Biomechanical effects of shod vs. unshod deadlift in males

Jacob La Marche
Iowa State University

Follow this and additional works at: https://lib.dr.iastate.edu/etd

Part of the Biomechanics Commons

Recommended Citation
La Marche, Jacob, "Biomechanical effects of shod vs. unshod deadlift in males" (2019). Graduate Theses and Dissertations. 17040.
https://lib.dr.iastate.edu/etd/17040

This Thesis is brought to you for free and open access by the Iowa State University Capstones, Theses and Dissertations at Iowa State University Digital Repository. It has been accepted for inclusion in Graduate Theses and Dissertations by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
Biomechanical effects of shod vs. unshod deadlift in males

by

Jacob La Marche

A thesis submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Major: Kinesiology

Program of Study Committee:
Jason Gillette, Major Professor
Tim Derrick
Laura Ellingson

The student author, whose presentation of the scholarship herein was approved by the program of study committee, is solely responsible for the content of this thesis. The Graduate College will ensure this thesis is globally accessible and will not permit alterations after a degree is conferred.

Iowa State University

Ames, Iowa

2019

Copyright © Jacob La Marche, 2019. All rights reserved.
## TABLE OF CONTENTS

LIST OF TABLES......................................................................................................................... iv

LIST OF FIGURES....................................................................................................................... v

ACKNOWLEDGEMENTS .............................................................................................................. vi

ABSTRACT ..................................................................................................................................... vii

CHAPTER 1. INTRODUCTION ..................................................................................................... 1
  Executive Summary ..................................................................................................................... 1

CHAPTER 2. LITERATURE REVIEW ............................................................................................ 3
  Introduction ................................................................................................................................. 3
  Deadlift Biomechanics .............................................................................................................. 4
    Conventional deadlift ............................................................................................................ 4
  Differences between Deadlift Styles ........................................................................................ 7
    Conventional vs. sumo deadlifts ......................................................................................... 7
    Conventional vs. hexagonal bar deadlifts ........................................................................ 8
  Accessories ............................................................................................................................... 9
    Weightlifting straps ............................................................................................................. 9
    Weightlifting belts ............................................................................................................... 10
  Shod vs. Unshod ....................................................................................................................... 10
    Power output ....................................................................................................................... 11
    Shoe height differences .................................................................................................... 11
  Squat Lifts and Footwear ....................................................................................................... 12
  Differences between Squat Lifts and Deadlifts ..................................................................... 12
  Epidemiology of Resistance Training Injuries ....................................................................... 13
    Incidence rates ................................................................................................................... 14
LIST OF TABLES

Table 1. National Strength and Conditioning one repetition maximum test ..........25

Table 2. Joint angles between conditions at point of lift off in degrees ...............28

Table 3. Joint angles between conditions at point of knee pass in degrees ............28

Table 4. Joint moments between conditions at point of lift off in Nm/kg ...............29

Table 5. Joint moments between conditions at point of knee pass in Nm/kg..........29

Table 6. Bar velocities in m/s ...................................................................................30

Table 7. Post-test survey responses ..........................................................................30
LIST OF FIGURES

Figure A1. Frontal view of shod static marker set ..................................................37

Figure A2. Sagittal view of shod static marker set ..................................................38

Figure A3. Frontal view of deadlift at lift off .........................................................39

Figure A4. Frontal view of deadlift at knee pass .................................................40

Figure A5. Frontal view of deadlift repetition completed ..............................41
ACKNOWLEDGEMENTS

I would like to acknowledge several people who have helped me on my journey of obtaining my thesis. First and foremost, I would like to thank my wife and children who put up with me during this time and never stopped supporting me, and especially to my girls who would sit in my office with me and listen to music while I worked. Secondly, I would like to thank my major professor for taking me in when I finally decided what I wanted to do for my thesis. I would also like to thank Mitchell Stephenson for helping with the coding in Matlab and offering specialized advice on the topic of strength and conditioning, along with Shekoofe Saadat who helped out with many data collections and always made them fun. Finally, I would like to thank the undergraduates who also helped with data collections. Your help is greatly appreciated in the process. Even the tiniest bit of help goes a long way with these collections. You all did great, thank you.
ABSTRACT

There are many forms of resistance training, with the barbell squat, bench press, and deadlift being three of the most popular exercises. The squat and bench press have been examined extensively, while the deadlift has not. The purpose of this study was to examine participants performing the barbell deadlift while wearing their normal lifting shoes and while barefoot. Thirty male participants aged 18-30 and with at least one year of deadlift experience were recruited for this study. An eight-camera system and a force platform were used to measure three-dimensional movements and ground reaction forces during 80% one repetition maximum deadlifts. Ankle, knee, and hip joint angles and moments were analyzed at the instance of lift off and knee pass, along with bar velocity at those same points. A pair-wise t-test was used with an alpha of 0.05. Ankle dorsiflexion angle (p = 0.018), knee flexion angle (p < 0.001), and knee flexion moment (p < 0.001) were significantly higher at the point of lift off in the shod condition. The bar velocity (p = 0.028) was significantly higher at knee pass in the shod condition. These results indicate that performing the deadlift while barefoot could benefit lifters who struggle with more flexed postures and/or have limited ankle dorsiflexion range of motion. These changes in posture likely led to the reduced knee flexion moments required to initiate bar lift off. However, lifting barefoot may decrease deadlift performance in terms of power generated as evidenced by lower bar velocity.
CHAPTER 1. INTRODUCTION

Executive Summary

Injuries are a part of life. Low back and lower extremity injuries that occur during weightlifting can be painful, costly, and take months to years to recover from. Sometimes, an individual may never fully recover from the injury. Looking at ways to reduce the chance of injury is important. The deadlift, being a common part of many resistance training programs, requires high levels of joint forces and moments on the lower back and lower extremity, making this movement likely to induce injury. This study investigated whether or not wearing shoes may reduce the chance of injury and/or increase performance during deadlifts.

Thirty male participants began by filling out the informed consent and a questionnaire, then completing a ten-minute general warm-up. Next, the participant’s one repetition maximum for the deadlift was determined following the National Strength and Conditioning Association guidelines. Following the one repetition maximum test, retroreflective markers were placed on bony landmarks of participants. Participants then performed five repetitions of the deadlift at 80% of their one repetition maximum for shod and unshod conditions. The shod condition involved performing the deadlift while the participant wore their normal lifting shoes, and the unshod condition involved performing the deadlift while the participant was barefoot. An eight-camera system tracked movement of the markers and the force platforms measured ground reaction forces while the participant performed the deadlifts.

Ankle, knee, and hip joint angles and moments in the sagittal plane, along with bar velocity, were analyzed at two different points in time: at lift off (when the bar markers are two
standard deviations above the resting height of the bar) and at knee pass (when the average height between the two markers passed the average height of the two knee markers). At the point of lift off, the ankle dorsiflexion and knee flexion angles were significantly lower in the unshod condition. At knee pass, the knee extension moment and bar velocity were significantly lower for the unshod condition. These findings indicate that there may be some benefits to performing the deadlift barefoot for individuals who struggle with more flexed postures, although there might be reductions power generation and performance.

