased dramatically, rejecting my hypothesis that the Don Joy Defiance III will decrease strength. Mortanza et al. presumed that this increase in extension strength was due to the fact that healthy subjects were used and they were able to overcome the restrictive mechanisms of the brace due to having a healthy knee.

**Hypothesis 6: The Don Joy Performer Sleeve will decrease strength.**

- 1.) Powers C, Doubleday K, Escudero C. Influence of patellofemoral bracing on pain, knee extensor torque, and gait function in females with patellofemoral pain. *Physiotherapy Theory & Practice* [serial online]. May 2008;24(3):143-150. Available from: Academic Search Premier, Ipswich, MA. Accessed November 7, 2016.

The study by Powers C et al. looked at the effects of knee sleeves on patella femoral pain. The results of this study proved the hypothesis that knee sleeves will decrease strength to be wrong. It was found the peak extension torque of subjects who had patella femoral pain and wore a knee brace increased while peak extension torque decreased when the subject was not wearing a brace.

### *Summary*

The results of these studies show support that both hinged knee braces as well as knee sleeves will decrease the range of motion of a subject. Results regarding how both hinged knee braces and knee sleeve effect strength are still inconclusive. Further research needs to be done to reveal the true effects that hinged knee braces and knee sleeves have on strength.



# Chapter 3

## Methods:

### *Subjects*

All 8 subjects were female students at Hanover College ranging in age from 18-22. These subjects were recruited through personal connections of the administrator for convenience. All were healthy subjects with no prior knowledge or use of knee braces and no recent knee injuries.

### *Pre-Test Protocol*

Subjects were asked to come to data collection wearing athletic shorts and tennis shoes as well as be well rested and not perform a workout prior to testing on test day.

### *Equipment*

- Cycle ergometer
- Goniometer
- Isokinetic Cybex Machine

### *Study Design*

#### *Sessions*

This study involved three sessions. The sessions were randomized. One session served as the control in which no brace was worn, one session wearing Don Joy Defiance III Brace, and another session wearing the Don Joy performer sleeve.

#### *Control Procedure*

1. 5 minute warm up on the cycle ergometer at 60 rpms with 0.5kg resistance.
2. Subject removed shoes and sat on table.
3. Administrator used goniometer to test knee extension and knee flexion of the subject.
4. An isokinetic cybex knee extension test at 60°/s with 2 practice reps and 5 test reps were performed.
5. 5 minute rest.
6. An isokinetic cybex knee extension test at 180°/s with 2 practice reps and 5 test reps were performed.

### *Defiance III Brace and Performer Sleeve Procedure*

All steps done wearing the appropriate brace or sleeve for the corresponding session.

1. 5 minute warm up on the cycle ergometer at 60 rpms with 0.5kg resistance.
2. Subject removed shoes and sat on table.
3. Administrator used goniometer to test knee extension and knee flexion of the subject.
4. An isokinetic cybex knee extension test at 60°/s with 2 practice reps and 5 test reps were performed.
5. 5 minute rest.
6. An isokinetic cybex knee extension test at 180°/s with 2 practice reps and 5 test reps were performed.

Throughout the duration of both the Don Joy Defiance III and Don Joy Performer Sleeve sessions comfort was recorded when:

- The brace was first put on.
- After the warm up was complete.
- After the 60°/s isokinetic cybex knee extension test.
- After the 180°/s isokinetic cybex knee extension test.

The following scale was used to record comfort:

Comfort		
8	Un-noticable	Psychological Discomfort
7	Occasionally Noticable	
6	Constantly Noticable	
5	Occasionally Annoying	
4	Constantly Annoying	Physical Pain
3	Itchy Irritant	
2	Concerning Pressure	
1	Hurts	
0	Painful	

Figure 4 Comfort Scale presented to the subjects during testing.

A scale of 1-3 was also used for the subjects to compare how they felt their performance was amongst sessions. 1 = best session 3 = worst session. After completing all sessions the subject was asked to order their three sessions 1-3 based on how they felt their performance. This test

was done to help determine if there were any psychological effects associated with the knee brace.

***What is considered to meaningful impact?***

- Knee Extension -  $\pm 10^\circ$
- Knee Flexion -  $\pm 10^\circ$
- Cybex Tests (Peak Torque) -  $\pm 5$  foot-pounds

**Pilot Data:**

The first round of pilot data collection was simply to learn the proper use of the goniometer and the isokinetic cybex machine. This process was helpful in ensuring that the two isokinetic cybex tests would be adequate for testing peak torque for knee extension.

*2<sup>nd</sup> round*

The second round of pilot data was conducted to further observe the effects of knee braces on strength and range of motion. Two subjects participated in the second round of pilot data. The non-dominant leg of each subject was tested. Each subject performed the two range of motion tests as well as the two isokinetic cybex tests. Both subjects were females with ages between 21-22 years old.

