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Diet and Exercise for Obese Adults with Knee Osteoarthritis

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SYNOPSIS

OA is a common chronic disease and there is a need for treatments that can be provided for the course of the disease with minimal adverse side effects. Exercise is a safe intervention in patients with knee osteoarthritis (OA) with few contraindications or adverse events. Indeed, there are few treatments that, from a public health perspective, can be delivered to a large proportion of those with OA with little associated adverse risk as exercise. Exercise therapy is recommended by all clinical guidelines for the management of knee osteoarthritis (OA) and this recommendation is supported by Level 1 evidence. Obesity is the most modifiable risk factor for knee OA. The mechanisms by which obesity affects osteoarthritis are of great concern to osteoarthritis researchers and clinicians who manage this disease. This paper reviews the physiologic and mechanical consequences of obesity and exercise on older adults with knee OA; the effects of long-term weight-loss and exercise interventions, and the utility and feasibility of translating these results to clinical practice.

Keywords

obesity; knee osteoarthritis; degenerative joint disease; exercise; weight loss

OBESITY AND THE RISK FOR OA DEVELOPMENT

First documented in 1945¹, numerous studies have verified the strong association between obesity and knee osteoarthritis (OA). Leach et al.² found that 83% of their female subjects with knee OA were obese compared with 42% of the control group. Coggon et al.³, in a case controlled study of 675 matched pairs, determined the risk of knee OA in people with a BMI ≥ 30 kg/m² was 6.8 times that of normal weight controls and increased exponentially as obesity increased (Figure 1). Felson et al.⁴ showed that a 5.1 kg loss in body mass over a 10 year period reduced the odds of developing OA by more than 50%. Ettinger et al.⁵ examined the effects of co-morbid diseases on disability and found that those with a BMI >30 kg/m² were 4.2 times more likely to have knee OA than persons with a BMI <30 kg/m². Knee OA and obesity were each significantly associated with poorer physical function, with odds ratios of 4.3 and 1.7, respectively; when obesity was combined with knee OA the odds ratio increased to 9.8. Taken together, these studies indicate that obesity is a major risk factor for knee OA.

The most common location of OA is in the small joints of the hand. Unlike knee OA, the association between obesity and hand OA is not strong. Doherty et al.⁶ reviewed the literature on hand OA and concluded that BMI and waist circumference were not risk

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factors, especially in older adults. Similarly, Kalichman and Kobylansky⁷ used an observational cross sectional design to study 745 women with hand OA and saw no relationship between BMI or waist circumference and hand OA. The authors suggested that obesity may be a mechanical rather than a systemic risk factor for OA. This would explain obesity's strong association with OA of weight bearing joints.

IMPACT OF OBESITY ON FUNCTION AND GAIT

Increasing BMI has an adverse effect on balance, muscle strength and gait, especially vertical ground reaction forces. The NHANES I and Epidemiologic Follow-up (NHEFS) studies revealed that obesity at baseline increased upper and lower body disability across 20 years of follow-up^{5,8}. More recently, Jenkins⁹ found that functional impairment in older adults increased as BMI increased. In the Cardiovascular Health Study, an adjusted odds ratio of 2.94 for self-reported mobility-related disability was found for those in the highest versus the lowest quintile of fat mass¹⁰.

As body weight increases there is an increase in both fat mass and fat free mass¹¹. The relationship between fat free mass and BMI is stronger in males, suggesting that an increase in BMI in females is due predominately to an increase in fat mass. Although these data imply that obese people have greater strength than their non-obese counterparts, the opposite actually is true. Specifically, when strength is represented as a function of body weight, both obese males and females are weaker, irrespective of age¹². In older adults aged 60–80 years, mean knee strength in obese males is 65% of body weight compared to 77% for controls, and 50% of body weight for obese females compared to 62% for non-obese females.

