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RESEARCH ARTICLE

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Preoperative Weight Loss Prior To Total Joint Arthroplasty

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Introduction

As the prevalence of obesity continues to rise, so do the challenges of proper surgical management of obese patients. Most recent estimates from 2015-2018 show that in the United States, 41.1% of adults over 20 years old are obese (Body Mass Index (BMI)≥30 kg/m^2) [1]. In comparison, between 2011-2014, 36.4% of adults over 20 years old were classified as obese [1].

Many studies have shown that obesity is a risk factor for osteoarthritis (OA) and the prevalence of obesity in total joint arthroplasty patients is reflective of this with about 39% of patients undergoing total hip arthroplasty (THA) and 55% of patients undergoing total knee arthroplasty (TKA) classified as obese [2-5].

In addition to being a risk factor for OA, obesity is also a known risk factor for post-operative complications. Post-operative surgical site infections (SSIs) and readmission rates are noted to be higher in obese patients [6-9]. These complications result in increased length of stay and hospital charges placing further burden on the healthcare system [10]. Because of this, BMI thresholds prior to TJA are becoming more prevalent in hospitals systems as they try and manage the burden of increased complications and costs when managing these patients [11]. However, the presence of these cutoffs can delay, and possibly deny care. It has been shown in some cases that up to 80% of patients may never meet their target weight [12,13].

Further research has also shown that obesity is associated with multiple nutritional and mineral deficiencies resulting in a paradoxical malnourished state [14,15]. Malnourished patients have been found to have a higher risk of adverse events, prolonged hospitalization, and delayed postoperative mobilization [16]. Continued malnourishment can eventually lead to sarcopenic obesity or the loss of muscle mass and continued increase of fat mass which has also been associated with increased surgical complications and mortality risk [17,18].

Many studies have examined the effects of bariatric surgery prior to TJA as an attempt to reduce the rate of complications associated with obesity. Recent meta-analyses show that the risk for peri-operative complications such as superficial and deep wound infections or revision surgery is not decreased in patients that undergo surgical weight loss prior to TJA [19,20].

As the prevalence of obesity, OA, and total knee and hip arthroplasties continue to rise, it is extremely important that patients are appropriately counseled on strategies to best improve their outcomes [21-23]. Although it is well known that weight loss results in improvement of cardiovascular and general metabolic function, it is less clear how weight loss in the peri-operative period affects outcomes [24-28]. While common practice is to have patients lose a certain percent of their weight prior to TJA, the methods that patients use to accomplish this goal are highly variable [29]. The purpose of this review is to evaluate the current available literature and determine how pre-operative weight loss affects post-operative complications in TJA.

Materials and Methods

Search algorithm

A systematic literature search of various databases (PubMed, CINAHL, Cochrane) was performed according to PRISMA criteria to identify work in which pre-operative weight loss was examined. The following search terms were used including the search algorithm: (weight loss) AND (arthroplasty OR total knee arthroplasty OR total hip arthroplasty) AND (outcomes OR infection OR revision OR complication). If a corresponding study was found, related articles were searched in Pubmed and searched for relevant publications. In addition, the reference section of relevant studies was also checked. After researching the literature according to the specific inclusion and exclusion criteria J.G and J.S. extracted the data from the selected studies.

The initial search provided 599 total results, of which 460 were unique. Further screening based on title excluded 398 articles. The remaining 62 articles were screened by abstract or full text review. After application of inclusion and exclusion criteria, only 5 articles were remaining. These 5 articles were independently reviewed by two authors (J.G. and J.S). The date last searched was 2/14/2022. Figure 1 illustrates the flowchart of literature selection. There was 1 single-blinded randomized control trial conducted in Denmark and 4 retrospective cohort studies from the United States.