*Results of pilot data*

Knee Extension	Control	Defiance III	Performer Sleeve
Subject 1	-1°	11°	0°
Subject 2	0°	17°	0°

**Figure 5. Pilot Data for knee extension of each subject during each session.**

Figure 5 reveals the knee extension of the two subjects who participate in pilot data. It was found that for both subjects there was a large impact ( $\pm 10^\circ$ ) when the subjects were wearing the Don Joy Defiance III brace. For subject 1 the brace affected extension by  $10^\circ$  for subject 2 the

Don Joy Defiance III affected extension by 17°. These results allowed the hypothesis that the Don Joy Defiance III brace will decrease extension to be accepted. It was also found that the Performer sleeve had no effect on the extension of the knee for either subject. This means that the hypothesis stating that the Don Joy Performer Sleeve will decrease knee flexion is rejected.

Knee Flexion	Control	Defiance III	Performer Sleeve
Subject 1	144°	116°	130°
Subject 2	142°	114°	131°

Figure 6. Pilot data for knee flexion of each subject during each session.

Figure 6 is displaying the results of knee flexion for both subjects during pilot data. The Don Joy Defiance III brace had the largest impact on the knee flexion of both subjects. The Don Joy Defiance III brace decreased flexion by 28°. The performer sleeve, though smaller than the Defiance III did have an impact on the knee flexion of both subjects by decreasing by 14° and 11°. These results allowed the hypotheses that the Don Joy Defiance III and the Don Joy Performer Sleeve will decrease flexion to be accepted.

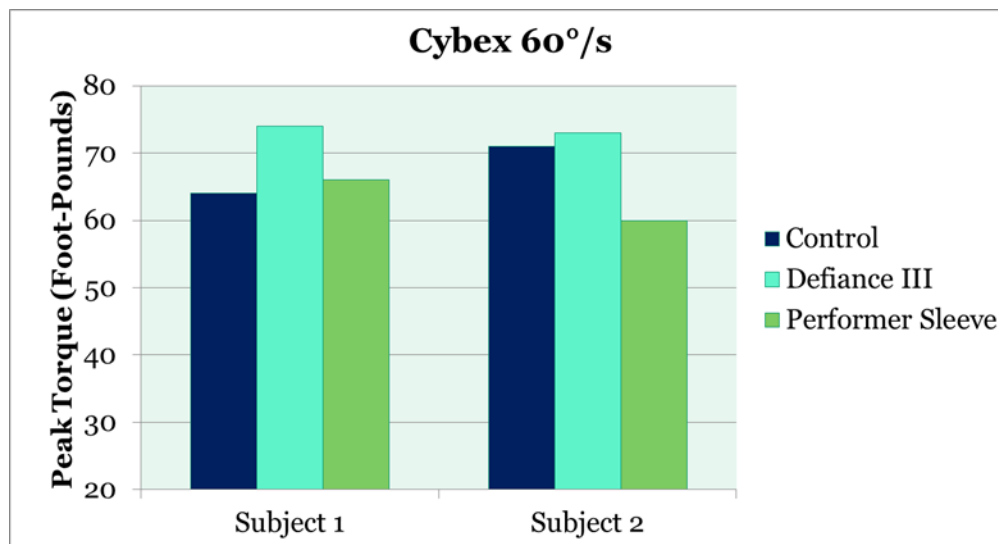


Figure 7. Pilot data for Isokinetic Cybex Test at 60°/s.

Figure 7 presents the pilot data found when two subjects participated in five repetition isokinetic cybex knee extension test wearing no brace, the Don Joy Defiance III Brace, and the Don Joy

Performer Sleeve. The results from this revealed that the Defiance III Brace had the greatest effect on strength during a 60°/s isokinetic test. The performer sleeve had no noteworthy effects on the strength of the subjects. The decrease in peak torque for subject two could be contributed to the lack of familiarity with the test. The Performer Knee Sleeve session was the first session that she performed and she struggled with understanding the test. These results cause the two hypotheses that the Don Joy Defiance III and Performer Sleeve will decrease strength to be rejected.

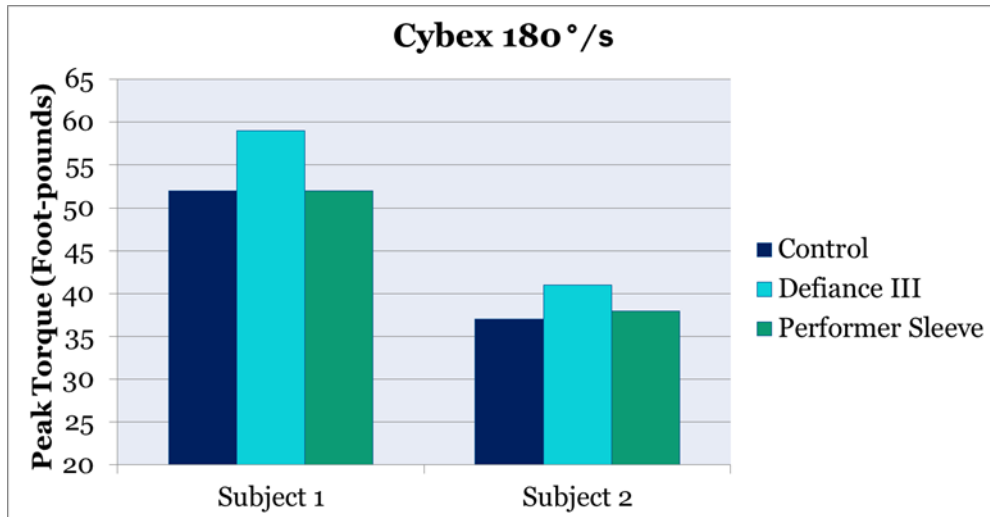


Figure 8. Pilot data for the Isokinetic Cybex knee extension test at 180°/s.

