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Post-Operative Cardiometabolic Effects of a Behavioral Intervention in Patents Undergoing Partial Meniscectomy

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POST-OPERATIVE CARDIOMETABOLIC EFFECTS OF A BEHAVIORAL INTERVENTION IN PATIENTS UNDERGOING PARTIAL MENISCECTOMY

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Post-operative Cardiometabolic Effects of a Behavioral Intervention in Patients Undergoing Partial Meniscectomy (December 2017)

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Patients recovering from orthopedic surgery experience reduced physical activity, increasing future risk for cardiometabolic disease and weight gain. A post-operative wellness consultation, with exercise and nutrition components, may modify the behavior of orthopedic patients to mitigate the detrimental effects of inactivity following surgery and the associated adverse health effects. **PURPOSE**: To evaluate the efficacy of a nutrition and exercise consultation on post-operative physical activity, serum metabolic markers, body composition, knee function, pain, and quality of life. **METHODS:** Twelve partial meniscectomy patients were evaluated 1 week (1W) and 6 weeks (6W) post-surgery, and randomly assigned to control (CON) or post-surgical consultation (PSC). The PSC received exercise and nutrition recommendations and a fitness tracking device for adherence. A questionnaire was used to predict physical activity level (PAL). Subjects were assessed for fasting blood glucose\, fasting insulin, C-reactive protein, and non-HDL cholesterol. The Lysholm Knee Score was administered to assess pain, and the Short Form Health Survey (SF-12) was further divided into a mental component summary (MCS) and a physical component summary. Body mass, percent body fat, and skeletal muscle mass were assessed using a multi-frequency bioelectrical impedance. Likert scales were used to measure the effectiveness of the PSC. Repeated measures ANOVAs were used to assess mean differences in between intervention groups at 1W and 6W. **RESULTS:** A significant mean difference in MCS scores was observed ($F_{(1,10)}$= 8.465, p=0.016, η^2_p=0.458) as MS subjects did not experience the reduction in MCS seen in CON. Subjects reported pre-injury PAL (1.59 ± .209), which were significantly reduced to (1.38 ± .093, p=0.001) during the pre-surgery period, but restored at 6W (1.47 ± .139) (p=0.001). No other differences were detected in the analyzed blood markers or body composition measurements between groups. **CONCLUSION**: A wellness consultation, focused on exercise and nutrition, appears to combat the decline in patient vitality and emotional well-being following surgery, without affecting markers of metabolic health. The high levels of healthy behaviors in our sample may have improved the patient resiliency to diminished cardiometabolic health following orthopedic injury.

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Chapter 1: Introduction

Since patients recovering from a recent orthopedic knee surgery are particularly susceptible to reduced activity levels, the incorporation of a fitness and nutrition assessment may aid clinicians in predicting patient outcomes and to formulate complementary, lifestyle interventions to combat diseases.

The weekly physical activity recommendation of 150 min of moderate exercise or 75 min of vigorous exercise has been endorsed by the American Heart Association, Center of Disease Control, American College of Sports Medicine, and World Health Organization [1-3]. In 2016, 51.7% of Americans were considered physically active according to this definition [4]. While inactivity itself is a risk factor for cardiovascular disease, it is known to contribute to comorbidities including increased adiposity, excessive blood lipids [5], inflammatory biomarkers [6], insulin resistance [7-9], reduced HDL cholesterol [10], high blood pressure [11], and an increased blood glucose. In addition, physical inactivity is a primary driver for the activation of inflammatory pathways promoting atherosclerosis, neurodegeneration, and tumor growth [12].

Inactivity and Arthroscopic Partial Meniscectomy

Arthroscopic partial meniscectomy is the most common orthopedic procedure performed in the United States [13]. Patients undergoing lower body orthopedic surgery are limited to a brief period of immobility followed by weeks to months of reduced mobility. Recovery from partial meniscectomy is generally aggressive with patients returning to work after 1-2 weeks and sporting activities after 3-6 weeks [14]. However, evidence suggests reduced activity levels may persist beyond the phase of recovery [15, 16]. The weeks following surgery may serve as a critical time to influence the restoration physical activity independent of the injured knee and concurrent with directives provided by sports medicine clinicians. Aside from a deterioration in cardiometabolic health, reduced activity may exacerbate orthopedic conditions despite the often conventional recommendation of exercise avoidance, especially from high-impact activities like running [17].

Cardiometabolic Effect of Inactivity

Although multiple cardioprotective pathways explain the inverse relationship between physical activity and cardiovascular disease [18], a key mechanism of protection associated with high cardiorespiratory fitness is low levels of systemic inflammation [19]. C-reactive protein (CRP) serves as a non-specific marker for systemic inflammation, and is associated with an elevated risk of atherosclerosis, myocardial infarction, stroke, peripheral artery disease, vascular death, and diabetes in those without known cardiovascular disease [20-23]. CRP levels inversely correlate with total physical activity, duration of moderate activity, duration of vigorous activities, and duration of sedentary behaviors in both men and women, independent of body adiposity or presence of type 2 diabetes [24]. In a study where step counts were reduced by 76% for two weeks, CRP levels increased by 25% [25]. It has yet to be determined whether the inactivity associated with recovery from arthroscopic knee surgery increases levels of CRP.

