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The Effects of Bariatric Surgery Weight Loss on Knee Pain in Patients with Knee Osteoarthritis: 2 Year Follow-up

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Abstract

Objective: Osteoarthritis has a multifactorial etiology, and obesity is consistently identified as an independent and modifiable risk factor. The purpose of our study was to examine if isolated weight loss through bariatric surgery provides long-term improvement in knee osteoarthritis symptoms at two year follow-up. We hypothesized that if weight loss after surgery was maintained, patients would continue to have improvement of knee osteoarthritis symptoms as measured by KOOS and WOMAC scores as compared to baseline.

Methods: This was a 2 year prospective observational study. 12 patients who met inclusion criteria (age 18-70, BMI>35 kg/m^2, with symptoms and radiographic evidence of knee osteoarthritis who were undergoing bariatric surgery) were examined. WOMAC and KOOS surveys were administered at baseline, and 6, 12 and 24 months post-surgery. Statistical analysis was performed using Student's t and Wilcoxon Signed Rank tests.

Results: Weight loss at six, twelve, and twenty-four months was statistically significant ($p<0.0001$) with an average weight loss of 27.1% at twenty-four months post-surgery. All variables from both KOOS and WOMAC assessments were significantly improved ($p<0.016$) when compared to baseline at 6, 12, and 24 months.

Conclusion: Isolated weight loss via bariatric surgery can successfully improve patients' symptoms of knee osteoarthritis as reported in WOMAC and KOOS scores for up to 2 years after the initial weight loss. We believe that weight loss should play a major role as one of the initial therapies for symptomatic knee arthritis in obese and overweight individuals.

Keywords: Osteoarthritis; Weight loss; Obesity; WOMAC; KOOS; Knee pain; Overweight

Introduction

Osteoarthritis currently affects 27 million adult individuals in the United States and is expected to increase to 67 million cases by 2030 [1,2]. The projected increase in the prevalence of osteoarthritis is comparable to the increase of overweight and obese individuals in the United States [3-5]. A link has been established between obesity and osteoarthritis, but the precise relationship has yet to be defined. Osteoarthritis has a multifactorial etiology, and obesity is consistently identified as an independent and modifiable risk factor. At present, overweight and obese individuals make up more than 67% of the United States adult population [3].

The combination of knee osteoarthritis and obesity has a profound impact on individuals' quality of life. An estimated 3.501 quality adjusted life years is lost for obese individuals with knee osteoarthritis [6]. Osteoarthritis is also considered one of the five leading causes of disability among elderly men and women in the United States [7].

The most commonly used treatments for osteoarthritis consist of non-steroidal anti-inflammatory drugs (NSAIDs), cortisone injections, viscosupplementation, knee arthroscopy, and ultimately knee arthroplasty. In addition to these most commonly used interventions, multiple recent studies have shown that weight loss and exercise can effectively improve function and decrease pain in overweight and obese individuals with knee osteoarthritis [8-14].

Currently the Osteoarthritis Research Society International (OARSI) has guidelines for the level of appropriateness of many non-surgical treatments based on whether the patient has knee-only or multiple-joint osteoarthritis and whether or not co-morbidities are present. Although commonly used, there are uncertain recommendations for viscosupplementation injections in all patients with knee osteoarthritis as well as uncertain recommendations for NSAIDs in patients with co-morbidities due to the risk of side effects. Despite these uncertain recommendations, these are two of the more commonly used interventions by patients. Often stressed less by many physicians is weight loss, which the OARSI recommends as a core treatment to osteoarthritis [15].

Current recommendations for weight loss for the treatment of knee osteoarthritis are 5% within 20 weeks [15]. Our study looked at isolated weight loss via bariatric surgery for the treatment of knee

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osteoarthritis, which is a treatment known for achieving larger weight loss. Bariatric surgery is a weight loss surgery intended for patients who have failed attempts on their own with a BMI ≥ 40 kg/m^2 or patients with a BMI 35 kg/m^2 in addition to obesity-related comorbidities such as hypertension, diabetes, and obstructive sleep apnea.

