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Most patients gain weight in the 2 years after total knee arthroplasty: comparison to a healthy control group

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SUMMARY

Objective: While joint arthroplasty improves the functional ability of persons with severe knee osteoarthritis (OA), the long-term effects of surgical intervention on body mass have not been evaluated. The objective of this study was to determine if a reduction in body mass index (BMI) was present following unilateral total knee arthroplasty (TKA) compared to an age-matched healthy control group who did not have surgery.

Method: One hundred and six adults with unilateral, end-stage knee OA and thirty-one persons without knee pain participated in the prospective longitudinal study. Subjects with OA underwent primary unilateral TKA and received post-operative out-patient physical therapy. Height, weight, quadriceps strength and self-perceived functional ability were measured at baseline and at a 2-year follow-up.

Results: There was a significant interaction effect between body mass over time and subject group ($P = 0.017$). BMI showed a significant increase over 2 years for the surgical group ($P < 0.001$), but not for the control group ($P = 0.842$). Sixty-six percent of the persons in the surgical group gained weight over the 2 years with an average weight gain of 6.4 kg, or 14 pounds, 2 years after their initial physical therapy visit. Educational level, marital status, income level and activity level prior to surgery were not related to post-surgical weight gain.

Conclusion: The majority of subjects gain weight after surgery and this cannot be attributed to the effects of aging. Weight gain after TKA should be treated as an independent concern and management of orthopedic impairments will not result in weight loss. Post-operative care should include access to nutrition or weight management professionals in addition to medical and physical therapy services.

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Introduction

High body mass index (BMI) is a co-morbidity associated with knee osteoarthritis (OA) and reduced mobility[1]. Joint pain, knee stiffness, and muscle weakness can contribute to a sedentary lifestyle that may promote weight gain in persons with knee OA[2]. Surgical interventions, such as total knee arthroplasty (TKA), have been proposed to reduce the symptomatic barriers to exercise and facilitate weight loss. While joint arthroplasty reduces pain and improves mobility of persons with severe knee OA, the long-term effects of surgical intervention on BMI have not been evaluated[3].

A reduction in BMI has important health implications. While high BMI is a risk factor for serious cardiovascular diseases[4,5], obesity also increases the risk for the initiation and progression of knee OA and may result in a higher incidence of bilateral knee disease[6–9]. High BMI is related to structural damage of the articular cartilage and subchondral tibial bone thickening as there is a four-fold increase in joint forces for every kilogram of body weight gained[10,11]. Structural damage coupled with high compressive forces may accelerate the disease process in the contralateral limb and result in decreasing functional ability after the primary TKA[6,12]. This is important because 3 years after TKA, pain in the non-operated limb is the strongest predictor of functional ability[13]. The incidence of contralateral knee replacement is very high, with 37% of unilateral TKA patients requiring a contralateral replacement within 10 years[14]. In addition, higher body mass after total joint replacement has also been identified as a significant risk factor for aseptic loosening of the components of the prosthesis and obese individuals have higher revision rates[15,16].

We do not know whether persons who undergo TKA for knee OA lose weight, although the integrity of the prosthesis and non-operative limb may be reliant on a reduction in body mass. Previous investigations have reported no decrease in body mass or decrease in circumferential limb and abdominal measurements 1 year after

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total knee or total hip arthroplasty[17–19]. However, self-report of functional ability and objective clinical measures are still improving 6 months and 1 year after surgery[20]. Therefore longitudinal measures at 1 year after surgery therefore may not permit enough time for evaluation of weight loss. A sufficient longitudinal assessment of functional changes and changes in BMI following TKA is currently lacking.

The primary purpose of this study was to determine if BMI changed in persons in the 2 years following TKA, compared to a healthy age-matched control group. We hypothesized that BMI would not change after TKA in the surgical group, or in the control group. In addition, we examined the relationship between body mass and quadriceps strength following TKA in order to assess the effect of increased body mass on clinical outcomes. Because increased BMI may expedite the disease process in the non-operated limb, we hypothesized that persons who gain weight after TKA will have a larger decrease in contralateral quadriceps strength 2 years after surgery.