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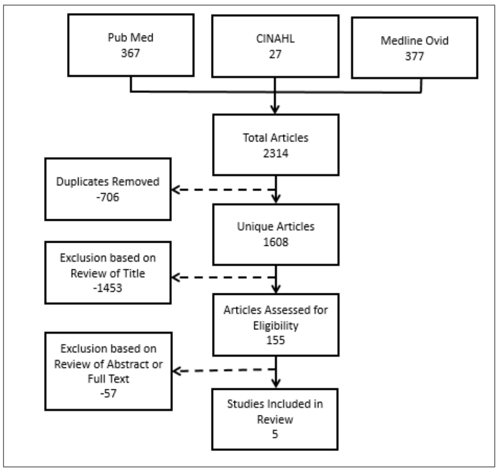

Figure 1: Search Algorithm

Inclusion and exclusion criteria

Studies met the inclusion criteria if they had the following characteristics: (1) patients with recorded weight loss prior to their arthroplasty surgery; (2) performed primary total hip or total knee arthroplasty; (3) reported post-operative outcomes or complications. Studies were excluded if they had the follow characteristics: (1) did not have a recorded weight loss prior to surgery; and (2) revision surgery. Multiple articles of one trial were included if they reported different outcome parameters.

Study Group

Table 1 illustrates the characteristics of the 5 included studies. Patient data were collected between 2008-2019. A total of 28,784 patient data and 29,144 primary total joint replacement were analyzed, with sample sizes ranging from 76 to 14,784 subjects. Among the studies that reported demographics, the mean age ranged from 62.2 to 67.1, mean BMI ranged from 28.4 to 36.9, and 61% of patients were women and 39% of patients were men. The mean follow up ranged from 1 year to 3.15 years. 2 studies focused on primary TKA, 1 study on primary THA, and 2 studies included both primary TKA and THA.

Table 1: Study Baseline Characteristics

Study (Author, Year)	Study Type	Collection period (year)	Patients (n)	Surgeries (n)	Age (years ± SD)	Females (n)	Follow up (years ± SD)	Types of Surgery	Outcome Measures
Kim et al, 2021	Retrospective Cohort 2015-2019	2015-2019	2660	3058	67.1 ± 8.71	1766 (57.8%)	3.15 ± 1.45	Primary TKA	LOS, facility discharge, 90-day ED visit, readmissions, All-cause revisions, PJI
Middleton et al, 2022	Retrospective Cohort	2015-2019	1589	1589	62.2 ± 11.0	672 (42.3%)	NR	Primary THA	LOS, all-cause 30-day readmission, complications (defined by CMS), mechanical complication, and SSI (within 90 days)
Liljensoe et al 2021,	Single blinded RCT	2011-2013	76	38	65 ± NR	54 (71%)	1 ± NR	Primary TKA	PCS, KOOS, 6-Min Walk Test
Inacio et al, 2014	Retrospective Cohort	2008-2010	9675	9675	NR	5880 (61%)	NR	Primary THA, Primary TKA	SSI (superficial and deep), 90-day readmissions
Inacio et al, 2014	Retrospective Cohort	2008-2010	14784	14784	NR	9115 (62%)	NR	Primary THA, Primary TKA	SSI (superficial and deep), 90-day readmissions

