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Nutrient Supplementation for Pre- and Post ACL Operation & Rehabilitation in Female Basketball Players

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**Nutrient Supplementation for Pre-and Post ACL Operation & Rehabilitation in Female Basketball
Players**

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Nova Southeastern University

NUT 6805 - Applied Nutrition Capstone

Dr. Petrosky

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Abstract:

Understanding how nutrition and dietary protocols can help female athletes in the process of “returning to sport” after an anterior cruciate ligament (ACL) repair surgery should be discussed amongst interprofessional post-operational care teams. Amongst athletes, female counterparts experience ACL injuries at a higher incidence rate than males, this is due to a variety of biological factors while returning to sport at a lower rate. Due to this, it is important to analyze and evaluate the data available from sports journals on the effects diet and supplements may have on the musculoskeletal system. ACL grafts are often taken from a donating section of the patient's tendons, which commonly can come from the quadriceps or patellar tendon. The subsequent muscular atrophy and tendon instability contribute to the difficult rehabilitation process as well and the time it takes for an ACL graft to be fully vascularized and integrated can prolong an athlete's return to sport. The literature aims to examine if there is a relationship between dietary supplementation of certain nutrients and improved recovery outcomes that can be used to increase an athlete's return to sport rate. This will be done through a literature review where gathered information will be used to design a nutritional protocol that can be paired with the traditional ACL rehabilitation protocol to aid female basketball players in their recovery and return to sport.

Hypothesis:

There is data in the current and available sports journal literature that can be used to create a dietary protocol that can potentially improve postoperative outcomes within the “normal” return to sport timeline in female basketball players after anterior cruciate ligament (ACL) surgery.

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Introduction:

Noncontact injuries in sports that require dynamic movements such as cutting, jumping, or short stops often involve the stabilizing joint capsule and ligaments of the knee. A combination of stabilizers serves as a relative restraint to movement across specific planes of motion controlling the degree of the knee from moving side to side and front to back.¹ In basketball one of the most common non-contact injuries is a torn ACL, but there is a disparity between male and female athletes in both frequency of injury and return to sport rates. The top injury seen in female basketball players is an anterior cruciate ligament (ACL) tear being eight times more likely to suffer this injury than males and 16% more likely to incur a tear within their career.² Per the Journal of Orthopaedics, the rate of female basketball athletes' ACL injuries is 3.5x higher than male basketball players.³ This was attributed to hormonal and anatomical differences in male and female athletes, for example, ACL volume was shown to be a key factor in ligament strength and female subjects had lower volume overall and narrower condylar notches, creating a higher risk for tears to occur.^{3,4,5} With surgery as the primary route to return to sport for athletes that experience ACL tears, the muscular atrophy associated with the donor tendon sites, such as the quadriceps tendon, is one of the main barriers to returning to sport.⁶ During this reconstructive surgery, an autograft tendon is taken from either the patellar tendon or quadriceps tendon to repair the ACL, thus leaving the area taken from experiencing high amounts of atrophy along with the entire leg experiencing atrophy with the inability to use the muscles for a prolonged period.⁶ The rate of return from an ACL injury averages between 6-12 months varying based on the individual's anatomy, surgery, and rehabilitation process.⁷ Beyond the physical barriers an athlete must overcome to make it back to their sport, there is also seen to be a psychological barrier that these athletes must overcome.⁶ Female athletes have been shown to have a lower rate of returning to their sport with limiting factors such as fear of reinjury, and anxiety due to perceived muscle weakness in the repaired knee.^{3,5} The current standard of care mainly focuses on musculoskeletal rehabilitation after the surgery is complete. This often includes electrostimulation, physical therapy, and supportive knee braces. With advances in nutrition studies, there

is literature supporting supplements such as fish oil and collagen that can assist with increasing muscle growth when paired with a complete, quality protein and exercise. This literature review aims to examine the available research on female basketball athlete ACL recovery, while also looking at how nutrition and dietary intervention can be a potential influence in improving patient outcomes after ACL surgery.