Methods

One hundred and six subjects who underwent a primary TKA participated in the 2-year longitudinal study (TKA group). These subjects were compared to an age-matched control group that had no history of knee pain, no history of lower extremity orthopedic impairments and no neurological or cardiopulmonary disorders (Table I). Subjects in the control group were recruited from the local community. All subjects completed an informed consent form that was approved by the Human Subjects Review Board prior to participating in any facet of the study. Persons in the TKA group all presented to the orthopedic surgeon with end-stage knee OA in a single limb and were excluded from the study if they had maximal pain in the contralateral limb greater than or equal to 4 out of 10 during daily activities. All TKAs were posterior cruciate ligament sacrificing condylar implants performed by one of three orthopedic surgeons from the same hospital. Subjects participating in this study were a sample from a larger clinical trial evaluating outcomes after TKA, clinical trial registry number NCT00224913.

Functional evaluations were completed at three different time points for the surgical group: baseline (mean 12.1 days prior arthroplasty) and subsequently at 1 year and 2 years after the surgery. The control group participated in a baseline evaluation and a 2-year follow-up. Functional evaluations consisted of anthropometric measurements (height and weight on the same medical scale), bilateral quadriceps strength measurements, as well as the activities of daily living portion of the self-administered Knee Outcome Score (KOS-ADLS). Subjects in the surgical group participated in post-operative out-patient physical therapy at the same clinic 2–3 times a week for 6 weeks with a median of 17 total visits. These subjects followed a well established protocol of modalities to reduce pain and inflammation, progressive strengthening and stretching exercises, manual therapy to improve range of motion and electrical stimulation to maximize quadriceps strength. All treatments were performed by physical therapists experienced in treating subjects after TKA.

Table I
Baseline and follow-up variables for the TKA and control groups

	TKA ($n = 106$)		Control ($n = 31$)		
	Mean	Range	Mean	Range	*P*-value
Baseline					
Age (years)	65.5 (8.8)	50–84	63.6 (8.3)	50–79	0.292
BMI (kg/m^2)	31.05 (5.5)	21.8–53.8	27.14 (4.5)	19.4–38.4	<0.001
Height (m)	1.71 (0.10)	1.47–1.88	1.71 (0.10)	1.56–1.91	0.959
Weight (kg)	91.51 (19.4)	47.6–162.8	79.94 (15.4)	57.1–113.4	0.003
KOS-ADLS (%)	50.0 (16.9)	8.6–88.6	98.3 (3.6)	85–100	<0.001
Gender (M/F) (%)	58/42		42/58		0.153
Obese (Y/N) (%)	51/49		19/81		0.002
2-year follow-up					
BMI (kg/m^2)	32.04 (6.2)	21.3–59.3	27.07 (4.6)	19.3–41.8	<0.001
Weight (kg)	94.00 (20.9)	47.6–179.6	80.09 (17.6)	54.9–126.7	0.001
KOS-ADLS (%)	84.12 (13.1)	45.7–100	94.98 (0.1)	75.7–100	<0.001
Obese (Y/N) (%)	57/43		16/84		<0.001

Quadriceps strength was quantified as the volitional knee extension force produced during a maximal isometric quadriceps effort. Force measurements were obtained on a Kin-Com Dynamometer (Harrison, TN, USA). Both raw strength values and strength normalized to BMI were analyzed. Data from both limbs was averaged for the control group and the limbs were reported separately for the TKA group. The KOS-ADLS is a self-administered questionnaire consisting of 14 questions about daily function. Subjects rank each question according to the level of difficulty each task presents based on the individuals' OA symptoms (5 = no difficulty, 0 = unable to complete). Scores for all questions are summed and divided by the maximal possible score of 70, then multiplied by 100, giving an upper end total score of 100. This test is a valid and reliable measure of an individual's self-report of functional ability[21,22].

To determine if BMI changed in either group over the 2 years (the primary aim of the study), BMI between groups was analyzed using an analysis of variance (ANOVA) with one repeated measure (test time). To address the secondary aim of the study (relationship between function and weight gain), the original group of 106 TKA subjects was also analyzed as two groups, subjects who gained weight (+BMI) and subjects who lost weight (−BMI), relative to pre-operative values. Subjects in the +BMI group were the persons that demonstrated any magnitude of weight gain at the 2-year follow-up and persons in the −BMI group were individuals that lost weight, or demonstrated no change in body mass by the 2-year follow-up. Paired *t*-tests were used to determine differences between quadriceps strength 1 and 2 years after surgery for both the +BMI and −BMI groups. This time range was chosen as this is the period that would most likely show changes in the contralateral limb. Subanalysis by obesity grade (BMI ≥ 30 vs BMI < 30), pre-operative BMI, age, gender and socioeconomic status were performed using independent samples *t*-test or chi-square test.

