ABSTRACT

BALANCE CONTROL DURING COMMON REHABILITATION EXERCISES IN OBESE INDIVIDUALS

Obesity rates have increased in the United States over the years, with approximately 30% of adults now considered obese. Obese individuals have poorer postural control than normal weight individuals during static stance. No analysis of balance during common strengthening activities has been performed. The squat and lunge are commonly utilized activities in physical therapy, and may challenge balance control.

The purpose of this study was to analyze the balance of obese females while performing squat and lunge activities, as measured by center of pressure area (CoP area) and center of pressure velocity (RMS-V).

The sway measures of twenty females (10 obese, 10 normal weight) were analyzed during the squat and lunge at 3 difficulty levels (squat: 60°, 70°, 80° knee angle; lunge: step of 1.0, 1.1, 1.2 times tibial length). Force plates were used to gather sway data. A repeated measures ANOVA was performed. Between-group effect size was also calculated as an indication of clinical relevance.

Sway was significantly higher in obese females than normal weight females during the lunge activity, indicated poorer balance control. This difference was not seen during the squatting activity. Because of this finding, clinicians may want to consider balance control as a variable when prescribing lunging activities to obese individuals.

Ashley Van Artsdalen
May 2015
BALANCE CONTROL DURING COMMON REHABILITATION EXERCISES IN OBESE INDIVIDUALS

by

Ashley Van Artsdalen

A project
submitted in partial fulfillment of the requirements for the degree of
Doctor of Physical Therapy
in the Department of Physical Therapy
College of Health and Human Services
California State University, Fresno
May 2015
APPROVED

For the Department of Physical Therapy:

We, the undersigned, certify that the project of the following student meets the required standards of scholarship, format, and style of the university and the student’s graduate degree program for the awarding of the doctoral degree.

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Dean, Division of Graduate Studies
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ACKNOWLEDGMENTS

I would like to thank my committee chair, Dr. Singh, for his support and guidance throughout the completion of this project. He has demonstrated the heart of a mentor throughout this journey. In addition, I would like to thank my committee members, Dr. Thompson and Dr. Adame-Walker, for their efforts, comments, and suggestions leading to the success of this project.
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BACKGROUND

Obesity, defined as a body mass index (BMI) of greater than 30 kg/m\(^2\), has been identified as a major, national health problem.\(^1\)\(^-\)\(^3\) The rate of obesity has increased significantly in the United States over the past few decades with approximately 30% of adults now considered obese.\(^4\)\(^-\)\(^6\) Because of this astronomical rise in obesity, a physical therapist will inevitably treat patients with obesity throughout their career, and may be required to consider alterations in treatment planning secondary to co-morbidities related to obesity. When obesity is discussed, a picture of a 500-pound patient may come to mind, but the 5’4” female who weighs 175 pounds is also considered obese. Many implications of the obesity epidemic have been identified, such as the increased risk for cardiovascular, pulmonary, and endocrine disease.\(^1\)\(^-\)\(^3\),\(^7\) Obesity is also related to an increased risk for falling and decreased postural stability, potentially secondary to less functional practice (lower activity levels) or increased pain.\(^8\) An area that has not been as extensively studied is the implication of obesity on balance in different functional positions.

A BMI of greater than 30 kg/m\(^2\) is able to rule in obesity with high specificity (90%), but has low power to rule out obesity with low sensitivity (50%) when comparing with percent body fat.\(^9\),\(^10\) For men, a body fat of greater than 25% is considered obese, and in women greater than 35% is considered obese.\(^9\),\(^10\) Waist circumference indicates health risk related to obesity, though it does not diagnose obesity itself.\(^11\) Waist to hip ratio is an indication of relative abdominal obesity, which is associated with risk for cardiovascular events, but again, does not diagnose obesity directly.\(^12\)
Two functional exercises commonly utilized in physical therapy practice which may challenge balance are the squat and the lunge. Due to the stance required for the lunge exercise, it has been suggested that the balance demands are higher than those required when performing the squat. However, both require greater balance control than static standing to achieve and maintain the positions. These exercises are prescribed to patients with a wide variety of conditions because they are considered to be functional, closed chain activities that target hip and thigh musculature. Both exercises result in a contraction pattern similar to that occurring during daily activities of walking and stair climbing, making these exercises ideal for increasing functional strength of the lower extremity. Also, both exercises can easily be made more challenging in force production and balance control demands by increasing the depth of movement or altering foot placement. It has been shown that taking a longer step (standardized to body height or leg length) during lunging increases muscular activity required; it has also been hypothesized that taking a longer step results in a less stable base of support.

