DETERMINING COMPENSATORY MUSCLE ACTIVATIONS IN SPRINTERS WITH LOWER LIMB AMPUTATION
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INTRODUCTION: The aim of this study was to make descriptive analyses of the muscles in the lower extremity of subjects with lower limb amputation during a maximum velocity sprint. Through the use of kinematic measures and electromyography (EMG), the researchers were able obtain a comprehensive picture of the sprinters with amputation. Research was designed to examine the use of compensatory muscle contractures and kinematic differences between comparable able-bodied sprinters and those with amputation performing at the highest levels. The principle aim of the research study was to examine compensatory muscle function in sprinters with transtibial amputation to determine which muscle groups are targeted most to replace speed and power lost by transected plantar and dorsi-flexors.

OBJECTIVE: The primary objective was to quantify muscle activation patterns from the unaffected limb and the affected limb of transtibial amputee sprinters in order to identify potential differences between legs. The secondary objective was to quantify muscle activation patterns from sprinters with and without amputation in order to identify potential compensatory control strategies used by athletes with amputations. The tertiary objective was to correlate compensatory muscle patterns to training and strengthening protocols as a means of improving athletic performance and reducing secondary injury in a specified activity.

METHODS: The study design utilized repeatable measures in an observational descriptive comparative analysis. Data was collected on five active US Paralympic track and field athletes (AMP), which were paralleled to five able-bodied athletes (NA) of similar caliber, all of which were at or near Olympic performance. Data for the study was collected using a wireless Noraxon Telemyo EMG system, the APDM human movement sensors, video gait analysis, and the Optojump. The researchers designated eight muscles in the lower limb of which the most muscle activation and compensatory patterns during the sprint was anticipated. These muscles were the tibialis anterior (TA), soleus (SOL), lateral gastrocnemius (LG), rectus femoris (RF), vastus lateralis (VL), biceps femoris (BF), semitendinosus (ST), and gluteus maximus (GM). Each athlete was suited with EMG electrodes over the designated muscle bellies and tested for their maximum voluntary contraction (MVC). Once the preliminary testing was complete the athletes were asked to execute 4-30m fly-in sprints at maximum velocity. The testing took place on an outdoor track located at the Olympic Training Center in Chula Vista, California.

RESULTS: The researchers have analyzed five steps from the four trials of seven subjects (4 amputees/ 3 non-amputees) running at 8.89 ± 0.29 m/s AMP and 9.74 ± 0.31 m/s NA respectively. Burst duration, mean spike amplitude and integrated area of collected EMG data were analyzed. While some differences and trends are visible in the data, the portions of the data that have been analyzed do not show statistically significant differences between legs. Further analysis of the results is needed to examine all factors and variables.

CONCLUSION: While the preliminary results are inconclusive, the researchers expect that a more complete analysis of our data set will enable us to further understand the biomechanics and compensatory mechanisms of sprinters with amputation.
1. ABSTRACT

The goal of this study was to make descriptive analyses of the muscles in the lower extremity of subjects with lower limb amputation during a maximum velocity sprint. Through the use of kinematic measures and electromyography (EMG), researchers were able obtain a comprehensive picture of the sprinters with amputation. The research was designed to examine the use of compensatory muscle contractures and kinematic differences between comparable able-bodied sprinters and those with amputation performing at the highest levels. The principle aim of the research study was to examine compensatory muscle function in sprinters with transtibial amputation to determine which muscle groups are targeted most to replace speed and power lost by transected plantar and dorsi-flexors.

2. INTRODUCTION

In the world of Paralympic sport, transtibial sprinters have entered into the 10-second range for the 100m sprint. These athletes are reaching extraordinary speeds despite not having the knowledge to fit them properly or a true understanding of their full body mechanics. Athletes performing at the elite level are pushing their bodies, talents and prosthetic limbs to great lengths with limited understanding of compensatory muscle function and joint biomechanics. As the fitting of running-specific prostheses (RSP) becomes more of a common occurrence, prosthetists, coaches and researchers, realize that the lack of knowledge about amputee sprinters is only preventing athletes from reaching their full potential. Prosthetists are fitting these amputee sprinters using able-bodied mechanics as the gold standard while knowing that amputee mechanics operate differently due to the lack of body mass, major articulating joints and bi-
articulating muscles. Therefore, a better understanding of the amputee mechanics is necessary to fully comprehend the training, coaching and fitting necessary for amputee sprinters.