Edwards et al. showed that bariatric surgery patients with radiographic evidence of knee osteoarthritis experience significant improvement in symptoms at both 6 months and 12 months post-surgery. Results of 24 patients at six and twelve months showed a significant weight loss of 25.9 kg and 32.4 kg respectively ($p<0.05$). All variables of the KOOS and WOMAC surveys also showed significant ($p<0.05$) improvement compared to baseline scores [16].

To the best of our knowledge, no study has followed results of knee osteoarthritis symptoms after surgically-induced weight loss after 12 months. This study's purpose was to further investigate the findings of Edwards et al. following the study patients out for a total of 24 months to investigate if symptomatic relief of knee osteoarthritis symptoms persists after the massive isolated weight loss via bariatric surgery. We hypothesized that if further weight loss was achieved or if current weight loss was maintained from 12 months to 24 months, patients should continue to have improvement of knee osteoarthritis symptoms as measured by KOOS and WOMAC as compared to baseline.

Methods

Study participants

In accordance with institutional IRB approved protocol (IRB#28727), 24 patients with both clinical and radiographic evidence of knee osteoarthritis were enrolled in the study after informed patient consent was received, as outlined by Edwards et al. [16]. Inclusion criteria included: age between 18 and 70, BMI ≥ 35 kg/m^2, and passing a psychological evaluation and institutional criteria for bariatric surgery. Individuals were excluded if they were unwilling to have radiographic imaging done of their knees or if they were unwilling to be evaluated by an orthopaedic surgeon. Potential candidates were also excluded if they had previous total knee arthroplasty, were currently taking prescription NSAIDs for pain or receiving either viscosupplementation or corticosteroid injections. Patients taking pain medications other than NSAIDs, such as Acetaminophen, were not excluded from the study.

Study design

The study was a 2 year prospective observational study. Two outcome measures used in this study, the Western Ontario and McMaster Universities (WOMAC) Index of Osteoarthritis and the Knee Osteoarthritis Outcome Score (KOOS) have both been previously validated in the literature [17,18]. Both are self-administered surveys, with the WOMAC assessing the three areas of pain, stiffness and physical function. The survey consists of 24 questions (5 pain, 2 stiffness, and 17 physical function). The KOOS consists of six areas which include symptoms (5 questions), stiffness (2 questions), pain (9 questions), function of daily living (17 questions), function in sports and recreational activities (5 questions) and quality of life (4 questions). The Likert scale was used in scoring both the WOMAC and KOOS and then transformed to a 100 point scale. Both surveys were to be completed at 4 points in the course of the 2 year study: at baseline prior to bariatric surgery, as well as 6, 12 and 24 months post-operation. WOMAC and KOOS surveys were mailed to participants and those surveys not returned were followed up with a phone call where the patient could elect to have another survey mailed to them or answer the two questionnaires over the phone.

Three bariatric surgery techniques were used on study participants at the discretion of the surgeon and patient. These included roux-en-Y gastric bypass (n=19) in which a proximal gastric pouch is surgically stapled off and then bypassed to the distal jejunum in a Y-shaped configuration with a 45 cm biliopancreatic limb and a 100-150 cm Roux limb with the purpose of restricting food intake and bypassing caloric and nutrient absorbing portions of the digestive tract. Realize Band placement (n=4) where an adjustable band is placed around the proximal stomach to restrict food passage, and finally sleeve gastrectomy (n=1) in which the stomach is reduced in size by stapling it vertically over an endoscope of about 36Fr following the greater curvature, leaving a smaller tube like stomach.

Patients' weight and height were measured at baseline using a calibrated scale in the bariatric surgery clinic. Weight measurements were repeated at the patient's regularly scheduled 6, 12 and 24 months follow-up visits with the bariatric surgery clinic. BMI was calculated from the patient's weight and height.

Statistical analysis was performed using only data from patients who returned both KOOS and WOMAC questionnaires and followed-up in bariatric surgery clinic to obtain a repeat weight measurement at all time frames of 6, 12 and 24 months (n=12).

