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Effect of an ACL tear on bone density and muscle mass contralaterally

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Honors Research Project

Carly Anenson & Rebecca Beitko

Abstract

The purpose of this study was to examine the relationship between tearing one of the major ligaments of the knee and this injury's influence on bone density. The research question that this experiment aimed to answer was "How does bone density and muscle mass of the upper and lower leg differ contralaterally in individuals who have had an anterior cruciate ligament (ACL) tear?"

METHODS: Twelve subjects who have suffered from an ACL tear and underwent reconstruction surgery participated in a dual- energy x-ray absorptiometry (DEXA) scan that analyzed their bone mineral content, bone mineral density, and muscle mass for their total body. The results for the legs were utilized in this study.

RESULTS: Statistical analysis of the measured bone mineral density values revealed a significant reduction in BMD from the control to injured leg ($t(11) = 2.283$, $p < 0.05$). There was no significant difference identified between the injured and control leg values for bone mineral content ($t(11) = 1.688$, $p > 0.05$) or for the lean mass ($t(11) = 1.372$, $p > 0.05$) of the lower extremity.

DISCUSSION: The results of our study were consistent with the findings of Lapella et. al (1999), which stated that BMD values decreased following ACL reconstructive surgery and failed to return to baseline by the 1-year mark post-operation. These results of significantly reduced BMD were confirmed and extended to 2-years post-operation in a 2014 study by van Meer et. al (2014). Our study examined the bone mineral density difference in individuals that underwent ACL reconstruction 1.0-10.5 years (M=4.38 yrs) prior to their participation in this study. Further research with a larger sample is needed to generalize our findings to a larger population demographic and to identify the role that participation in regular physical activity has

on the BMD differences in those who have undergone ACL reconstruction over longer periods of time.

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Introduction

One of the most common injuries to the knee is a rupture of the anterior cruciate ligament (ACL). ACL ruptures occur most often in athletes participating in sports that require quick direction changes such as soccer, football, and lacrosse. When an ACL rupture occurs, other soft tissue structures that support the knee can be damaged, too. Damage can be done to the menisci, posterior cruciate ligament, and the medial and lateral collateral ligaments. Sprains or tears of the ligaments can be incomplete, but full tears are more common (AAOS, 2014).

ACL ruptures are usually treated with a reconstruction surgery, especially for athletes. Reconstruction surgery replaces the torn ligament with new tissue, typically a graft that is taken from another part of the body or from a cadaver (AAOS, 2014). As a result of having surgery, patients are non-weight bearing for a couple weeks. Due to the lack of leg usage and direct effects of chemical change following trauma and reconstruction, a decrease in muscle mass and bone mineral density can be predicted. Even when tolerated weight bearing begins, the therapy can take months to achieve a normal and healthy functionality (AAOS, 2014). The current study further investigated how the lack of weight bearing over the course of recovery affects the injured leg at least 12 months post reconstruction surgery.

The research question for this investigation was, "How does bone density and muscle mass of the upper and lower leg differ contralaterally in individuals who have had an anterior cruciate ligament (ACL) tear?" It was hypothesized that a patient who underwent ACL reconstruction surgery more than 12 months ago will have significantly diminished muscle mass and bone mineral density in the injured leg as compared to the non-injured control leg. This study analyzed the Lean muscle Mass (LM), Bone Mineral Content (BMC), and Bone Mineral Density (BMD) to determine the existence of any differences between the injured and non-injured leg.

In answering this research question, opportunities for future research and study may arise. If there is a long-term bone density deficiency found in individuals who have torn their ACL following reconstruction and physical rehabilitation, this may increase the risk of other musculoskeletal injury and/or medical conditions, such as osteoporosis. In completing this research project, we will contribute to research in our field of interest and future careers in physical and occupational therapy. These findings may prompt further research regarding the effectiveness of current treatments of this and similar injuries.