Figure 8 demonstrates the results from the pilot data involving two subjects who participated in an isokinetic knee extension cybex test at 180°/s. The results from this test were similar to the test at 60°/s. The Don Joy Defiance III Knee Brace increased the strength of both subjects by 5 foot-pounds or more compared to the control. The Don Joy Performer Sleeve appeared to have little to no change in strength for both subjects compared to the control trial. This caused both hypotheses regarding the Don Joy Defiance III and the Don Joy Performer Sleeve decreasing strength to be rejected.

<b>Defiance III</b>	<b>Subject 1</b>	<b>Subject 2</b>
Brace 1 <sup>st</sup> put on	4	4
After warm up	5	4
After 1 <sup>st</sup> cybex test	5	4
After 2 <sup>nd</sup> cybex test	3	4

Figure 9. Pilot Data displaying the comfort of each subject during the Don Joy Defiance III session.

The results in figure 9 reveal that Don Joy Defiance III Brace was occasionally annoying to subject 1 and constantly annoying to subject 2. The comfort results would indicate that the Don Joy Defiance III has psychological effects that could have an impact on the performance of the subject. These results are inconsistent with how the subjects actually performed during the Don Joy Defiance III session.

<b>Sleeve</b>	<b>Subject 1</b>	<b>Subject 2</b>
Brace 1 <sup>st</sup> put on	8	5
After warm up	8	4
After 1 <sup>st</sup> cybex test	5	4
After 2 <sup>nd</sup> cybex test	5	4

Figure 10 Pilot Data displaying the comfort results during the session in which the Don Joy Performer Sleeve was worn.

The comfort results displayed in figure 10 show that subject 1 found the Don Joy Performer sleeve to not be noticeable at first, but did find the sleeve occasionally annoying after exercise. Subject two found the brace to be annoying throughout the entire session. The comfort results for the performer sleeve session do not line up with the way the subjects performed during the strength tests.

- ❖ Comparison of performance across trials was not recorded during pilot data but was recorded during actual data collection.

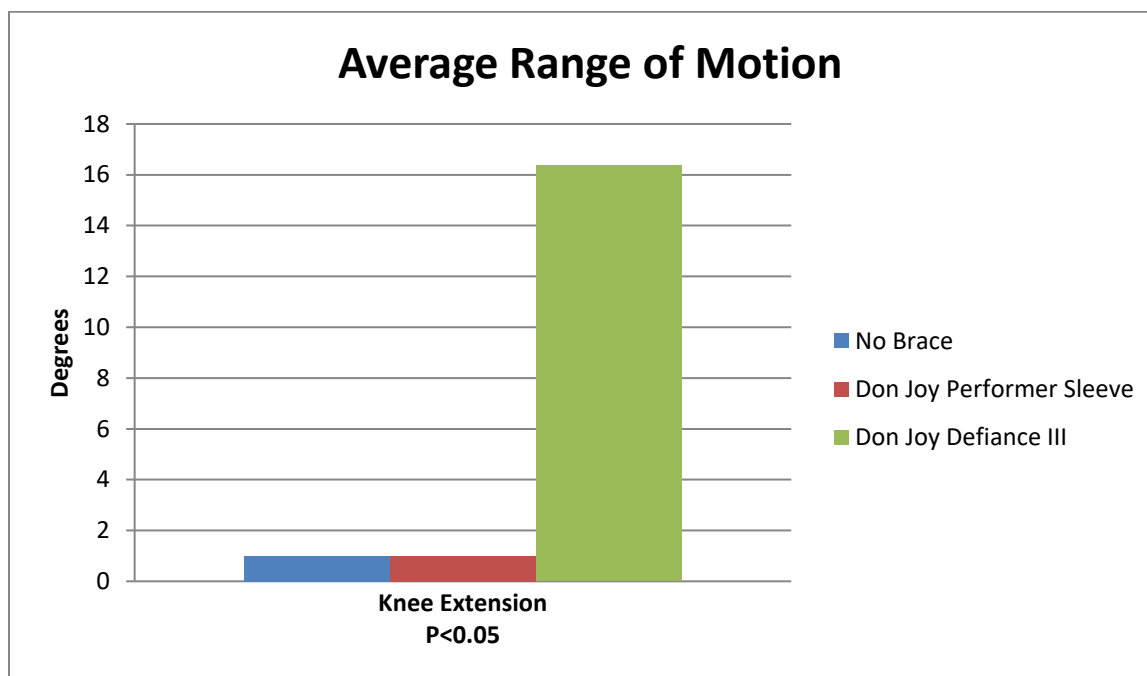
*Summary:*

Pilot data allowed for trial and error to occur in order to come up with concrete controlled methods. The data shows support that the knee braces have a negative effect on range of motion but have a neutral or positive effect on strength. More data collection will be needed in order to make conclusions about the effects of knee braces on strength and range of motion.