Statistical analysis

Paired statistical tests were applied on the data collected in order to detect a change in the WOMAC and KOOS scores from baseline to six, twelve and twenty-four months. Student's t test and Wilcoxon Signed Rank tests were used to determine the P values. Bonferonni correction was applied for multiple comparisons adjusting the P value for significance to 0.05/3 (0.016). Analysis was applied to investigate the relationships between changes in weight and BMI with changes in KOOS and WOMAC scores. The analyses were completed using the SAS Version 9.3.

Results

During the study enrollment period, 54 patients were undergoing bariatric surgery. Of those patients, 24 patients met the study criteria and agreed to participate in the study. Edwards et al. described the results of these patients (n=24) at 6 and 12 months follow-up [16]. Of the original 24 patients initially enrolled, 12 patients fulfilled all inclusion criteria, including completing surveys and weights at all time periods, and are the subject of this investigation. Of these 12 patients, all but one patient had roux-en-Y gastric bypass surgery. The one patient that did not had Realize Band placement. Of the 12 patients lost to follow-up, 6 completed both WOMAC and KOOS surveys but did not follow-up with bariatric surgery clinic to obtain a weight and 2 patients returned to bariatric surgery clinic but did not return surveys. The 4 other patients failed to return both surveys and follow-up in clinic for a repeat weight.

The mean weight for the patients was 112.6 kg at baseline compared to 87.0 kg ($P<0.0001$), 82.0 kg ($P<0.0001$) and 81.9 kg ($P<0.0001$) at 6-, 12- and 24-months post-surgery respectively (Figure 1). The mean BMI at baseline was 42.0 kg/m^2 as compared to 32.5 kg/m^2 ($P<0.0001$), 30.7 kg/m^2 ($P<0.0001$), and 30.7 kg/m^2 ($P<0.0001$) at 6, 12 and 24 months respectively (Figure 2). The average decrease in BMI relative to baseline at 6, 12 and 24 months was 22.8%, 27.1%, and 27.1% respectively. The one patient in the study who received Realize Band placement lost

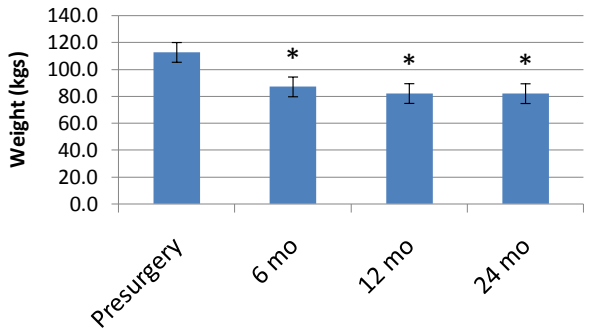

Figure 1: Comparison of body weight from baseline (pre-surgery) through 24 months at post-surgical follow-up appointments.Standard error bars are present.The (*) indicates significant weight loss as compared to baseline at 6, 12 and 24 months (P<0.0001). n=12.

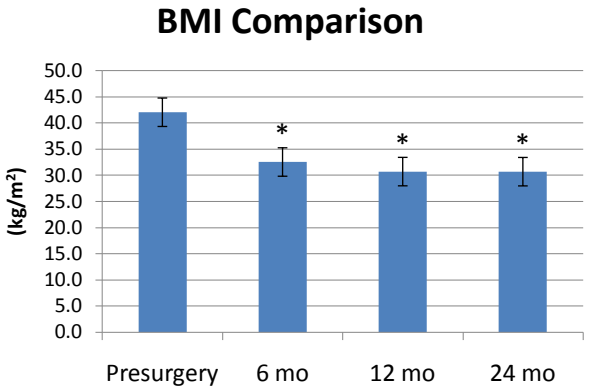

Figure 2: Comparison of body mass index (BMI) from baseline (pre-surgery) through 24 months at post-surgical follow-up appointments. Standard error bars are present. The (*) indicates significant weight loss as compared to baseline at 6, 12 and 24 months (P<0.0001). n=12.

minimal weight, 3.16%, 2.77% and 2.37% weight loss at 6, 12 and 24 months. The range of weight loss among the twelve patients ranged from 3.16%-30.42% at 6-months, 2.77%-36.67% at 12 months, and 2.37%-41.50% at 24 months.