Review of Literature:

Female athletes are more at risk of suffering an ACL tear due to reasons such as anatomical, mechanical, and hormonal factors. Anatomically women's articular geometry, intercondylar notch width, tibial slope, ACL size, and knee alignment are all correlated to their increased risk.⁵ All of these anatomical factors provide stability in the knee while performing movements, especially the cutting movement which is highly associated with this injury. Mechanically the female body is hypermobile, increasing the joint's laxity which is also correlated to injury.⁵ With basketball being a sport that uses frequent landing, cutting, and jumping, the knee is put in vulnerable positions where the laxity of the knee is increased and stability of the knee is decreased. The female body has a cyclical hormonal difference from the male counterpart that results in a change of coordination.⁵ This hormone is seen during the menstrual cycle, where during this phase there is an anterior tibial translation - a movement that is correlated with ACL tears.⁵

After suffering an ACL tear, athletes have the option of various grafts when going into surgery. The ACL reconstructive surgery as a whole has an 80% return to sport rate, a 65% preinjury level of participation, and a 55% return to competitive sport rate.⁷ Two of the most common choices for grafting are the quadriceps tendon or the patellar tendon autograft for reconstructive surgery.⁶ These grafts are similar, only differing in the area they are taken from - the quadriceps tendon or patellar tendon. No matter the grafting site for the ACL reconstructive surgery, the muscle within the leg is lost. Immobilization and disuse are often accompanied by an injury, which results in muscle tissue being lost which can happen in as little as 36 hours to five days of inactivity.⁸ With an ACL injury requiring an athlete to not use the injured leg as well as the autograft operation, muscle atrophy occurs resulting in the individual having to

build their leg muscle from scratch. This is where the rehabilitation process is important, the knee is mobilized again as well and the muscle is built back up.

Upon completion of ACL reconstruction, the rehabilitation process begins. The two main approaches physical therapists use for this process are either an accelerated approach or a conservative approach. An accelerated approach includes early unrestricted motion, immediate weight-bearing as tolerated, eliminating immobilizing braces, and a patient-dependent aim to return to play within six months.⁷ The main difference between the two processes is the timeline to return, which ultimately enhances the speed at which the individual recovers. An accelerated approach returns an athlete as soon as six months whereas a conservative approach returns an athlete in about nine months. Following the completion of either rehabilitation process a multitude of tests and measurements are completed to identify the physical readiness of the athlete. These tests include a range of motion, quadriceps and hamstring strength, joint laxity, and limb symmetry index, along with the outcome of quality measures of single-limb hop tests and balance.⁷

With an understanding of the female body being biologically more prone to ACL injury and an understanding of the surgical and recovery process, we began looking at the rehabilitation protocol and nutritional protocol of these athletes during their recovery process. There were combinational programs that have been researched to see the effects of proteins and supplementation on the surgical, recovery, and rehabilitation process of ACL tears.

Once an injury such as an ACL tear occurs, the demand for amino acids increases for wound healing, tissue rebuilding, and catabolism of the skeletal muscle.⁸ Protein consumption is significant in these individuals because of the loss of muscle and immobilization that accompanies an ACL tear and reconstructive surgery. Along with the repair from injury, amino acids help in the healing and repair of incisions and tissue repairs.⁸ There is a recommended increase of protein consumption to 1.6 g/kg/d - 3.0g/kg/d throughout the recovery and rehabilitation process from an ACL tear.⁸ The study conducted by the Department of Nutritional Sciences, University of Connecticut, showed that high-protein diets can

positively impact the stimulation of myofibrillar protein synthesis. The study was focused on increasing protein intake before the surgical repair of the ACL to examine the effects of reducing muscle loss due to disuse.⁹ The data found showed that it warrants further research to examine the effects of increasing protein to an optimal level upon receiving a positive MRI result for a torn ACL. Reducing the muscle loss before surgery may help athletes reduce further atrophy that is commonly seen after the donor's tendon is extracted from the patient's targeted muscle group. Each athlete will have varying rates of physical activity during rehabilitation and speed at which they return to certain strength-building activities. Given the varying schedules each athlete will have, the timing of the supplements can be flexible but in a study published by The Journal of Athletic Training, it is recommended to consume 20-40 grams of protein every 3-4 hours to reach the desired daily protein intake while maximizing absorption.¹⁰