Balance is defined as the maintenance of the center of gravity over a given base of support. Similarly, stability is defined as the ability to maintain a balanced state. Balance can be broken down into static, dynamic, and reactive processes. During static squat and lunge positions, static balance would be the focus. This refers to the ability of the individual to preserve their center of gravity over their base of support while their base of support is not moving. Maintaining balance requires a complex interaction of sensory and motor activity, which has to be integrated appropriately in the central nervous system. Biomechanical, muscular, joint, and gravity considerations all contribute to the complexity of maintaining balance.
Balance control can be measured in many different ways, from observational sway measures to complex, instrumented tests. Research has shown that the use of force plates to quantify center of pressure (CoP) measures is sensitive to changes in balance control.\textsuperscript{5,18-22} Center of pressure sway area and velocity are 2 commonly utilized measures and increases in both have been correlated with poorer balance control and increased risk for falling.\textsuperscript{5,19-22} Specifically, it has been suggested that the magnitude of CoP (CoP area) reflects the effective use of the sensory balance systems, and CoP velocity is related to the motor activity necessary to achieve postural control.\textsuperscript{5,7} The root-mean-square of medial-lateral and anterior-posterior CoP velocity (RMS-V) yields information about the overall sway velocity during a trial.

Obesity has been linked to increased risk for falls throughout the literature. Obesity is related to an anteriorly displaced center of gravity, decreasing postural stability; and typically a wider base of support is necessary for comfortable balance control in obese individuals.\textsuperscript{23,24} Cross-sectional studies have concluded that obese individuals demonstrate significantly greater CoP area and CoP velocity than normal weight individuals during static stance with eyes open and eyes closed.\textsuperscript{7,22,25-29} Studies of elderly individuals have identified greater CoP area and CoP velocity in certain stance conditions in fallers when compared to non-fallers.\textsuperscript{21} Therefore, it is reasonable to posit that increases in CoP area and CoP velocity during stance in obese individuals would be associated with increased risk for loss of balance and falling. Furthermore, epidemiologic studies have revealed that obese individuals are at greater risk for falls than normal weight individuals.\textsuperscript{20} It has also been demonstrated that obese individuals must dedicate more attention to the task of remaining balanced than their normal weight counterparts, resulting
in decreased ability to dual task. Difficulty performing dual task activities has been linked to increased fall risk.\textsuperscript{30}

The relationship between obesity and balance deficits has been identified during static standing. However, there have been no investigations on the link between obesity and balance control during execution of simple, commonly performed exercises. If this information is investigated, clinicians may better understand how to tailor exercise programs to this patient population. In addition, this knowledge could direct physical therapists how to best increase performance and decrease the risk for loss of balance, falls, and injury in their patients who are obese. The purpose of this study was to analyze the balance of obese females while performing squat and lunge activities, as measured by CoP area and RMS-V. It was hypothesized that obese females would have poorer balance control than their normal weight counterparts in these activities, and that, as the difficulty of the activities increased, the balance control deficits would be more apparent.
METHODS

Subjects

A total of 20 subjects were recruited for this investigation. The sample included 10 obese females with a mean BMI of 39.23 ± 6.67 kg/m$^2$ and mean age of 37.4 ± 3.7 years and 10 age-matched normal weight females with a mean BMI of 21.50 ± 1.55 kg/m$^2$ and mean age of 38.1 ± 4.5 years. The waist and hip circumference of the obese subjects were 110.88 ± 13.73 cm and 127.78 ± 14.96 cm, respectively; and of the normal weight subjects were 77.50 ± 11.84 cm and 92.95 ± 7.80, respectively. The waist to hip ratio was 0.87 ± 0.04 for the obese group and 0.83 ± 0.11 for normal weight group. Subjects were all free from disease processes that could influence balance control including the following: lower limb pain, diabetes, CVA history, and recent surgery (within the past year). All subjects provided informed consent preceding participation in the study. The study was approved by the University of Iowa Human IRB.