Literature Review

The single most stabilizing structure within the knee joint, the anterior cruciate ligament (ACL), is one of the most common musculoskeletal injury sites for young adults (Leppala et al., 1999). ACL injury incidence rates are currently rising and often co-occur with acute damage to other areas of the knee, including the cartilage, menisci, and other ligaments as well as bruising to the bones (Mundermann et al., 2015). With an annual incidence in around 10,000 people in the U.S. general population, ACL rupture has been shown to be linked to increased rates of osteoarthritis (van Meer et al., 2014), as displayed in the von Porat, et al. (2004) 14-year study that demonstrated their participants' mean disability score increasing by 11 points between the 7-year and the 14-year follow-up evaluations completed by the researchers. Considering this increased rate of premature osteoarthritis and the nearly immediate post-traumatic bone loss in the knee caused by ACL rupture and reconstruction (Leppala et al., 1999), it is important that further examination of bone mineral density (BMD) deficits and imbalances be completed for timelines beyond the 1- to 2-year period of current research to identify if increased risk of other orthopedic conditions, such as osteopenia or osteoporosis, exists for individuals that have suffered an ACL rupture.

Osteopenia is defined as having a low bone mineral density (BMD). BMD test results are evaluated on a standard T-score range, with osteopenia being diagnosed at a T-score between -1.0 to -2.5 (Buencamino et al., 2009). If left undiagnosed and untreated, osteopenia may develop into osteoporosis, indicated by a T-score at or below -2.5. Osteoporosis is defined as "a systemic skeletal disease characterized by low bone mass and microarchitectural deterioration of bone tissue with a consequent increase in bone fragility and susceptibility to fracture" (Kanis et al., 2008). Based on this definition, it is apparent that low bone mass is an important risk factor of fracture as well as other skeletal abnormalities. Because osteopenia and osteoporosis increase the risk of future orthopedic conditions and injury, such as bone fractures (Kanis et al., 2008), predisposition to developing these conditions as a result of previous ACL injury should be examined and is therefore the aim of this study.

As of current research, bone mineral density is the only aspect measurable in clinical practice, making it the cornerstone for the diagnosis and management of osteopenia and osteoporosis. Bone mineral density is the amount of bone mass per unit volume (volumetric density, g/cm^3) which can be measured in vivo using a few methods (Kanis et al., 2008), including the peripheral quantitative computed tomography and dual-energy x-ray absorptiometry (DEXA), as described in the research studies discussed above. Based on BMD measurement techniques utilized by previous researchers and on equipment access, the authors of this study have selected to measure bone mineral density with DEXA. Using the DEXA to measure BMD is based on the principle that the absorption of X-rays is sensitive to calcium content of tissue and can be used to obtain a whole skeleton scan or specific sites (Kanis et al., 2008). This study examined BMD in the structures surrounding the knee joint.

Based on current knowledge of the influence habitual exercise has on preventing and then managing these conditions of decreased BMD (Buencamino et al., 2009), and based on the inclusion of a questionnaire regarding patients' activity level prior to injury and at the time of their baseline measurement that was incorporated into the evaluation of patients BMD in the van Meer et al. (2014) study, our study included a pre-participation questionnaire that asks about physical activity history prior to injury in addition to current activity levels. Based on the inclusion of various scales addressing other dimensions of knee health/function in the 14-year von Porat et al. (2004) study that examined osteoarthritis development post-ACL reconstruction, our survey incorporated questions to identify more subjective effects following ACL recovery. The three scales utilized in this study evaluated patients in areas, such as pain, symptoms of daily living, instability, and support (von Porat et al., 2004), which prompted our questions on feelings of weakness or imbalance in the injured versus uninjured leg.

Previous investigations were conducted retroactively, as causing an ACL rupture for the purposes of an experiment or research study would be considered unethical. Our study was conducted in the same manner. These studies also controlled for several variables that our study was unable to control. One of these variables is the type of reconstructive surgery the patient underwent following ACL rupture. As we are not following our participants from time of injury, through reconstruction and rehabilitation, and beyond, we do not have control over the type of surgical intervention they underwent. Our pre-participation survey included a question about the type of surgery performed. The current study did not have individual baseline BMD measurement at the time of injury, so the BMD values of the injured knee will be compared to that of the uninjured leg, designated as the "control."

A study of contralateral BMD changes (measured by CT scan) in the operated versus uninjured knee following ACL reconstruction, Mundermann et al. (2015) found that total, cortical, and trabecular BMD all decreased in the injured/operated leg following reconstruction, then slightly increased but did not reach baseline levels. The contralateral leg BMD remained at baseline for the first 3 months, decreased to month 6, then returned to normal by 12 months post-operation. Baseline values of BMD for this study were collected following injury and before reconstruction. We did not have access to this data, our BMD values were compared against age norms and will be compared between each leg to identify if an imbalance exists. We utilized a sample of both males and females aged 18-30 years. Mundermann et al. (2015) study found their results were not statistically influenced by age or gender, a finding confirmed in the following studies as well.