Muscle weakness in older adults is of great consequence. It is the second leading cause of falls in the elderly, accounting for 17% of all falls¹³. Falls are the leading cause of death by injury in older adults. Three-quarters of deaths due to falls occur in adults older than 65 years. Only one-half of those older adults hospitalized due to falls will be alive after 1 year. By 2030, deaths due to falls will reach 280,000 Americans annually¹⁴.

Falls occur due to a loss in balance; hence, it is common to use measures of balance to identify people who are more susceptible to falls. Kejonen et al.¹⁵ found significant correlations between poor balance and high BMI in women, but not in men, once again suggesting that muscle weakness is a mediator of poor balance and falls. Within older adults with a BMI above 30 kg/m², Jadelis et al.¹⁶ found that for a given amount of knee strength, the more severe the obesity, the worse the balance. This suggests that obesity, independent of strength, is a risk factor for poor balance and falls.

Plantar fasciitis and heel pain are commonly associated with obesity. In a case-controlled study, obese subjects were 5 times more likely to have heel pain than their non-obese counterparts with an odds ratio of 5.6¹⁷. Similarly, obese men and women exert greater plantar pressure during both standing and walking^{18–22}. Hills et al. found a significant correlation ($r = 0.81$) between mid-foot peak pressure and BMI¹⁹ (Figure 2). Gravante et al.²³ found greater mid-foot weight bearing area in obese men and women versus a control. The additional pressure on the medial longitudinal arch could have a detrimental effect on the plantar ligaments resulting in its collapse. Considering that the medial longitudinal arch is critical in distributing loads to both the rearfoot and forefoot, it is not surprising that foot ailments are common among obese people.

Abnormal gait is also characteristic of obese people. Messier et al.²⁴ found that a severely overweight population walked with bilateral abducted forefeet or a more toed-out stance that was 276% greater than a normal weight group. Chodera and Levell²⁵ suggested that the feet

have different functions, with the more abducted forefoot responsible for balance and the less abducted foot responsible for direction. In severely obese people, the amount of abduction is significantly greater in both feet relative to a normal weight control group, indicating a need for balance and suggesting that balance is more important than direction²⁴.

In addition to the greater forefoot angles, severely obese people have more rearfoot motion.²⁴ More specifically, greater touchdown angle, more pronation range of motion, and a faster pronation velocity are typical of severely obese gait. This excessive rearfoot motion may cause injury and discomfort and have a negative effect on mobility.

Liu and Nigg²⁶ examined the effects of rigid and soft tissue mass on impact forces during running. They termed the soft tissue mass wobbling mass. Their spring-damper-mass model consisted of upper and lower body rigid and wobbling masses. A computer simulation found that upper body wobbling mass had no effect on impact forces, but had a strong influence on the propulsive peak. As upper body wobbling mass increased, vertical force propulsive peaks increased. In contrast, an increase in lower body wobbling mass showed a strong influence on impact peak forces. These results suggest that obese individuals would exert greater forces during gait, due to their greater wobbling mass.

Empirical data support Liu and Nigg's model. Messier et al²⁷ found a strong positive association between BMI and peak ground reaction forces ($r = 0.76$, $p = 0.0001$) in older adults with knee OA. This was also the case in a study by Browning and Kram²⁸, who found that obese people exerted 60% greater vertical ground reaction forces compared to normal weight people (Figure 3).

Obesity is also related to a fear of falling and injury risk^{29;30}. Austin et al²⁹ followed 1,282 community-dwelling women aged 70–85 years for 3 years and found that fear of falling at baseline was independently associated with obesity, and obesity also was associated with the new-onset of fear of falling in women who were symptom free at baseline. In a sample of over 42,000 adults, the odds of sustaining an injury were greater among those with excess weight. As BMI category increased from overweight (25.0 kg/m^2 BMI 29.9 kg/m^2) to class III obesity (BMI 40.0 kg/m^2) the odds of sustaining an injury, including those related to falls, rose from 15% to 48%³⁰.