WOMAC scores for the participants were compared at baseline, 6, 12 and 24 months. There was a significant improvement from baseline (P<0.016) in all subscales including pain, stiffness and physical function at 6, 12 and 24 months (Figure 3). On a 100 point scale, pain scores improved by 26.4 (P=0.0008), 28.2 (P=0.0004), and 31.8 (P<0.0001) points at 6, 12 and 24 months respectively compared to baseline. Stiffness scores improved compared to baseline by 28.0 points at 6 months (P=0.0080), 36.8 points at 12 months (P=0.0013) and 35.8 points at 24 months (P=0.0011). Physical function scores improved by 28.4 (P=0.0006), 30.4 (P=0.0002) and 29.5 points (P=0.0001) at 6, 12 and 24 months respectively.

KOOS scores showed a similar improvement from baseline. Symptoms and stiffness, pain, function of daily living, function in sports and recreational activities, and quality of life all showed significant improvement (P<0.016) at all time frames as compared to baseline (Figure 4).

Discussion

Our study showed that patients who underwent bariatric surgery to achieve substantial weight loss experienced significant symptomatic relief of the knee osteoarthritis symptoms at 6 months and those improvements lasted the duration of a 2 year period. Pain, stiffness, physical function, function in sports and quality of life all showed significant improvement throughout the duration of the study as compared to baseline. Patients in the study lost the majority of their weight within the first six months post-operatively. From that point on, patients may have had some additional weight loss or gain but on a whole their weights were stable.

Few studies have examined weight loss as an option for treating knee osteoarthritis. To the author's knowledge, this is the first study to prospectively follow symptoms of knee osteoarthritis after isolated weight loss and shown improvement out to 2 years.

Miller et al. used an intensive weight loss protocol utilizing partial meal replacements, education and exercise to achieve an average weight loss of 8.7% in study participants at 6 months. When comparing their measures on WOMAC at 6 months to a weight stable control group, the authors found that the weight loss group had significant improvements in all measures of WOMAC as compared to the weight stable group. They also found that all changes in physical function measurements except for the WOMAC stiffness score correlated significantly with weight loss [9]. Although this study shows that moderate amounts

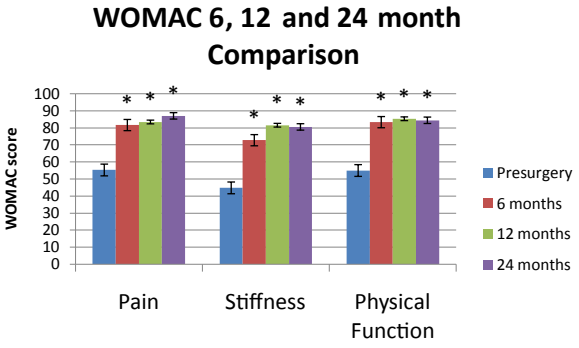

Figure 3: WOMAC pain, stiffness, and physical function through 24 months. Standard error bars are present. The (*) indicates significant changes when compared to baseline (P<0.016). n=12.

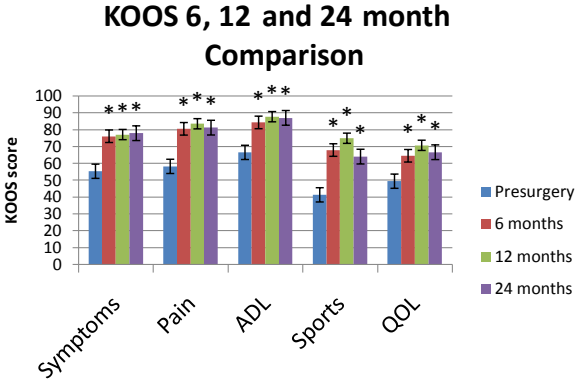

Figure 4: KOOS symptoms, pain, ADL, sports and QOL through 24 months. Standard error bars are present. The (*) indicates significant changes when compared to baseline (P<0.016). n=12.

of weight loss, 8.7%, can improve symptoms, it is unclear as to what degree the improvements were due to the weight loss alone as both exercise and education were additional interventions. In contrast, our study is unique in that the only intervention was weight loss, with the patients not taking anti-inflammatory medications, injections, physical therapy, education or prescribed exercise protocols throughout the duration of the study.