## Chapter 4

**Data and Results:**

Figure 11.

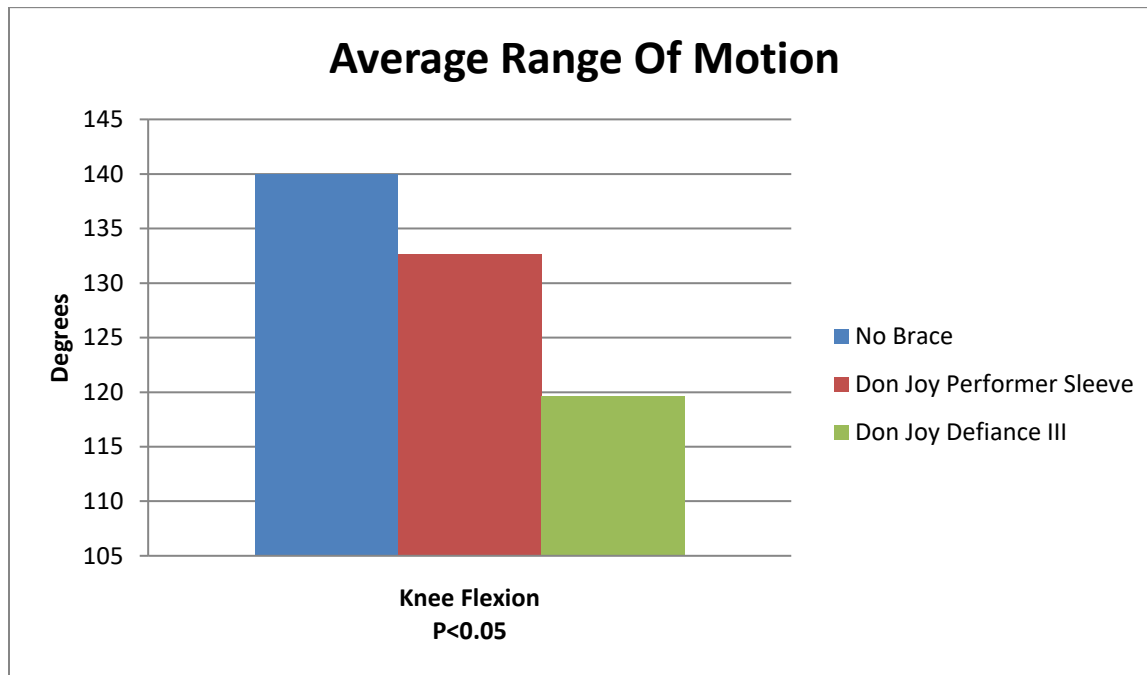


**Figure 11.** shows the average knee extension in degrees between the Don Joy Defiance III brace, Don Joy Performer Sleeve, and no brace. The average knee extension for the Don Joy Defiance III brace was 16.375°, while the average knee extension for both the Performer Sleeve and no brace were 0°.

Hypothesis 2: The Don Joy Defiance III Knee Brace will decrease extension. **Accepted**

Hypothesis 5: The Don Joy Performer Sleeve with decrease extension. **Rejected**

Figure 12.



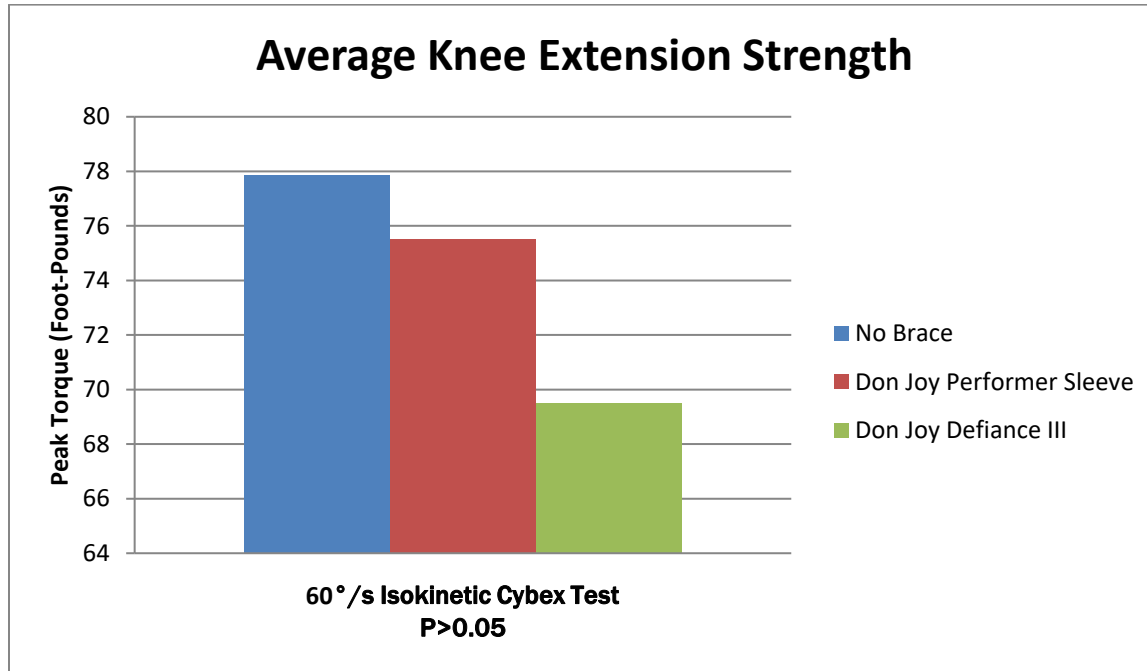
**Figure 12.** shows the average knee flexion in degrees when the subjects were wearing the Don Joy Defiance III, Don Joy Performer Sleeve, and while not wearing any type of brace. Flexion was there greatest when no brace was worn with a range of motion of 140°. The Don Joy Defiance III have the greatest restriction on knee extension, restricting the knee to 119.625°.