There are very few studies analyzing the patterns of transtibial compensation with the use of RSPs. Findings suggest that lower limb amputee sprinters use a multitude of compensatory patterns on the unaffected and affected limb, especially when moving at such high velocities.\textsuperscript{2,6} Compensatory patterns such as increased hip and knee extension moments on the affected limb as well as an increased amount of work at each of these joints respectively.\textsuperscript{3} The affected limb (AL) is limited by the amount of vertical ground reaction force (GRF) it is able to produce due to the RSP and muscle weakness. The unaffected limb (UL) compensates for this lack of generated vertical force by producing on average nine percent more. The limit in vertical force generation on the AL is said to be the major limiting factor when it trying to compete at maximum velocities\textsuperscript{5}. Studies done analyzing amputees running at various velocities on SACH feet have shown that there is an increased level of total work done on the sound limb but that the kinematics are comparable to able-bodied athletes. There is about a 70\% increase in total work done on the unaffected limb as a whole when compared to able bodied athletes.\textsuperscript{4} Due to the developments in RSPs, amputees are now able to achieve the same up-on-the-toes gait patterns as able-bodied sprinters. This similar gait pattern creates overall similar kinematics to able-bodied sprinters.\textsuperscript{2} It has yet to be investigated how exactly the RSP impacts compensatory muscular activity on the sound limb.

Whether and how unilateral transtibial sprinters use muscles in the unaffected limb to compensate for the lack of foot and ankle on the affected limb is the focus of this paper. Five elite unilateral transtibial sprinters operating at maximum velocity, wireless EMG and high-speed cameras were used to study these compensatory patterns. The patterns demonstrated on the
AL were compared to the muscular patterns and kinematics on the UL, as well as to the limb of an able-bodied athlete of comparable athletic level. The muscles chosen to explore during this study, have been selected based on prior investigations of able-bodied sprinters. The quadriceps are expected to fire from late swing to mid-stance, the hamstrings and gluteus maximus were activated the most during mid-swing to mid-stance. While the contrast of able-bodied to corresponding UL joint angles have in past studies been comparable and increasingly similar as you reach the hip, these muscles work the hardest to propel the limb forward and transfer energy to the opposing, AL during the sprint cycle. Due to this activity in able-bodied sprinters, the research team hypothesized that the activity in the proximal thigh musculature, specifically the hip extensors, would be greater in the UL compared to the AL during a maximal velocity sprint in elite transtibial sprinters.

3. OBJECTIVES

The primary objective was to quantify muscle activation patterns from the unaffected limb and the affected limb of transtibial amputee sprinters in order to identify potential differences between legs. Differences will be determined through a comparison of surface EMG data and gait patterns between the unaffected and affected limbs. The secondary objective of this study was to quantify muscle activation patterns from sprinters with and without amputation in order to identify potential compensatory control strategies used by athletes with amputations. By comparing athletes of similar build, stature, and skill researchers will be able to determine how athletes with amputations are recruiting their residual musculature to achieve performances that are similar to unaffected athletes. The tertiary objective was to correlate compensatory muscle patterns to training and strengthening protocols as a means of improving athletic performance.
and reducing secondary injury in a specified activity. By determining the compensatory patterns of our amputees researchers will be better suited to fit and train these athletes for their sport.

4. METHODS

4.1 Subjects

Data was collected on five active U.S. Paralympic track and field athletes, which were paralleled to five able-bodied athletes of similar caliber, all of which were at or near Olympic performance (n=10; AMP=5, NA=5). The subjects were highly trained professional athletes, specializing in sports ranging from the 100m sprint to 400m hurdles. All athletes were between the ages of 18-35 years old. Both male and female athletes were included in this study. The five athletes with amputation were all unilateral transtibial athletes, T44 classification. These athletes wore their existing running specific prosthesis (RSP) optimized for sprinting events. Anthropometrics of each subject were recorded before data collection occurred: height, weight, leg length, leg circumference, type of RSP and style of suspension. The average age of our athletes was 26.4 ± 3.7 years (AMP= 27.2 ± 4.1 years, NA= 25.6 ± 3.5 years), with a weight of 77.2 ± 6.8 kgs (AMP= 76.5 ± 4.4 kg, NA= 78 ± 9.1kgs). All subjects were informed of the purpose of this study and written consent was obtained from each subject before testing. The study met bioethics committee approval.