This thesis is divided into two main chapters. Chapter two is a review of current literature related to deadlift biomechanics. Chapter three is a manuscript ‘Biomechanical effects of shod vs. unshod deadlift’ that will be submitted to the Journal of Strength and Conditioning Research. Chapter four is a summary of general conclusions.
CHAPTER 2. LITERATURE REVIEW

Introduction

An individual’s health is a vitally important aspect of life. Without being healthy, an individual can more easily succumb to disease and injuries. One way to stay healthy is by resistance training. Resistance training is one part of the physical activity guidelines and strengthens the musculoskeletal system of the human body. Resistance training comes in many forms, including using equipment such as dumbbells, barbells, and resistance bands (Caspersen et al., 1985).

There are seven primal patterns to human movement: squat, lunge, push, pull, bend, twist, and gait (Chek, 2003). Resistance training focuses on all of these movement patterns except for the gait. Knowing these patterns and executing them properly while resistance training is key to reducing risk for injury. There are three main lifts in powerlifting: the barbell back squat, the barbell bench press, and the barbell deadlift. These three lifts cover four of the six movement patterns for resistance training. The squat includes squat and bend, the bench press includes push, and the deadlift includes squat, bend, and pull.

One key aspect of resistance training is to have a strong base (Baechle & Earle, 2008). Without a strong base, an individual can easily lose their balance and injure themselves in the process of performing the exercise. With the bench press, it is simple to have a strong base. An individual needs to have the five points of contact: firmly planted feet (two points), glutes (one point), shoulder blades (one point), and head (one point). From there, the lifter only needs to have a firm grip of the bar and either safety bars or spotters in place for the exercise to be
successfully executed. The bench press has five points of contact and therefore a stable base, but the squat and the deadlift only have two points of contact: the feet. With such an emphasis being placed on the feet, even minor changes can have an impact on the safety of the lift. Examples of minor changes in a stable base include foot position, ankle flexibility, and type of footwear.

**Deadlift Biomechanics**

There are different types of deadlifts. There is the conventional style of deadlift and then there are unconventional styles of deadlifts, such as the sumo deadlift (Piper & Waller, 2001). The basis for all styles of deadlifts include picking up a weight from the ground and then standing erect. The main differences between conventional and sumo deadlifts are foot position and hand grip position. For the conventional deadlift, an individual stands directly behind the bar with their feet placed shoulder width apart and their hand grip positioned outside the thighs. For the sumo deadlift, the feet are wider than shoulder width apart and the hand grip position is between the thighs. These are the main two deadlift variations used in competitions. However, there are other forms of deadlifts, such as the hexagonal or trap bar deadlift and the Romanian or stiff-legged deadlift. For example, the trap bar deadlift moves the bar path from in front of the body to in line with the body. These two styles of deadlifts are more accessory lifts than main lifts.

**Conventional deadlift**

To perform the conventional style deadlift, an individual starts with their feet about shoulder width apart, with the balls of their feet directly under the bar (Farley, 1995; Graham, 2000). The individual then grasps the bar with their hands slightly outside the knees, resulting in
a grip width that should be slightly wider than shoulder width. The hips should then be in line with or slightly below the knee, and the back should be flat and stabilized at about forty-five degrees to the floor.

Starting with the concentric or ascent phase, the movement begins with the hip and knee joint simultaneously extending. The bar should make contact with the thigh about one-fourth the way up the femur above the patella. During the lift, it is crucial that the spinal erectors are contracted to keep the back as flat as possible to prevent rounding of the back. If the individual fails to keep the back straight and excessive rounding occurs, this will cause traction of the vertebrae, stretching of the ligaments, and possibly tearing of the muscles. By tilting the head upwards, this will stimulate the trapezius and spinal erectors to contract most effectively. As the bar continues its upward path, the knees and the hips continue to extend. The knees complete extension first, and the hips to continue to extend after this point. The lift is considered complete when the person is standing in a natural erect position, with shoulders back, but not with the spine hyperextended (Farley, 1995; Graham, 2000).

For the eccentric (descent) phase of the lift, it is paramount that the individual keeps their back as rigid and as flat or slightly arched as possible. Flexing the hips and knees allows the bar to be lowered to the ground with control (Graham, 2000). The barbell should remain as close to the body as possible throughout the descent phase. Maintaining a close bar position relative to the body reduces moments applied to the body (McGuigan et al., 1996). If the lifter is completing multiple repetitions, they will lightly touch the plates on the floor or if they are done, gently set the barbell on the ground (Graham, 2000).
While the musculature for most deadlifts is the same (Bird & Barrington-Higgs, 2010), the rate at which the muscles contribute varies based on which deadlift is being performed. For the conventional deadlift, the main musculature involved revolves around the knee, hip, and back (Farley, 1995; Graham, 2000). For the knee joint, the muscles include the vastus lateralis, vastus medialis, vastus intermedius, and rectus femoris for knee extension.

The hip joint muscles involved in the conventional deadlift are the gluteus maximus, biceps femoris, semimembranosus, and semitendinosus (Farley, 1995; Graham, 2000). These muscles contract and allow for hip extension. Moving up from the hip into the lower back, the muscles involved in conventional deadlift include the ilocostalis thoracis, ilocostalis lumborum, longissimus dorsi, and spinalis dorsi. These four muscles make up the erector spinae. The other muscles involved in keeping the lower back erect are the intertransversarii, interspinalis, and the multifidus. The contraction of these muscles allows for the lower back to stay erect and prevent rounding.

While the aforementioned lower back muscles keep the lumbar region from rounding during the conventional deadlift, the thoracic region has a different set of muscles to keep the upper back from rounding (Farley, 1995; Graham, 2000). The trapezius, rhomboids, and latissimus dorsi are thoracic spine muscles that allow for retraction of the scapula. Additional muscles involved in the conventional deadlift include the biceps and finger flexors to stabilize the bar and the deltoid and rotator cuff muscles to stabilize the shoulder (Farley, 1995; Graham, 2000).
Differences between Deadlift Styles

While the conventional deadlift is a staple of the power movements, it is not the only style of deadlift. Deadlifts that have a similar focus to the conventional deadlift are the sumo and hexagonal bar deadlifts, while there are other deadlift styles that focus on mainly the lower legs. The conventional deadlift is the only style currently used in professional meets, although the sumo deadlift is starting to gain more acceptance in the competitive scene. While the conventional deadlift was analyzed in the current study, it is informative to consider how lifting technique can affect body movement and loading on the body.

Conventional vs. sumo deadlifts

The other common variation of the deadlift is the sumo deadlift. The main differences between the sumo and conventional deadlifts are that the feet are wider than shoulder width, the hands are placed closer together, and the lifter is more upright (Escamila et al., 2000; Escamila et al., 2002; McGuigan et al., 1996; Piper & Waller, 2001). When comparing the sumo and conventional style deadlifts, Escamila et al. (2000) found several differences between the two lifts. The first difference was the usage rate in the powerlifting meet they observed, with 70% of the lifters using the conventional deadlift. At the heavier weight classes (90-125+ kg), the rate at which the conventional deadlift was used jumped to 85% and for the lighter weight classes (52-82 kg), it fell to 55%.