Obese adults make adjustments to help stabilize their larger mass and reduce fall risk. DeVita et al.³¹ compared obese and lean adults and noted that the obese group increased ankle torque during walking, but showed no difference in knee or hip torque. Specifically, the ankle plantar flexors act eccentrically to control the forward motion of the leg throughout stance, to stabilize body mass, and at toe-off, assist in propulsion. The greater mass in obese people requires more ankle plantar flexor torque to perform these tasks.

Obese people also try to reduce the load on the knee by shortening stride length and reducing the knee extensor torque. In an obese cohort, the greater the BMI, the shorter the stride length and the lower the knee joint extensor/flexor torque, with an actual shifting from an overall extensor torque to a dominant flexor torque at high BMIs. This switch results in knee stability being provided by the hamstrings rather than the quadriceps. In lean subjects, the relationships between BMI and stride length and knee torques do not exist, indicating that lower BMI values have little effect on gait³¹. In summary, during gait obese adults exert greater forces than normal weight adults. As obesity worsens this compensatory strategy increases, and minimizing these loads is attempted by shortening stride length. Taken together, these results suggest that adjusting gait mechanics without reducing body weight does not eliminate the detrimental effects obesity has on the lower extremity.

INFLAMMATION AND OA

Recent studies confirm that low-grade inflammation plays a pathophysiological role in OA. It may contribute to functional limitation, disease progression, and lower the pain threshold. One of our earlier studies showed that the inflammatory cytokine interleukin-1 beta (IL-1 β) was present in the joint fluids of OA patients³². IL-1 β is believed to play a role in mediating joint inflammation and cartilage degradation in OA. Likewise, an inflammatory component associated with OA can be detected in the circulation, since serum concentrations of inflammatory markers such as cytokines (interleukin-6, IL-6; TNF α) and the acute-phase reactant C-reactive protein (CRP) are higher in persons with knee or hip OA compared to those without OA³³⁻³⁵. Longitudinal studies demonstrate that high serum levels of CRP and TNF- α predict increased radiographic progression of knee OA as much as 5 years later^{34;36;37}. Moreover, a few studies, including one from our group³⁸, associate OA severity and physical function with higher inflammatory markers in the blood^{39;40}. Thus, severity, mobility, pain, stiffness and radiographic progression are at least partly mediated by the level of chronic inflammation in OA patients. Diffusion of cytokines from the synovial fluid into the cartilage could contribute to the cartilage matrix loss observed in OA by stimulating chondrocyte catabolic activity and inhibiting anabolic activity. The adipokine leptin increases synthesis of TGF β within the joint and TGF β is a known stimulator of osteophyte formation⁴¹. Weight loss lowers serum leptin levels in OA subjects and is related to improved function⁴².

EFFECTS OF WEIGHT LOSS

Weight loss reduces risk factors for symptomatic knee OA and lowers pro-inflammatory cytokines and adipokines thought to play a role in cartilage degradation. Our Arthritis, Diet, and Activity Promotion Trial (ADAPT)⁴³ diet groups achieved 5% weight loss over 18 months using a reduced-calorie diet with behavioral strategies, and the Physical Activity, Inflammation, and Body Composition Trial (PACT) pilot study achieved a 9% weight loss over 6 months in obese older adults with knee OA by combining a partial meal-replacement plan with accepted behavioral strategies⁴⁴. Using a similar cohort and an intensive low-energy diet that achieved an 11% weight loss, Christensen et al.⁴⁵ found a 3-fold improvement in WOMAC function over an 8-week period compared to a control diet group who lost 4% of their body weight. Cognitive strategies were used to promote behavior change. A recent meta-analysis of 35 potential trials identified only four that met the authors' inclusion criteria. From these four studies, they concluded that weight loss in knee OA patients significantly reduces disability and that a weight loss of at least 10% would result in a moderate-to-large clinical effect⁴⁶. Christensen et al.⁴⁵ concluded that weight loss should be the first-choice therapy for obese adults with knee OA.