While the effects of sedentary behavior across years and decades are well documented, acute and dramatic reductions in activity may have similar detrimental consequences [26]. Both total fat and visceral fat levels have been shown to be significantly increased in response to prolonged bed rest, an effect prevented with low-volume resistance training [27]. Mazzucco et. al. found that 35 days of bed rest in 24 active, healthy males resulted in a 47% increase in the homeostatic model assessment index of insulin resistance (HOMA), increased triglycerides by 51%, and decreased HDL cholesterol by 12%. Non-HDL cholesterol is currently thought to be among the most predictive blood lipid ratios for determining heart disease risk since it accounts for all atherogenic apolipoprotein B containing particles [28, 29]. It is currently unknown whether changes in HDL-cholesterol levels occur in response to inactivity induced by recovery from arthroscopic knee surgery.

Extreme restrictions in physical activity may not result in similar outcomes as patients enduring post-surgery rehabilitation. However, studies of restricted daily movement [30] have shown various levels of metabolic dysfunction [30-32]. Interestingly, Olsen and colleagues analyzed 10 young healthy men who routinely exceeded 10,000 steps per day who were asked to reduce their physical activity levels to below 1,500 steps per day for a period of 14 days. Following the intervention, visceral adipose tissue increased significantly by 7% and was attributed to reductions in activity [33]. Insulin sensitivity also declined as demonstrated by increases in postabsorptive insulin and postprandial glucose by 66.9 and 63.5%, respectively. Surprisingly, these metabolic exacerbations occurred after just two weeks of reduced activity and were attributed to lower signaling of insulin-stimulating proteins in skeletal muscle [33].

In a review of studies that transitioned high activity subjects to low daily ambulatory activity, Thyfault et. al. suggested that a repartitioning of energy into storage after a transition to inactivity is necessary, protective, and caused by an adjustment in the muscle's energy demands [34]. The mild decline insulin sensitivity that occurs in response to brief sedentary periods, while benign, may serve as a foundation and necessary precursor for pathological processes such as inflammation, oxidative stress, and lipid intermediates to activate insulin resistance [35, 36]. Maintenance of insulin sensitivity may be important for effective anabolic adaptations during rehabilitation and recovery [25, 37, 38]. This acute reduction or inhibition of anabolic activity may have long-term consequences. In middle-aged patients, for example, quadriceps strength of the meniscectomized leg is significantly reduced compared to patient's non-operated leg four years after surgery. This decreased force production significantly affects knee function, increases pain, and lessens quality of life in these patients [39]. The degrees to which shifts in fat patterns, lean mass, and insulin sensitivity occur in response to inactivity related to arthroscopic knee surgery have yet to be studied.

Post-Surgical Exercise Recommendations

The aforementioned evidence indicating severe cardiometabolic consequences to inactivity following orthopedic injury suggests it would be appropriate for patients to receive exercise recommendations to mitigate these effects. The American Academy of Orthopedic

Surgeons (AAOS) recommends to exercise for 20-30 min 2-3 times per day following surgery and suggests a progression from non weight bearing activities (i.e. exercise bike) in the first two weeks, to walking after two weeks, and running 6-8 weeks after surgery [40]. While the percentage of patients receiving exercise recommendations by physicians rose from 22.6% in 2000 to 32.4% in 2010, no evidence currently exists on the prevalence of orthopedic patients receiving exercise prescriptions [41].

Post-Surgical Dietary Recommendations

Dietary Recommendations may also be an important consideration requiring emphasis during recovery from injury [42-45]. Surgical recovery may require increased protein needs [46]. In a study of 47 soccer players undergoing arthroscopic knee surgery, a group consuming an additional 1g/kg body weight protein supplement yielded greater quadriceps hypertrophy compared to controls[46]. Consumption of omega 3 fatty acids appear to protect against lipid-induced insulin resistance [47], induce genes that promote mitochondrial biogenesis [48], and mitigate weight gain during inactivity by increasing satiety [49]. Due to their causal relationship with metabolic diseases [50], consumption of processed carbohydrates should be reduced in accordance with recommendations from the American Heart Association, which suggests an appropriate upper limit of daily added sugar consumption is 100 kcal/d for most American women, 150 kcal/d for most American men [51]. Vitamins, minerals, and phytonutrients play integral roles in the phases of recovery. Consumption of Vitamin A, Vitamin C, and copper are integral for the formation of collagen [42, 43, 45] while zinc, a commonly deficient mineral, plays an important role in the protein synthesis necessary for tissue repair [52]. The effect of dietary recommendations on recovery outcomes in orthopedic knee patients has yet to be researched.

While the efficacy of using wearable fitness devices (WFD) for specific measurement purposes remains in question, the mere use of these devices to self-monitor fitness levels may improve physical activity levels and health outcomes [53]. Adherence and the effect of wearable fitness tracking devices on patient outcomes have yet to be studied in patients undergoing arthroscopic knee surgery.

The purpose of the proposed study was to assess the effect of physical inactivity after undergoing a partial meniscectomy on changes in metabolic, cardiovascular, inflammatory, behavioral, and functional profiles from baseline to six weeks post surgery. In addition, we analyzed the effectiveness of a wellness program, using dietary recommendations and an exercise prescription, on these cardiometabolic and functional variables during recovery from surgery. We hypothesized that physical inactivity during the study period would increase the risk of metabolic disease, and that a comprehensive wellness intervention would ameliorate this risk.