Table 2: Study Design, Metrics, and Pertinent Findings

Study (Author, Year)	WL intervention	Study Cohorts	Patients in Each Group (n)	Mean BMI at Time of Surgery (kg/m² ± SD)	Mean Decrease in BMI in WL Group (kg/m²)	Significant Findings
Kim et al, 2021	None	• Weight gain (WG; BMI change ≥5%) • Weight loss (WL; BMI change ≥5%) • Same (BMI change <5%)	• 516 • 492 • 1652	NR	NR	• Pre WL predictive of post WG • Pre WL associated with longer LOS, 90-day ED visits, readmissions, 2-fold greater risk of all-cause revision, but not PJI • Pre WL with post WL had highest risk for all-cause revision • Pre WL with post weight maintained had elevated risk for all-cause revision and PJI • Pre WL with post WG ≥5% not associated with revision or PJI
Middleton et al, 2022	None	• BMI <40 kg/m² at all time points prior to surgery (BMI <40) • BMI >40 kg/m² at time of surgery regardless of BMI at 24-3 mo pre (BMI >40) • BMI >40 kg/m² 24-3 mo pre and BMI <40 at time of surgery (WL)	• 1387 • 96 • 106	30.8 ± 6.2	5.67 ± 3.9	• WL group had higher 30-day readmission, mechanical complications vs. BMI <40 (OR 2.90; 1.14-6.52, 95% CI) • WL group had increased risk on mechanical complications vs. BMI <40 (OR 3.07; 1.14-8.25, 95% CI) • WL group likely to experience any complication vs BMI <40 (OR 2.65; 1.11-5.67 95% CI) • WL group had 16% increase in median LOS vs. BMI <40 • No difference in risk of readmission, mechanical complication, and rate of complication between BMI >40 and BMI <40
Liljensoe et al, 2021	Yes	• Diet group • Control group	• 38 • 38	• 28.4 ± 1.0 • 31.2 ± 1.4	3.2 ± NR	• No difference in SF-36 PCS, MCS, KOOS subscale scores, 6MW, and complications between diet and control group • Weight change, BMI, fat mass, % fat mass, % lean mass, bone mass, TGLY, leptin, HDL in favor of diet group • Lean mass decreased in diet group

Inacio et al, 2014	None	• Weight gain (WG; increased body weight by ≥5%) • Weight loss (WL; decreased body weight by ≥5%) • Same weight (SW; body weight change <5%)	• THA WG: 258 • THA WL: 732 • THA SW: 3076 • TKA WG: 817 • TKA WL: 1332 • TKA SW: 8569	NR	NR	• No difference in risk of SSI and 90-day readmission in THA WG and THA WL vs. THA SW • No difference in risk of SSI and 90-day readmission in TKA WG and TKA WL vs. TKA SW
Inacio et al, 2014	None	• Pre weight loss (WL) • Same weight (SW)	• THA WL: 444 • THA SW: 2110 • TKA WL: 937 • TKA SW: 6184	• THA WL: 35.8 ± 4.8 • THA SW: 34.6 ± 4.2 • TKA WL: 36.9 ± 5.4 • TKA SW: 35.3 ± 4.5	• THA WL: 4 ± NR • TKA WL: 3.9 ± NR	• Higher risk of deep SSI in THA WL vs. THA SW (OR = 3.77; 1.59-8.95, 95% CI) • No difference in likelihood of superficial SSI and 90-day readmission in THA WL vs. THA SW • Greater likelihood of 90-day readmission in TKA WL vs. TKA SW (OR 1.63, 1.16-2.28, 95% CI) • No difference in likelihood of SSI in TKA WL vs. TKA SW

WL indicates weight loss; BMI, body mass index; SD, standard deviation; NR, not reported; Pre, preoperative; Post, postoperative; LOS, length of stay; ED, emergency department; PJI, periprosthetic joint infection; mo, months; OR, odds ratio; SF-36, Short-Form 36; PCS, Physical Function Component Score; MCS, Mental Component Score; KOOS, Knee injury and Osteoarthritis Outcome Score; 6MW, 6-Min Walk Test; TGLY, triglyceride; HDL, high-density lipoprotein cholesterol; THA, total hip arthroplasty; TKA, total knee arthroplasty; SSI, surgical site infection