Randomized clinical trials (RCTs) that examined weight loss in adults over 65 years reported no difference in mortality compared to groups that did not lose weight^{47;48}. In contrast, randomization to weight reduction in the ADAPT trial decreased the risk of mortality by 50% (Hazard rate ratio = 0.5, CI = 0.3–1.0) over 8 years of follow-up (weight loss groups = 15 deaths; non-weight loss groups = 30 deaths)⁴⁹. Diehr et al.⁵⁰ suggested that for the aged population, quality of life and years of healthy life may be more appropriate outcomes than mortality. However, the ADAPT follow-up mortality data provide new evidence for clinicians regarding the importance of intentional weight loss in older adults.

Loss of bone and muscle mass is a problem in weight-loss programs for older adults. Weight loss is associated with decreased bone-mineral density^{51;52}, increased bone turnover⁵², and increased fracture rates^{53;54}. Fiatarone Singh⁵⁵ noted that combining hypocaloric diets with aerobic exercise in older adults resulted in loss of lean mass, that resistance training tended

to offset. Janssen et al.⁵⁶ found no lean tissue loss when diet was combined with resistance or aerobic training in premenopausal women. In contrast, Wang et al.⁵⁷ found that a 6-month weight-loss intervention that incorporated partial meal replacements and aerobic and resistance exercises for older obese adults with knee OA resulted in an 8.1% weight loss of which 19.9% was lean mass. However, the exercise training improved knee-extensor strength 37% compared to a 1% loss of strength in a weight-stable control group. These results show that intentional weight loss, when combined with aerobic and resistance exercise training, improves knee- extensor strength despite loss of lean body mass.

DIETARY WEIGHT LOSS INTERVENTIONS

Wadden et al.^{58;59} note that achieving permanent weight loss in obese individuals is difficult. Successful weight loss and maintenance programs include behavioral change strategies, extended treatment, increased hours of intervention contact, adherence to a rigorous diet, participation in exercise, and inclusion of significant others^{60;61}. Wing improved weight loss with increased treatment duration and intensity⁶². While maintaining weight loss is challenging, individual attention to coping strategies and increased intervention efforts during the maintenance phase have produced success. Approximately 80% of clients on moderate calorie restriction will remain in treatment for 20 weeks, and approximately 50% will lose 9.1 kg or more. An average weekly loss of 0.4 to 0.5 kg, with an average 1/3 regained 1 year after treatment is expected. Perri et al.⁶³ showed that a 13.2 kg weight loss was maintained by participants in a 20-week behavioral therapy program followed by an 18-week maintenance program with bi-weekly contact. Maintaining weight loss seems to require rigorous follow-up contacts. Esposito et al.⁶⁴ produced a 14.7% loss in body weight over a 2 year period in women following a moderate energy restricted diet of 1300 kcals/day for year 1 and 1500 kcals/day for year 2. This intervention employed education, individualized goal setting, self-monitoring, and a structured exercise program.

The long-term effectiveness of low-fat and low carbohydrate diets are currently under considerable debate. Meta-analyses have found them no more effective than a low-calorie diet in reducing weight and improving cardiovascular risk factors^{65;66}. Increasingly popular meal-replacement diet drinks have been studied as a complement to reduced-calorie diets (termed partial meal-replacement diets). Heymsfield⁶⁷ performed meta-and pooled analyses of 6 clinical trials that compared partial meal-replacement to reduced calorie diet plans and found greater weight loss, reduced risk factors, and a lower drop-out rate with the partial meal-replacement plan, but the small number of trials limited conclusions.