Christensen et al. compared two diets to examine how the amount of weight loss affects WOMAC measures over an 8 week period. They found that the low-energy diet group had an average weight loss of 11.1% compared to 4.3% of the conventional diet group over the 8 weeks of the study. The low-energy diet but not the conventional diet group had significant changes in WOMAC measures, leading them to conclude that setting a goal of 10% weight loss was reasonable to improve symptoms of knee osteoarthritis [10]. Our study differs from this study and others in that our patients achieved and maintained at 24 months an average of 27.1% total body weight loss, far exceeding their recommended weight loss goal of 10%. This significant weight loss is not easily achieved or sustained through non-surgical measures.

Similar to our study, Richette et al. examined 44 patients with radiographically confirmed knee osteoarthritis who were to undergo bariatric surgery. Patients were similarly excluded if they had recent use of corticosteroid injections or viscosupplementation. After surgery, patients had a mean total body weight reduction of 20% at 6 months, and significant improvement in OA pain scores on the VAS and all measures of WOMAC. They also further analyzed serum levels of inflammatory markers and found that IL-6, high sensitivity C-reactive protein, and others were significantly decreased after bariatric surgery. There were also significant changes in joint biomarkers as well, raising the question of whether or not the substantial weight loss improves knee osteoarthritis by forces of knee joint loading alone [19] or are there more systemic effects on inflammation which leads to decreases in symptoms of knee osteoarthritis [11,20,21].

Abu-Abeid et al. also examined obese patients after surgically induced weight loss and found that weight loss significantly improved medial joint space and self-reported pain and function scores over 3 months. The study population consisted of obese patients with negative radiographic evidence of knee osteoarthritis on the Kellgren Lawrence index [12].

Although the above two studies both show that isolated weight loss via bariatric surgery seems to positively affect symptoms and function in patients with knee osteoarthritis, our study is the only one to show that these improvements of knee osteoarthritis symptoms last for up to 24 months after the initial weight loss.

Howarth et al. surveyed 45 patients with a BMI ≥ 30 kg/m^2 with radiographic evidence of knee arthritis and found that 64% believed that weight affected their joint pain. 89% of the study patients had tried to lose weight at some point. Of those individuals who attempted to lose weight, the mean weight loss was 9 kg, but 55% lost less weight than they had expected to lose and only 25% of the individuals managed to maintain the weight loss [22]. We believe that current research shows that weight loss is a good treatment option for knee osteoarthritis, but the most appropriate clinical manner in which patients achieve this weight loss has yet to be determined. These results show that although patients understand the importance that weight loss plays in the treatment of their knee osteoarthritis and will attempt a weight loss program, the long term value of this may be limited because in this study only 25% of individuals surveyed managed to maintain the weight loss. In contrast, our study showed that participants maintained their weight loss after bariatric surgery out to two years, therefore there may be some benefit to surgical versus non-surgical weight loss in the obese population with knee osteoarthritis.

Current treatments of patients with knee osteoarthritis include activity modification, over the counter and prescription analgesics and NSAIDs, cortisone injections, viscosupplementation and knee arthroplasty. NSAIDs, although useful in alleviating pain and swelling associated with osteoarthritis, account for a large number of emergency department admissions due to upper gastrointestinal side effects. In a UK study of 65,000 emergency admissions for upper G.I. related symptoms, 12,000 of those were related to NSAID use [23]. These common interventions also play a role in the mounting health care costs that knee osteoarthritis is responsible for. Osteoarthritis accounts for approximately $149.4 billion in insurer expenses and $36.1 billion in out of pocket expenses [24]. One study reported that osteoarthritis ranked second in cost attributable to being overweight only behind coronary heart disease [25].