4.2 Data Collection

The study design utilized repeatable measures in an observational descriptive comparative analysis. Data was collected using a wireless Noraxon Telemyo EMG system, the APDM human movement sensors, video gait analysis, and the Optojump. The Optojump is an optical measurement system that collects kinematic measures such as flight time and step length, over a predefined length and period. The wireless Noraxon Telemyo EMG system are surface
electrodes set to record the muscle activity in magnitude and duration of the designated superficial muscles. Researchers selected eight muscles in the lower limb of which the most muscle activation and compensatory patterns during the sprint was anticipated. These muscles were the tibialis anterior (TA), soleus (SOL), lateral gastrocnemius (LG), rectus femoris (RF), vastus lateralis (VL), biceps femoris (BF), semitendinosus (ST), and gluteus maximus (GM). The APDM human movement sensors were placed on the upper arms bilaterally and the lower lumbar spine. The athletes wore their own running specific prosthesis (RSP) suited for sprinting events. Style of suspension, type and classification of RSP were all noted but not the objective of this study. This information may be investigated further in other studies.

Each athlete was suited with EMG electrodes over the designated muscle bellies and tested for their maximum voluntary contraction (MVC). The research team tested their MVC with the use of the subject’s isometric contraction, a wooden chair and a stiff resistance band. Once the preliminary testing was complete the athletes performed 4-30m fly-in sprints at maximum velocity. Each athlete was given 30m drop-in to reach maximum velocity. The athletes followed self-selected warm-up, cool down, maximum velocity, and recovery procedures. The testing took place on an outdoor track located at the Olympic Training Center in Chula Vista, California. The trials took place over a two-day span, however each athlete was only present for a couple hours on either day.

4.3 Data Processing

Data was processed through the use of MatLab and Microsoft Excel. The bursts of contractions were analyzed with human eye and processed through codes in MatLab. MVCs were calculated and analyzed first to allow researchers to normalize the contractions recorded throughout the trial. Each athlete participated in four trials. Kinetic and kinematic measures were
recorded for all four trials. Trials were recorded using high-speed video cameras, OptoJump, ADPM Motion Sensors, and Noraxon Wireless Electrodes.

Each trial was processed according to muscle and subject group. Muscle contractions were analyzed per step pulling out burst duration, integrated area and mean spike amplitude. The EMG signals analyzed were correlated with data collected from the OptoJump allowing researchers to integrate footfall timing. The OptoJump allowed us to take the following measures into consideration: flight time, contact time, stride length, step length, speed, acceleration and height.

5. RESULTS

Researchers analyzed five steps from the four trials of seven subjects (4 amputees/ 3 non-amputees) running at 8.89 ± 0.29 m/s AMP and 9.74 ± 0.31 m/s NA respectively. Integrated area, mean spike amplitude and burst duration have been analyzed. All graphs were analyzed per step per trial per athlete. The integrated area graph (Figure 1) compared the area under each burst of recorded EMG. The mean spike amplitude graph (Figure 2) showed the average peaks per burst of recorded EMG. The burst duration graph (Figure 3) associated the duration of each burst of recorded EMG. Statistical analysis was performed using T-Tests and ANOVA. All tests proved to be insignificant at this time. More analysis will need to be performed in order to determine the level of significance. While our results are insignificant at this time researchers did find differences in the mean spike amplitude and similarities in the burst duration between the muscles.

6. DISCUSSION

The normalized mean spike amplitude of GM in the AL & UL was lower compared to NA. The burst duration of GM was longer in the AL and shorter in the UL compared to NA.
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While there is insufficient data to test true statistical significance, this may be a potential targeting area for muscle training in Paralympic athletes, because there is apparent asymmetry in the AL proximal muscle group as compared to both their UL and the performance of their able-bodied counterparts. The lower mean spike amplitude but increased burst duration of GM AL indicates lower power generation over a wider band, proving that this is one of the prime compensatory muscles. Further research will be needed to understand the affect more fully, but the hip extensors may be a target area for additional training research.