Leppala, et al.(1999) found in their 1-year study that traced BMD changes with the DEXA scan that statistically significant interlimb changes existed in BMD in the calcaneus, trochanter, and femoral neck, with greater changes in the proximal tibia, patella, and distal femur in the group that was treated with reconstructive surgery. These results were not significantly associated with sex, age, height, weight, functional knee scores, or muscular strength (Leppala et al., 1999). They were unable to identify bone recovery during the length of this 1-year study (Leppala et al., 1999). Long-term bone recovery seems to be associated with the functional outcome. Given the functional level of our participants, who have all been medically cleared, we hope to see a full recovery in BMD.

In a 2014 study that examined BMD changes over a 2-year period following ACL injury, van Meer, et al. (2014) found that compared to the baseline, all regions of interest (ROIs) demonstrated a significantly lower BMD level at the 1-yr follow-up mark, and while all regions except the medial tibia showed a significant increase in BMD by the 2-year follow-up, the central and lateral tibia and the medial femur all remained at levels significantly lower than baseline levels. They found that compared to the control, contralateral leg, the injured knee had significantly lower BMD levels in each of the ROIs during each measurement (van Meer et al., 2014). Additionally, they found that patients with higher activity scores prior to treatment had higher baseline BMD and experienced a larger drop in BMD levels during follow-up (van Meer et al., 2014).

While there have been several studies examining bone mineral density changes within the first two years following ACL rupture, there have been inconsistencies in the findings of whether BMD returns to baseline by the 1-year or 2-year post-injury/-reconstruction mark or whether it returns to baseline at all. Due to discrepancies in previous investigations, and because of the documented worsening of osteoarthritis symptoms over a longer timeframe, the current study examined the effect of ACL rupture on osteopenia and osteoporosis rates in individuals that have suffered a rupture and underwent reconstructive surgery greater than 1 year prior their participation in this study. It was hypothesized that the participants would show decreased lower limb BMD on the side of the ACL injury when compared to the control leg. It was also hypothesized that this reduction in BMD would be less apparent in individuals currently engaging in regular physical activity (at least 30 min./d of moderate activity on 3+ d/wk. for at least the last 3 mo.) of weight-bearing exercises/activities (ACSM, 2018).

Methods

Participants

Twelve patients (7 female, 5 male) ages 18-30 (mean age 22.75 years), with a surgical reconstruction of a ruptured ACL participated in the study. All participants were recruited based on the following criteria: (1) suffered an Anterior Cruciate Ligament tear and had reconstruction surgery more than twelve months ago; (2) 18 years or older; (3) willing to complete a Dual-energy X-ray absorptiometry (DEXA) scan. Participants completed an informed consent waiver consistent with the policies regarding the use of human subjects as approved by The University of Akron's Institutional Review Board. Individuals who were pregnant were excluded from the study due to health risks involving the DEXA. Participants also completed a questionnaire, self-reporting data regarding their demographic and injury history information, perceived weakness/imbalance between legs, and physical activity levels. Participation in regular physical activity (PA) was determined using the American College of Sports Medicine (ACSM) description of regular PA, stating that the individual engages in moderate activity for at least 30 minutes a day on 3 or more days per week for a minimum of 3 months (ACSM, 2018). Our subjects' duration between injury and their participation in the study ranged from twelve months to ten years and six months.

Equipment

Whole body composition was estimated using a GE® Prodigy bone densitometer (GE Medical Systems, 2003). DEXA machines use tightly controlled x-ray beams to measure body composition. Bone mineral density, fat mass, lean body mass, and body fat percentage can all be measured via the DEXA. Percent body fat was calculated by dividing fat mass by total body tissue. After removing all jewelry and metals, participants were asked to lay quietly, arms at their sides, on the scanning bed while the scanning began at the head and moved slowly to the feet. Assessment was completed in 10-20 minutes per subject. Prior to testing, anthropometric measurement of weight was taken using a Dectecto beam scale (Cardinal/Dectecto, 2014).

Study Protocol

Each subject participated in a thirty-minute session which consisted of a brief information session in which they signed the informed consent form, filled out the demographic information form, and completed the DEXA full body scan. Instructions were provided to participants the day before their appointment. They were instructed to wear comfortable clothing without metal (zippers, buttons, jewelry) and to be prepared to answer questions of the details regarding their injury and reconstruction. Testing procedures were consistent for all participants. Each participant was instructed to take their shoes off and remove all objects from their pockets. They were then weighed on a digital scale. Participants were instructed to lie supine with hips and knees extended against the table with their arms by their sides, unmoving, until the completion of the scan.