Data shows support for six months of a high dose of fish oil increasing the mTOR pathway, leading to muscle protein synthesis (MPS) turnover which allows for increased muscle growth sensitivity and increased lean muscle mass in patients.¹³ Collagen supplementation can play a similar role in tendon re-strengthening that can use an increased consumption following resistance exercise for the portions of tendons used as ACL donors to help return tendon stability to the operated region.¹¹ In a study conducted by The School of Sport and Exercise Sciences, Liverpool John Moores University with female soccer players as the sample population; they found pairing 30 grams of collagen with 500mg of Vitamin C had a meaningful impact on patellar tendon strength. The data reported by the researchers showed there was not an increase in size of the tested patellar tendons when viewed under ultrasound. Although the plyometric testing between both groups showed an increase in mechanical and material strength in the collagen-supplemented group providing the basis for recommendation in ACL rehabilitation.¹² While the spacing out of protein-rich meals has been shown to assist in MPS and muscle atrophy is one of the major postoperative side effects of ACL surgery, fish oil and collagen supplementation could benefit athletes in their recovery journey.

As discussed, a high dosage of fish oil can be shown to improve recovery and soreness. In a study completed by VanDusseldorp and colleagues, this particular supplementation was studied to see the benefits fish oil has on recovery and soreness following eccentric exercise. Thirty-two college-aged resistance-trained individuals were supplemented with either 2, 4, or 6 g/day of fish oil or a placebo for seven weeks.¹³ The first week included familiarity of testing being completed followed by six weeks of supplementation, where pre-exercise screening was completed familiarizing participants with the assessments including vertical jump, knee extensor strength, 40-yard sprint, T-test agility, and perceived soreness.¹³ With the maintenance of a regular diet other than a change one week before the study ended where the protein consumption needed to be 1.2 g/kg/day and ended the experiment performing a one-repetition maximum back squat before moving into the previous tests.¹³ Upon completion of the study, the results were able to show the benefits of a high dose of fish oil is beneficial for recovery and soreness. Perceived soreness rates for six grams of fish oil were lower than the placebo, two grams, and four grams showing the significance fish oil has on recovery and soreness.¹³

Nutritional considerations were looked at for recovery and rehabilitation in an article by Smith-Ryan and colleagues on protein importance alongside glucose. With glucose being in most carbohydrates, this leads us to understand the combination of protein and carbohydrates for individuals dealing with an injury. “The goal of rehabilitative nutrition is to provide enough calories and protein to aid in wound healing and prevent a loss of lean muscle mass,” was stated within Smith-Ryan’s article justifying lean muscle mass being a factor that is inevitable when dealing with an injury and specifically one as significant as an ACL.⁸ A nutrient needed more specifically than overall calories is protein. After an injury, amino acid intake is increased. The demand for amino acids is used for wound healing, tissue rebuilding, and glycemic control, all of which are important after suffering an injury and more importantly when the injury requires surgery.⁸ Within this article there were specific numbers relating to female ACL tear that breaks down the energy and macronutrient needs in an individual. For an 18-year-old that is 5’4” and weighs 130 lbs, their energy needs are as follows; resting metabolic rate: 1430-1480

kcal/d, activity level: 1.2 (sedentary); stress factor: 1.2 (minor surgery); with a collective total energy need of 2000-2100 kcal/day.⁸ It then provided a breakdown of the macronutrient intake for this individual where they should consume 3.0-5.0 g/kg of carbohydrates, 1.0 g/kg of fats, and 2.0-3.0 g/kg of protein.⁸ With this, an example was provided of recommendations for all macronutrients as well as talked about how they would help during the injury. These nutritional recommendations would help reduce surgical complications, minimize muscle loss, and maximize getting the athlete back to competing.⁸ The combination of these macronutrients, specifically protein, is highly important when suffering from an injury and undergoing surgery that will decrease muscle loss within days.