Protocol

The following subject demographics were collected by a single tester: height, weight, waist and hip circumference, and tibial length. Waist circumference was measured at the level of the right iliac crest, and hip circumference was measured at the widest point of the hip. A single tester placed infrared emitting diodes (IREDS) on the lateral foot, tibial shaft, lateral thigh, pelvis and upper trunk of each subject. A custom femoral tracking device traced femoral epicondyle motion (Figure 1). Pelvic and trunk marker triads were attached to 5 cm extensions with base plates affixed over the sacrum and lower cervical vertebrae (Figure 1).
Segments were tracked via a generated link-based model. Anatomical models were generated by digitizing anatomical landmarks relative to segment local coordinate systems, with the subject standing in a neutral position\textsuperscript{33,34} (Figure 1). The reliability of digitizing the anterior superior iliac spine (ASIS) was demonstrated on 6 obese and 7 normal-weight subjects by re-digitizing the ASIS landmarks at the end of the digitizing process. The respective ICCs for obese/normal-weight subjects for the X, Y, and Z locations were 0.93/0.99; 0.92/0.86; and 0.99/0.99.

Kinematic data were collected using an Optotrak motion analysis system (Model 3020, Northern Digital Inc., Waterloo, Ontario, Canada). Data were collected at 60 Hz and were filtered at 6 Hz, using a zero-phase lag, 4\textsuperscript{th}-order, Butterworth low pass filter. Kinetic and COP data was collected by using Kistler force plates (Kistler, NY). Visual 3D software (C-Motion Inc. Kingston, Ontario) was used to perform link-segment calculations.

**Activities Measured**

All individuals performed 2 trials of each of the following activities: static standing with eyes open for 30 seconds, squatting with feet shoulder width apart held for 3 seconds at 3 knee angles (60°, 70°, 80°), and lunging with feet shoulder width apart held for 3 seconds at 3 step lengths (1x, 1.1x, 1.2x tibial length). For lunging, data was collected with the dominate leg forward. The specific positions for each level were verified utilizing real-time feedback. The subjects did not have any upper extremity support during the activities. For safety, a gait belt was placed on the subject, and a spotter was located on the side of the subject. A wide chair was placed behind the subjects during the squat activity to prevent any injuries should a loss of balance occur.
CoP Measurement

Center of pressure area and velocity were collected using Kistler force plates. For the standing trials, 30 seconds of sway data were collected. The entire 30 seconds were analyzed as a whole. Seconds 2-5 were analyzed separately to mimic the 3 seconds of static squat and lunge data collected. The values of CoP area and RMS-V were calculated for the individual trials of each difficulty level of the lunge and squat. The means of the 2 trials were then utilized for further analysis.

Statistical Analysis

Descriptive statistics in form of means and standard deviation were calculated. A 2-way, repeated measures ANOVA model with group (obese versus normal-weight) as a between subject factor was performed to investigate differences in CoP area and RMS-V for the squat and the lunge. SPSS (Statistics 20, IBM Corp., Armonk, New York, United States) was used for analysis, with p-value < 0.05 considered significant. Post-hoc power was calculated to determine the ability of the sample to find statistical significance. To present an indication of clinical relevance, between-group effect size was calculated using [obese group mean-normal weight group mean]/pooled standard deviation. The results were interpreted utilizing Cohen’s guidelines. Linear correlation coefficients were calculated to determine the relationship between BMI, waist circumference, and waist to hip ratio and CoP area and RMS-V.
RESULTS

Standing

In the standing with eyes open (30 seconds) test condition, there was a significant difference between obese and normal weight females for RMS-V (p=0.011), but not for CoP area (p=0.070). The post-hoc power was 0.447 for CoP area and 0.772 for RMS-V, revealing a moderate powered study. The r-values between BMI and sway data and between and waist circumference and sway data indicated moderate correlations. The r-values between waist to hip ratio and sway data revealed low correlations (Table 1). When analyzing the 3 second component of the standing with eyes open condition, a significant difference between obese and normal weight females was seen for both RMS-V (p=0.008) and CoP area (p=0.039). The post-hoc power was moderate at .558 for CoP area and high at 0.801 for RMS-V, revealing a moderate to high powered study. The r-values for BMI and waist circumference and sway data indicated moderate correlations, and between waist to hip ratio and sway data indicated low correlations (Table 1).