When the scan was complete and the data printed out, the participants received a copy of the full body scan. The results were explained to the participants, including the specific data the study examined as well as information regarding their body composition. The study utilized the information regarding bone mineral density and content, and lean muscle mass of the left and right legs.

Measurements/Statistical Analysis

The difference in contralateral measurements of Lean (muscle) Mass (LM), Bone Mineral Content (BMC), and Bone Mineral Density (BMD) of the legs were determined by comparing the injured leg values to the control leg and was then analyzed for statistical significance with a *one-tailed t-test* to evaluate if the injured leg values were significantly lower than those of the control leg. The significance of this directional difference was evaluated on an alpha level of

0.05 (95% confidence interval).

Results

According to statistical analysis, there was no significant reduction in BMC (Figure 1) from the control to injured leg ($t(11) = -0.010$, $p > 0.05$) and no significant reduction in LM (Figure 3) from the control to injured leg ($t(11) = 1.372$, $p > 0.05$). Analysis did reveal a significant reduction in BMD (Figure 2) from the control to injured leg ($t(11) = 2.283$, $p < 0.05$). The difference values collected on these three variables are represented in the figures below. The numerical data summary of the differences is organized by subject in the Appendix D tables.

Table 1
Participant Demographics & Injury Information

	Female	Male	Total Population
n	7	5	12
Mean Age (years)	22.86	22.6	22.75
Mean Time since surgery (years)	4.52	4.18	4.38
Physically Active	6	5	11
Imbalance or Instability	5	2	7

Table 1: Summary of participant demographics and injury information gathered from the Pre-Participation Survey (Appendix B).

Figure 1

Bone Mineral Content (BMC) Results

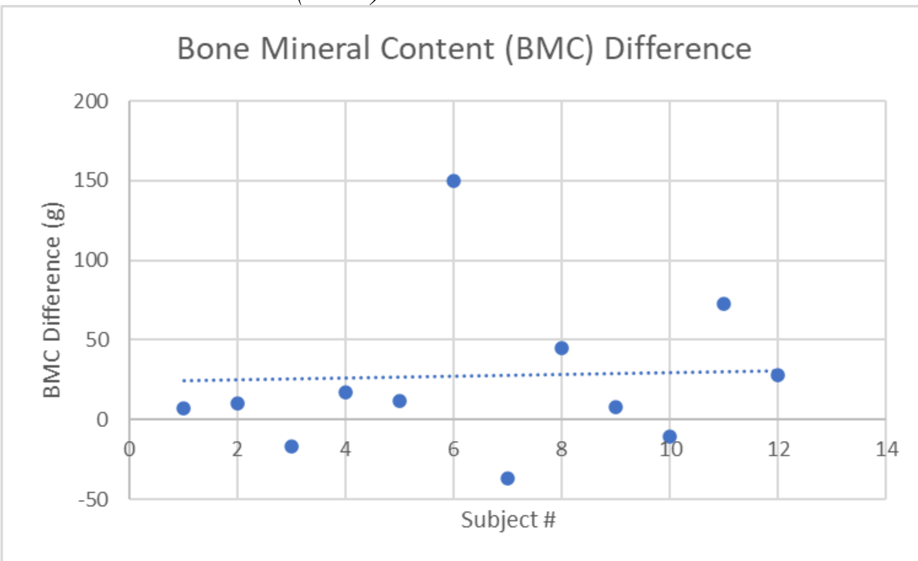

Figure 1: Summary of BMC measurement data by subject and the difference observed between the injured and control leg values. The mean difference (M_D) of BMD for the sample was 23.8 g with a standard deviation of (s) 48.85 g. The statistical analysis showed no significant reduction in BMC from the control to injured leg *($t(11) = 1.688$, $p > 0.05$)*.