Results

There was a significant main effect of time on BMI between baseline and 2 years ($P = 0.039$) with a significant interaction effect between the TKA and control groups ($P = 0.017$). Follow-up paired *t*-tests revealed that persons in the TKA group showed a significant increase in BMI within 2 years ($P < 0.001$), whereas the control group showed no change ($P = 0.842$) (Table I). Similarly, body mass (kg) increased over the 2 years ($P = 0.015$), with a significant interaction effect ($P = 0.028$). Follow-up paired *t*-tests revealed that the TKA group showed a significant increase from baseline body mass ($P < 0.001$), but the control group had no change in body mass ($P = 0.877$) (Fig. 1). Sixty-six percent of the subjects in the TKA group showed an increase in body weight over the 2 years that averaged 5.42 kg (11.9 pounds) from pre-operative values and 6.41 kg (14.1) pounds from initial physical therapy evaluation. In the 34% of the TKA subjects that showed a reduction in body weight, average weight loss was 1.9 kg (4.1 pounds) from pre-operative values. Mean and median BMI change for the entire TKA group was an increase of 1.5 kg/m^2 and 1.16 kg/m^2, respectively. Compared to the control group, persons in the TKA group had significantly higher BMI and body weight at baseline and 2-year follow-up measurements (Table I). Weight gain in the TKA group

Table II
Analysis of pre-operative variables in the BMI subgroups from the TKA group (Op. = operated; non-op. = non-operated)

		+BMI ($n=70$)	−BMI ($n=36$)	*P*-value
Age (years)		64.7 (8.9)	67.0 (8.6)	0.203
Pre-op BMI (kg/m^2)		31.38 (5.4)	30.43 (5.6)	0.403
Pre-op KOS-ADLS (%)		48.9 (16.1)	52.3 (18.4)	0.357
Strength (Op. limb) (*N*/BMI)		19.1 (7.9)	19.0 (7.4)	0.926
Strength (non-op. limb) (*N*/BMI)		23.6 (9.0)	23.0 (9.8)	0.591
Gender (M/F) (%)		59/41	54/46	0.371
Obese (Y/N) (%)		48/52	48/52	0.550
Activity level	Sedentary	25	33.3	0.09
	Sitting, standing	34.6	40	
	Walking	40.4	20	
	Heavy manual labor	0	6.7	
Spare-time activity level	Inactive	46.3	45.2	0.08
	Mildly active	33.3	51.6	
	Moderately active	16.7	0	
	Very active	3.7	3.2	
Employment	Full time	31.5	25.8	0.77
	Part time	9.3	3.2	
	Light duty	1.9	0	
	Disabled	13	12.9	
	Retired	35.2	45.2	
	Unemployed	0	0	
	Homemaker	9.3	12.9	
Marital status	Single	3.7	6.5	0.65
	Married	79.6	67.7	
	Live w/sig. Other	0	0	
	Divorced/separated	5.6	6.5	
	Widowed	11.1	19.4	
Income level	<20,000	2.3	17.4	0.16
	20–35,000	16.3	17.4	
	35–50,000	23.3	17.4	
	50–70,000	18.6	26.1	
	>70,000	39.5	21.7	
Education	Some High School	3.7	3.3	0.83
	High School Grad	18.5	30	
	Some College	31.5	26.7	
	College Grad	14.8	16.7	
	Some post-grad	9.3	10	
	Post-grad Degree	22.2	13.3	
Ethnicity	Caucasian	91.4	97	0.55
	African–American	6.9	3	
	Hispanic	1.7	0	

did not differ by age, pre-operative BMI, KOS-ADLS score, gender, obesity grade or socioeconomic status (Table II).

One hundred and one subjects from the TKA group had complete quadriceps strength data over the 2 years. Persons in the +BMI group showed a significant reduction in normalized and raw quadriceps strength on the non-operated limb between 1 and 2 years ($P=0.002$ and $P=0.014$, respectively) (Fig. 2). The −BMI group did not show any change in normalized or raw strength between 1 and 2 years ($P=0.244$ and $P=0.863$) (Fig. 2). There were no differences in operated and non-operated side quadriceps strength between the +BMI and −BMI group at baseline (Table II). Normalized quadriceps strength for the control group was 28.33 N m/kg at baseline. This significantly decreased at the 2-year follow-up to 23.77 N m/kg ($P<0.001$). Using a Mann–Whitney *U* test, no differences were found for BMI at initial evaluation, 1 or 2-year follow-up or in change in BMI over time between the subgroup that did and did not have complete strength data.