Results

Liljensoe et al conducted a single-blinded, single-center RCT and randomized 76 patients to either 8 weeks of preoperative weight loss therapy along with a 12-month postoperative weight maintenance program (n = 36) or to standard care that did not involve any nutritional instructions (n = 36) [30]. The preoperative intervention consisted of a low-energy liquid diet (810 kcal/day) using commercial formula foods and weekly 1.5-hour group nutritional education sessions. The pre-intervention BMI of the diet group was comparable to that of the control group at 31.6 kg/m^2 (CI 95% 30.6-32.6) and 31.2 kg/m^2 (CI 95% 29.8-32.6), respectively. The pre-intervention weight of the diet group was also similar to that of the control group at 105.4 kg (CI 95% 101.2-109.6) and 104.4 kg (CI 95% 99.4-109.3), respectively. The diet group demonstrated a mean BMI decrease of 3.2 kg/m^2 and mean weight loss of 10.7kg by the date of surgery, which was significantly lower than the control group for both measures (p <0.05). 50% of the patients in the diet group experienced mild adverse events possibly related to the intervention such as cramps, sleeplessness, and dry skin. No other adverse events were noted. There were no significant differences in patient-reported outcome measures, knee function, mobility, and perioperative, in-hospital, or postoperative complications between the two groups at 1 year follow-up. Thomasen et al reported the 7-year follow-up from the same study and found that the weight loss group was unable to sustain their weight loss and that there were no differences in knee ROM or patient reported outcome measures between both groups [31].

Kim et al conducted a retrospective cohort review evaluating 2660 patients with BMI ≥18.5 kg/m^2 who underwent 3058 primary TKAs with minimum 2-year follow-up [32]. The mean age of patients was 67.1 (range 19-93) years, with 57.8% of patients being female and 42.2% male. Patients were grouped into those who gained, lost, or maintained weight. Clinically significant BMI gain and loss was defined as BMI change ≥5% per Food and Drug Administration guidelines. Mean BMI was not reported. Preoperatively, 66.3% of patients maintained their weight while 19.4% and 18.5% demonstrated clinically significant BMI gain and loss, respectively. Preoperative weight loss was associated with longer hospital stays, higher likelihood of 90-day ED visits, readmissions, and approximately 2-fold greater risk of all-cause revision (excluding risk for PJI). Patients who lost weight preoperatively and continued to lose weight postoperatively had the highest risk for all-cause revision (adjusted HR 4.22 95% CI 1.23-14.46), while those who lost weight preoperatively and maintained that weight after TKA also had a higher risk for all-cause revision (adjusted HR 2.78, 95% CI 1.29-5.99) and PJI (adjusted HR 3.13, 95% CI 1.30-7.53). Of note, preoperative weight loss was predictive of postoperative weight gain (P <0.001), and patients that lost weight preoperatively and regained it postoperatively did not have an elevated risk for all-cause revision or PJI (P = 0.069).

Middleton et al conducted a retrospective cohort study including 1589 patients >18 years old who underwent primary THA and divided the patients into 3 groups: BMI <40 kg/m^2 (n = 1387), BMI >40 kg/m^2 (n = 96), and a weight loss group that recorded BMI >40 kg/m^2 within 3 months to 24 months prior to surgery and BMI <40 kg/m^2 at time of surgery (n = 106) [33]. Mean age of patients was 65.4 ± 11.1 years, 58% were female and 42% male, and mean BMI was 30.8 ± 6.2 kg/m^2. The weight loss group had a mean BMI decrease of 5.67 ± 3.90 kg/m^2 by the day of surgery. Adjusted logistic regression analysis showed that the weight loss group had a higher risk of all-cause 30-day readmission compared to the BMI <40 kg/m^2 group (OR 2.70, 95% CI 1.19-6.17). Further, the weight loss group had a higher risk of complications (as defined by Centers for Medicare and Medicaid Services (CMS)) than the BMI <40 group (OR 2.47, 95% CI 1.09-5.59). In an unadjusted analysis, the weight loss group was more likely to experience mechanical complications (as defined by CMS) than the BMI <40 kg/m^2 group (OR 3.07, 95% CI 1.14-8.25). Linear regression analysis that controlled for age, sex, and ASA status showed that the weight loss group had a 16% increase in median length of stay (P = 0.002) compared to the BMI <40 group. Notably, the authors state that statistical comparisons between the weight loss group and the BMI >40 kg/m^2 group were not able to be performed due to insufficient numbers of readmissions and complications.