Squatting

No significant change in CoP area (p=0.401) or RMS-V (p=0.057) was seen in the 3 squatting depths by the obese subjects. There was also no significant difference between obese and normal weight females for CoP area (p=0.120) or for RMS-V (p=0.212) (Figures 2 and 3). Though there was no significant difference, post-hoc power was 0.340 and 0.231 for CoP area and RMS-V revealing an underpowered study. Cohen’s D effect size was moderate for CoP area (0.73) and for RMS-V (0.53). The r-values for BMI, waist circumference, and waist to hip ratio and CoP area for each squat level indicated low correlations. The r-values between BMI and waist circumference and RMS-V for the 3 levels
indicated low to moderate correlations, and waist to hip ratio and RMS-V indicated low correlations (Table 1).

**Lunging**

In the obese females, no significant difference in CoP area (p=0.297) or RMS-V (p=0.412) was seen with increasing lunge step distance. There was, however, a significant difference between obese and normal weight females for CoP area (p<0.001) and for RMS-V (p=0.005) during the lunge activity (Figures 4 and 5). Post-hoc power was 1.00 for CoP area and 0.860 and RMS-V, revealing a high powered study. Cohen’s D effect size was large for CoP area (2.56) and for RMS-V (1.39). The r-values for BMI and waist circumference and CoP area for lungel, lungel.1, lunge 1.2 indicated moderate to high correlations, and waist to hip ratio and RMS-V indicated low correlations. The r-values for BMI and waist circumference and RMS-V for the 3 levels indicated moderate to high correlations, and waist to hip ratio and RMS-V indicated low correlations (Table 1).
DISCUSSION

In the present study, postural sway was evaluated during static standing, squatting and lunging activities in normal weight and obese females. CoP area and RMS-V were analyzed to reflect balance as it has been suggested that they reflect the effective use of the sensory balance systems and the motor control required to remain balanced.\(^5,7\) Obese females demonstrated decreased postural control when compared to normal weight females during static standing and lunging activities, but not during squatting.

**Standing**

This study identified a significant increase in sway in obese females as compared to normal weight females during static standing with eyes open. This is likely due to the subjects’ anteriorly displaced center of gravity.\(^23,24\) This may result in increased muscular activity required to maintain balance secondary to lack of optimal center of gravity positioning over the base of support.\(^23,24\) This finding is consistent with current research, also identifying poorer postural control in obese individuals as compared to normal weight individuals.\(^7,22,25-29\) In addition, BMI was moderately, positively correlated to increases in RMS-V and CoP area, reflective of poorer balance. This is consistent with a study conducted by Hue et al.\(^7\) in which body weight, controlled for height (similarly to BMI), accounted for 52% of the variation in CoP speed during static stance with eyes open. Interestingly, Hue et al.\(^7\) also found that body weight, controlled for height, was the only factor that was predictive for increased sway parameters during static stance with eyes open when examining body weight, foot length, and age. This indicates the significance that obesity has on balance control, and suggests the importance of weight reduction in obese individuals.
**Squatting**

Analysis revealed that the depth of the squatting activity did not significantly alter sway during performance, suggesting that squat depth changes may not influence balance control significantly. Although there was no significant difference in sway identified between the obese and normal weight groups, the medium effect size identified a trend suggesting that obese individuals demonstrate increased sway when compared with their normal weight counterparts (Figures 2 and 3). However, BMI, waist circumference, and waist to hip ratio were not correlated highly with sway during squatting, suggesting the possibly of other contributing factors (Table 1). The lack of significant differences between groups and the low correlation between BMI and sway is likely due to the fact that a subject’s center of gravity is maintained over the base of support during the activity, minimizing the challenge to balance control.\(^\text{13}\) Even with increased adiposity and alteration in obese subjects’ center of gravity, the base of support seems to be sufficient for maintenance of balance. This suggests that clinicians may prescribe squatting activities to their obese patients without significant fear of loss of balance regardless of BMI or depth of the squat (up to 80°).

**Lunging**

In lunging activities, on the other hand, a significant difference in balance was identified between obese and normal weight females. The length of the lunge step during the activity (up to 1.2x tibial length) did not result in any significant differences in balance control (Figures 4 and 5). Sway was highly correlated to BMI during lunging (Table 1). There was a linear relationship of sway to BMI during lunging which suggests that, as BMI continues to increase into the morbidly obese range, balance control may further deteriorate. Whereas during a squatting activity the base of support remains stable, the base of support during a
lunge is altered. Changing base of support increases balance demands on obese individuals who already demonstrate increased sway during activities with a normal BOS. This suggests that clinicians may want to evaluate balance control prior to prescribing lunging exercises to obese individuals.