There was a significant effect of time on KOS scores. At 2-year follow-up, mean KOS scores in the TKA group were significantly

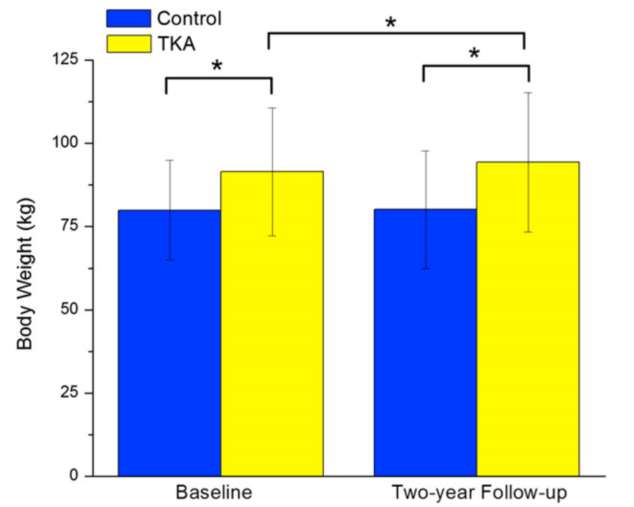

Fig. 1. There was a significant increase in body weight for the TKA group over 2 years ($P<0.001$) and the TKA group had mean body weight that was significantly greater than the control group at all time points ($P<0.001$).

higher than pre-operative values ($P<0.001$) (Table I). The pre-operative mean was 50.0 (16.9) and this increased to 84.4 (10.8) at 1 year and 84.1 (13.1) after 2 years. KOS scores showed a significant increase in the TKA group between baseline and 1 year ($P<0.001$), however no significant changes were found between 1- and 2-year follow-ups ($P=0.762$).

Discussion

It has been the long-standing notion of clinicians and patients that when joint pain is relieved after surgical intervention, the barriers to exercise will be ameliorated and weight loss can be achieved. Our findings do not support this notion. Instead, our findings are similar to previous work that found no reduction in body mass up to 1 year after total joint replacement[18,23]. However, where these studies found no reduction in body weight at 1 year, we found a significant and clinically meaningful increase in body weight by 2 years after surgery, with the majority of persons (66%) gaining weight after TKA. Our results are similar to a report by Aderinto *et al.*, that found a similar increase in body weight

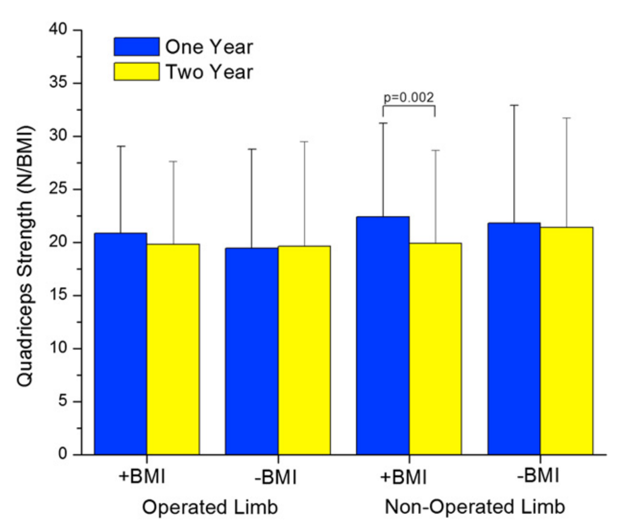

Fig. 2. Persons in the +BMI group showed a significant reduction in quadriceps strength on the non-operative side between 1 and 2 years.

(average 6.7 kg in persons that were obese prior to surgery) by 3 years after total hip replacement[24]. Weight gain in our study cannot be attributed to normal effects of aging because this trend was significantly different than a control group measured over the same time interval. Although functional gains plateau after 1 year, BMI continues to increase, while quadriceps strength on the non-operated limb decreases in persons that continue to gain weight.