Table 1: Study Breakdown

Author (Year), Article, & Journal	Supplement(s) Used	Dosage & Timing of Supplement(s)	Duration of Supplement(s)	Type of Exercise With Supplementation	Results of Supplement(s)
Howard E.E (2022), Effect of high-protein diets on integrated myofibrillar protein synthesis before anterior cruciate ligament reconstruction Nutrients MDPI	1.9 grams of protein per Kg of lean body mass	5 equally portioned protein-based meals were provided along with 1 protein-rich snack For an “optimal” protein diet	2 weeks before the operation	No exercise was noted before surgery.	- Before surgery, protein was increased to 1.9g/kg and MyoPS tended to be greater in the test group
Smith-Ryan et al. (2020), Nutritional considerations and strategies to facilitate injury recovery and rehabilitation J. Athl. Train.	2.0 to 3.0 g/kg/ daily of whey protein	20 to 40 g of total dietary protein per sitting every 3-4 hours	Daily during the rehabilitation period, 9 monthly average	Standard rehabilitation exercises noted	- Caloric intake increase before surgery noted and increased protein intake noted after surgery led to reduced muscle atrophy
Bridge et al (2023), Collagen supplementation in female soccer players	Collagen hydrolysate	30 grams paired with 500 mg of vitamin C	10-week supplementation	Soccer training with plyometric exercises and strength training	- The size of the tendons examined remained the same, but tendon strength was noted to have

Front Physiology		No noted time of consumption			increased in the test group.
Oertez-Hagemann (2019), Effects of 12 weeks of hypertrophy resistance exercise training combined with collagen peptide supplementation on the skeletal muscle proteome in recreationally active men Nutrients MDPI	Collagen Peptide	15g of collagen peptide (COL) (1.66 g/kg/day protein) OR 15g of non-caloric placebo (1.86 g/kg/day protein) Consumed within 60 minutes after each training session	In the 12-week study, the supplement was consumed daily for the whole duration of the study	Full body hypertrophy exercise three times per week with four exercises using barbells	- Increase of hydroxyproline (an amino acid) in blood sample two hours after consuming COL - Slight increase in strength with collagen peptide consumption over the placebo - Body mass and fat-free mass increased in collagen peptide-consuming participants - Significant increase in rowing when consuming collagen peptide
VanDusseldorp (2020), Impact of varying dosages of fish oil on recovery and soreness following eccentric exercise Nutrients MDPI	Fish oil Normal diet intake up until one week before pre-testing, protein intake increased to 1.2 g/kg/day for the study	2, 4, or 6 g/day of fish oil OR 2, 4, or 6 g/day of placebo No note of the timing of the supplement	The supplement was consumed for roughly 7.5 weeks	Eccentric exercise: performed their own workouts and exercises 3-5 days per week (3-8 hours per week in total)	- Measure the dose-response impact of fish oil supplementation on markers of recovery following vigorous eccentric exercise - 6 grams of fish oil was most significant at reducing muscle soreness - Increased activation of muscle protein synthesis for muscle mass

Research/Review Question & Specific Aims of Project:

How does the supplementation of protein and supporting dietary supplements, both pre- and post-operation positively influence the recovery of a female basketball athlete who has suffered an ACL tear and will undergo surgery to begin the recovery process? Can nutritional intervention reduce the number of female athletes who do not feel physically and mentally ready to return to play after surgery?

Our project aims to present how protein supplementation when combined with supplements such as collagen and a high-dose fish oil can promote strength recovery and muscle hypertrophy while resistance training in athletes as they begin to rebuild their surrounding musculature.¹ We will propose a potential nutrition intervention that can be paired with a traditional ACL rehabilitation protocol that aims for repairment post-injury and also accounts for rehabilitation strengthening for future prevention of a contralateral tear or retears of the repaired ligament. The basis for the nutritional protocol will include suggested windows for protein timing and duration of consumption along with complementary supplementation led by the data available. Within the provided research daily intake values of protein and supportive supplementation will be stated which will be used to provide a calculated average intake for the sample groups and has been proven to show consistency in results.

Methods:

- Using a 7-year range of databases such as Pubmed to compose our literature references
 - Selecting literature that is free of conflicting interests from the authors
 - Dietary intervention literature as the main data sources
- Once the literature review is complete taking the relevant data that was found to create a streamlined dietary protocol
 - Our dietary protocol will aim to use protein supplementation accompanied by collagen, vitamin C, and fish oil for muscle and tendon repair and enhancement in the pre- and post-operation on ACL tears in females to increase the success rate of return to play.
- We will pair our dietary protocol with the traditional ACL rehabilitation protocol
 - Our dietary protocol will be combined with the traditional ACL rehabilitation to show the effects of the supplements throughout the rehabilitation
 - The rehabilitation protocol and our dietary protocol will work cohesively for the betterment of the individual