Hergenroeder et al found that obese individuals self-report their mobility as lower than their normal weight counterparts. It was also found that obese individuals had increased difficulty completing balance activities secondary to difficulties achieving the positions required. Lack of mobility could have contributed to the increased sway demonstrated by participants in this study during the lunge activity, as it requires an altered base of support, which would be inherently more difficult for obese subjects to attain.

Another factor to consider during exercise prescription is setting and distractions. Mignardot et al demonstrated that obese individuals require increased attention to balance control during tasks with altered base of support. In the current study, dual-tasking was not analyzed. Specific attention was given to ensure subjects were not distracted during the activities. If dual-tasking was incorporated, the results may have differed, especially in squatting where no differences were detected. Given the limited information available, it may be wise to initially limit distractions and dual-tasking during activities such as squatting and lunging with obese individuals in order to increase attention to the task of remaining balanced.

**Limitations**

The sample size may have limited the ability to obtain statistical significance. Sample size calculations were not possible prior to the study secondary to the lack of literature available on squat and lunge activities in obese
individuals. Post-hoc power analysis revealed good power (0.86 to 1.00) for the lunge activity, but low power (0.231 to 0.340) for the squat activity. The low power may have contributed to the lack of significant findings for squatting.

Another limitation of the current study is that no analysis of perceived imbalance was performed. It has been demonstrated that obese individuals report decreased physical function and mobility as compared with their normal weight counterpart. This self-perceived functioning may carryover to balance during dynamic tasks, though it has not been shown to carryover to static balance tasks. Clinically, this information would be significant because it may help to inform physical therapists on compliance with home exercise programs including these activities. If patients perceive imbalance, they may be less inclined to complete the activities on a home exercise program for fear of falling.

A potential limitation was the depth of the squat, which was limited to 80 degrees of knee flexion. This was determined from a pilot investigation which indicated reluctance of obese females to complete a deeper squat. With squat depths of greater than 80 degrees, challenges to balance control may have been even greater and different outcomes may have been obtained.

A fourth limitation of the current study was the exclusion of individuals with disease processes. This was necessary to get baseline information about balance control in normal weight versus obese females. This would mimic clientele participating in a wellness program, but does not necessarily reflect a physical therapy patient population. Further research should be conducted to determine if obese individuals with lower extremity pain or dysfunction have poorer balance control and to explore the implications this may have on rehabilitation.
Conclusion

An obese individual may come to physical therapy to address an orthopedic condition or for general wellness. In this case, squats and lunges may be incorporated into a program to improve lower extremity, functional strength.\textsuperscript{13,14} Research has shown that obese individuals have increased fall risk and poorer postural control than their normal weight counterparts; therefore, it would be important for the clinician to consider that the 5’4”, 175 pound female being seen for general wellness may suffer from balance deficits.\textsuperscript{7,22,25-29} It has been demonstrated that specifically targeting balance control during rehabilitation will improve balance in obese individuals.\textsuperscript{37} Therefore, a clinician treating this patient may want to integrate specific balance training activities into the exercise program, in addition to strengthening activities. Though these activities will improve balance, weight reduction has been shown to have a greater influence on improving postural control, and should be encouraged for all obese individuals.\textsuperscript{28,29,37,38} The clinician should treat the whole patient and determine if strength, balance, and/or weight reduction exercises are appropriate.
REFERENCES
REFERENCES


TABLES
### Table 1. Correlation Between BMI, Waist Circumference, and Waist to Hip Ratio and COP Area and RMS-V. Reported as r.

<table>
<thead>
<tr>
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<th>30 sec stand</th>
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<td>60° 70° 80°</td>
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* * indicates moderate to high correlation
FIGURES
Figure 1. Skeletal model of subject during squat (left), posterior placement of markers (center), skeletal model of a subject during lunge (right).

Figure 2. Squat sway area means by group.
Figure 3. Squat sway velocity means by group

Figure 4. Lunge sway area means by group
Figure 5. Lunge Sway Velocity Means by Group
APPENDIX: INFORMED CONSENT AND IRB APPROVAL
INFORMED CONSENT DOCUMENT

Project Title: Gait Changes in Obese and Normal Weight Individuals Over a 30 Minute Walking Session.