Inacio et al completed a retrospective cohort study of obese (BMI ≥ 30 kg/m^2) patients (n = 14784) who underwent primary unilateral TKA and THA for osteoarthritis without history of surgical weight loss [34]. The cohort was stratified to 6 groups: those who gained weight one-year pre-TKA (TKA weight gain group; n = 817), lost weight pre-TKA (TKA weight loss group; n = 1332), remained the same weight pre-TKA (TKA same weight group; n = 8569), gained weight pre-THA (THA weight gain group; n = 258), lost weight pre-THA (THA weight loss group; n = 732), and remained the same weight pre-THA (n = 3076). The mean BMI and the magnitude of BMI changes in each group were not reported. An adjusted analysis showed that the risk of SSI, both deep and superficial as defined by CDC/National Healthcare Safety Network criteria, and the risk of 90-day readmission was not significantly different in patients who gained or lost weight preoperatively with either TKA or THA compared to those who remained the same weight.

Inacio et al conducted another retrospective analysis of 9,675 patients with BMI ≥30 kg/m^2 one year prior to their primary unilateral THA or TKA secondary to osteoarthritis [35]. There were 4 primary study groups in this study: those that underwent TKA who non-surgically lost weight (≥5% change in body weight) and kept it off post-operatively (TKA weight loss group; n = 937), those that underwent TKA without significant weight changes (TKA same weight group; n = 6,184), those that underwent THA who non-surgically lost weight and kept it off post-operatively (THA weight loss group; n = 444), and those that underwent THA without significant weight changes (THA same weight group; n = 2110). The mean BMI of the TKA weight loss group pre-operatively was 36.9 kg/m^2 ± 5.4 and 33.0 kg/m^2 ± 4.8 post-operatively, while the mean BMI of the TKA same weight group was 35.3 kg/m^2 ± 4.5 preoperatively and 35.2 kg/m^2 ± 4.6 post-operatively. The mean BMI of the THA weight loss group pre-operatively was 35.8 kg/m^2 ± 4.8 and 31.8 kg/m^2 ± 4.5 post-operatively, whereas the mean BMI of the THA same weight group was 34.6 kg/m^2 ± 4.2 pre-operatively and 34.5 kg/m^2 ± 4.3 post-operatively. Their study found that the THA weight loss group had a higher likelihood of deep SSI (as defined per CDC and Prevention/National Healthcare Safety Network) compared to the THA same weight group (OR 3.77, 95% CI 1.59 to 8.95). Additional pertinent findings include a greater likelihood of 90-day re-admission in the TKA weight loss group compared to the TKA same weight group (OR 1.63, 95% CI 1.16 to 2.28).

Discussion

There is a strong association between osteoarthritis and obesity, and weight loss has been identified as a safe and effective long-term treatment modality for knee and hip osteoarthritis [36-40]. In 2013, the American Association of Hip and Knee surgeons evidence-based committee identified BMI >30 kg/m^2 as the threshold that correlated with increasing perioperative complications following total joint arthroplasty and deemed BMI >40kg/m^2 as an appropriate value that may warrant delaying total joint arthroplasty due to higher complication profiles [11]. Previous studies have recommended preoperative weight loss for obese patients prior to undergoing either total knee or hip arthroplasty owing to relatively unfavorable outcomes [41-43]. However, there has been recent studies that suggest the contrary—that weight loss prior to total joint arthroplasty may not necessarily be as beneficial as previously thought [23,32,35,44].