The normalized mean spike amplitude of BF and ST were greater in the UL but for a shorter burst duration than NA. The normalized mean spike amplitude of RF and VL were greater in the AL, but RF had shorter burst duration than NA. VL had an identical duration across AL, UL, and NA. The normalized mean spike amplitude of the LG, SOL, and TA were less in the UL but has a longer burst duration than NA.

When examining the quadriceps, the patterns observed are opposite to GM, in that the activation profiles have shorter duration but with greater spike amplitude in some cases and asymmetry from the contralateral limb in others. This pattern is likely due to the limitations in force production by the RSPs (5). As we know, quadriceps are the main component in force production during a sprint. We believe they are compensating for the limit in force production by the RSP.

The differences between the AL and the UL in the Paralympic group are also an interesting area of focus and training as the muscle activation profiles from one leg to another show initial signs of asymmetry. This may be resultant from the biomechanics or deflection pattern of the RSP, which may alter stride and step length parameters affecting muscle activation curves and duration. Additional thought can be put into optimizing RSPs for an individual athlete.
to improve symmetry and deflection parameters, which in turn could allow for more efficient use of hip and core musculature for sprinters with amputation.

Further examinations would extend our findings, comparing and contrasting additional data collected on stride length, ground contact time and flight time. This information will provide insight on how the asymmetries in these parameters match with some of the asymmetries seen in the muscle activation profiles. This evidence could be substantial in informing future designs of RSPs and training patterns to further improve symmetry, burst duration, and power among the specific muscle groups.

7. CONCLUSION

While the preliminary results are inconclusive, the research team expects a more complete analysis of our data set will enable a further understanding of the biomechanics and compensatory mechanisms of sprinters with amputation. Researchers hope this information will allow us to better train athletes with amputation, fit them with activity specific prosthesis and to reduce the occurrence of injury in athletes with amputation.

8. ACKNOWLEDGEMENTS

This study was funded by Baylor College of Medicine, the Paralympic Sport and Science Research Consortium and the Texas Society for Allied Heath.

9. REFERENCES


10. Novacheck, TF. The biomechanics of running. *Gait and Posture* 1998; 7: 77-95,

10. TABLES AND FIGURES

**NORMALIZED INTEGRATED AREA**

Figure 1: Normalized Integrated Area: The area under the EMG signal for each specified burst.

**NORMALIZED MEAN SPIKE AMPLITUDE**

Figure 2: Normalized Mean Spike Amplitude. The mean amplitude for each spike over a burst of EMG for the specified muscle.

**BURST DURATION**

Figure 3: Burst Duration. The average duration of an EMG burst for the specified muscle.
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Figure 4 (11): A. Anterior & B. Posterior pictorial discription of muscular activity. Green represents areas of greater peak activity and red represents muscles with lower peak activity in athletes with amputation compared to athletes without.
11. Appendix

**Study Protocol Title:** Determining Compensatory Muscle Activations in Sprinters with Lower Limb Amputations

**List of Abbreviations:**

TT- Transtibial, amputation that occurs below the knee

Txx- Describes a Paralympic athlete with an amputation

T42- Single above knee amputation (or combined arm/leg amputation) or similar disability

T43- Double below knee amputation (or combined arm/leg amputation) or similar disability

T44- Single below knee amputation or an athlete who can walk with moderately reduced function in one or both legs

T45- Double above elbow or double below elbow amputations or similar disability

T46- Single above elbow or below elbow amputation or similar disability

RSP- Running specific prosthesis

UL- Unaffected, sound limb

AL- Affected, amputated limb

EMG- Electromyography

OptoJump- An optical measurement system consisting of a series of bars with LEDs communicating continuously, detecting interruptions and calculating flight and contact times based on the retrieved data ([http://www.optojump.com](http://www.optojump.com))

APDM Movement Analysis Sensors- Wireless, wearable movement monitors allows kinematic analysis with real time data collection
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Study Site: US Olympic/Paralympic Training Center in Chula Vista, California

Research Synopsis:

Study Title: Analysis of Compensatory Muscle Function and Kinematic Data in Elite Sprinters With and Without Amputation

Hypothesis: Researchers hypothesize that hip extensors (Gluteus Maximus, Biceps Femoris, Semitendinosus, Semimembranosus) will have the greatest amount of compensatory activation both in magnitude and duration during the swing phase of the gait cycle.