Biomechanically, one difference between the two lifts was that at the point of lift off, the sumo group had a more upright trunk and shank position (Escamila et al., 2000). Another difference was between the lift-off phase and the bar passing the knee, where the conventional group had a greater range of motion at the shank, knees, and hips. A third difference was when
the bar passed the knee, the conventional group had a more vertical shank, but the thighs were more parallel to the ground.

Comparing moments and moment arms between the two groups, the sumo group produced ankle dorsiflexor moments exclusively, while the conventional group produced ankle plantar flexor moments (Escamila et al., 2000). Interestingly, while both groups had knee extensor moments at the lift off, only the sumo group generated knee extensor moments when the bar passed the knee and at lift completion. In contrast, the conventional group had knee flexion moments when the bar passed the knee and at lift completion. There was no significant difference in hip moments between the two groups. The greater ankle and knee moments for the conventional deadlift may also result in greater moments at the lower back.

**Conventional vs. hexagonal bar deadlifts**

While the sumo and conventional deadlifts are popular, there is another option for those who do not want to place as high of moments on the lower back. In an electromyography (EMG) study done by Camara et al. (2016), significantly higher erector spinae activation was found for the hexagonal bar as compared to the conventional deadlift. There was also greater quadriceps activation with the hexagonal bar deadlift, while greater hamstring activation was found with the conventional deadlift. Therefore, the hexagonal bar deadlift appears to be better for training the quadriceps, while the straight bar deadlift appears to be better for training the hamstrings. In another study conducted by Swinton et al. (2011), they concluded that because the load of the hexagonal bar was closer to the ankle, there was about a 75% reduction in horizontal displacement. This reduction in horizontal displacement allowed the load to stay closer to the lifter’s center of gravity and decreased moment arms.
Accessories

As an individual grows in strength, deficits start to become more evident. One way that lifters combat deficits is by using accessories. Straps and weightlifting belts are two very common accessories that one may see at a fitness facility. Straps are used to increase the amount of load an individual can hold in their hands, while belts increase intra-abdominal pressure and stabilize the spine. In the current study, participants were allowed to use accessories that they would normally use during deadlifting, so it is important to be aware of possible effects on performance.

Weightlifting straps

A common accessory that can be found in many gyms and training facilities is weightlifting straps. These straps are used to help an individual lift a weight in a pulling motion, reducing the reliance on the lifter’s grip strength alone. Coswig et al. (2015) examined the difference between performing the conventional deadlift with and without straps. They found ratings of perceived exertion (RPE) on different body parts varied depending on whether the subject lifted with straps or not (Coswig et al., 2015). There was a significant difference between the general RPE with straps compared to no straps. It was also noted that the RPE for the lumbar spine and forearms were also significantly different. The lumbar spine RPE was higher with the straps group, and the forearm RPE was higher in the non-strap group. The limiting factor in the one repetition maximum test was grip strength. By using straps, it resulted in a lower forearm RPE and allowed for a greater amount of weight to be pulled for the deadlift.
Weightlifting belts

Another common accessory, even more common than lift straps, are weightlifting belts. These belts are made of strong material and wrapped around the torso. When loads are placed upon the spine, it creates compression and shear forces, and one way to reduce these forces is by increasing intra-abdominal pressure (Harman et al., 1988). This study looked at the use of belts and the increase in intra-abdominal pressure. They found that performing the deadlift with a belt produced higher peak intra-abdominal pressures than without a belt. While the peak pressure and force were not significantly different between the two groups, the initial pressure and forces in the intra-abdominal area were significantly higher. The authors noted that if a lifter trains with a belt at near maximal level, then lifts without a belt at the same level, the lifter may not be able to generate the same intra-abdominal pressures.

Shod vs. Unshod

Deadlifts are one of the three powerlifts and a core component of Olympic lifts, with loading through the feet at the bottom of the kinetic chain. While most gyms require a lifter to have shoes on, others are more lenient about footwear when deadlifting and squatting. Since barefoot or minimalist running has become popular, some shoe companies have developed shoes that have no heel elevation and have minimal material. While researchers have investigated differences for shod and unshod squat lifts, there has been relatively little research in this area for the deadlift.
Power output

A study was conducted investigating power output between shod vs. unshod deadlifts (Hammer et al., 2017). The unshod condition was found to have a faster rate of force development and higher peak force. It was also found that the shod condition had more displacement in the medio-lateral peak center of pressure. The authors noted the shoe cushioning in the shod condition decreased the rate of force development and peak force, while increasing the medio-lateral peak center of pressure.

Shoe height differences

Sunny (2015) examined different heel height conditions ranging from 0.00 to 1.50 inches, increasing in increments of 0.25 inches. For this study, participants were fitted with retroreflective markers at the second metatarsal head, lateral malleolus, lateral femoral epicondyles, greater trochanter, sacrum, T10, and C7 (Sunny, 2015). Potential limitations of this study included a marker set that may not have been sufficient for 3-D kinematic data and that force platforms were not used to collect ground reaction forces.

Participants performed the deadlift at 70% of their one repetition maximum, and completed three repetitions of the different heel height conditions (Sunny, 2015). A two-minute rest time was given between each condition. The one repetition maximum test and heel height testing were conducted on different days. Using 70% of a participant’s one repetition maximum should allow for prevention of fatigue, but only performing three repetitions may not be adequate for the lifter to achieve a consistent deadlift pattern.

The author found no significant differences in joint angles between the heel height conditions, inferring that ankle mobility has little or no effect on the set up for the deadlift
(Sunny, 2015). It should also be noted that this study used wooden blocks for its shod conditions and not shoes. Using wooden blocks may not be an accurate representation for shoes of different heel heights. The wooden blocks may have affected the perception of the participant and ultimately affected the results.

**Squat Lifts and Footwear**

Squats are a popular exercise that is used for both strength training and rehabilitation (Sato et al., 2012). In its simplest form, the squat in the eccentric phase is flexion at the hips, knees, and ankles. In the concentric phase, there is then extension of the hips, knees, and ankles. Performing the squat with weight lifting shoes has been found to significantly reduce trunk lean displacement as compared to running shoes (Sato et al., 2012). This decrease in forward trunk lean may reduce the amount of shear force applied to the lower back. In contrast, Whitting et al. (2016) did not find a significant effect of wearing weightlifting shoes versus athletic shoes on peak trunk lean during the squat lift. Another study compared barefoot, barefoot on a declined platform, and weightlifting shoes (Lee et al., 2017). They found no significant differences in thoracic, lumbar, and knee kinematics among the three conditions. However, they noticed a trend of greater peak knee flexion in the two conditions with raised heels (weightlifting shoe and barefoot on a decline platform).

**Differences between Squat Lifts and Deadlifts**

Squats are one of the three lifts in powerlifting (Hales et al., 2009). Squat lifts have many of the same active muscle groups as does the deadlift, such as the gluteal, quadriceps, hamstrings, and core musculature. With similar active muscle groups, biomechanical
differences between the squat lift and the deadlift are of interest. Hales et al. (2009) studied kinematic differences between the back squat and the conventional style deadlift. They found significant differences between the squat lift and deadlift for nearly all of the joint angles measured, including the hip, knee, and ankle angles during the beginning of the ascent phase. Therefore, they concluded that the analysis of the kinematic data for the back squat and the conventional deadlift indicated that the lifts are markedly different.