In overweight and obese adults with knee OA, caloric restriction combined with an appropriate calorie distribution (15–20% from protein; < 30% from fat; 45–60% from carbohydrate) should be the focus of any dietary intervention. Decreasing body weight will impact the osteoarthritis disease pathways by reducing the load on the knee and lowering pro-inflammatory cytokine activity⁶⁸. An initial energy- intake deficit of 800–1000 kcals/day with a minimum intake of 1100 kcal for women and 1200 kcals for men would provide a safe and effective weight loss plan⁶⁸. A weight loss of 5% of body weight will reduce pain, improve function, and increase mobility⁴³. Considering the potential effects of weight loss on the osteoarthritic process, a reduction in body weight of 2 to 3 times this magnitude (10%–15%) may slow disease progression⁶⁸.

EFFECTS OF EXERCISE

The difficulty patients with knee OA have with activities of daily living often results in activity avoidance. Aerobic exercise is an effective non-pharmacologic treatment with medium effect sizes for improvements in pain and function ($ES_{\text{pooled}} = 0.46\text{--}0.52$)⁶⁹. Walking is the most common mode of aerobic exercise tested in the older, disabled

population, although aquatic exercise has also proven effective in improving clinical symptoms^{70–74}.

Several studies have shown that pain, physical function, and walking distance improve an average of 26%, 31%, and 15%, respectively with short-term aerobic walking exercise^{74;75}. Long-term walking programs have shown significant improvements in self-reported function (1–11%), slowing the decline in physical function commonly seen in this disabled population (Figure 4)^{76–78}. A randomized clinical trial of an 18-month walking program in community dwelling older adults with knee OA reduced disability and pain, and improved balance, and physical performance relative to a health education control group⁷⁶. A biomechanical gait analysis revealed that the improved mobility of the aerobic treatment group was associated with greater knee and ankle angular velocities and vertical and anteroposterior propulsive forces, characteristics that are related to faster walking speeds. In a similar cohort, higher adherence to a physical activity program was associated with better mobility and self-reported physical function⁷⁹. The Arthritis Diet and Activity Promotion Trial (ADAPT) exercise group that consisted of walking and low intensity strength training showed statistically significant and clinically relevant (16%) long-term gains in mobility, effectively slowing the increase in mobility impairment common in an older OA population⁴³.

Aerobic exercise in older adults is more effective as a weight maintenance than a weight loss intervention. The exercise only group in ADAPT lost 3.5 kg or 3.7% of their baseline body weight after 18 months of exercise compared to 5.2 kg and 5.7%, and 4.6 kg and 4.9% for the diet plus exercise and diet only groups, respectively⁴³. Furthermore, a 6-month aerobic exercise program resulted in a 1.8 kg weight loss, whereas the exercise and diet group lost 8.5 kg³². Taken together, these results indicate that long-term aerobic exercise in this disabled population improves mobility and pain, and is an effective weight maintenance intervention.

Sarcopenia and associated muscle weakness are thought to contribute to disability and pain in patients with knee osteoarthritis (OA)⁸⁰. Quadriceps weakness is an independent and modifiable risk factor for knee OA^{81;82}. Muscle strengthening to combat sarcopenia and improve muscle quality in knee OA patients is recommended in published treatment guidelines^{83;84}. Over the short-term (8 weeks), both low- and high-intensity strength training are effective compared to a control group; high-intensity training had more effect on knee extensor strength (23% improvement vs. 15% for low-intensity)⁸⁵. Long-term low intensity strength training in older adults with knee OA improved function, reduced pain, and improved strength relative to a health education control group⁷⁶. In a review, Hurley and Roth⁸⁰ noted that strength training is beneficial for people with knee OA, but *the appropriate intensity and effect of long-term interventions are unclear*.

Strength training intensity or load is often defined as percent of one repetition maximum (%1RM)⁸⁶. High-intensity training is typically done at 70–85% 1RM. One reason most knee OA studies use low-to-moderate regimens is a concern that the population might not tolerate intense training. King et al.⁸⁷ used an intensity level of 60% of baseline strength as a target resistance for patients with medial knee OA and varus alignment during a 12-week isokinetic strength training pilot program. They defined 60% 1RM as “high-intensity”, but the American College of Sports Medicine⁸⁶ defines it as moderate. They elicited 28% and 30% gains in knee extensor and flexor strength at an angular velocity of 60 deg/s; however, the study lacked a control group. Knee pain did not change, and adherence was 88% across all participants. The study did show that knee OA patients can perform strength training at higher intensity levels than previously used.