Hypothesis 1: The Don Joy Defiance III will decrease flexion. **Accepted**

Hypothesis 4: The Don Joy Performer Sleeve will decrease flexion. **Accepted**



Figure 13.

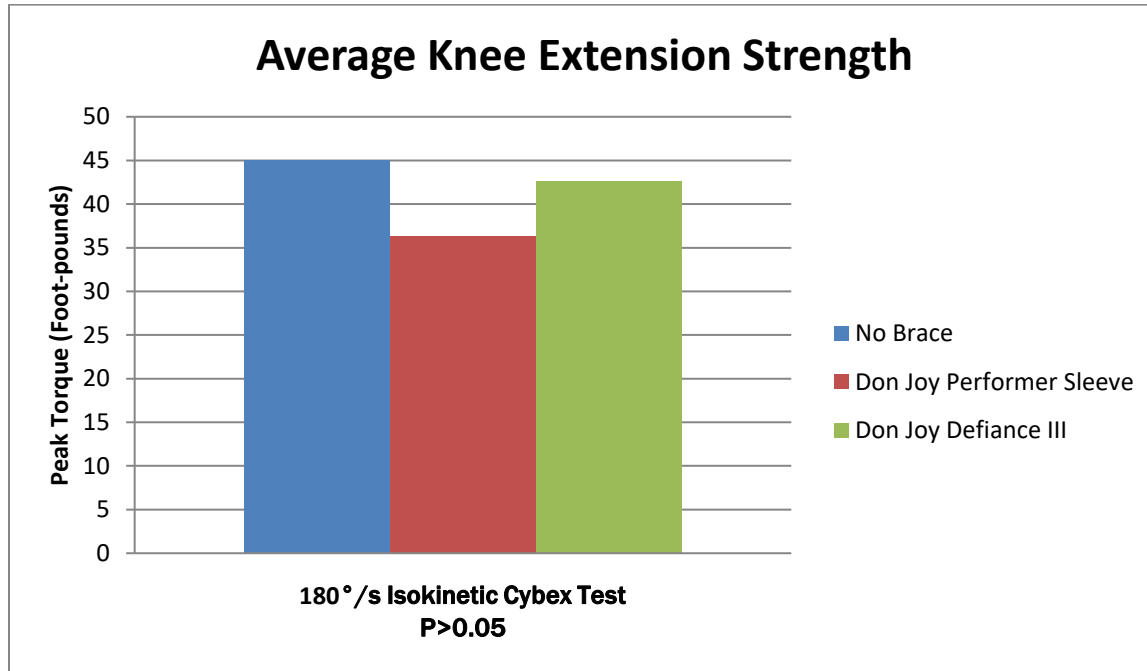


**Figure 13.** shows the average knee extension strength at a speed of 60°/s on the Isokinetic Cybex Machine. The no brace trial produced the highest average peak torque of 77.875 foot-pounds. The average peak torque, 69.5 foot-pounds, was the lowest when subjects were wearing the Don Joy Defiance III. The average when subjects wore the Don Joy Performer Sleeve was between the two at 75.5 foot-pounds.

Hypothesis 3: The Don Joy Defiance III will decrease strength. **Rejected**

Hypothesis 6: The Don Joy Performer Sleeve will decrease strength. **Rejected**

Figure 14.