One of the main differences between the back squat and the conventional deadlift is the bar placement (Hales et al., 2009). The bar starting point in the back squat is on the upper back by the trapezius muscles, while the deadlift bar starting position is by the ground between the ankle and the knee. The squat movement follows a pattern of descent followed by ascent, while the deadlift is opposite, ascent followed by descent. It was found that the sticking point was significantly different between the conventional deadlift and the back squat. The difference in sticking point occurred due to differences in ankle, knee, and hip angular positioning. In addition, the bar velocity was significantly different when comparing the deadlift and squat lift. Hales et al. (2009) concluded that the sticking point mechanisms differ between the back squat and the conventional deadlift. Combined with kinematic differences between the deadlift and back squat, they also concluded that there is no direct or specific cross-over effect existing between the individual lifts.

Epidemiology of Resistance Training Injuries

However unfortunate, injuries are a part of life. The goal of resistance training is to reduce and prevent the prevalence of injuries as much as possible. This section will examine the
rate and incidence of injuries attributed to weightlifting, along with risk factors associated with lower back and lower extremity injuries and pain.

**Incidence rates**

Quatman et al. (2009) examined the differences in injury rate for strength training between sexes for 14 to 30 year-old patients. They found an approximately 6 to 1 ratio in strength training injuries between males and females. In addition, they noted that males had a significantly greater chance of strains and sprains than compared to females. The trunk area was the most common injury site for both sexes; however, males had a significantly greater chance of sustaining a trunk injury compared to females. However, females only made up 16.5% of the total strength training injuries for this study. The authors noted that, this disparity likely reflects that females were less involved in strength training then males and may not suffer injuries as often as males during resistance training activities.

The question of safety in weight training, including powerlifting, resistance training, body building, and weight lifting, is an important one. In a comparison of 40 categories across 15 different sports, resistance training had the lowest incidence rate per 100 hours of any other sport (Hamill, 1994). For the deadlift, the lower back and lower extremities were most likely to become injured (Siewe et al., 2014). It should be noted that many of these sports, including resistance training, had some oversight of a qualified professional, whether it be a coach or trainer. Even with the low injury rate of resistance training, there still needs to be adequate instruction for individuals seeking to learn the sport, and supervision needs to be provided. There seems to be little risk involved in resistance training of any form under proper
supervision and instruction. However, many individuals still lift without proper supervision, and this justifies increasing the safety of resistance training.

In a systematic review conducted by Aasa et al. (2017), they found that the spine, knee, and shoulder were the most common joints injured in Olympic weightlifting. The lower back appeared in every study that was included in the systematic review that reported injury locations (Aasa et al., 2017). In the seven studies that reported the injury location, the lower back had the highest incidence rate in three studies, ranked second in two studies, and ranked third or lower in the other two studies. The authors also stated that there is a high load on the spine during the deadlift, with some compressive forces averaging over 17,000 N in elite powerlifters.

In another systematic review by Keogh & Winwood (2017), the incidence rate for the lower back was consistently in the top three most injured locations, with several studies having the lower back as the most injured location. The reviewed studies included weightlifting, powerlifting, bodybuilding, strongman, Highland Games, and CrossFit. The deadlift is a common strength building exercise for all of the aforementioned activities. It is a key component in powerlifting and CrossFit, and core component in Olympic lifting. There is a high risk of injury to the lower back regardless of the activity being completed (Keogh & Winwood, 2017), and the deadlift may be a common link.

Medical costs and recovery

Medical costs for injuries are staggering in the United States (Dagenais et al., 2008; Druss et al., 2002), with cost of lower back pain alone amassing billions of dollars in direct and indirect medical expenses. Druss et al. (2002) examined data from 1996 and found that the
average cost to correct a back problem was $956. They estimated the amount of people with lower back problems was 13.2 million, resulting in a national cost of over 12.2 billion dollars in lost work days.

The amount of money the United States spends on low back pain is significantly higher than other countries in both direct and indirect costs (Dagenais et al., 2008). However, the authors also noted that lower back pain is an expensive economic burden wherever it was studied. A reason for having such a high cost of low back problems was attributed to the United States also having the highest rate of surgery for back pain in this study of twelve countries (Andersson, 1999).

One of the costs associated with lower back pain is the time of recovery (Andersson, 1999). While most individuals recovered relatively quickly and without function loss, there were others whose recovery did not fare as well. While most in the study recovered by 12 weeks, only half of those who were unable to recover by six months returned to work. After a two-year period of being absence from work, the rate of return was near zero.

**Gap in Knowledge**

Previous research about the deadlift has focused on performing the deadlift with different bars or feet positioning relative to the bar. However, there is little information about performing the deadlift using a flat sole or barefoot. Previous research about squat lifts has examined differences due to footwear, but there are fundamental kinematic and movement pattern differences between the deadlift and squat lift. The gap in the research is whether or not deadlifting with shoes is detrimental to performance of the lift itself and/or places the lifter at a higher chance of injury.
Research objectives

The objective of this study was to compare the effects of performing the deadlift with or without shoes on lower extremity biomechanics and lifting performance. Ankle, knee, and hip joint angles and moments were determined to assess lower extremity biomechanics during the deadlift, while bar velocity was used to assess lifting performance. Sunny (2015) found no changes in joint angles between heel height conditions, and Hammer et al. (2017) found a faster rate of force development for the unshod condition during deadlifts. Consistent with these previous studies, the hypothesis was that ankle dorsiflexion, knee flexion, and hip flexion angles would be similar when deadlifting in the shod and unshod conditions, but bar velocity would increase in the unshod condition.


CHAPTER 3. BIOMECHANICAL EFFECTS OF SHOD VS. UNSHOD

DEADLIFT

A paper to be submitted to the Journal of Strength and Conditioning Research

Introduction

Deadlifts are one of the three powerlifts and a core component of Olympic lifts, with loading through the feet at the bottom of the kinetic chain. While most gyms require a lifter to have shoes on, others are more lenient about footwear when deadlifting and squatting. Since barefoot or minimalist running has become popular, some shoe companies have developed shoes that have no heel elevation and have minimal material. While researchers have investigated differences in biomechanics and injury potential for shod and unshod squat lifts, there has been relatively little research in this area for the deadlift.

Squats are a popular exercise that is used for both strength training and rehabilitation. Performing the squat with weightlifting shoes has been found to significantly reduce trunk lean displacement as compared to running shoes (Sato et al., 2012). This decrease in forward trunk lean may reduce the amount of shear force applied to the lower back. In contrast, Whitting et al. (2016) did not find a significant effect of wearing weightlifting shoes versus athletic shoes on peak trunk lean during the squat lift. Another study compared barefoot, barefoot on a declined platform, and weightlifting shoes (Lee et al., 2017). They found no significant differences in thoracic, lumbar, and knee kinematics among the three conditions. However, they noticed a
trend of greater peak knee flexion in the two conditions with raised heels (weightlifting shoe and barefoot on a decline platform).