Caserotti et al.⁸⁸ compared changes in strength and power in old and very old healthy women assigned to either a 12-week, high-intensity (75–80% 1RM) program or a control group. The former significantly improved in strength and power relative to age-matched controls. The protocol was safe (no injuries, although one subject dropped out after 1 session due to “fear of injury”) and well tolerated (86% completed the study). van den Ende et al.⁸⁹ compared 12-week, high- (70–85% max) and low-intensity training that included dynamic weight-bearing exercises in 100 patients with rheumatoid arthritis. The high-intensity group significantly improved in strength relative to the low-intensity group with no change in measures of disease activity (medication use, swollen joint count, Ritchie index etc.) and an attendance rate over 75%. These studies indicate that older adult patients can tolerate high-intensity strength training, and arthritis pain is not exacerbated.

High-intensity strength training may reduce thigh fat mass and increase thigh muscle mass. An 18-week, high-intensity, lower extremity strength training program for 76–78-year-old healthy women significantly decreased % fat within the quadriceps (using computed tomography) versus a walking group (0.9% *decrease* for the strength training group versus a 0.7% *increase* for the walking group), and increased quadriceps lean cross-sectional area. Surprisingly, 12-weeks of high-intensity resistance training combined with a low protein diet significantly decreased serum levels of CRP and IL-6, and this was accompanied by increased vastus lateralis muscle fiber area and increased muscle strength compared to a low protein diet only group in older adults with chronic kidney disease⁹⁰. A 16-week high-intensity strength training program in 20 sedentary HIV infected men resulted in a significant decreases in total fat mass and limb fat mass (measured with DXA scan) compared to an endurance training group⁹¹. Body weight decreased in both groups, with no between-group difference. In comparison to a sedentary control group, adult women that have strength trained for at least 1 year are significantly stronger, walk with a significantly lower loading rate, and have significantly fewer occurrences of heel strike transient forces, an indication of reduced loads on the lower extremity⁹². These studies indicate that short-term high-intensity strength training is well tolerated in healthy and diseased older adults, increases thigh muscle strength, decreases thigh fat depots, and reduces pro-inflammatory cytokines and knee joint loads. The long-term effects of this novel approach to resistance training in older adults with knee pain are untested.

EXERCISE PRESCRIPTION

Short-term and long-term aerobic and resistance training programs are safe and effective treatments for knee osteoarthritis. Traditional 3 days/week, 1 hr/day programs have been the most common regimens studied. Unfortunately, little is known regarding the dose response to exercise in this older, mostly female, sedentary, and predominately overweight population. Continuous weight bearing aerobic exercise such as walking can be difficult initially for knee OA patients who experience significant pain. Starting with short bouts of exercise and inserting several rest periods when the patient has progressed to 30 or 40 minutes of walking will improve adherence. Adding several resistance training exercises between periods of walking has proven effective and popular with patients⁴³. The intensity of the exercise intervention may differ depending on the desired outcomes. If the goal is making exercise a part of a healthy lifestyle, then continued participation is more important than intensity. The U.S. health system remains predicated on providing acute, episodic care that is inadequate to address the altered patterns of chronic disease now facing the American public⁹³. Long-term approaches that include exercise as a non-pharmacologic co-therapy should be part of the standard-of-care in the treatment of lower extremity osteoarthritis.