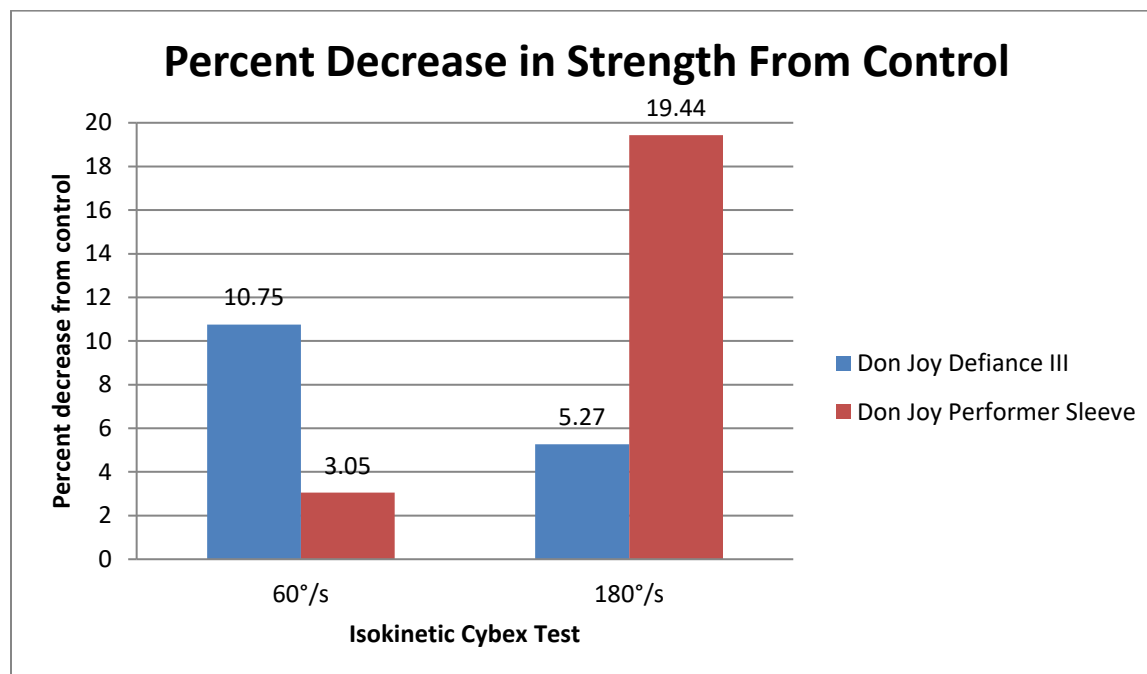


**Figure 14.** shows the average knee extension strength using an isokinetic Cybex Machine at 180°/s. The average peak torque when no brace was worn was the greatest at 45 foot-pounds. The averages when the Don Joy Defiance III and the Don Joy Performer Sleeve were worn were lower with a peak torque of 42.625 and 36.25 foot-pounds respectively.

Hypothesis 3: The Don Joy Defiance III will decrease strength. **Rejected**

Hypothesis 6: The Don Joy Performer Sleeve will decrease strength. **Rejected**

Figure 15.



**Figure 15.** shows the average percent decrease of the Don Joy Defiance III brace as well as the Don Joy Performer Sleeve. Both the brace and the sleeve decreased in peak torque compared to the control (no brace). During the 60°/s test the Don Joy Defiance III decreased strength by 10.75%. During the 180°/s test the Defiance III decreased strength by 5.277%. When wearing the Don Joy Performer Sleeve Average peak torque decreased by 3.05% during the 60°/s test and by 19.44% during the 180°/s test.

Though the data collected involving strength was not found to be statistically significant figure 15 demonstrates the general trend found when wearing the Don Joy Defiance III and the Don Joy Performer Sleeve. It is assumed that with further investigation and the testing of more subjects, the effects on strength will become statistically significant.

	Brace First On	After Warm Up	After First Test	After Second Test
Don Joy Defiance III	4.5	4.375	5	5.125
Don Joy Performer Sleeve	6.125	5.875	5.875	6
No Brace	8	8	8	8

**Figure 16.** shows the average self-reported score on the comfort scale while not wearing a brace, while wearing the Don Joy Defiance III and while wearing the Don Joy Performer sleeve. Subjects

felt the most discomfort while wearing the Don Joy Defiance III with scores ranging from 4.375-5.125 which is labelled as constantly annoying to occasionally annoying. The Don Joy Performer Sleeve was considered on average to be constantly noticeable to the subjects.

#### *Summary:*

Both the Don Joy Defiance III and the Don Joy Performer Sleeve had a negative impact on range of motion. When subjects wore the Don Joy Defiance III their flexion as well as extension was significantly ( $P < 0.05$ ) compromised. When the Don Joy Performer sleeve was worn, there was little impact on extension of the knee joint but the sleeve did significantly ( $P < .05$ ) compromise knee flexion.

Though the findings regarding strength were not statistically significant ( $P > 0.05$ ), there was a trend and a moderate decrease in strength with both braces. The decrease with the Don Joy Defiance III was greater than with the sleeve. The decline in range of motion could have been a contributor to the decrease in strength. Less comfort also could have been a contributing factor.

## Chapter 5

### **Discussion:**

#### **Why was an isokinetic test chosen?**

An isokinetic muscle contraction is one in which the muscle contracts and shortens at a constant speed. Isokinetic exercises are strength training exercises performed on an apparatus such as a dynamometer (i.e. Cybex Machine), which maintains a constant speed of movement. Isokinetic tests are often chosen for maximal strength workout. The reason that an isokinetic knee extension test was utilized for this study was because the speed of movement is limited causing momentum to be eliminated allowing tension to remain focused on the specific muscle being investigated (quadriceps).

#### **Why was a goniometer chosen to measure range of motion?**

A goniometer was chosen as the method for measuring range of motion because of the easy access to it as well as how cheap the test is. Lastly, a goniometer test is a relatively easy test to administer on a consistent basis once the technique is learned.