Study Population: Paralympic sprinters with T44 classification and able-bodied sprinters ranging from 18-35 years old.

Study Design: Researchers will analyze the compensatory muscle activations of transtibial amputee sprinters with the use of high-speed cameras, the OptoJump, wireless electromyography (EMG), and APDM wireless movement sensors. Each athlete will complete no more than 10-30m fly-in sprints over the course of two days with surface EMG electrodes recording activity of
the vastus lateralis, vastus medialis, rectus femoris, biceps femoris, semitendinosus, semimembranosus, iliopsoas, and gluteus maximus, bilaterally.

**Sample Size:** 14 participants- 7 sprinters with amputation, 7 sprinters without amputation

**Study Duration:** 1.5 years

**Primary Objective:** To quantify muscle activation patterns from the unaffected limb and the affected limb of transtibial amputee sprinters in order to identify potential differences between legs.

**Secondary Objective:** To quantify muscle activation patterns from sprinters with and without amputation in order to identify potential compensatory control strategies used by athletes with amputations.

**Tertiary Objective:** To correlate compensatory muscle patterns to training and strengthening protocols as a means of improving athletic performance and reducing secondary injury in a specified activity.

**Background and Significance:**

Through several similar studies, researchers have begun to uncover differences between the unaffected and affected limbs of amputee sprinters (Sanderson 1996, Buckley 1999, Buckley 2000, Hobera 2013). During sprinting, the affected limb has a longer time in stance and diminished time in swing relative to the sound limbs. These observations are coupled with reduced ground reaction forces generated by the affected limb and an altered whole body center of mass trajectory. This distinction has been attributed to the reduced mass and lack of muscles below the knee. Further, the differences between limbs are almost entirely speed dependent; as the speed of the athlete increases, there is increase in the marked differences.
Additional studies have shown substantial dissimilarity in the running mechanics between amputee and intact-limb sprinters. For example, transtibial amputee sprinters have an increase in mechanical work, relative to sprinters without amputation, during the swing phase of the sound limb generates as much as a 70% more mechanical work during the sprint cycle compared to sprinters without amputation. In contrast, the affected limb produces nearly the same amount of work during swing compared to sprinters without amputation (Buckley 1999). Buckley has proposed that the increased levels of work on the sound limb may be due to the energy transfer mechanisms compensating for reduced power output from the affected limb. While it is clear that the increased mechanical work is due to muscular output from the sound limb, relatively little is known about the compensatory muscle activation patterns used amputee sprinters. Identification of compensatory control strategies will provide valuable insight into how athletes are adapting to using running specific prostheses and may lead to better training protocols that increase performance and reduce running related injuries.

The muscles chosen to explore during this study have been carefully selected based on prior investigations of sprinters without amputation. The quadriceps were found to fire from late swing to mid-stance, the hamstrings and gluteus maximus were activated the most during mid-swing to mid-stance. In contrast, sprinters without amputation had joint angles that were comparable and increasingly similar at proximal joints. These proximal muscles work the hardest to propel the limb forward and transfer energy to the opposing affected side during the sprint cycle. Researchers hypothesize that these proximal muscles will have the greatest amount of compensatory activation both in magnitude and duration during the swing phase of the gait cycle.
Objectives:

Primary Objective: To quantify muscle activation patterns from the unaffected limb and the affected limb of transtibial amputee sprinters in order to identify potential differences between legs. Differences will be determined through a comparison of surface EMG data and gait patterns between the unaffected and affected limbs.

Secondary Objective: To quantify muscle activation patterns from sprinters with and without amputation in order to identify potential compensatory control strategies used by athletes with amputations. By comparing athletes of similar build, stature, and skill researchers will be able to determine how athletes with amputations are recruiting their residual musculature to achieve performances that are similar to unaffected athletes.