SOCIAL COGNITIVE BEHAVIORAL STRATEGIES IN WEIGHT LOSS AND EXERCISE INTERVENTIONS

The reciprocal interaction of personal factors (e.g., beliefs and values), social influence (e.g., support and strain), and physical environment (e.g., structure and access to resources) can improve weight loss and fitness by modifying both eating and physical activity behaviors⁹⁴. We have achieved retention rates ~80% in 3 large scale clinical trials (FAST, ADAPT, IDEA). Our protocols have evolved from social cognitive theory, group dynamics literature, and over 15 years clinical trials research experience.

Social cognitive theory is based on 3 constructs: self-efficacy expectations, outcome expectations, and incentives. Self-efficacy expectations represent individuals' beliefs that they can act to satisfy situational demands. Such beliefs are determined by prior behavior, physical symptoms (e.g., pain, fatigue), appetite, affect, and social/environmental factors⁹⁴. The physical activity literature has studied them in relation to the ability to perform functional tasks or physical challenges of varying difficulty⁹⁵⁻⁹⁷, and both the physical activity and eating behavior literatures have examined them under various environmental, social, and emotional stressors. Because self-regulation is important to successful behavior change, our clinical trials use goal setting and self-monitoring^{98;99}.

Outcome expectations refer to the anticipated costs and benefits of a behavior. People are more likely to try, if the perceived consequences have a favorable cost/benefit ratio⁹⁸. Some people simply do not know the negative health effects of being overweight/obese and sedentary or are unduly optimistic about their own fate. They often become disappointed when lifestyle interventions do not meet their unrealistic expectations about how much weight they can lose, cause pain and fatigue, or prohibit a valued ethnic food.

Incentives refer to the value that people associate with outcomes⁹⁸. In our weight-loss clinical trials knowing how much participants value controlling their physical disability and/or reducing their weight; the dissatisfaction differential between the goal and the current weight; and the commitment to competing behaviors, such as responsibilities to families or friends is critical information that permits the nutrition interventionist to personalize the intervention.

We train our diet and exercise interventionists in social cognitive behavioral strategies for their use with the participants. In addition, our health psychologist reviews participant progress with the interventionists biweekly and discusses strategies to use with participants that are finding it difficult to adhere to the intervention. Success stories are also discussed to reinforce successful behavioral strategies.

THE FUTURE OF WEIGHT LOSS AND EXERCISE INTERVENTIONS

OARSI guidelines recommend a combination of non-pharmacological and pharmacological interventions for the treatment of knee osteoarthritis⁸³. In addition to the challenges presented for any weight loss intervention, the age and chronic pain associated with the knee OA population create additional barriers. Nevertheless, dietary weight loss trials demonstrate significant improvements in pain and function with a weight loss of as little as 5%. Weight loss reduces inflammation and joint loads, but there is no evidence that disease progression is altered. A meta-analysis of previous weight loss interventions suggests that at least a 10% weight loss is necessary to have a large clinical effect⁴⁶. Unfortunately, diet interventions lasting longer than 1 year that attain at least a 10% weight loss are rare. There is ongoing long-term efforts to determine whether a 10% weight loss has a disease modifying effect by either slowing or stopping osteoarthritis disease progression⁶⁸. Weight

loss has beneficial effects well beyond those specific to knee OA. These include reduced risk of cardiovascular disease, type II diabetes, hypertension, foot pain, gout, and sleep apnea. Obesity is the most modifiable risk factor for knee OA and weight loss should be part of the standard-of-care for overweight and obese adults with knee OA.

Exercise is a safe intervention in patients with knee osteoarthritis (OA) with few contraindications or adverse events. Indeed, there are few treatments that, from a public health perspective, can be delivered to a large proportion of those with OA with little associated adverse risk as exercise. Exercise therapy is recommended by all clinical guidelines for the management of knee osteoarthritis (OA) and this recommendation is supported by Level 1 evidence. Previous studies have shown that standard exercise interventions for knee OA patients (i.e., walking and low-intensity strength training) result in modest improvements in pain and function without detectable effects on disease progression. Despite the strong supportive evidence exercise is grossly underutilized in clinical practice.