Squat lifts have many of the same active muscle groups as does the deadlift, such as the gluteal, quadriceps, hamstrings, and core musculature. With similar active muscle groups, biomechanical differences between the squat lift and the deadlift are of interest. Hales et al. (2009) studied kinematic differences between the back squat and the conventional style deadlift. They found significant differences between the squat lift and deadlift for nearly all of the joint angles measured, including the hip, knee, and ankle angles during the beginning of the ascent phase. Therefore, they concluded that the analysis of the kinematic data for the back squat and the conventional deadlift indicated that the lifts are markedly different.

Hammer et al. (2007) investigated power output between shod vs. unshod deadlifts. The unshod condition was found to have a faster rate of force development and higher peak force. It was also found that the shod condition had more displacement in the medio-lateral peak center of pressure. Sunny (2015) examined different heel height conditions ranging from 0.00 to 1.50 inches. Participants performed the deadlift at 70% of their one repetition maximum, and completed three repetitions of the different heel height conditions. The author found no significant differences in joint angles between the heel height conditions, inferring that ankle mobility has little or no effect on the set up for the deadlift. It should also be noted that this study used wooden blocks for its shod conditions and not shoes. Using wooden blocks may not be an accurate representation for shoes of different heel heights. The wooden blocks may have affected the perception of the participant and ultimately affected the results.
Previous research about the deadlift has focused on performing the deadlift with different bars or feet positioning relative to the bar. However, there is little information about performing the deadlift using a flat sole or barefoot. Previous research about squat lifts has examined differences due to footwear, but there are fundamental kinematic and movement pattern differences between the deadlift and squat lift. The gap in the research is whether or not deadlifting with shoes is detrimental to performance of the lift itself and/or places the lifter at a higher risk of injury.

The objective of this study was to compare the effects of performing the deadlift with or without shoes on lower extremity biomechanics and lifting performance. Sunny (2015) found no changes in joint angles between heel height conditions, and Hammer et al. (2017) found a faster rate of force development for the unshod condition during deadlifts. Consistent with these previous studies, the hypothesis was that ankle dorsiflexion, knee flexion, and hip flexion angles would be similar when deadlifting in the shod and unshod condition, but bar velocity would increase in the unshod condition.

Methods

Participants

Thirty male participants aged 18-30 years were recruited for this study (21.6 ± 3.2 years, 81.1 ± 10.7 kg, 1.77 ± 0.07 m, 80% one rep max 113.3 ± 24.7 kg). Only males were recruited due to their higher rate of being injured during resistance training than females (Quatman et al., 2009). The inclusion criteria included at least one year of deadlift experience and engaging in resistance training at least three times per week. The exclusion criteria included a history of
lower body or back surgery, a lower body or back injury within the past six months, or current health conditions that could affect performance in a deadlift (including fatigue from previous physical activity at the time of testing). At the beginning of the session, the participant’s completed a health questionnaire to ensure that inclusion and exclusion criteria were met. All procedures were approved by the University Institutional Review Board and participants provided informed consent forms prior to testing (Appendix B).

**Warm up and one repetition maximum testing**

A warm up began with a five-minute light jog at a self-selected pace on a treadmill. Participants then performed a standardized series of dynamic stretches that target the active muscles used in the conventional deadlift. The dynamic warm-up stretches focused on the quadriceps, hamstring, and gluteal muscle groups. After completion of the warm-up, the participant’s age, height, and weight were measured and recorded. Next, the participant completed the one repetition maximum for the conventional deadlift using the testing protocol set forth by the National Strength and Conditioning Association as shown in Table 1:
### Table 1. National Strength and Conditioning Association one repetition maximum test

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Warm-up with a light load to be easily performed for eight to twelve repetitions</td>
</tr>
<tr>
<td>2.</td>
<td>Rest one minute</td>
</tr>
<tr>
<td>3.</td>
<td>Perform another warm-up set of five repetitions by adding 10-30 pounds or an increase of five to ten percent</td>
</tr>
<tr>
<td>4.</td>
<td>Rest two to four minutes</td>
</tr>
<tr>
<td>5.</td>
<td>Increase the load to begin testing the one repetition maximum by adding 10-30 pounds or an increase of five to ten percent</td>
</tr>
<tr>
<td>6.</td>
<td>If the subject was successful, then allow a two to four minutes rest before increasing the weight again as before</td>
</tr>
<tr>
<td>7.</td>
<td>If the subject failed, then reduce the weight by subtracting five to ten pounds or 2.5 to 5%</td>
</tr>
<tr>
<td>8.</td>
<td>Continue to increase or decrease weight until the subject can perform one repetition with proper technique. One repetition maximum should be reached within three to five testing sets.</td>
</tr>
</tbody>
</table>

### Experimental Protocol

The research team then placed twenty-three retroreflective markers on bony landmarks of the participant’s dominant foot, leg, thigh, pelvis, shoulders, neck, and bar (figure A1 and A2). Static trials were collected for the shod and unshod condition. Before testing the conditions,
there was a three to six minute rest period between the end of the one repetition maximum test and the beginning of the first condition.

A repeated-measures design was used to compare the biomechanical effects of deadlifting in shod and unshod (barefoot) conditions. The data collection procedure involved the participant performing a deadlift at 80% of his maximum one repetition lift for five repetitions for the shod and unshod conditions. The order of conditions was counterbalanced across participants to help avoid potential effects of fatigue affecting overall comparisons. For the shod condition, the participant performed the deadlift while wearing their normal weightlifting shoes. For the unshod condition, the participant performed the deadlift while barefoot. The rest time between conditions was at least three minutes and up to six minutes. Rest time started as soon as the last repetition was completed and stopped when the participant became set at the bar. Participants completed a short survey at the conclusion of the data collection.

An eight-camera motion analysis system (Vicon, Oxford, UK) was used to measure body movement by tracking retroreflective markers placed on anatomical landmarks. An in-ground force platform (AMTI, Watertown, MA) was used to measure ground reaction forces and centers of pressure under the right foot. Video and force platform data were collected at a sampling frequency of 200 Hz and synchronized using Nexus software (Vicon, Oxford, UK). Data were filtered using a symmetric, low-pass Butterworth filter with a cutoff frequency of 10 Hz.

**Data analysis**

Ankle, knee, and hip joint angles were calculated using Euler-Cardan angles with a rotation sequence of flexion/extension, abduction/adduction, and internal/external rotation. Joint moments were calculated using inverse dynamics starting with the force platforms and
working successively through the ankle, knee, and hip. Bar velocity was determined from bar marker positions using the first central difference method.

Joint angles, joint moments, and bar velocity were calculated at bar lift off and knee pass. Bar lift off was defined when the bar markers are two standard deviations above the resting height of the bar, calculated from the vertical bar position after the last repetition. Knee pass was defined as when the average of the bar markers passes the average of the knee markers. The middle three repetitions were analyzed to allow the participant to get into the rhythm of the lift for the first repetition, while preparing to set the bar down during the final repetition. The middle three repetitions were averaged, and a pair-wise t-test was used to compare the shod and unshod conditions.

Using a power analysis, it was determined that a total sample size of twenty-nine was required to maintain a power of 0.81. The effect size was 0.55. Statistical significance was set at alpha of 0.05 for bar velocity and a Bonferroni adjustment was used for the joint angles and moments with statistical significance set at an alpha of < 0.017.