Figure 2

Bone Mineral Density (BMD) Result

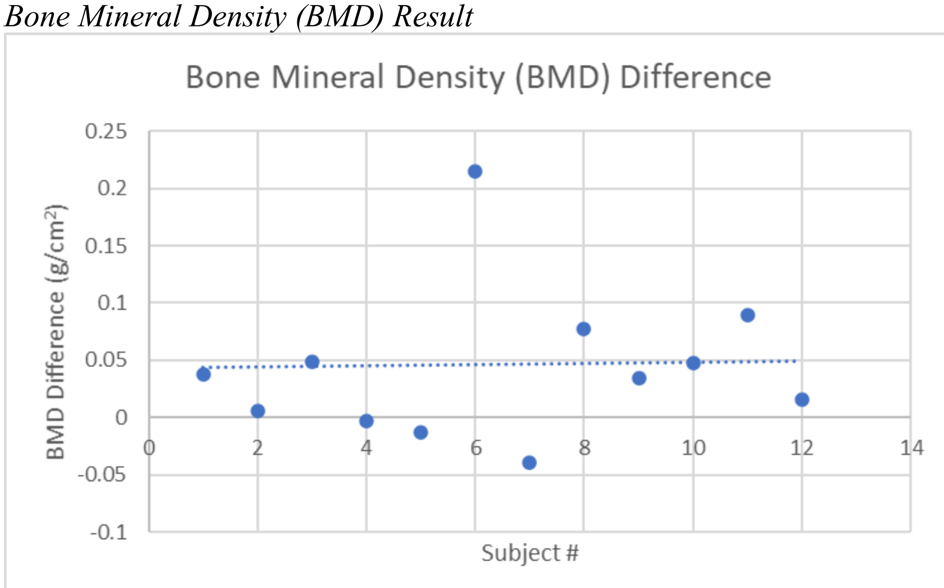

Figure 2: Summary of BMD measurement data by subject and the difference observed between the injured and control leg values. The mean difference (M_D) of BMD for the sample was 0.0432 g/cm^2 with a standard deviation (s) of 0.0655 g/cm^2. The statistical analysis showed a significant reduction in BMD from the control to injured leg *($t(11) = 2.283$, $p < 0.05$)*.

Figure 3
Lean Mass (LM) Results

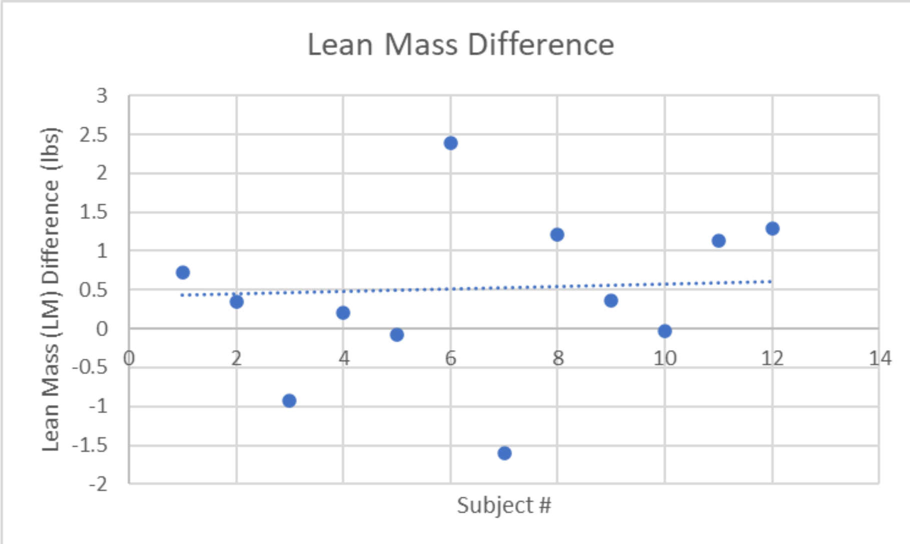

Figure 3: Summary of LM measurement data by subject and the difference observed between the injured and control leg values. The mean difference (M_D) of LM for the sample was 0.418 lb with a standard deviation (s) of 1.06 lb. The statistical analysis showed no significant reduction in LM from the control to injured leg *($t(11) = 1.372$, $p > 0.05$)*.

Discussion

A significant difference between the injured and control leg values was not identified for bone mineral content (M_D = -0.292 g) or for the lean mass (M_D=0.418 lb) of the lower extremity. This would indicate that on average, these variables are not affected by ACL injury and reconstruction in the long term, a finding with positive outcome implications, as these variables re-balance during the recovery process following reconstruction.