Obesity, especially morbid obesity with a BMI ≥ 40, has been shown to increase complications in patients undergoing knee arthroplasty. A review of the current literature by A Workgroup of the American Association of Hip and Knee Surgeons Evidence Based Committee, found that multiple studies show an increase in wound complications and infections in obese patients. Additional studies have shown trends towards higher revision rates in the morbidly obese compared to non-obese patients [26].

Studies such as these have led many practicing orthopaedic surgeons to recommend weight loss to their patients before they would consider performing a total knee arthroplasty, but as many studies have shown weight loss is often difficult to achieve and most of all, maintain. This raises the question of whether it would be appropriate to recommend bariatric surgery as a possible option for morbidly obese patients. This would most appropriately apply to those with past attempts at dieting without permanent success despite compliance with a weight loss program as a means of treating their knee osteoarthritis symptoms or at least placing them in a better position to become a candidate for future total knee arthoplasty. Further research would need to be done examining the risk-benefit ratio of surgically induced weight loss for patients with symptomatic knee osteoarthritis.

We recognize that a weakness in our study is that we had 50% follow-up at 24 months. For the sake of consistency of sample size across all of the statistical analyses, only complete data from a particular visit was used. There were some study participants who yielded incomplete data at a visit that were not included. 6 patients completed surveys but did not return to their clinic appointment for their weight measurement. Being that we are at a tertiary medical center where patients often travel distances for their appointments, if a patient is doing well, they are not as likely to return to this 2 year visit if they need to travel a distance. From the partial data that we have from these patients we expect that they likely maintained their weight loss over this time period. Additionally, 2 patients who returned to bariatric surgery clinic for their weight but did not return surveys had maintained their weight loss. The incomplete data can be faulted on our study design where patients were not given the surveys in clinic but instead were mailed them or followed up with phone calls. These patients were unable to be reached through either of these methods. When analyzed, the partial data was consistent with the complete data, so that there does not appear to be a bias from excluding the partial data.

In conclusion, we have shown that isolated weight loss through bariatric surgery can successfully improve patients' symptoms of knee osteoarthritis as reported in WOMAC and KOOS scores for up to 2 years after the weight loss. We believe that weight loss should play a major role as one of the initial therapies for symptomatic knee arthritis. Further research needs to be done to determine whether similar improvements can be obtained with weight loss alone in patients with more severe degrees of knee osteoarthritis.