Because the majority of the TKA group gained weight, the integrity of the non-surgical limb may be jeopardized after the primary TKA. The amount of weight gain seen in the persons with a higher BMI at 2 years corresponds to a mean increase in knee joint compressive forces of approximately 21.6 kg, or 212 N, with each step[11]. This finding is particularly worrisome when it is coupled with recent findings that after TKA persons move asymmetrically and load the non-operated knee joint excessively and abnormally[25,26]. Accumulated over time, this increase in intersegmental force, attributed to asymmetrical movement patterns and weight gain, will expedite the disease process on the non-operated side. This is highlighted by the different strength trends in the non-operated limbs between the +BMI and −BMI groups. While the trend of strength recovery in the operated limb was very similar between the +BMI and −BMI groups, persons in the +BMI group had a significant reduction in the quadriceps strength of the non-operated limb between 1 and 2 years (Fig. 2). Quadriceps strength on non-operated side at 2-year follow-up was similar to the pre-operative quadriceps strength on the index limb (Table I). This is a clinically meaningful result. Since quadriceps weakness is highly associated with poor functional ability, persons that gain weight after surgery may have lower long-term functional ability or opt to have a TKA on the cognate knee to manage the symptoms and disability associated with knee OA[27]. Although the control group also showed a decrease in knee strength over time, previous work has shown that the decrease in knee strength after TKA exceeds the strength loss due to the effects of aging alone[13].

Weight gain in this study cannot be attributed to differences in employment status, marital status, income level, education or activity level as there were no significant differences between the +BMI and −BMI groups. While there was a trend towards a difference between groups for activity level and spare-time activity level, we are confident that the difference is not meaningful, because the persons who gained weight tended to be *more* active prior to surgery. These individuals spent a larger percentage of time “walking” throughout the day or being “moderately active” in their spare-time activities (Table II). Therefore we cannot predict which individuals will gain weight after surgery simply by assessing employment status, marital status, income level, education or activity levels prior to surgery. This finding substantiates the need to treat post-operative weight gain as an independent concern that will not be avoided due to a high activity level prior to surgery.

While post-operative activity level was not monitored, we did evaluate self-perceived functional ability after surgery. Despite the increase in BMI, subjects did show an increase in self-perceived functional ability, although the mean KOS-ADLS values were still lower than the control group (Table I). This is consistent with previous findings[3,20,28]. This reinforces the idea that high body weight should be treated as a separate condition that will not resolve with an increase in functional ability.

In addition to functional and orthopedic impairments that may arise as a result of weight gain after TKA, these individuals are at a higher risk for future cardiovascular sequellae[5,29]. Self-report of function improved from pre-operative values and medical practitioners should emphasize the importance of using the functional gains to decrease BMI and subsequently reduce the risk of developing cardiovascular disorders. While the development of OA in the contralateral knee may result in pain and require surgery, the end result is rarely life-threatening. Serious cardiopulmonary events for which obesity and increased BMI are risk factors, however, have a much higher mortality rate. If post-operative pain in either the operative or non-operative limb continue to be barriers to exercise, clinicians and health professionals should employ or recommend activities such as upper body ergometry or water aerobics and swimming. These activities offer a cardiopulmonary workout without loading the lower extremity.

Several limitations exist in this study. The subject pool was relatively small and homogeneous from a small geographic area. Physical activity after completion of the physical therapy protocol was not documented which may impact the change in body mass 2 years after surgery. Radiographs were not obtained 2 years after surgery to determine if there was radiographic evidence of joint space narrowing or cartilage deterioration in the non-operative limb. Future studies evaluating the impact of weight gain after TKA should carefully assess the patient’s physical activity level and radiographic joint integrity in a longitudinal manner.

The control group in the present study comprised healthy subjects without lower extremity pathology. The use of this comparison group, instead of a comparison group of persons with OA, excludes the possibility of determining whether patients that elect to undergo TKA would have gained a similar amount of weight had they had not opted to undergo the surgery. Additionally, it should be noted that the control group had a lower baseline BMI. This is expected since increased BMI is associated with, and a risk factor for, knee OA[1,10,30]. However, this difference did not likely impact the findings because weight gain occurred independent of baseline body mass. Despite a healthy control group with lower baseline BMI, we demonstrated that persons after TKA did not utilize functional gains to reduce body mass.

In summary, reducing body weight is an important factor to address before and after TKA. Weight gain was not related to normal aging, as persons who did not undergo TKA showed no increase in body weight over the same time period. Weight gain after TKA should be treated as an independent concern and we should not assume that knee replacement and management of orthopedic impairments will result in weight loss[31]. Even in the presence of OA, programs promoting weight loss have been successful[32,33]. While medical and physical therapy services are a standard of care after joint replacement, pre- and post-operative care should also include access to nutrition and or weight management professionals. Targeted weight loss interventions as a component of treatment of end-stage knee OA and after surgery may improve physical abilities and self-perceived functional outcomes in patients who have undergone TKA for OA. Future studies should evaluate whether weight loss after TKA improves the long-term integrity of the non-operated limb using radiographic and functional measures.

Conflicts of interest

None.

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