The significant reduction in bone mineral density that remained on average (M_D=0.0432 g/cm^2) may indicate a lasting effect of the ACL injury on BMD, supporting the hypothesis that the injured leg would show a decreased BMD value compared to the control, uninjured leg. Our BMD results are consistent with the results of Lapella et al. (1999). In their 1 year follow up study, there was a significant decrease in BMD that did not return to normal after 12 months post-operation. Our study examined BMD comparisons 12 months to 10.5 years post-surgery.

Even after 10 years, the BMD of the injured leg has not returned to normal (ie. compared to the uninjured control leg). These results are also consistent with van Meer et. al (2014) which found a decreased BMD significantly below the baseline after two years post operation. The significance of this interlimb difference is further supported by Nazarian et al. (2010), as they found no significant difference in BMD based on leg dominance in their healthy control group.

BMD naturally declines with age and combined with injury related decreased levels could result in a predisposition to certain orthopedic conditions, such as osteopenia or osteoporosis. Aging has also been linked to increased incidence of osteoarthritis (Sheth, 2022). However, long-term studies are necessary to determine the validity of this prediction. Utilizing longitudinal studies could demonstrate how BMD values may fluctuate over time and elucidate individual differences in our findings. We were able to limit the effect of individual differences in BMD, BMC, and LM values by evaluating the difference score for each subject rather than the average of their raw data measurements.

One weakness of our study is that we do not have baseline BMD data, and can therefore only analyze if deficits or imbalances in BMD currently exist. If we had more time and could identify patients with ACL rupture history closer to their date of injury, more individual measurements could be taken to examine how the injury's long-term effects on BMD develop and change over time. BMD changes could be tracked from the time of injury, and at several points following reconstruction for a period of 10-15 years or more to track whether this reduction in BMD persists for longer periods of time and the extent to which it exists.

Over time, bone loss occurs naturally as individuals age. One aspect of the study that we lacked control over was the amount of time that had passed between the date of their injury and their DEXA scan. The time since reconstruction for our participants ranged from 12 months to approximately 10.5 years. These time disparities could have led to individual discrepancies in the results when compared to measuring all participants at pre-set and consistent intervals following reconstruction. However, since the subjects control leg and injured leg have had the same amount of time elapse between injury and participation in the study, we were able to compare individual values to identify a controlled difference score, which was analyzed to identify if significant differences between the legs exist. Another weakness of this study is the low number of participants (n=12), which may prevent these findings from being generalized beyond our sample. Therefore, additional research with a larger sample size is warranted. Having a larger sample size may also enable conclusions to be drawn based on the role that regular physical activity plays in reducing the mean BMD difference that was displayed in our findings. Because all but one participant currently participates in regular physical activity (at least 30 min./d of moderate activity on 3+ d/wk. for at least the last 3 mo.), as defined by the American College of Sports Medicine (ACSM, 2018), we were not able to test or draw conclusions on our hypothesis that regular physical activity would reduce this mean difference.

Having the opportunity to design and implement a research project as a team was a unique opportunity for us. Neither of us had done research prior to this, so it was a valuable takeaway from our undergraduate experience and furthered our education in a positive way. The autonomy we were given in creating the study coupled with the academic support from our advisors and sponsors made this a great experience for us. Although we are going into different fields (physical therapy and occupational therapy), the process of recovery and the lasting effect of an injury is a key aspect in our futures. Additionally, this gave us the opportunity to experience working with another person within our field of study and learn how important communication and adaptability is when working with clients and collaborating with other professionals. We had to schedule our participants, which depended on our schedules and their schedules, which sometimes would change at the last minute. Overall, this experience provided a positive experience on our academics and will push us into future research within our fields.

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Appendix A

Informed Consent

School of Exercise and Nutrition Sciences
Akron, OH 44325-5103
(330) 972-7473 Office
(330) 972-5293 Fax

Title of Study: Effect of an ACL tear on contralateral bone density and muscle mass

Informed Consent Form

For Prospective Collection of Data/Information

Introduction: You are invited to participate in a research study that will compare bone mineral density (BMD) and muscle mass contralaterally following an Anterior Cruciate Ligament (ACL) tear. This research will be conducted by Carly Anenson and Rebecca Beitko (Principal Investigators) and Dr. Ronald Otterstetter, Ph.D., a faculty member in the Department of Exercise and Nutrition Sciences at the University of Akron.

Purpose: This research study will examine the relationship between tearing one of the major ligaments of the knee and this injury's influence on bone density and muscle mass. Conclusions could be drawn regarding the possibility of increased risk of having osteoporosis or osteopenia for individuals with a history of ACL tear.