Discussion/Results:

The available data for studies that focused solely on female basketball participants was very limited. There were studies solely focused on female ACL recovery statistics and return to normal sports activities, but as we examined the nutrition side of the literature, we had to expand the journals considered. The results that were seen, painted a positive outlook for the potential of helping athletes in recovering from their surgery. The timeline for returning to sports can vary by ± 3 months depending on the approach taken by the physicians and the athlete.¹⁵ The conservative model is generally seen as nine months of rehabilitation, and six months for accelerated return but one study published by Orthopaedic Journal of Sports Medicine showed thirteen months was the average for National Basketball Association players to return.⁹ Given the moderate differences in timelines, nine months can be seen as a median for an athlete to return to their sport, with each athlete potentially needing more or less time for rehabilitation based on their body and the process taken. Vaudreuil et al reported, “In the latter stages of rehabilitation, fear of reinjury and psychological readiness has been shown to be prime determinants of a successful return to sport.”⁷ Within a nine-month timeframe, the supplementation of an athlete's diet with protein, collagen with vitamin C, and fish oil could provide added benefits when paired with their normal rehabilitation routine to assist athletes in their journey to “feel” prepared when cleared by their healthcare providers. The studies considered the benefits in recovery for each supplement, although in our findings the main takeaway is the potential for the usage in conjunction with one another.

Vitamin C supplementation in recovering patients showed potential for the metabolic increase in the synthesis of Type 1 collagen fibers. 15 grams of collagen peptides were found to have support in helping increase muscle strength, and tendon recovery and increase fat-free mass in a 12-week trial.^{11,15} With the correlation between vitamin C and collagen synthesis, the data supports maintaining a vitamin C supplement for the duration of the time an athlete supplements collagen during rehabilitation.

It is well documented that increasing the protein found in an average person's diet can help with increasing lean body mass when taken appropriately and properly spaced out to optimize intake. The

“right” amount of protein for athletes can vary greatly, and even more so when scaling up to help recover from muscle atrophy and injury. The United States Department of Agriculture Dietary Reference Intakes (USDA RDIs) recommend 0.8 grams of protein per kilogram of lean body mass, but in the literature the data supports 1.6–2.5g per kg of lean body mass, a larger amount, to be spaced over the course of 4-6 meals and shakes.¹⁰ Ideally, maintaining an equally spaced out window of consumption would help optimize the benefits of increasing protein intake, aiming to create a 3-4 hour cycle between each protein-rich meal. The higher protein intake when paired with the anabolic strengthening exercises required for returning to sport can lead to muscle gain and retention in athletes. The role of fish oil in muscle protein synthesis was also examined and the role it may play in helping recover the lost muscle mass from surgical atrophy during the return to sport window. Trials that included up to 6 grams of fish oil when compared to a placebo, showed a reduced perceived level of muscle soreness post-exercise, and increased activation of MPS over 7 weeks.¹³

Although none of the trials were taken to or past the nine-month mark for the discussed supplements, the positive individual results show that in conjunction with one another, athletes could see an improvement in their surgical rehabilitation process. Reducing the discomfort perceived while assisting in promoting muscle growth and muscle retention can be pivotal for patients aiming to return to their sport within the 9-14 month timeline. Muscle atrophy is one of the main obstacles to overcome, The sensation of muscle imbalance can hinder an athlete's confidence in their movements, and actual muscle imbalance can lead to increased risks of re-tears or contralateral tears.

With the above information, we have created our nutritional protocol to be paired with the traditional ACL rehabilitation protocol as follows in Table 2 below:

Table 2: Proposed Nutritional Protocol

Supplement	Time & dosage	Length of time supplemented	Benefits we are looking for
<p>Protein - Whey protein or a complete protein of choice by the individual</p>	<p>2.0-3.0 grams of protein per kilogram of lean body mass depending on activity level in rehabilitation.</p> <p>Maintain an average of 30 grams of protein per meal or snack 5 times per day.</p>	<p>A higher dose of protein would be advised throughout the length of the conservative approach to rehabilitation.</p> <p>We will start with 2 weeks of protein supplementation before the individual's operation and 6 weeks following the operation before evaluating</p> <p>Depending on the evaluation we may continue this for the entirety of the rehab (9 months)</p>	<p>Decreased muscle atrophy from the initial immobility period after ACL surgery.</p> <p>Increased lean muscle mass in the donor muscle group in recovery once rehabilitation begins on the repaired knee.</p>
<p>Collagen peptides paired with Vitamin C</p>	<p>15-30 grams per day paired with 500 mg of vitamin C</p> <p>These will be taken together 60 minutes before their rehabilitation session</p>	<p>We will supplement the collagen peptides paired with vitamin C for the first 6 weeks post-operation during the initial rehabilitation process</p>	<p>Short-term testing showed benefits for tendon strengthening from 10-12 weeks.</p> <p>Increased overall tendon strength when paired with lower body targeted exercises</p> <p>With the trauma associated with tendons used as donor sites for ACL replacement, reevaluation upon return to sport testing is suggested.</p>
<p>Fish oil</p>	<p>2-6 grams of fish oil daily</p> <p>This will also be taken 60 minutes before their</p>	<p>We will supplement this for the first 6 weeks post-operation before evaluating</p>	<p>Increased lean body mass with extended use.</p> <p>Reduced muscle soreness sensation in</p>

	rehabilitation session	If we see good results we will keep the athlete on this supplementation for the remainder of their rehabilitation process	patients. Patient readiness to return to sport and their leg muscle mass should be near equal
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Protocol Rationale:

With the information found within our research, our protocol entails consumption of protein (in whey or complete form), collagen peptide paired with vitamin C, and fish oil daily for six weeks except for protein which will have an additional two weeks before the individual’s surgery date. The recovering females will consume 2.0-3.0 g/kg of protein in increments throughout the day; 15-30 g/day of collagen peptides paired with 500 mg of vitamins C and 2-6 g of fish oil 60 minutes before their rehabilitation session. We chose these dosages and timings based on the research we found. On average the supplement was consumed between 7-12 weeks with few studies consuming for the entirety of the 9-month rehabilitation. We will have these individuals consume the selected dosages at the same times daily for six weeks before evaluating the athlete and their process. Depending on where the athlete stands we will continue supplementation or start to wean off the athlete supplementing the collagen peptide, vitamin C, and fish oil. We will keep the individual on protein supplementation for the duration of their rehabilitation.

Conclusion:

ACL injuries are seen frequently in sports such as basketball, where changing direction and pivoting movements are common. In women, the risk for ACL tears is significantly higher than seen in male counterparts due to a variety of anatomical and biological factors. Although with a reduced rate at which female athletes recover to return to their sport, nutrition can play a role in increasing positive surgical and recovery outcomes. In the review, the benefits of multiple supplements were discussed, With the variance in surgical graft sites, rehabilitation procedures, and patient demographics, there will not be a “One size fits all” approach to assisting the recovery process. Each patient presents a unique case,

although the aim is to help provide a framework protocol in which recovering athletes can see the potential benefits of supplementing their current diet during rehab to help them reach their goals. Each athlete may not aim to return to their respective sport in the fastest time frame possible, NBA players have collectively taken longer to return to basketball when compared to the “conservative model” of nine months recovery time. Confidence in movement and reducing the fear associated with re-injury risks are the last hurdle athletes face when recovering from traumatic sports injuries. Reducing physical obstacles such as muscle loss and tendon instability can help athletes regain their confidence in participating in sports.

Acknowledgment:

We would like to give thanks to Dr. Petrosky (Nova Southeastern University) for the guidance and feedback throughout the entirety of the project. Dr. Gordon (Nova Southeastern University) for being a great mentor throughout the project and meeting with us to provide feedback and project guidance. Nova Southeastern University’s Writing Center was instrumental in finding the ideal organizational structure for this literature review.

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Appendices:

Together, equally worked throughout the entire paper adding their thoughts and ideas as they were relevant to the portion while also reviewing their partner's work to make sure the information worked well. In this particular submission, they worked through finalizing the paper and protocol. They made changes to the suggested comments given by Dr. Petrosky and Dr. Gordon added information they felt was needed to complete the paper. There was a final review by both partners before agreeing to submit.

Upon completion of the final paper, they collectively put together a PowerPoint that will be used in their presentation to show their understanding of their project.