**Results**

There were significant differences in the ankle and knee joint angles between the two conditions at lift off (Table 2). The shod condition resulted in significantly higher ankle dorsiflexion ($p = 0.018$) and knee flexion ($p < 0.001$) angles at lift off. There were no significant differences between the shod and unshod conditions for the ankle, knee, and hip angles at knee pass (Table 3).
Table 2. Joint angles between conditions at point of lift off in degrees. Positive values indicate ankle dorsiflexion, knee flexion, and hip flexion angles. * indicates significantly higher joint angle.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Ankle</th>
<th>Knee</th>
<th>Hip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shod</td>
<td>7.1±5.0 *</td>
<td>51.4±7.7 *</td>
<td>67.8±11.9</td>
</tr>
<tr>
<td>Unshod</td>
<td>5.6±5.5</td>
<td>47.6±7.9</td>
<td>66.2±13.1</td>
</tr>
<tr>
<td>p-value</td>
<td>0.018</td>
<td>&lt;0.001</td>
<td>0.077</td>
</tr>
</tbody>
</table>

Table 3. Joint angles between conditions at point of knee pass in degrees. Positive values indicate ankle dorsiflexion, knee flexion, and hip flexion angles.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Ankle</th>
<th>Knee</th>
<th>Hip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shod</td>
<td>-5.6±4.0</td>
<td>19.0±5.8</td>
<td>44.0±7.9</td>
</tr>
<tr>
<td>Unshod</td>
<td>-5.2±4.4</td>
<td>20.0±5.7</td>
<td>44.3±9.0</td>
</tr>
<tr>
<td>p-value</td>
<td>0.471</td>
<td>0.055</td>
<td>0.642</td>
</tr>
</tbody>
</table>

There was a significant difference in knee joint moment between the two conditions at lift off (Table 4). The shod condition resulted in a significantly higher knee flexion moment (p < 0.001) at lift off. There were no significant differences between the shod and unshod conditions for the ankle, knee, and hip moments at knee pass (Table 5).
Table 4. Joint moments between conditions at point of lift off in Nm/kg. Positive values indicate ankle plantar flexion, knee extension, and hip extension moments. * indicates significantly higher joint moment.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Ankle</th>
<th>Knee</th>
<th>Hip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shod</td>
<td>1.0±0.3</td>
<td>-0.5±0.4</td>
<td>2.8±0.3</td>
</tr>
<tr>
<td>Unshod</td>
<td>1.0±0.4</td>
<td>-0.3±0.4</td>
<td>2.8±0.3</td>
</tr>
<tr>
<td>p-value</td>
<td>0.680</td>
<td>&lt;0.001</td>
<td>0.789</td>
</tr>
</tbody>
</table>

Table 5. Joint moments between conditions at point of knee pass in Nm/kg. Positive values indicate ankle plantar flexion, knee extension, and hip extension moments.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Ankle</th>
<th>Knee</th>
<th>Hip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shod</td>
<td>0.62±0.33</td>
<td>0.53±0.26</td>
<td>2.40±0.31</td>
</tr>
<tr>
<td>Unshod</td>
<td>0.65±0.35</td>
<td>0.52±0.29</td>
<td>2.40±0.29</td>
</tr>
<tr>
<td>p-value</td>
<td>0.261</td>
<td>0.693</td>
<td>0.820</td>
</tr>
</tbody>
</table>

There was a significant difference in bar velocity between the two conditions at knee pass (Table 6). The shod condition resulted in a significantly higher bar velocity (p = 0.028) at knee pass. There was not a significant difference between the shod and unshod conditions for the bar velocity at lift off (Table 6).
Table 6. Bar velocities in m/s. * indicates significantly higher bar velocity.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Lift Off</th>
<th>Knee Pass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shod</td>
<td>0.272±0.07</td>
<td>0.748*±0.13</td>
</tr>
<tr>
<td>Unshod</td>
<td>0.274±0.06</td>
<td>0.724±0.14</td>
</tr>
<tr>
<td>p-value</td>
<td>0.765</td>
<td>0.028</td>
</tr>
</tbody>
</table>

In the post-test survey, 83% of participants indicated that they normally lift with shoes on (Table 7). However, 66% of participants indicated they preferred lifting barefoot compared to 21% preferring to lift with shoes and 14% undecided. When asked why they preferred the unshod condition over the shod condition, many participants answered either they felt more power or more stable while being barefoot.

Table 7. Post-test survey responses

<table>
<thead>
<tr>
<th>Normal Lifting Condition</th>
<th>Testing Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shod</td>
<td>Shod</td>
</tr>
<tr>
<td>Unshod</td>
<td>24</td>
</tr>
</tbody>
</table>

Discussion

While the squat has been studied quite extensively (Comfort et., 2018; Lee et al., 2017; Hales et al., 2009; Whitting et al., 2016), the deadlift has received less attention. The purpose of
this study was to compare joint angles, joint moments, and bar velocity when deadlifting with and without shoes. The hypothesis that ankle dorsiflexion, knee flexion, and hip flexion angles would be similar when deadlifting in the shod and unshod conditions was not supported. Instead, ankle dorsiflexion and knee flexion angles were significantly lower in the unshod condition. These results indicate that performing the deadlift while barefoot could benefit lifters who struggle with more flexed postures and/or have limited ankle dorsiflexion range of motion. This is in contrast to Sunny (2015), who did not find any differences in joint angles when comparing deadlifts performed with different heel heights. The discrepancy in results may be due to Sunny (2015) using wooden blocks to adjust heel height, while the participant’s normal lifting shoes were used in this study. The heel heights in the study done by Sunny (2015) had a range of 0.25 to 1.50 inches, while in contrast, our study had a heel height range of 0.00 to 1.50 cm. While there was overlap in the range of heel heights, our minimum and maximum heel heights were lower than Sunny (2015). This difference between shoes and wooden blocks could very well have led to the differences in results that we found compared to Sunny (2015).

The hypothesis that bar velocity would be increased in the unshod condition was also not supported. Instead, the bar velocity was significantly lower in the unshod position at the point of knee pass. It is possible that lifting barefoot may decrease deadlift performance in terms of power generated as evidenced by this reduced bar velocity. In contrast, Hammer et al. (2017) looked at the rate of force development of the bar and concluded that there was a faster rate of force development in the unshod condition. This difference could be because in the Hammer et al. (2017) study, they instructed their subjects to lift the bar as fast as possible during the concentric phase. In the current study, participants were instructed to maintain
good lifting technique during the five repetitions. The bar velocity was likely dependent upon the lifter focusing on form rather than lifting as fast as possible.

We are not aware of any previous studies that have compared joint moments between shod and unshod conditions during the deadlift. In this study, deadlifting barefoot resulted in a significantly lower knee flexion moment at lift off. Thus, lifting barefoot may benefit those who struggle to generate or balance this knee moment at the initiation of the deadlift. The reduced knee flexion moment may be due to the reduced ankle dorsiflexion and knee flexion angles at lift off when lifting barefoot. Reduced knee flexion moments may also be due to different bar positions relative to the knee joint when lifting barefoot. It should be noted as well that a majority of the participants for this study normally deadlifted while wearing shoes (Table 9). Since most of the participants were used to wearing shoes, deadlifting while barefoot would have been unfamiliar to them. This may have caused the decrease in bar velocity because they were focusing more on deadlift form in the unfamiliar condition.