The effectiveness of utilizing more intense variants of exercise co-therapies to improve symptoms associated with OA, slow disease progression, and impact the underlying mechanisms of OA beyond what has been achieved with less intense regimens is under researched; the belief being that such aggressive therapy would exacerbate OA symptoms. Indeed, the most effective combinations of intensity and duration for both aerobic and resistance interventions are unclear.

The Role of the Physician

NIH has identified research on intervention approaches that incorporate primary care practice as a high priority¹⁰⁰. Patients generally perceive that the primary care physician should have a role in weight management¹⁰¹. A recent study found that only 42% of obese adults who visited their health care professional during a 12-month span were advised to lose weight¹⁰². Similar results are common with physicians prescribing exercise as a primary co-therapy¹⁰³. In visits in which either diet or exercise were discussed, a median of 0.7 minutes (42 seconds) was spent discussing the topic¹⁰⁴.

Integrating the primary care physician and nurse into weight loss or exercise intervention trials has met with modest success. Ashley et al.¹⁰⁵ enrolled 113 overweight premenopausal women in a 1 year weight loss program. A primary care office intervention (meeting with primary care physician or nurse) combined with partial meal replacements was compared to traditional dietitian led groups with and without meal replacements. Over the course of 52 weeks, the dietitian led group with meal replacements resulted in greater weight loss (9.1%) compared to the traditional dietitian group (4.1%) and the primary care plus meal replacement group (4.3%). All three groups were successful in achieving and maintaining weight loss.

A multi-center evidence based weight management model was implemented in 47 clinical practices involving 1256 obese patients¹⁰⁶. This comprehensive program involved four phases: setting priorities, setting guidelines, measuring performance, and improving performance. Both general practice physicians and practice nurses were recruited at each clinical site. The weight loss target was 5–10% of initial baseline weight. Preliminary results indicate that one-third of all patients at 12-month follow-up had a clinically relevant weight loss of greater than 5% of baseline body weight. Of the 58 general practices that began the trial, 15 dropped out due primarily to lack of resources and time. The authors concluded that a primary care weight-management model can be used as part of a multi-strategic approach to manage obesity in the community.

Primary care physicians are well positioned to impact a large segment of the population with sedentary lifestyles and are at risk for many chronic diseases¹⁰⁷. While most physicians mention physical activity to their patients, only a small percentage assess physical fitness or write a prescription for physical activity promotion programs (15%). When physicians are teamed with exercise specialists to prescribe and counsel patients to increase their physical activity, total energy expenditure, leisure time physical activity, and quality of life significantly improve in as little as 12 months¹⁰⁸. The Activity Counseling Trial (ACT)¹⁰⁹ compared usual care physician advice to assistance (advice plus behavioral counseling at physician visits) and counseling (advice plus assistance plus regular telephone counseling and behavioral classes) and found that after 24 months, women in the assistance and counseling groups significantly increased cardiorespiratory fitness by 5%, but did not increase total physical activity. For men, there were no statistical differences between the groups in these measures. The total contact time over 24 months was 3 hours for the assistance intervention and between 5.6 (men) and 8.9 (women) hours for the counseling group. Compared to advice, the assistance intervention cost \$500/participant and the counseling cost \$1100/participant over 2 years. *Taken together, these studies suggest that involving physicians in the prescription of exercise to their patients is possible and that integrating their advice with trained exercise specialists elicits better results.*

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Figure 1.
Odds of knee OA (Odds ratios and 95% confidence intervals) attributable to BMI (for 12 BMI categories of BMI)³.

Figure 2.
Relationship between midfoot peak pressure and BMI¹⁹.

Figure 3.

Vertical ground reaction forces during the stance phase of gait. Obese individuals exert 60% more vertical ground reaction force than normal-weight individuals²⁸.

Figure 4. Disability versus duration of intervention for the aerobic, resistance training, and health education control groups. Lower values indicate less disability⁷⁶.