Chapter 2: Methods

Subjects

A total of 13 men and women between the ages of 19 and 67 participated in this study. All subjects were screened with a health history questionnaire for any health-related barriers to participating in an exercise program, such as diagnosed cardiovascular disease, metabolic disease, chronic inflammatory diseases, non-surgery related orthopedic issues affecting capacity to exercise, and mental illness. Subjects were excluded from the study if they had previously worn a fitness tracking device or if they did not have daily access to a smartphone. Participants agreed to wear a fitness tracking device throughout the duration of the five-week study and to allow researchers to access their Fitbit account remotely. All procedures and risks were thoroughly explained to every participant before obtaining his or her written informed consent, and were approved by the University of Miami Human Subjects Research Office.

Experimental Design

Patients volunteering for the study were grouped using a stratified randomization technique into either the University of Miami Guardrails Wellness Intervention or a non-intervention control. All participants were assessed at their 7-10 d post-surgery office visit (1W), and reassessed during their 6-week office visit (6W) at UHealth Sports Medicine. Subjects were matched based on their physical activity level (PAL) score (described below) using a stratified randomization technique, to ensure similar risks of weight gain, and cardiometabolic alterations associated with post-operative changes in activity [54].

Patient PAL were categorized into Low (PAL between 1.25 and 1.34), Moderate (PAL between 1.34 and 1.47), and High (PAL 1.47 and 2.00) groups [55]. Within each PAL category, patients were distributed randomly and evenly across the two treatment groups.

Testing Protocol

During the regularly scheduled 1W and 6W post-operative appointments, patients were evaluated for body composition, PAL, blood pressure, knee function, mental and physical health, and blood was drawn for measures of fasting insulin, glucose, blood lipids, and CRP. Self-reported PAL was assessed pre-injury, pre-surgery, 1W, and 6W using a physical activity questionnaire that required a self-report of activities and their duration performed during a typical week. Both structured exercise, and other daily activity were included in the analysis. PAL was quantified in met minutes (METmin) by referencing the Compendium of Physical Activities [56]. The PAL, a ratio of total daily energy expenditure and energy expended via physical activity, was computed using the Cunningham formula for computing resting energy expenditure using lean body mass measured at 1W [57, 58]. After sitting for at least 5 min, blood pressure and resting heart rate were assessed. Rate Pressure Product (RPP), an index of myocardial oxygen demand, was computed by multiplying the resting heart rate by the systolic blood pressure [59-62].

Body composition was analyzed using the InBody 570 (Biospace, Seoul, Korea) bioelectrical impedance system that uses an 8 point tactile electrode method and a 3-frequency direct segment multifrequency (5, 50, 500 kHz) to provide regional body fat and lean mass distribution [63]. Weight, body fat percentage, skeletal muscle mass, and muscle mass of the surgical and non-surgical leg were collected from the InBody 570. In addition, skin folds were assessed using a calibrated Lange Body Fat & Skin Fold Caliper at three sites (triceps, abdominal, and thigh) and girth measurements were recorded at three sites (neck, waist, and hip). Patients performed a grip strength assessment using a Jamar Technologies Hydraulic Hand Dynamometer.

Participants completed the The Lysholm Knee Score (LKS) and the SF-12 Health Survey (SF-12) at each time point [64, 65]. The LKS is an outcome measure of arthroscopic knee surgery used to document the patient's evaluation of function during recovery. The score of 0 to 100 points is comprised of eight domains: limp, locking, pain, stair-climbing, use of supports, instability, swelling, and squatting [64]. The SF-12 is used to assess physical and mental and health [65]. The 12 items in the SF-12 are summarized as two scores: the physical component summary (PCS) and the mental component summary (MCS). Higher scores indicate better health status in these areas [66].

Serum Analysis

Blood samples were collected after a 12-hour fasting period by phlebotomists at the Lennar Foundation Medical Center at 1W and 6W and analyzed for high sensitivity C-reactive protein (hsCRP), a lipid panel, insulin, and glucose using the CORE Laboratory at the University of Miami Diabetes Research Institute. Samples were obtained in clot activator serum tubes and placed at room temperature for 30 min and centrifuged for 10 min at 3500 rpm [67]. Serum was immediately aspirated and stored at -80°C before being transported for analysis.

Post-Surgery Group Assignment

Patients were randomly assigned to either a control group (CON) or a post-surgery consultation group (PSC). CON subjects completed the post-surgical screening during their 7-10 day follow up appointment, but did not receive any information regarding their current health status or recommendations to improve outcomes across the five-week intervention duration. Patients in the PSC group received both an exercise physiology consultation as well as a FitBit HR fitness tracking device. The consultation included an evaluation of the patients' current health status and provided individualized recommendations regarding their dietary and physical activity needs. Recommendations were derived from a 15-item dietary questionnaire that included food frequency items related to daily consumption of green leafy vegetables (GLV), sulfur rich vegetables (SRV), colorful fruits and vegetables (CFV), and weekly consumption of beef, pork, and processed meat (RPM). These items were used to estimate daily fruit and vegetable intake (FV) by summing GLV, SRV, and CFV. The ratio of plant to animal intake has been identified as a marker of dietary quality [68, 69]. The University of Miami's Guardrails Patient Wellness Report consists of four sections:

1) Metabolic Section: The metabolic section provides an interpretation of collected body composition data, including BMI, body fat percentage, waist-to-hip, waist-to-height parameters, and an explanation of the relative health risks associated with their results. Pre-injury caloric expenditure was computed as well as the patient's projected post-surgery energy expenditure. Patients are shown estimations of caloric surplus and weight gain that could result if they made no alterations to their diet.