A total of 13,847 TKA patients and 8,209 THA patients were included in the studies above that examined the results of non-surgical pre-operative weight loss on post-operative outcomes. These studies illustrate an unexpected finding that weight loss prior to TJA may result in equivocal or even worse clinical patient outcomes. They show that pre-operative weight loss can result in a higher risk of infections or revisions, longer hospital stays, or increased rates of readmissions. In addition to the main studies noted above, other authors have also examined pre-operative weight loss and noted a paucity of evidence that supports a clear relationship between weight loss and reduction in complications [23,44,45]. Similar to non-operative weight loss, the results of surgical weight loss interventions prior to TJA also seem to be mixed. Nickel et al demonstrated greater risk in those who underwent bariatric surgery prior to total knee arthroplasty compared to the BMI >40 kg/m^2 group and a seminal systematic review by Smith et al further highlights the ineffectiveness of bariatric surgery reducing complication rates or improving clinical outcomes when performed prior to TJA [19,46].

While BMI has been the hallmark of metrics used to quantify a patient's clinical status, other markers of nutritional health may better predict postoperative outcomes in arthroplasty. Markers such as albumin have been noted to affect post-operative outcomes and studies have shown that morbid obesity is an independent risk factor for hypoalbuminemia [47]. Hypoalbuminemia has been associated with an increase in 30-day complications, worse post-operative outcomes, and also been shown to have a higher prognostic capacity than BMI for predicting risk of periprosthetic infection after TJA [48-51]. Interestingly, Courtney et al showed it was hypoalbuminemia, and not morbid obesity, that was an independent risk factor for complications following TJA [52]. While physicians should certainly inform patients that a higher BMI affects infection risk, the discussion should involve noting that simply reducing their BMI might not be enough to alleviate post-operative risks. Due to the chronicity of obesity and its effects on multiple biochemical pathways in the body, it is possible that increased amount of time from the weight loss episode could lessen a patient's risk profile. Overall, it is clear that further research into nutritional optimization, timing of weight loss, and additional markers of surgical risk are indicated in order to best mitigate complications in obese patients.

Finally, the reality of obese patients achieving a BMI <40 kg/m^2 needs to be addressed. An observational study by Shapiro et al followed patients with BMI >40 kg/m^2 who were initially denied TJA, and the analyzed success rate of achieving BMI >40kg/m^2 via lifestyle modifications was 8.6% [13,28]. Another study by Springer et al showed that only 6.9% of patients who were initially denied for TJA due to BMI >40 kg/m^2 achieved BMI <40kg/m^2 without bariatric surgery [52]. Although obesity is strongly associated with osteoarthritis that may require TJA, precluding patients from the surgery due to BMI may prohibit the majority of patients from ever undergoing TJA. It may be worth reassessing if current strict weight loss or BMI cutoffs are warranted.

There are several limitations to this study. A retrospectively registered protocol was utilized for screening and extraction of literature. Although a comprehensive literature search strategy was utilized for this review, other relevant studies may have inadvertently been excluded. Only 1 study was a RCT, and the other 4 were retrospective studies. As our primary focus was on the effect of BMI loss on TJA outcomes, other health benefits of BMI reduction in patients were not explored. The 2 studies by Inacio et al may have had duplicate patients as they used the same Total Joint Replacement registry for each study. There was heterogeneity in patient demographics, as Kim et al and Middleton et al had patient cohorts that were not classified as obese in their study whereas Liljensoe et al and Inacio et al specifically included patients with BMI ≥30 kg/m^2. With these limitations in mind, this review is aimed at elucidating the relationship between preoperative weight loss per BMI and outcomes in TJA, reflecting on the validity and reliance of BMI as a marker of surgical risk [53].

Conclusion

This systematic review of preoperative weight loss as measured by BMI prior to TJA suggests that preoperative weight loss confers either equivalent outcomes or may be associated with increased postoperative complications. More RCTs are warranted that analyze whether weight loss intervention resulting in reduced BMI in obese patients is an independent predictor of improved clinical outcomes. Further, a reassessment of the current guidelines may be necessary as they may indirectly encourage obese patients to undertake rigorous weight loss goals which may actually be increasing their risk profile.

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