Principal Investigator: Bhupinder Singh
Research Team Contact: Bhupinder Singh 319-384-6893
                        H John Yack 319-35-9802

This consent form describes the research study to help you decide if you want to participate. This form provides important information about what you will be asked to do during the study, about the risks and benefits of the study, and about your rights as a research subject.

- If you have any questions about or do not understand something in this form, you should ask the research team for more information.
- You should discuss your participation with anyone you choose such as family or friends.
- Do not agree to participate in this study unless the research team has answered your questions and you decide that you want to be part of this study.

WHAT IS THE PURPOSE OF THIS STUDY?

This is a research study. We are inviting you to participate in this research study because you are 30-45 years old healthy female who is either 1) an obese subject with BMI 30-45 kg/m$^2$ OR 2) a normal weight subject with BMI less than 25 kg/m$^2$.

The purpose of this research study is to explore differences in gait patterns between obese and normal weight subjects over a 30-minute treadmill walking session. We hypothesize that the gait pattern in obese individuals will change differently than normal weight subjects, as they start to fatigue, resulting in more stress across the knee joint.

HOW MANY PEOPLE WILL PARTICIPATE?

We are recruiting 50 subjects aged 30-45 years old, 20 obese and 10 normal weight, who will take part in this study conducted by investigators at the University of Iowa.

HOW LONG WILL I BE IN THIS STUDY?

- If you agree to take part in this study, your involvement will last for 2 hours during a single study session.
WHAT WILL HAPPEN DURING THIS STUDY?

The study has two different groups. If you are assigned to the first group for treadmill walking:

- You will be asked to come to the Orthopedic Gait Analysis Laboratory, 01421 JPP. You will be asked to change into shorts that expose your lower limbs.
- You will sign the Informed consent form and complete the Physical Activity Readiness and the Jackson Non-Exercise Questionnaires. You may skip any question you prefer not to answer.
- You will be allowed to practice walking on the treadmill for 2 minutes and then walk along the hallway for 2 minutes at your self-selected speed.
- Markers will be applied to your lower limb, pelvis and trunk using double sided tape and a computerized model will be generated.
- You will be asked to walk along an 8 meter walkway at the same self-selected speed, achieved earlier during the 2 minute walk, to evaluate your walking pattern.
- After the gait evaluation, you will walk on the treadmill your self-selected speed for two sessions.
- The first session will be 8 minutes, with first 4 minutes on the level treadmill and then the treadmill will be inclined to 5 percent grade for the last 4 minutes.
- The second session will be 25 minutes on the level treadmill.
- Your heart rate, oxygen saturation, and exertion levels will be continuously monitored to ensure safety.
- A post-treadmill gait evaluation will be conducted, over ground, after the 25 minute treadmill walking session.

For the second group, 10 Obese and 10 non-obese subjects will be tested while performing common functional activities and exercises.

- Markers will be applied to your lower limb, pelvis and trunk using double sided tape and a computerized model will be generated.
- You will be asked to perform the following activities.
  a) Double limb squat.
  b) Forward Lunge.
  c) Step up on a staircase.
  d) Lateral Bending to the right side while standing.
- The subjects will report pain and discomfort with Visual analog pain scale at the end of each activity.
Audio Recording/Video Recording/Photographs

One aspect of this study involves making video recording of your walking. These recordings will be used for qualitative analysis to help interpret the data. Only the gait lab research team members will have access to the video recordings. These video images will be destroyed two-months after being recorded. If you do not feel comfortable being recorded on video you can still participate in the study.

[ ] Yes  [ ] No  I give you permission to make video recordings of me during this study.

WHAT ARE THE RISKS OF THIS STUDY?

You may experience one or more of the risks indicated below from being in this study. In addition to these, there may be other unknown risks, or risks that we did not anticipate, associated with being in this study.

- The risks to the study are minimal. Physical risks include skin irritation from double-sided tape used to secure the markers.
- You may experience some discomfort when the tape is removed.
- You may also feel uncomfortable or embarrassed having the areas exposed for positioning of surface electrodes during the testing. The electrodes will be applied in a secure area, to minimize any embarrassment.
- The questionnaires entail little risk. Information will be kept as confidential as possible through the use of code numbers on all forms and in all data analysis programs.
- You may loose balance or fall while walking on the treadmill. To minimize this risk, you can hold on to the side bars while walking and stop the treadmill whenever needed. A research assistant will be present near the treadmill to monitor at all times during the walking session.