2) Cardiovascular Section: Cardiovascular parameters such as blood pressure and resting heart rate were used to estimate heart disease risk. In addition, a heart age was computed based on risk factors for heart disease. Three heart rate ranges are provided as percentage of the predicted maximum heart rate (HrMax) for the purpose of prescribing exercise: a fatmax zone (80% HrMax), anaerobic threshold zone (90% HrMax), and an aerobic interval zone (> 90% HrMax). While the aerobic exercise prescription was written based on the exercise physiologist's discretion, the report included an explanation of the each zone's purpose as well as a heart rate range, estimated walking/running pace, and caloric expenditure.

3) Nutrition Section: Each dietary parameter from the dietary questionnaire was presented with patients' intake status and an explanation of the importance of its consumption. Macronutrient recommendations were based on the acceptable macronutrient distribution range established by the Institute of Medicine [70]. Sugar intake recommendations were from World Health Organization [71], and other nutrient intake recommendations were derived from Harvard's Healthy Eating Plate as captured in the AHEI-2010 [72].

4) *Recommendations*: The final page of the patient report included a summary of the aforementioned dietary recommendations for both the inflammation/immobilization and rehabilitation/ regeneration phases of recovery. During a review of recommendations, a special emphasis was placed on encouraging patients to increase the consumption of protein, omega 3 fatty acids, Vitamin A, Vitamin C, copper, and zinc and decrease the consumption of processed carbohydrates and free sugars. These recommendations are thought to assist in collagen

development and improve rates of protein synthesis during recovery from orthopedic surgery [25, 52, 73-75].

Patients in the PSC group were issued a FitBit HR fitness band at the time of their 1W assessment and were instructed to wear the device daily for the length of the study period. Patients agreed to the terms of use prior to the administration of the FitBit. FitBit assigns all users a daily goal to complete 10,000 steps, a volume associated with an "active" activity level [76]. Subjects monitored their progress using the FitBit device and mobile phone application and were instructed how to track steps, distance traveled, and heart rate. The purpose of the inclusion of the fitness tracking device was to monitor changes in cardiometabolic outcomes in patients who have the ability to actively monitor their activity. After the intervention, a ten-point Likert scale was used to survey the consultation's benefit on physical activity and dietary decisions, as well as the benefit of the fitness tracking device.

Statistical Analysis

Results were analyzed using SPSS 24.0 software (IBM, Armonk, NY), and are presented as Means (SE), unless otherwise indicated. Repeated measures ANOVAs (2 x 2) were conducted to test the significance of the within-subjects factor (post-surgical appointment) and the between subjects factor (group) on dependent variables, including measures of body composition, activity level, cardiovascular health, metabolic health and functional outcomes. Significance was set a priori at alpha < 0.05. Linear regression analyses assessed the influence of predictors of 6W SF-12 PCS and MCS scores. A multiple regression analysis was used to test if dietary habits collected at 1W significantly predicted the reported influence of the PSC intervention on dietary behavior.

Chapter 3: Results

Subject Characteristics

We recruited 27 patients undergoing partial meniscectomy on a single leg at University of Miami's UHealth Sports Medicine for this study. Fourteen subjects were screened and one subject was excluded due to pre-existing cardiovascular disease. Thirteen subjects were enrolled in the study and one individual was excluded from the study for failing to attend the scheduled 6W appointment. A total of 12 subjects (8 male and 4 female) completed the study (Table 1). Eight subjects were assessed during their regularly scheduled post-operative appointments. Four subjects were assessed on a separate morning during the same week of their 6W appointment. Patients were stratified by activity level group into CON (6 high PAL, 2 moderate PAL) and PSC (6 high PAL, 1 moderate PAL, 1 low PAL). Each group contained four males and two females.

Physical Activity Level

Importantly, patients reported an average time between meniscal injury and surgery of 7.2 ± 1.2 months. During this time period, subjects experienced a significant decrease in PAL from 1.59 ± 0.06 pre-injury to 1.38 ± 0.03 pre-surgery ($t(11)=4.249$, $p=0.001$) (Figure 2) that was associated with a decline of 350 kcal of exercise-associated energy expenditure per day. As expected, subjects gained an average of 1.6 ± 3.3 kg during this period of reduced activity. However, this weight gain did not significantly correlate with the reduction in PAL after injury ($r=.530$, $p=0.076$). Patients reduced their activity further ($t_{(11)}=2.284$, $p=0.043$) to a PAL score of 1.30 ± 0.02 during their recovery from surgery leading up to the 1W visit. At the 6W visit, there was a significant restoration of PAL in both groups to 1.47 ± .04 ($t_{(11)}$=-4.352, p=0.001), though not to pre-injury levels. There were no mean differences in the increased PAL from 1W to 6W between the control (0.157 ± 0.07) and PSC (0.173 ± 0.04) groups (p=0.272), despite subjects in the PSC averaging 54 kcal/d greater increase in physical activity than CON.