Procedures: After signing the informed consent form you will lie down on the DEXA machine and undergo a scan. The scan will be performed by a licensed professional. Under any circumstance you may stop the test at any time. If you do not feel comfortable under-going the scan you are not required to have the scan.

Pre-Test Instructions: You are instructed to wear proper clothing during the tests, such as sweatpants or athletic shorts and at-shirt. Please remove all metal from your person before lying on the DEXA machine. This includes piercings or any belts. To obtain the BMD reading you undergo a Dual-energy X-ray absorptiometry (DEXA or DXA scan). DEXA is a full body scan that uses low energy X-rays to view bone density. The scan will approximately take 6 minutes. Age and gender will be self reported by participants.

Risks and Discomforts: DEXA uses low energy X-rays to view bone density. The radiation dose is low and risks associated are the same as any other X-ray device. (1/110th of a typical medical X-ray and much less than a CAT scan); and each of you will be asked to take part in one scan. However, it must be noted that DEXA scans are common in research and clinical settings and pose minimal risk (any radiation exposure theoretically carries some risk), but no discomforts.

Benefits: Participants may choose to receive their report from their DEXA scan, but there is no direct benefit of participation.

The University of Akron

School of Exercise and Nutrition Sciences
Akron, OH 44325-5103
(330) 972-7473 Office
(330) 972-5293 Fax

Inclusion criteria: Participant must be at least 18 years of age and has experienced an ACL tear at least 12 months ago.

Exclusions: You are not eligible to participate in this research project if you are under 18 or pregnant. If you have received any other X-ray or radiation type scan within this past week, you will not be able to participate until at least 7 days have passed since last exposure.

Right to refuse or withdraw: Taking part in this project is entirely up to you, and no one will hold it against you if you decide not to do it. If you do take part, you may stop at any time.

Anonymous and Confidential Data Collection: Any identifying information collected will be kept in a secure location and only the researchers will have access to the data. You will not be individually identified in any publication or presentation of the research results. Only aggregate data will be used. Your signed consent form will be kept separate from your data, and nobody will be able to link your responses to you.

Confidentiality of records: You will be assigned numbers to maintain anonymity. Data from the sensor will be saved on the University of Akron's secure server. Data will be kept for 10 years. Only the PI on the project will have access to the original data. Any paperwork will be stored in the PI's office for 3 years.

Who to contact with questions: Ronald Otterstetter: 330-972-7738 . This project has been reviewed and approved by The University of Akron Institutional Review Board. If you have any questions about your rights as a research participant, you may call the IRB at (330) 972-7666.

Acceptance & signature: I have read the information provided above and all of my questions have been answered. I voluntarily agree to participate in this study. I will receive a copy of this consent form for my information.

____________________________ ____________________
Participant Signature **Date**

Appendix B

Pre-participation Survey

Subject # ____

Background Information

Are you or is there a chance that you are pregnant? Yes ____ No ____

Age: _____

Gender: Male ____ Female ____

Injury Information

Knee injured: Right ___ Left ___ Date of Injury (mm/dd/yyyy) _____________

Check one: Ligament rupture was a(n) ___ complete / ___ incomplete tear.

Structures injured (e.g., ACL, MCL, meniscus, other): ________________________________

____

Did you have reconstructive surgery? Yes ____ No ____

Date of Reconstruction (mm/dd/yyyy) _____ / _____ / _______

Type of Reconstruction ____

Length of postoperative rehabilitation program: __________ (weeks)

Do you currently experience feelings of weakness or imbalance when comparing your injured and uninjured knee/leg?

Yes ____ No ____

If answered yes, please describe (if possible): ________________________________

____

Activity History

Describe your level of physical activity prior to injury (e.g., participation in a competitive or contact sport, running, strength training, yoga, etc.). Please include an estimation of d/wk or hr/wk if applicable.

____

____

____

Describe your current level of physical activity. Please include an estimation of d/wk or hr/wk if applicable.

____

____

____

Appendix C

EXERCISE RESEARCH STUDY LOOKING FOR VOLUNTEERS

THE HUMAN PERFORMANCE LABORATORY IN THE SCHOOL OF EXERCISE AND NUTRITION SCIENCES IS LOOKING FOR VOLUNTEERS TO PARTICIPATE IN A STUDY EVALUATING <u>BONE DENSITY AND MUSCLE MASS OF THE LEGS POST ACL SURGERY</u>. YOUR PARTICIPATION IN THE STUDY CONSISTS OF PERFORMING A DUAL ENERGY XRAY ABSORPTIOMETRY SCAN.