There were several limitations to this study. Back injuries are common during deadlifting, but L5/S1 joint moments and compression forces were not calculated in this study. In order to add L5/S1 loading to future protocols, retroreflective markers would need to be placed on both legs for a bottom-up analysis or additional markers on the upper body for a top-down analysis. Hip moments were nearly identical when comparing the shod and unshod conditions, so it is possible that we also would not have seen any differences in L5/S1 moments. Another limitation is that only males were included as participants in this study, so the results may not be generalizable to females. Future studies that include females would provide
additional evidence whether or not the changes observed in males while deadlifting barefoot also apply to females.

In summary, deadlifting barefoot resulted in lower ankle dorsiflexion angle, knee flexion angle, and knee flexion moment at lift off. Deadlifting barefoot also resulted in lower bar velocity at knee pass. These results indicate that performing the deadlift while barefoot could benefit lifters who struggle with more flexed postures and/or have limited ankle dorsiflexion range of motion. These changes in posture likely led to the reduced knee flexion moments required to initiate bar lift off. However, lifting barefoot may decrease deadlift performance in terms of power generated as evidenced by reduced bar velocity.

References


CHAPTER 4. GENERAL CONCLUSIONS

In conclusion, the purpose of this study was to examine the effects of deadlifting barefoot on ankle, knee, and hip joint angles and moments as biomechanical measures. Bar velocity was also determined as a performance measure. Two critical time points for successful execution of the deadlift, lift off and knee pass, were analyzed. Deadlifting barefoot resulted in lower ankle dorsiflexion angle, knee flexion angle, and knee flexion moment at lift off. In addition, lifting barefoot resulted in lower bar velocity at knee pass.

For future studies, collecting data with female participants in the shod vs. unshod conditions may be of value for wider generalization. Potential sex differences between males and females in the deadlift may also be of interest. In addition, future studies could analyze L5/S1 moments and compressive forces as lower back injury risk factors. This would require markers on both legs or additional markers on the upper body. Furthermore, it was observed that some lifters used a touch and go pattern versus a pause and rest pattern. A future study could compare if there are biomechanical differences between these two deadlift techniques.

The real-world applications for this study were to look at whether deadlifting barefoot affected and deadlifting biomechanics and performance. The findings indicated that deadlifting barefoot may benefit those with reduced ankle range of motion. Deadlifting barefoot may also result in reduced lifting performance if the goal is power generation. However, the goal of the deadlift is not always to lift the weight as fast as possible, but to complete the lift while maintaining proper form. While not all gyms allow one to lift barefoot and one should also take caution when lifting barefoot as well, the vast majority of participants preferred lifting
barefoot. If the opportunity arises to lift in either a barefoot or in a minimalist shoe, lifters may find it preferable to their regular shoes.
APPENDIX A. MARKER SET AND DEADLIFT POSITIONS

Figure A1. Frontal view of shod static marker set
Figure A2. Sagittal view of shod static marker set
Figure A3. Frontal view of deadlift at lift off
Figure A4. Frontal view of deadlift at knee pass
Figure A5. Frontal view of deadlift repetition completed
APPENDIX B: INFORMED CONSENT DOCUMENT AND SURVEYS/QUESTIONNAIRES

Date: 03/06/2019
To: Jacob Lamarche  Jason Gillette
From: Office for Responsible Research
Title: Biomechanical Effects of Shod vs. Unshod Deadlift
IRB ID: 18-317
Submission Type: Modification  Review Type: Expedited
Approval Date: 03/06/2019  Approval Expiration Date: N/A

The project referenced above has received approval from the Institutional Review Board (IRB) at Iowa State University according to the dates shown above. Please refer to the IRB ID number shown above in all correspondence regarding this study.

To ensure compliance with federal regulations (45 CFR 46 & 21 CFR 56), please be sure to:

- Use only the approved study materials in your research, including the recruitment materials and informed consent documents that have the IRB approval stamp.
- Retain signed informed consent documents for 3 years after the close of the study, when documented consent is required.
- Obtain IRB approval prior to implementing any changes to the study or study materials.
- Promptly inform the IRB of any addition of or change in federal funding for this study. Approval of the protocol referenced above applies only to funding sources that are specifically identified in the corresponding IRB application.
- Inform the IRB if the Principal Investigator and/or Supervising Investigator end their role or involvement with the project with sufficient time to allow an alternate PI/Supervising Investigator to assume oversight responsibility. Projects must have an eligible PI to remain open.
- Immediately inform the IRB of (1) all serious and/or unexpected adverse experiences involving risks to subjects or others; and (2) any other unanticipated problems involving risks to subjects or others.
- IRB approval means that you have met the requirements of federal regulations and ISU policies governing human subjects research. Approval from other entities may also be needed. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of
Biomechanical Effects of Shod vs. Unshod Deadlift

-Informed Consent Document-

*To be completed by the volunteer*

**Investigators:** Jacob LaMarche and Dr. Jason Gillette

This form describes a research project. It has information to help you decide whether or not you wish to participate. Research studies include only people who choose to take part—your participation is completely voluntary. Please discuss any questions you have about the study or about this form with the project staff before deciding to participate.

**Introduction**

With increased interest and participation in resistance training, it is important to understand safe lifting practices. In relationship to the deadlift, little research has been completed on wearing shoes during the lift. This research study is looking into the different effects of shod (wearing shoes) vs unshod (barefoot) on ankle, knee, hip, and low back movement and loading when performing the deadlift.

You are being invited to participate in this study because you are 18-30 years old and have at least one year of resistance training and deadlift experience. You should not participate if you have had lower body or back surgery, if you have had a lower body or back injury within that past 6 months, or if you have and health conditions that could affect performance in a deadlift (this includes fatigue from previous physical activity at the time of testing).

**Description of Procedures**

Data collection will be performed in the Biomechanics Lab at 178N Forker Building, Iowa State University. You will be tested individually, and sessions will not overlap. At the beginning of the session, you will first review the inclusion/exclusion criteria, the informed consent (this document), and health questionnaire. Pending your acceptance, you will sign the informed consent (this document), complete the subsequent forms, and proceed with the data collection. Athletic clothing and your normal weightlifting shoes are required, and clothing can be provided in a range of sizes if needed. The total time estimated for the session is about one hour.

Your age and anthropometrics (height, weight) will then be measured and recorded, respectively. After a 5-minute light jog at a self-selected pace on a treadmill and a standardized series of dynamic stretches, you will then go through the one repetition maximum testing protocol set forth by the National Strength and Conditioning Association. The research team will then place retroreflective markers on bony landmarks of your dominant foot, leg, thigh, and pelvis.

The data collection procedure will involve you performing a deadlift at 80% of your maximum one repetition lift for two different conditions. One condition will be with your shoes on and the other will be barefoot. You will perform 5 lifts in each condition with a 3 to 5 minute rest between the two trials.