Intervention Outcomes

There were no significant within- or between-group mean differences in the change of blood glucose, insulin, triglycerides, or CRP between 1W and 6W (p >.05) (Figure 3). In addition, there were no significant within- or between-group mean differences in the change of body weight, skin folds body fat percentage, circumference values, grip strength, or rate pressure product between 1W and 6W (p >.05). While there were trends for a decrease in Non-HDL cholesterol (p=0.077) and an increase in skeletal muscle mass (p=0.088) from 1W to 6W, they did not reach statistical significance.

In all patients, there was a significant main effect of time in knee function LKS ($F_{(2,20)}$= 12.436, p<.01, η^2_p=0.544) and pain (F(2,20)= 10.693, p<.01, η^2_p=0.517) that did not differ between groups. The PSC patients did not experience a reduction in SF-12 MCS scores ($F_{(1,10)}$= 8.465, p=0.016, η^2_p=0.458) as seen in CON (Figure 4).

Wearable Fitness Device Influence

Two subjects reported technical issues with their WFD and were provided replacements within 48 hours of contacting the study coordinator. There was a >90% compliance over the 5 week duration of the study for the use of the WFD, and self-reported physical activity was supported by the WFD data after excluding water-based activities in which the device cannot be worn. On a 10-point Likert scale, patients reported the influence of wearing a fitness tracking device on physical activity levels as 6.17 ± 1.30. However, self-report of WFD benefit did not significantly correlate with the changes or absolute amounts of physical activity in these subjects ($p > 0.01$).

Post-Surgical Consultation Dietary Influence

As expected, the self-reported benefit of dietary consultation was inversely associated with levels of baseline fruit and vegetable intake, and directly linked to red and processed meat consumption (Figure 5). In fact, these two variables, daily servings of fruits and vegetables (FV) and daily servings of red or processed meat (RPM), explained 90.2% of the variance in the self-reported benefits of the nutritional consultation (R^2=.902, $F_{(2,3)}$=13.795, p=0.031).

Chapter 4: Discussion

The objectives of this study were to identify whether physical inactivity during the post-operative study period would increase the risk of metabolic disease and discover if a comprehensive wellness intervention would ameliorate changes in this risk. The population in this study was accustomed to unusually high levels of physical activity, approximately 2-3 times of the optimal physical activity guidelines for Americans. Indeed, the Center of Disease Control reported that in 2015, 33.6% of adults in the United States meet the World Health Organization's criteria for "added health benefits", a doubling of the U.S. physical activity recommendations to 300 min/wk of moderate physical activity or 150 min/wk of vigorous physical activity. Considering that moderate intensities range from 3-6 metabolic equivalents, this equates to 900-1800 METmin per week. In the patients sampled in the present study, 83.3% reported pre-injury physical activity levels exceeding 900 METmin per week, with a mean of 2709 ± 1946 METmin per week (Figure 6).

Injury to the knee occurred on average 7.2 ± 1.2 months prior to the surgery. During this time period, patients experienced an estimated 61.1% reduction in activity level to 1056 ± 858 METmin per week. This reduction is attributed to the avoidance of traditional modes of exercise due to reduced knee functional capacity [LKS = 64.24 ± 5.30] and elevated knee pain [4.64 ± 0.83], as well as a lack of ability or willingness to match pre-injury energy expenditures with tolerable exercise modalities. The reduction in activity was associated with a modest gain in body mass of 1.43 kg, but varied significantly depending on the body composition health of the patient. Lean patients scoring above the 60th percentile (ACSM criteria of Good / Excellent) according to their body fat percentage lost 0.91 ± 0.80 kg., while patients below the 40th percentile (High/Obese) gained an average of 2.91 ± 0.57 kg. The weight loss in the lean subjects despite the decrease in activity may be attributed to a greater loss of lean body mass. This would be consistent with Olsen et. al. who reduced daily steps of active individuals by over 85% and found a decrease in body weight and loss of lean mass in just 14 days [34].

The average time between injury and our initial assessment was 7.2 months. Adverse health effects, due to injury-associated changes in activity, may have occurred during the more acute time period following the injury. Further studies are warranted to investigate deconditioning effects on cardiometabolic variables in the more immediate period following orthopedic trauma, especially among individuals who were previously active where the modification in lifestyle would be more severe.

The post-surgical intervention included a consultation conveying dietary and physical activity needs as well as the administration of FitBit HR wearable fitness tracking devices. Using a 10-point Likert scale, PSC patients reported a moderate influence from the consultation's physical activity (5.2 ±1.3) and dietary (5.5 ± 1.4) components, and the inclusion of the WFD (6.2 ± 1.3). These responses may be attributed to the high fitness level and pre-existing healthy lifestyle habits in our study population.