#### **What is the difference between the Don Joy Defiance III and the Don Joy Performer Sleeve?**

The Don Joy Performer sleeve adds compression and warmth to the knee to help increase blood flow. In addition to increasing blood flow, the knee sleeve limits the patella

movement and is designed to help increase proprioception, the capacity to feel the position of a joint in a space that is sensed by the central nervous system. A knee sleeve is different than a knee brace in the sense that the sleeve does not provide ligament support (4). The Don Joy Defiance III brace is utilized for ligament instabilities. The brace has an aluminum frame with a four point leverage system and fourpoint hinges that are used to help protect the ACL, MCL, PCL, and LCL of an athlete. The greatest difference between the Don Joy Defiance III and the Don Joy Performer sleeve is that the Defiance III does not allow for side to side movement and it is intentionally designed to restrict range of motion.

### **Why do knee braces decrease the range of motion of the knee joint?**

Knee Braces are designed with a specific function and that if often times to support the knee. Since there are many different materials that are involved to make a proper stabilizing knee brace, there are many different components of the knee brace that can affect the way the joint flexes and extends. Often times individuals have a greater range of motion than the brace allows for. For example, the Don Joy Defiance III reduced knee flexion by an average of  $20^{\circ}$  and decreased knee extension by  $16^{\circ}$ . The Don Joy Performer sleeve that is made of a layer of neoprene rubber reduced knee flexion by an average of almost  $8^{\circ}$  compared to when the subjects were not wearing any type of knee brace. Thus, this shows that a knee brace can reduce the range of motion of someone who has a healthy fully functional knee.

### **What are the impacts of the loss of full range of motion on the knee joint?**

The body is designed to move in a specific way, thus maintaining full range of motion is ideal for good health. Having full range of motion of the knee joint can help to reduce joint pain as well as increase strength and balance. If there is a loss in range of motion in the knee joint, the risk for injury can increase due to the greater load that is places on the collagenous tissues and muscles.

### **Why is a non-braced knee stronger than a braced knee?**

Wearing a knee brace can help to provide stabilization to a hurt or injured knee but it does cause a decrease in the range of motion of the knee. A decrease in the range of motion of the knee can affect ones activities of daily living. A decrease in flexion and extension can affect simple activities such as walking, by causing one to limp and thus have an abnormal gait. This can put unwanted pressures on other areas of the joint as well. Along with distribution to activities of daily living, the inability to go through a joints entire range of motion can also decrease the strength of that joint. A study by Pinto et al. found that when subjects went through the full range of motion while performing a particular exercise, their strength increase by 25.7% whereas the group who only went through partial range of motion only increased their strength by 16% (10). Based upon the results of the present study it is believed that the same thing is occurring.

Both the Don Joy Defiance III brace and the Don Joy Performer Sleeve decreased the range of motion about the knee joint contributing to the decrease in knee strength. The results also showed that the larger the range of motion deficit, the greater the impact on strength.

### **Did wearing a brace have any psychological effects on subjects?**

The Don Joy Defiance III and the Don Joy Performer Sleeve not only proved to have effects on strength but psychological effects as well. The larger the brace and the more components the brace has to it, the more annoying the subjects felt the brace was and the worse they felt they performed during the isokinetic Cybex Tests. All subjects reported the Don Joy Defiance III as being the most uncomfortable brace, followed by the Don Joy Performer Sleeve. All subjects also reported that they felt their performance was the best when no brace was worn, and the worst when the Don Joy Defiance III was worn. Many subjects reported on the fact that they could not believe that people actually wore these braces while playing sports, especially the Don Joy Defiance III. These comfort results show that there are not only physical effects of wearing a knee brace but psychological effects as well.

### **Why the variation in strength scores between 60°/s and 180°/s Isokinetic Cybex tests?**

The 60°/s Isokinetic Cybex test provided great resistance, whereas the 180°/s test provided little to no resistance. The subjects were very confused by and struggled with the 180°/s test because it was so different from the 60°/s test, by allowing them to kick out (knee extension) at a faster rate. Subjects had a hard time realizing that the harder that they pushed against the machine the more it would resist them. Because of the confusion with this test, the scores did not appear to be the best efforts, therefore the 180°/s Isokinetic Cybex test was not put into high consideration when concluding about the findings of this study.

In future studies, it may be helpful to have an orientation trial in which the subjects can gather an understanding of the way both the 60°/s and 180°/s Isokinetic Knee Extension Cybex Tests work to avoid confusion.

### **When should an athlete stop wearing a brace?**

Based upon the results of the present study, if a brace is worn when a knee is healthy, compensatory injuries could occur. Because of slight reduction in strength, this suggests that the sooner you remove the brace after healing the better. This means that braces used as a prevention device could be harmful to performance. Therefore, braces seem to be beneficial immediately after an injury, not before or after healing has occurred. Since data suggest that the Don Joy Defiance III elicited a larger decrease in strength followed by the Don Joy Performer Sleeve, a progression from the Don Joy Defiance III to the Don Joy Performer Sleeve to ultimately

no brace is recommended. This approach could help not only with physical performance, but removing discomfort could help psychologically as well.

***Improvements for future studies:***

- Increase number of subjects
- Broaden age range
- Use both male and female subjects
- Utilize more knee braces
- Test more sport specific exercises and movements

**Conclusion:**

The findings of this study indicate that both the Don Joy Defiance III and the Don Joy Performer Sleeve impact the range of motion about the knee joint. While wearing the Don Joy Defiance III and the Don Joy Performer Sleeve did not show a statistically significant impact on strength (peak torque) there still appeared to be a modest decline in strength.