**Risks or Discomforts**

While participating in this study you may experience the following risks or discomforts:

Any physical performance presents the risk of musculoskeletal injury. Situations of increased rates of loading (such as deadlifting) present the possibility of bruising or muscular soreness, and in extreme cases injuries such as muscle, tendon, and ligament strains or ruptures.

To combat these possibilities, inclusion/exclusion criteria and the testing maneuvers were specifically designed. You are required to be a healthy, physically-active individual without a history of musculoskeletal injury to be tested, which should minimize the chance of injury. If you identify any increases in pain or unsteadiness, or if the researchers notice particularly dangerous movement patterns or performance variability, the session will be stopped. The minimum of 3 minutes rest between trials should effectively combat fatigue (by allowing for adequate time for muscular recovery) which could lead to overuse injury or soreness, and more rest is allowed.
Benefits
If you decide to participate in this study, there will be no direct benefit to you. It is hoped that the information gained in this study will benefit society by providing information on footwear for deadlifting to minimize injury.

Costs and Compensation
You will not have any costs from participating in this study. You will not be compensated for participating in this study. Participants can potentially receive extra credit (of no more than 0.5% the class grade) if enrolled in Kinesiology classes that offer such an opportunity. Kinesiology classes that do offer this option also offer alternative sources for extra credit. Please review your class syllabus and talk to your instructor. For example, sections of KIN 355 taught by Dr. Gillette offer multiple opportunities to obtain extra credit by participating in research-based and non-research based data collections. Completing this Informed Consent document is considered participation. If the session is stopped for any reason, you are still entitled to extra credit.

Participant Rights
Participating in this study is completely voluntary. You may choose not to take part in the study or to stop participating at any time, for any reason, without penalty or negative consequences. You can skip any survey questions that you do not wish to answer. Your choice of whether or not to participate will have no impact on you as a student, nor have any impact on your relationship/employment with Dr. Gillette.

If you have any questions about the rights of research subjects or research-related injury, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3115, Office for Responsible Research, Iowa State University, Ames, Iowa 50011.

Research Injury
Please tell the researchers if you believe you have any injuries caused by your participation in the study. The researchers may be able to assist you with locating emergency treatment, if appropriate, but you or your insurance company will be responsible for the cost. Eligible Iowa State University students may obtain treatment from the Thelen Student Health Center. By agreeing to participate in the study, you do not give up your right to seek payment if you are harmed as a result of being in this study. However, claims for payment sought from the University will only be paid to the extent permitted by Iowa law, including the Iowa Tort Claims Act (Iowa Code Chapter 669).

Confidentiality
Records identifying participants will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available. However, federal government regulatory agencies, auditing departments of Iowa State University, and the Institutional Review Board (a committee that reviews and approves human subject research studies) may inspect and/or copy study records for quality assurance and data analysis. These records may contain private information.

To ensure confidentiality to the extent permitted by law, the following measures will be taken:
Any data recorded about you will be dissociated from your identity through a numeric key unrelated to your identifying details. The data and your name will be separately secured in locked filing cabinets in a locked office on campus. Digital data will be stored on password-protected computer. These data can be only identified by participant number.

When the data from this study is eventually presented, no information derived from the data will indicate your identity. De-identified information collected about you during this study may be shared with other researchers or used for future research studies. We will not obtain additional informed consent from you before sharing the de-identified data.

Questions
You are encouraged to ask questions at any time during this study. For further information about the study, contact Jacob LaMarche at jacob91@iastate.edu or Dr. Jason Gillette at gillette@iastate.edu or (515) 294-8310.

Office for Responsible Research
Revised 8/6/13
Page 2 of 3
Consent and Authorization Provisions:

Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document, and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.

Participant’s Name (printed) ______________________________________________________

Participant’s Signature __________________________ Date _________________________

Witnessing Investigator’s Signature __________________________ Participant #_________
Biomechanical Effects of Shod vs. Unshod Deadlift

-Demographics/Anthrometrics Information Sheet-

*To be completed by the researchers*

Researcher(s): 
Date: 

Participant Number: 
80%

Age: 
Foot Dominance: 

Height: 
Class EC: 

Weight: 
Shoe drop: 

Sex: 

One Rep Max
Biomechanical Effects of Shod vs. Unshod Deadlift

-Health Questionnaire-

*To be completed by the volunteer*

Have you ever been diagnosed with or had any of the following?

- Heart Attack? [Yes No]
- Heart Surgery? [Yes No]
- Cerebrovascular accident (e.g. Stroke)? [Yes No]
- Transient Ischemic Attack (TIA)? [Yes No]
- Carotid Artery Disease? [Yes No]
- Cardiac Catheterization? [Yes No]
- Coronary Angioplasty? [Yes No]
- Pacemaker/Implantable Cardiac Device? [Yes No]
- Irregular Heart Rate/Heart Rhythm Disturbance? [Yes No]
- Atrial Fibrillation? [Yes No]
- Heart Valve Disease? [Yes No]
- Heart Failure? [Yes No]
- Heart Murmur? [Yes No]
- Heart Transplantation? [Yes No]
- Aneurysm (ballooning/bulging of an artery)? [Yes No]
- Syncope (loss of consciousness)? [Yes No]
- Hypertension (high blood pressure)? [Yes No]
- Congenital Heart Disease? [Yes No]
- Prediabetes [Yes No]
- Type 2 Diabetes [Yes No]
- Type 1 Diabetes [Yes No]

Have you ever experienced any of the following symptoms?

- Chest discomfort with exertion? [Yes No]
- Unreasonable breathlessness (shortness of breath)? [Yes No]
- Dizziness, fainting, or blackouts? [Yes No]
- Syncope (loss of consciousness)? [Yes No]
- Hypoxia (low oxygen levels)? [Yes No]
Problems with your blood sugar levels? Yes No
Do you currently take medication(s) for heart disease? Yes No
Do you currently take medication(s) for high blood pressure? Yes No
Have you been diagnosed with osteoporosis or osteopenia? Yes No
Has a health care provider ever told you that you have sarcopenia? Yes No
Have you ever had a concussion? Yes No
Have you ever had a balance problem? Yes No
Have you ever had any bone fractures? Yes No
  \textbf{Where and when?}
Have you ever had ligament / tendon sprains or ruptures? Yes No
  \textbf{Where and when?}
Have you ever had joint dislocations or joint replacements? Yes No
  \textbf{Where and when?}
Have you ever had muscle strains or muscle injuries? Yes No
  \textbf{Where and when?}
Have you ever had any surgeries? Yes No
  \textbf{Where and when?}
Do you have any current orthopedic problems? Yes No
  \textbf{Where?}
Have you ever had a lower extremity injury that prevented participation in physical activity for more than 2 weeks over the past 6 months? Yes No
  \textbf{What specifically?}
Do you have any other conditions that prevent you from participating in exercise and sporting activities? Yes No
  \textbf{What specifically?}
Are you allergic to latex or adhesive? Yes No
What is your sports experience (middle / high school, club, university, etc.)? Please list the type of sports, level of competition, and the starting and end year.

What are your current exercise and sports activities? Please list type of exercise and sports and the frequency and duration.