Further research could be implemented to determine if such an intervention is useful in an inactive, at-risk population. In support of this notion, the subject benefitting most from our intervention was sedentary and had a BMI over 30 (34.68 kg/m^2). This subject had a 912 METmin per week increase in physical activity, and an added 212 kcal expended via exercise per day. This physical activity level was corroborated by the FitBit fitness tracking device worn through the study duration. Furthermore, in the five-week intervention, this subject reduced weight by 2.0 kg, from 89.0 to 87.0 kg, non-HDL cholesterol from 236 to 205, triglycerides from 265 to 248 mg/dL, and waist circumference from 42.0 to 41.0 in. Moreover, this subject had the greatest increase in MCS in the sample (+1.5 SD), moving from the level associated with depression, anxiety, and other mental disorders to an above average range of a healthy population [77].

The present study found that an intervention targeting restoration of activity levels among recovering patients prevented the decline in SF-12 mental health scores seen with control subjects. These findings reflect improvements such as reduced perceived role-limitations and emotional problems, as well as improved vitality and social functioning [79]. This may be attributed to interactions during a consultation that challenged patients to take additional measures towards restoring health status, such as a large focus on diet and alternative exercise modalities. This may be important, especially if patients reduce their physical activity due to a lack of confidence in the repaired knee. For example, in the first prospective study to use validated questionnaires to assess outcomes in patients with partial meniscectomy, Roos et. al. found a reduced quality of life (QOL) measured using the SF-36 and reduced PAL 14 weeks after surgery [78]. Their results suggested that, although patients' pain, swelling, and other symptoms were alleviated, patients lacked confidence in their knee, resulting in reduction of physical activity [78].

It remains unclear whether the use of WFD independently improved physical activity levels in a population accustomed to high levels of physical activity. Subjects who received the WFD reported mixed reviews regarding the benefit of the device. Of the six subjects in the PSC group, three subjects reported a high benefit (≥ 8/10), two subjects reported moderate benefit (5/10), and one subject reported no benefit at all (1/10). Subject feedback regarding their WFD usage suggested a greater impact in administering devices to those with lower PALs. Future research could be used to identify cost-effectiveness of allocating WFD's to select patient groups, particularly those unaccustomed to physical activity.

The methods of this study targeted the overall effectiveness of recommendations in a consultation setting. Future investigation into behavioral change models in recovering patient populations should identify the influence of specific dietary changes. In addition, it was assumed that dietary habits would not change in the control group over the intervention period. In future studies, all groups should complete dietary assessment, across all time points.

Aside from a highly active group of subjects, most of the subjects in our study presented with good dietary behaviors compared to the general U.S. population. Our subjects consumed significantly more fruits and vegetables, and far less red and processed meat than the conventional American diet. Americans consume 603 servings of fruit and vegetables (excluding fruit juice) per year [80] or 1.68 servings per day, while patients in the PSC group reported an average consumption 4.17 servings. Americans averaged 47.3 kg per capita of red meat, pork, and processed meat consumption, which at 65 g per serving equates to 14 servings per week [81]. In contrast, subjects in this study reported consuming beef, pork, or processed meat an average of two times per week. High correlations between the benefit of dietary recommendations on both baseline FV intake and FV/RPM intake warrants further investigation into the efficacy of a post-surgical dietary consultation.

Timing of dietary recommendations may also influence cardiometabolic outcomes. Recommendations targeting improved insulin sensitivity and collagen regeneration may have been better served prior to surgery in order to influence outcomes during first week of recovery. This study examined a surgery with a relative short recovery period to assess the effectiveness of a wellness intervention. Such interventions may be more effective in more invasive surgeries due to the greater time required for recovery.

Chapter 5: Conclusion

Patients undergoing orthopedic surgery to the lower limb experience reductions in physical activity, which may persist beyond recovery and negatively impact their health. Although patients in the present study reported a moderate benefit from the post-surgical intervention in mental health status, the wellness intervention targeting diet and physical activity was not as effective as predicted. This was likely due to the pre-existing healthy behaviors in the assessed population, which greatly exceeded those of the general public. Moreover, our data suggest that healthy behaviors, such as high fruit and vegetable intake, may cause individuals to be more resilient to the negative consequences associated with injury and surgical recovery than expected. Complimentary wellness interventions aiming to ameliorate decreases in health following orthopedic injury, would seem more plausible in the general public than in extremely active and healthy populations.

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FIGURES

Figure 1. Surgical Reassessment Questionnaire

1) To what degree did your pre-surgery evaluation influence your dietary habits during the recovery process?

1	2	3	4	5	6	7	8	9	10
Not at all				Moderately					Very Much

2) To what degree did your pre-surgery evaluation influence your physical activity during the recovery process compared to how you otherwise would have moved without the assessment and consultation?