Tertiary Objective: To correlate compensatory muscle patterns to training and strengthening protocols as a means of improving athletic performance and reducing secondary injury in a specified activity. By determining the compensatory patterns of our amputees we will be better suited to fit and train these athletes for their sport. Specifically, researchers will be able to both identify which muscles need to be strengthened and explore potential changes in technique that may reduce damaging loading patterns.

Study Design/Methodology:

All individuals with amputation will wear their existing running specific prosthesis (RSP) optimized for sprinting events. All athletes will follow self-selected warm up, cool down, maximum velocity, and recovery procedures during the study. Wireless surface EMG electrodes will be placed bilaterally on the proximal leg muscles: vastus lateralis, vastus medialis, rectus femoris, gluteus maximus, semitendinosus, semimembranosus, and biceps femoris.
Experiment 1: Researchers will establish electrode placement sites through background research and working with experienced researchers to identify sites and test applicability and placement of electrodes on individuals with transtibial amputation. Experimentation will be done with 1-2 athletes to verify data collection is possible and repeatable.

Experiment 2: Each of the sprinters will be fitted with electrodes and wireless motion sensors over the target muscles. All sprinters will run multiple 30-meter fly-in sprints (no more than 10), in order to ensure data is repeatable and of high quality; data will be recorded throughout the entire trial. Data will be collected on the track through the use of wireless EMG system, the APDM motion sensors, the OptoJump, and two high-speed cameras. The subjects will be recorded using high-speed cameras in both the coronal and sagittal planes. High-speed cameras, APDM motion sensors and the Optojump will allow analysis of kinematic data and correlation of kinematic data to EMG data. Data will be collected on 7 sprinters without amputation and 7 sprinters with amputation. Each of the sprinters will perform self-selected warm up, cool down, maximum velocity and resting procedures between trials, with trials being completed with on his or her own running specific prosthesis.

Study Population:
A total of 14 subjects will be recruited to participate in the study; 7 elite sprinters with transtibial amputation and 7 elite sprinters without amputation.

Inclusion Criteria: In order to be considered for our study all athletes will be actively participating in the International Olympic Committee or otherwise organized group. Seven of the 14 participants will be amputee sprinters with T44 classification. Athletes without amputation will be competitive track and field athletes competing at collegiate level or beyond. All athletes must be between the ages of 18 and 35.
Exclusion Criteria: Athletes that do not meet inclusion criteria will not be included in the study. Specifically, athletes with an injury within the past 6 months or athletes with T42, T43, T45, T46 classification will excluded from participation in this study.

Study Duration/Study Timeline:
Stage 1: Background Research—12 Months, March 2014- March 2015
Stage 2: Data Collection – 2 Days, March 27, 28 2015
Stage 3: Data Analysis—6 Months, April 2015- October 2015
Stage 4: Presentation and Publication— December 2015

Informed Consent Process:
The study will be thoroughly explained to each subject. Every subject will elect in as volunteers in the study and can terminate at any time. Participating subjects will be asked to sign a consent form stating their understanding and willingness to participate in the study. Please see consent form on the last page of this document.

Privacy and Confidentiality: Subject’s names will be kept on a password-protected database and will be linked only with a study identification number for this research. There are no patient identifiers. All data will be entered into a computer that is password-protected. Data will be stored in the investigator’s locked office and maintained for a minimum of three years after the completion of the study.

Risk-Benefit:
This study provides significant benefit, low risk. The outcomes of this study will benefit athletes, prosthetists, physical therapists, biomechanists, physicians, and physicians assistants in rehab organizations, as well as others working with sport performance and training of individuals with amputations. This study will benefit the participants by providing targeted information on their
own muscle activities and patterns allowing them to target specific workouts to improve performance. The knowledge gained from this study will help us optimize fitting and training protocols in order to better address the performance of amputee sprinters through identifying areas of compensation and correlating relationships from kinematic data. This understanding may also reduce the risk of future injury for athletes with amputation. Lastly, this study will act as a springboard for additional work with amputee sprinters allowing us to further narrow and target specific training regimens.