TO BE ELIGIBLE FOR THE STUDY, YOU NEED TO MEET THE FOLLOWING CRITERIA:

- Must have suffered an ACL tear more than 12 months ago
- Must be at least 18 years of age
- Must be able and willing to complete a DEXA SCAN

IF YOU ARE INTERESTED, PLEASE CONTACT:

CARLY ANENSON at (330) 715-4492

or

BECKY BEITKO at (330) 212-2541

Appendix D

Data Tables

Table A1

Bone Mineral Content (BMC) Results

Subject#	Injured Leg (g)	Control Leg (g)	BMC Difference (g) (Control - Injured)
BC1	465	472	7
BC2	475	485	10
BC3	703	686	-17
BC4	424	441	17
BC5	543	555	12
BC6	528	678	150
BC7	609	572	-37
BC8	655	700	45
BC9	540	548	8
BC10	601.7	591.3	-10.4
BC11	521	594	73
BC12	746	774	28

Table A1: Summary of BMC measurement data by subject and the difference observed between the injured and control leg values. The mean difference (M_D) of BMD for the sample was 23.8 g with a standard deviation of (s) 48.85 g. The statistical analysis showed no significant reduction in BMC from the control to injured leg ($t(11) = 1.688$, $p > 0.05$).

Table A2:

Bone Mineral Density (BMD) Results

Subject #	Injured Leg (g/cm^2)	Control Leg (g/cm^2)	BMD Difference (g/cm^2) (Control - Injured)
BC1	1.323	1.361	0.038
BC2	1.348	1.354	0.006
BC3	1.453	1.502	0.049
BC4	1.349	1.346	-0.003
BC5	1.337	1.324	-0.013
BC6	1.27	1.485	0.215
BC7	1.467	1.428	-0.039
BC8	1.48	1.557	0.077
BC9	1.483	1.517	0.034
BC10	1.407	1.455	0.048
BC11	1.319	1.409	0.09
BC12	1.709	1.725	0.016

Table A2: Summary of BMD measurement data by subject and the difference observed between the injured and control leg values. The mean difference (M_D) of BMD for the sample was 0.0432 g/cm^2 with a standard deviation (s) of 0.0655 g/cm^2. The statistical analysis showed a significant reduction in BMD from the control to injured leg ($t(11) = 2.283$, $p < 0.05$).

Table A3
Lean Mass (LM) Results

Subject #	Injured Leg (lbs)	Control Leg (lbs)	LM Difference (lbs) (Control - Injured)
BC1	16.27	16.99	0.72
BC2	14.12	14.47	0.35
BC3	28.2	27.27	-0.93
BC4	17.23	17.44	0.21
BC5	16.11	16.03	-0.08
BC6	18.17	20.56	2.39
BC7	25.63	24.03	-1.6
BC8	27.91	29.12	1.21
BC9	18.32	18.68	0.36
BC10	26.52	26.49	-0.03
BC11	19.18	20.31	1.13
BC12	24.7	25.99	1.29

Table A3: Summary of LM measurement data by subject and the difference observed between the injured and control leg values. The mean difference (M_D) of LM for the sample was 0.418 lb with a standard deviation (s) of 1.06 lb. The statistical analysis showed no significant reduction in LM from the control to injured leg ($t(11) = 1.372$, $p > 0.05$).

Table A4
Survey Data Summary

Subject	Gender	Age (years)	Time since surgery (years)	Physically Active?	Imbalances or Instability?
BC1	F	22	7.66	Yes	Yes
BC2	F	24	7.83	No	Yes
BC3	M	26	4.17	Yes	No
BC4	F	20	3.08	Yes	No
BC5	F	21	6.42	Yes	Yes
BC6	F	23	3.17	Yes	Yes
BC7	M	27	10.58	Yes	No
BC8	M	20	2.08	Yes	Yes
BC9	F	30	2.5	Yes	No
BC10	M	18	2.5	Yes	No
BC11	F	20	1	Yes	Yes
BC12	M	22	1.58	Yes	Yes

Table A4: Summary of Pre-Participation Survey (Appx. B) data collected, organized by subject.