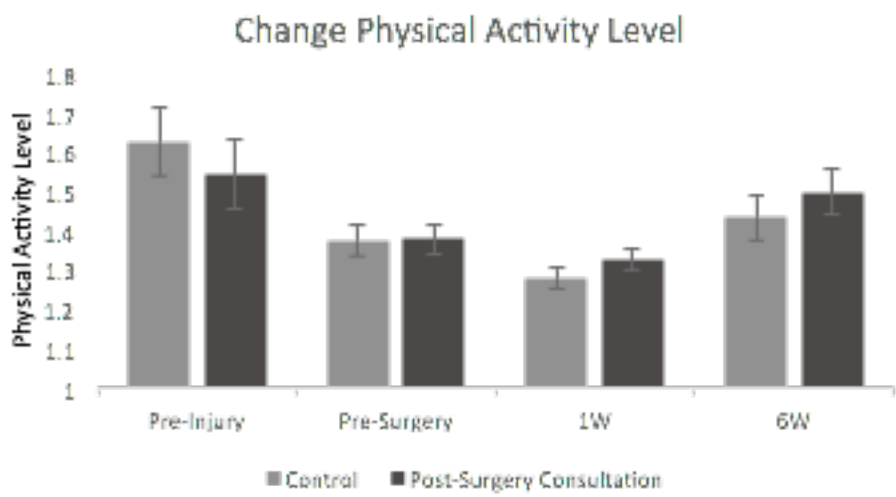
1	2	3	4	5	6	7	8	9	10
Not at all				Moderately					Very Much

If you've been issued a FitBit:

3) How much did the fitness tracking device and mobile application influence your physical activity level over the 1 month period after your surgery?

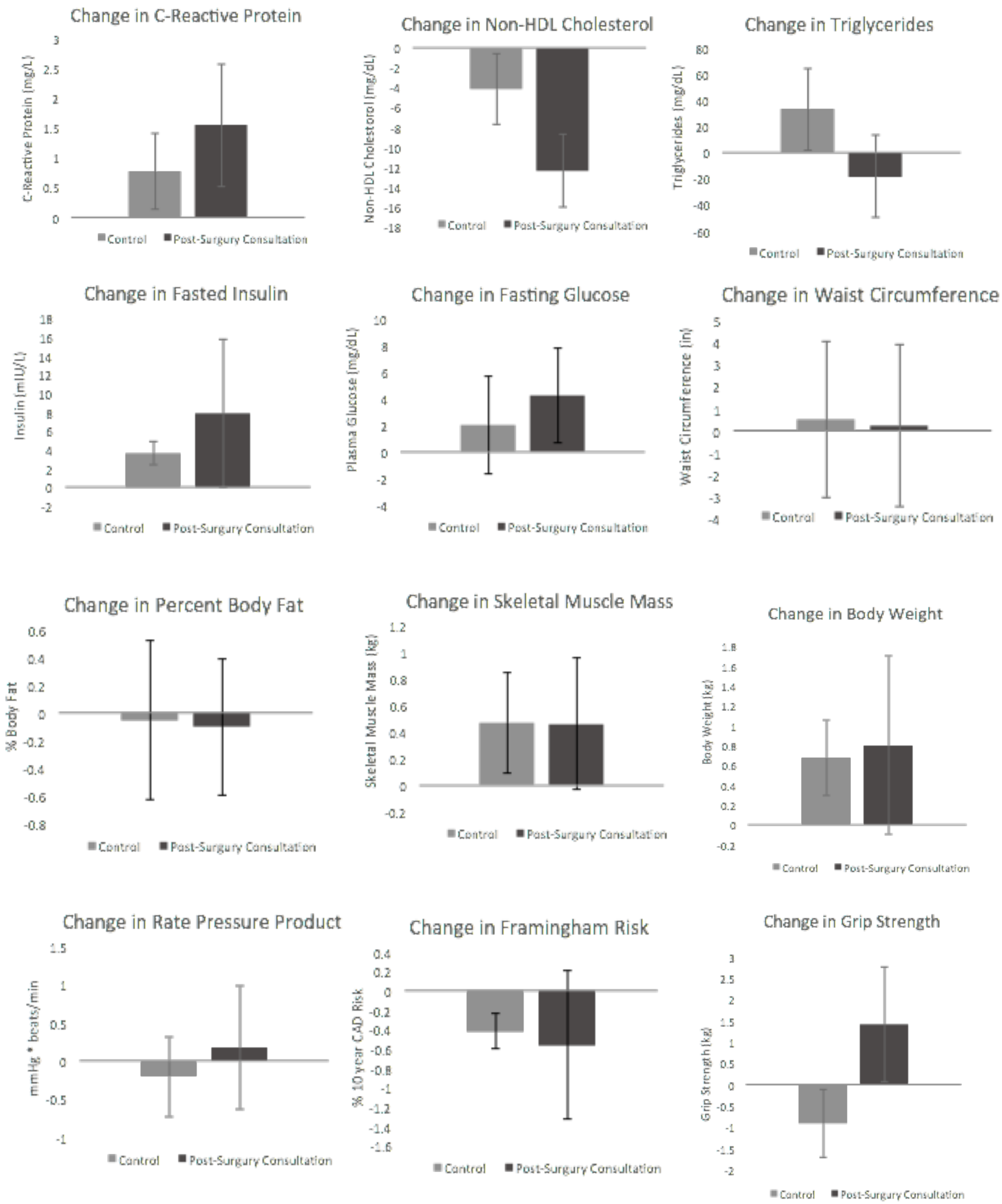
1	2	3	4	5	6	7	8	9	10
Not at all				Moderately					Very Much