**Risk to Participant:** This study will add very minimal risk compared to the subject’s day-to-day life. All individuals with amputations will wear their existing sport specific prosthesis as optimized for sprinting events. All athletes will follow self-selected warm up, cool down, maximum velocity, and recovery procedures during the study. Since this study is equipped with the knowledge and experience of Olympic trained athletes and coaches, our study will present exceptionally minimal risk to the athletes involved. For the electrodes used, the output signals are low voltage and low current and thus pose no reasonable risk to the operator or athlete while using wireless electrodes. None-the-less, only qualified personnel will manage these connections.

**Benefits to Participant:** This study will benefit the participants by providing targeted information on their own muscle activities and patterns allowing them to target specific workouts to improve performance.

**Data Safety Monitoring:**

The Principal Investigators of this study will be responsible for monitoring the progress and protocols throughout the duration of this study. Any changes made to the study dates or designs will be reported to the IRB and to the Office of Clinical Research.
Publication and Presentation Plans:

Plan to present data in December 2015.

References:


CONSENT FOR PARTICIPATION

DETERMINING COMPENSATORY MUSCLE ACTIVATIONS IN SPRINTERS WITH LOWER LIMB AMPUTATIONS

You are being asked to take part in a research study looking at muscle firing patterns in sprinters with and without amputation. Please read this form carefully and ask any questions you may have before agreeing to take part in the study.

Background: There have been few research studies investigating the differences between the affected and unaffected limb of amputee sprinters. We have found that the swing phase of the unaffected limb generates more work than the affected limb during a sprint cycle. However, we are uncertain which muscles are producing additional work. Due to this lack of understanding of amputee sprinters, we have been fitting and training amputees based on average human gait and performance patterns.

Purpose Of This Study: The purpose of this study to determine if different muscles are used in sprinters with leg amputation as compared to able bodied sprinters in the same category. The muscle patterns will be examined through collection of EMG, and running will be analyzed through video, optical sensors, and timers.

What We Will Ask You To Do: If you agree to participate in this study, we will measure your muscle activity through wireless EMG, and analyze various patterns in running gait and stride using the OptoJump (http://www.optojump.com) optical measurement system, ADPM (http://apdm.com) wearable sensors and high-speed video during 4-30 meter maximum velocity sprint trials. Data collection should not last more than one day for any participant.
Risks And Benefits: This study has low risk. This study will benefit the participant by providing targeted information on their own muscle use during sprinting. It will also help to identify patterns in muscle activity which may allow the participant to change or fine tune a work out to improve performance or speed. The knowledge gained from this study will help us change prosthetic fitting and training protocols in order to improve the speed and performance of those sprinting or running after a leg amputation. The study will help researchers and coaches to identify whether or not sprinters with amputations use different muscles to run with, and how an amputee sprinter may need to compensate to increase speed after the loss of the calf muscles.

Compensation: We will not be paying you to participate in this study. Although, with your written request, we will provide information on your own muscle activities and patterns to you and your coaches for analysis and use in your training regimens.

Your Results Will Be Completely Confidential: The research data from this study will be kept private and will only be accessible to the researchers. While information from the study may be presented publicly it will be presented without identifiable information. We will ask for your permission if we want to display any of the video data as part of a public presentation on our findings.

Taking Part Is Voluntary: Taking part in this study in completely voluntary. If at any point you decide not to participate, you are free to withdraw your consent and discontinue participation without penalty.

If you have questions: The researchers conducting this study are Breanne Moen, Jared Howell, Francois Van Der Watt, Craig McGowan, and Alena Grabowski. If you have unanswered questions, please contact Breanne Moen at bmoen@bcm.edu (916)790-0080, or Jared Howell at jaredh@bcm.edu (713)798-3093 (Daytime) or 630-456-2607 (After-Hours). If you have any questions or concerns regarding your rights as a subject in this study, you may contact the Institutional Review Board (IRB) at irb@bcm.edu or (713)798-6970.

You will be given a copy of this form to keep for your records.

Statement of Consent: I have read the above information, and have received answers to any questions I asked. I consent to take part in the study.

Your Signature __________________________ Date __________

Your Name (printed) __________________________________________

In addition to agreeing to participate, I also consent to having the trial video-recorded.

Your Signature __________________________ Date __________

Signature of person obtaining consent __________________________ Date __________

Printed name of person obtaining consent __________________________ Date __________

The researcher will keep this consent form for at least three years beyond the end of the study.