WHAT ARE THE BENEFITS OF THIS STUDY?

You will not benefit from this study. However, we hope that in the future, other people might benefit from this study because the knowledge we gain will help us explore how walking effects the stresses at the weight bearing joints in obese and normal weight individuals.

These findings may provide valuable information and could be important in designing optimal therapeutic walking programs for weight reduction and management.

WILL IT COST ME ANYTHING TO BE IN THIS STUDY?

You will not have any additional costs for being in this research study.
WILL I BE PAID FOR PARTICIPATING?

You will be paid for being in this research study. You will be paid $30 for your participation in the study and parking will be provided at no cost. You will need to provide your social security number (SSN) in order for us to pay you. You may choose to participate without being paid if you do not wish to provide your social security number (SSN) for this purpose. You may also need to provide your address if a check will be mailed to you. If your social security number is obtained for payment purposes only, it will not be retained for research purposes.

WHO IS FUNDING THIS STUDY?

The University and the research team are receiving no payments from other agencies, organizations, or companies to conduct this research study. Support for this project is through the Graduate Program in Physical Therapy and Rehabilitation Science.

WHAT IF I AM INJURED AS A RESULT OF THIS STUDY?

- If you are injured or become ill from taking part in this study, medical treatment is available at the University of Iowa Hospitals and Clinics.
- The University of Iowa does not plan to provide free medical care or payment for treatment of any illness or injury resulting from this study unless it is the direct result of proven negligence by a University employee.
- If you experience a research-related illness or injury, you and/or your medical or hospital insurance carrier will be responsible for the cost of treatment.

WHAT ABOUT CONFIDENTIALITY?

We will keep your participation in this research study confidential to the extent permitted by law. However, it is possible that other people such as those indicated below may become aware of your participation in this study and may inspect and copy records pertaining to this research. Some of these records could contain information that personally identifies you.

- federal government regulatory agencies,
- auditing departments of the University of Iowa, and
- the University of Iowa Institutional Review Board (a committee that reviews and approves research studies)

To help protect your confidentiality, we use identification code numbers only on data forms, have locked filing cabinets and storage areas in the gait analysis lab, and use password-protected computer files. If we write a report or article about this study or share the study data set with others, we will do so in such a way that you cannot be directly identified.
The University of Iowa Hospitals and Clinics generally requires that we document in your medical record chart that you are participating in this study. The information included in the chart will provide contact information for the research team as well as information about the risks associated with this study. We will keep this Informed Consent Document in our research files; it will not be placed in your medical record chart.

**IS BEING IN THIS STUDY VOLUNTARY?**

Taking part in this research study is completely voluntary. You may choose not to take part at all. If you decide to be in this study, you may stop participating at any time. If you decide not to be in this study, or if you stop participating at any time, you won’t be penalized or lose any benefits for which you otherwise qualify.

**WHAT IF I HAVE QUESTIONS?**

We encourage you to ask questions. If you have any questions about the research study itself, please contact: Dr. John Yack, PhD 319-335-9802. If you experience a research-related injury, please contact: Dr. John Yack, PhD 319-335-9802.

If you have questions, concerns, or complaints about your rights as a research subject or about research related injury, please contact the Human Subjects Office, 105 Hardin Library for the Health Sciences, 600 Newton Rd, The University of Iowa, Iowa City, IA 52242-1098, (319) 335-6564, or e-mail irb@uiowa.edu. General information about being a research subject can be found by clicking “Info for Public” on the Human Subjects Office web site, http://research.uiowa.edu/hso. To offer input about your experiences as a research subject or to speak to someone other than the research staff, call the Human Subjects Office at the number above.

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This Informed Consent Document is not a contract. It is a written explanation of what will happen during the study if you decide to participate. You are not waiving any legal rights by signing this Informed Consent Document. Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Subject's Name (printed):  
__________________________________________________________________________
Do not sign this form if today’s date is on or after $STAMP_EXP_DT.

__________________________________________
_______________________________
(Signature of Subject) (Date)

Statement of Person Who Obtained Consent

I have discussed the above points with the subject or, where appropriate, with the subject’s legally authorized representative. It is my opinion that the subject understands the risks, benefits, and procedures involved with participation in this research study.

__________________________________________
_______________________________
(Signature of Person who Obtained Consent) (Date)
Fresno State

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**Ashley Van Artsdalen**

Type full name as it appears on submission

April 16, 2015

Date