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# Informed Consent

This study is being conducted by Shelby Adams of Hanover College, Hanover, Indiana, as part of the Independent Study requirement of the Kinesiology and Integrative Physiology major. The study has been approved by Dr. Bryant Stamford, Chair of Hanover College Kinesiology and Integrative Physiology Department. The purpose of this research is to determine the impact ankle taping has on range of motion and power output.

As a participant, you will be asked to

- Engage in exercising on a cycle ergometer at 60 rpms and 0.5 kg resistance.
- Engage in a range of motion measurement where you will be asked to pull your heel toward your glutes as far as possible (flexion) and also extend leg out as straight as possible (extension).
- Engage in all of the above with a Don Joy Defiance III knee brace and Don Joy performer sleeve on your knee.
- Engage in exercise on a cybex machine and in a range of motion measurement while wearing the provided knee brace.

Because this research involves exercise on both a cycle ergometer and a cybex, there are risks involved in participating. The risks include ( but are not limited to) falling of cycle ergometer due to loss of footing which could potentially lead to injury, muscle strains, increased heart rate and blood pressure, injuries involving the cybex, and other possibilities. If at any time, you feel uncomfortable during exercise, please inform the researcher and the session will be stopped immediately. You are free to terminate your participation at any time and for any reason.

Due to the physical aspects of this research study, it is imperative that risks are reduced to a minimum. It is therefore assumed that as far as you are aware, you are in good health and that you do not have any of the following conditions:

- High blood pressure
- Heart murmur
- Diabetes
- Any heart or artery surgery
- Asthma
- Any illness or fever within the past week
- Currently taking prescription medications

All information gathered from the study will remain confidential. The results recorded from each individual will be presented anonymously. The results of this study have the ability to be published, however, the identification of the participant will remain private.

In signing this form, you agree that you understand the procedures outlined above and are willing to participate in this study. You understand the inherent risks in this type of study and will not hold the researcher or Hanover College responsible for any injury occurring. You are free to discontinue without an explanation or penalty involved.

If you have any questions, please feel free to contact Shelby Adams at [adamss17@hanover.edu](mailto:adamss17@hanover.edu) or Dr. Bryant Stamford at [stamford@hanover.edu](mailto:stamford@hanover.edu)

Name or participant (please print): \_\_\_\_\_

\_\_\_\_\_  
Signature of participant:

\_\_\_\_\_  
Date:

\_\_\_\_\_  
Signature of Researcher

\_\_\_\_\_  
Date:

## Debriefing Form

The study in which you just participated was designed to determine the effects of knee bracing on range of motion and strength .You were asked to participate in a series of sessions that tested range of motion and strength with knee brace, knee sleeve, and during exercise with applied brace.

Please do not discuss this study with other potential participants until the semester is over. If people know what we're testing before the study begins, they may respond differently, jeopardizing our results.

If you have any questions, please contact:

For questions about the research itself, you may contact the researcher: Shelby Adams at [adamss17@hanover.edu](mailto:adamss17@hanover.edu)

For questions about your rights as a participant in this research, you may contact the faculty member supervising the research and the chair of Hanover College's Institutional Review Board, Dr.Dean Jacks, at [jacksd@hanover.edu](mailto:jacksd@hanover.edu)

## IRB Approval

Study number 2016078, titled **Effects of Knee Braces on Strength and Range of Motion** has been approved by the Hanover College Institutional Review Board. The study was classified as “Expedited.”

Specifically, the IRB found that the study qualified as Expedited4: “Category 4: Collection of data through noninvasive procedures (not involving general anesthesia or sedation) routinely employed in clinical practice, excluding procedures involving x-rays or microwaves. Where medical devices are employed, they must be cleared/approved for marketing. (Studies intended to evaluate the safety and effectiveness of the medical device are not generally eligible for expedited review, including studies of cleared medical devices for new indications.) Examples: (a) physical sensors that are applied either to the surface of the body or at a distance and do not involve input of significant amounts of energy into the subject or an invasion of the subject’s privacy; (b) weighing or testing sensory acuity; (c) magnetic resonance imaging; (d) electrocardiography, electroencephalography, thermography, detection of naturally occurring radioactivity, electroretinography, ultrasound, diagnostic infrared imaging, doppler blood flow, and echocardiography; (e) moderate exercise, muscular strength testing, body composition assessment, and flexibility testing where appropriate given the age, weight, and health of the individual.” [\[reference\]](#).

**This approval authorizes the authors of this application to begin data collection.** This approval will expire on Dec 7, 2017.

Any changes to the procedure must be approved by the IRB prior to making those changes. Authors may request a modification to their procedure by logging in to [irb.hanover.edu](http://irb.hanover.edu), navigating to the approved application, going to the Submit section, and clicking the *Request Modification* button. This will create a clone of the original application with a new study number, to which modifications can be made. If you have any questions, please contact either the IRB webmaster, Bill Altermatt, at [altermattw@hanover.edu](mailto:altermattw@hanover.edu), or the chair of the Hanover College Institutional Review Board, Dean Jacks, at [jacks@hanover.edu](mailto:jacks@hanover.edu)