Figure 2. Changes in Physical Activity Level



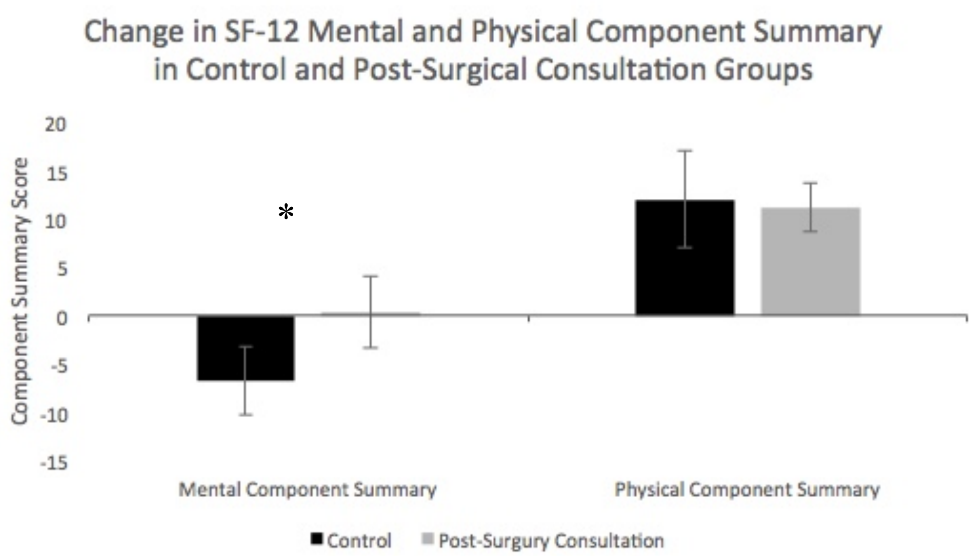
Error bars represent standard error.

Figure 3. Mean Differences in Cardiometabolic Measures Between 1W and 6W



Error bars represent standard error.

Figure 4. Changes in Mental and Physical Component Summary Scores



* significant mean difference, p = 0.016
Error bars represent standard error.

Figure 5. Relationship Between Previous Vegetable and Red/Processed Meat Consumption and Reported Influence of Dietary Consultation

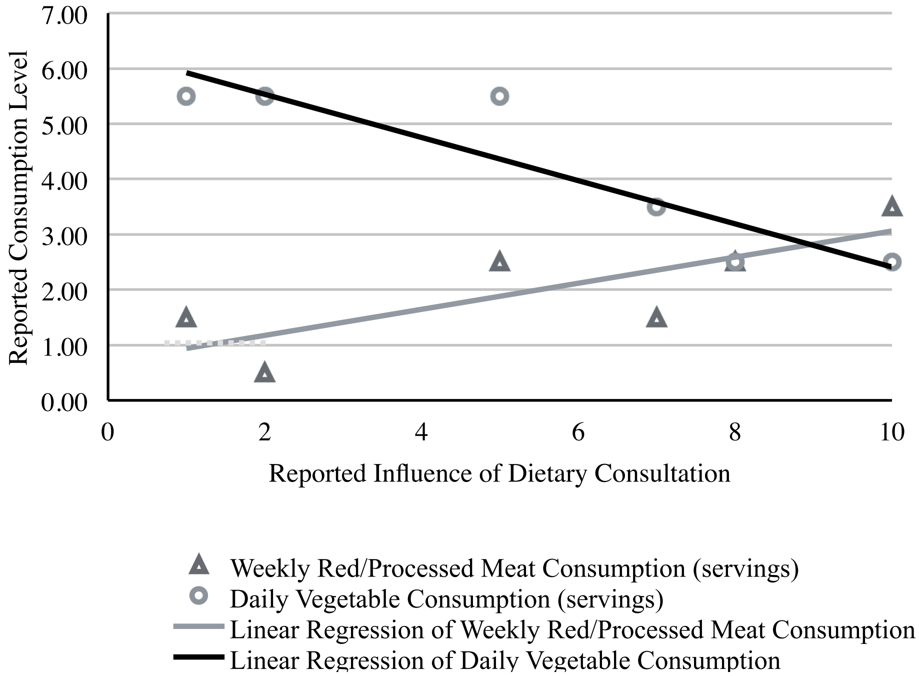


Figure 6. Sample-Population Activity Level Comparisons

TABLES

Table 1. Baseline Characteristics of Subjects Participating in the Study

Predictor Variable	All Subjects n=12	Control n=6	Post-Surgery Consultation n=6	p
Age, y	46.5 ± 4.3	44.7 ± 5.6	48.3 ± 7.0	>0.05
Gender	M=8 F=4	M=4 F=2	M=4 F=2	
Weight, kg	86.2 ± 4.0	84.5 ± 5.4	87.8 ± 6.1	>0.05
Percent Body Fat, %	25.9 ± 2.6	25.2 ± 3.0	26.5 ± 4.5	>0.05
Skeletal Muscle Mass, kg	36.2 ± 2.6	35.9 ± 3.7	36.5 ± 4.1	>0.05
Estimated Pre-Injury PAL	1.58 ± .06	1.62 ± .10	1.54 ± .08	>0.05
Estimated Pre-Surgery PAL	1.38 ± .03	1.38 ± .05	1.38 ± .03	>0.05
Time between injury and surgery (months)	6.3 ± .8	7.6 ± 1.0	7.6 ± 1.0	>0.05

Values are mean ± SE