References

1. Lawrence RC, Felson DT, Helmick CG, Arnold LM, Choi H, et al. (2008) Estimates of the prevalence of arthritis and other rheumatic conditions in the United States. Part II. Arthritis Rheum 58: 26-35.
2. Hootman JM, Helmick CG (2006) Projections of US prevalence of arthritis and associated activity limitations. Arthritis Rheum 54: 226-229.
3. National Center for Health Statistics (2009) Prevalence of overweight, obesity and extreme obesity among adults: United States, trends 1960-62 through 2005-2006. Centers for Disease Control and Prevention.
4. Felson DT, Zhang Y, Hannan MT, Naimark A, Weissman B, et al. (1997) Risk factors for incident radiographic knee osteoarthritis in the elderly: the Framingham Study. Arthritis Rheum 40: 728-733.
5. Cooper C, Snow S, McAlindon TE, Kellingray S, Stuart B, et al. (2000) Risk factors for the incidence and progression of radiographic knee osteoarthritis. Arthritis Rheum 43: 995-1000.
6. Losina E, Walensky RP, Reichmann WM, Holt HL, Gerlovin H, et al. (2011) Impact of obesity and knee osteoarthritis on morbidity and mortality in older Americans. Ann Intern Med 154: 217-226.
7. Osteoarthritis of the Knee: State of the Condition. American Academy of Orthopedic Surgeons. 2004.
8. Messier SP, Loeser RF, Miller GD, Morgan TM, Rejeski WJ, et al. (2004) Exercise and dietary weight loss in overweight and obese older adults with knee osteoarthritis: the Arthritis, Diet, and Activity Promotion Trial. Arthritis Rheum 50: 1501-1510.
9. Miller GD, Nicklas BJ, Davis C, Loeser RF, Lenchik L, et al. (2006) Intensive weight loss program improves physical function in older obese adults with knee osteoarthritis. Obesity (Silver Spring) 14: 1219-1230.
10. Christensen R, Astrup A, Bliddal H (2005) Weight loss: The treatment of choice for knee osteoarthritis? A randomized trial. Osteoarthritis Cartilage 13: 20-27.
11. Richette P, Poitou C, Garnero P, Vicaut E, Bouillot JL, et al. (2011) Benefits of massive weight loss on symptoms, systemic inflammation and cartilage turnover in obese patients with knee osteoarthritis. Ann Rheum Dis 70: 139-144.
12. Abu-Abeid S, Wishnitzer N, Szold A, Liebergall M, Manor O (2005) The influence of surgically-induced weight loss on the knee joint. Obes Surg 15: 1437-1442.
13. Foy CG, Lewis CE, Hairston KG, Miller GD, Lang W, et al. (2011) Intensive lifestyle intervention improves physical function among obese adults with knee pain: findings from the Look AHEAD trial. Obesity (Silver Spring) 19: 83-93.
14. Riecke BF, Christensen R, Christensen P, Leeds AR, Boesen M, et al. (2010) Comparing two low-energy diets for the treatment of knee osteoarthritis symptoms in obese patients: a pragmatic randomized clinical trial. Osteoarthritis Cartilage 18: 746-754.
15. McAlindon TE, Bannuru RR, Sullivan MC, Arden NK, Berenbaum F, et al. (2014) OARSI guidelines for the non-surgical management of knee osteoarthritis. Osteoarthritis and Cartilage. 22:363-338.
16. Edwards C, Rogers A, Lynch S, Pylawka T, Silvis M, et al. (2012) The effects of bariatric surgery weight loss on knee pain in patients with osteoarthritis of the knee. Arthritis 2012: 504189.
17. Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW (1988) Validation study of WOMAC: A health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. J Rheumatol 15: 1833-1840.
18. Roos EM, Toksvig-Larsen S (2003) Knee injury and Osteoarthritis Outcome Score (KOOS)-validation and comparison to the WOMAC in total knee replacement. Health Qual Life Outcomes 25: 1-17.
19. Messier SP, Legault C, Loeser RF, Van Arsdale SJ, Davis C, et al. (2011) Does high weight loss in older adults with knee osteoarthritis affect bone-on-bone joint loads and muscle forces during walking? Osteoarthritis Cartilage 19: 272-280.
20. Berry PA, Jones SW, Cicuttini FM, Wluka AE, Maciewicz RA (2011) Temporal relationship between serum adipokines, biomarkers of bone and cartilage turnover, and cartilage volume loss in a population with clinical knee osteoarthritis. Arthritis Rheum 63: 700-707.
21. Nicklas BJ, Ambrosius W, Messier SP, Miller GD, Penninx BW, et al. (2004) Diet-induced weight loss, exercise, and chronic inflammation in older, obese adults: A randomized controlled clinical trial. Am J Clin Nutr 79: 544-551.
22. Howarth D, Inman D, Lingard E, McCaskie A, Gerrand C (2010) Barriers to weight loss in obese patients with knee osteoarthritis. Ann R Coll Surg Engl 92: 338-340.
23. Blower A, Brooks A, Fenn G, Hill A, Pearce M, et al. (1997) Emergency admissions for upper gastrointestinal disease and their relation to NSAID use. Aliment Pharm Ther. 11:283-291.
24. Kotlarz H, Gunnarsson CL, Fang H, Rizzo JA (2009) Insurer and out-of-pocket costs of osteoarthritis in the US: evidence from national survey data. Arthritis Rheum 60: 3546-3553.
25. Moffatt E, Shack LG, Petz GJ, Sauvé JK, Hayward K, et al. (2011) The cost of obesity and overweight in 2005: a case study of Alberta, Canada. Can J Public Health 102: 144-148.
26. Workgroup of the American Association of Hip and Knee Surgeons Evidence Based Committee (2013) Obesity and total joint arthroplasty: a literature based review. J Arthroplasty 28: 714-721.