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Weight and Activity Change in Overweight and Obese Patients After Primary Total Knee Arthroplasty

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Abstract: Few studies have examined the effect of primary total knee arthroplasty on the weight and physical activity of overweight and obese patients in the United States. We conducted a prospective study of changes in mean weight, body mass index (BMI), and physical activity over 2 years in 188 consecutive overweight or obese patients. Weight, BMI, and physical activity, evaluated using the Lower Extremity Activity Scale (LEAS), were assessed preoperatively and at 1 and 2 years. At 2 years, no significant weight change was found ($P = .80$), but BMI increased by 0.46 kg/m^2 ($P = .049$). The LEAS score increased from preoperatively to 2 years ($P < .001$). Preoperative LEAS score was not associated with weight or BMI at 2 years. This finding has implications for patient expectations and preoperative counseling. **Key words:** total knee arthroplasty, outcomes, obesity, weight, body mass index, activity.

In 2003 to 2004, 66.3% of adults 20 years or older in the United States were overweight or obese (body mass index [BMI] > 25 kg/m^2) [1], and the prevalence of overweight and obesity is increasing. The increase has also occurred in the age groups that most frequently have total knee arthroplasty (TKA): 71.0% of adults ≥60 years are overweight or obese [1,2]. The prevalence of overweight and obesity may even be higher among patients having TKA because increased weight is a risk factor for osteoarthritis of the knee [3]. Overweight and obese patients with symptomatic knee arthritis commonly undergo TKA for severe pain and disability, and TKA relieves pain and improves function for as long as 15 years after the surgery [4,5].

High preoperative weight and BMI have been reported to be a risk factor for surgical complications and adverse postoperative outcomes [6-10], though several studies have shown that even obese patients can have a successful outcome with only a slightly increased risk of complications [10-15]. Nevertheless, some surgeons recommend preoperative weight loss to facilitate the procedure and to decrease complications [15]. We, like others, have found that overweight and obese patients often claim they are unable to lose weight because pain from severe arthritis of the knee limits their activity and thus their ability to expend calories [16,17]. These patients often believe that TKA will permit an increase in their physical activity and enable them to lose weight postoperatively.

Little is known, however, about whether patients' weight or BMI change after arthroplasty. Previous studies examining weight and BMI change after total knee or total hip arthroplasty have found mixed results, but overall, they suggest that lower extremity arthroplasty does not facilitate weight loss [17-21]. Three studies in the United Kingdom and one in the United States found that total hip arthroplasty patients gained weight [17-19] or increased in BMI [20] postoperatively. Woodruff and Stone [18] and Heisel et al [19] found that patients undergoing TKA had an increase in mean body weight, but the increase was not significant. Pritchett and Bortel [21] found

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Lower Extremity Activity Scale*

Please read through each description given below, pick the ONE description that best describes your regular daily activity and put a check in that box (Check only one box).

☐ 1. I am confined to bed all day. (1)

☐ 2. I am confined to bed most of the day except for minimal transfer activities (going to the bathroom, etc.) (2)

☐ 3. I am either in bed or sitting in a chair most of the day. (3)

☐ 4. I sit most of the day, except for minimal transfer activities, no walking or standing. (4)

☐ 5. I sit most of the day, but I stand occasionally and walk a minimal amount in my house. (I may rarely leave the house for an appointment and may require the use of a wheelchair or scooter for transportation.) (5)

☐ 6. I walk around my house to a moderate degree but I don't leave the house on a regular basis. I may leave the house occasionally for an appointment. (6)

☐ 7. I walk around my house and go outside at will, walking one or two blocks at a time. (7)

☐ 8. I walk around my house, go outside at will and walk several blocks at a time without any assistance (weather permitting). (8)

☐ 9. I am up and about at will in my house and can go out and walk as much as I would like with no restrictions (weather permitting). (9)

10. I am up and about at will in my house and outside. I also work outside the house in a:
- ☐ minimally (10)
- ☐ moderately (11)
- ☐ extremely active job (12)

(Please check the best description of your work level.)

11. I am up and about at will in my house and outside. I also participate in relaxed physical activity such as jogging, dancing, cycling, swimming:
- ☐ occasionally (2-3 times per month) (13)
- ☐ 2-3 times per week (14)
- ☐ daily (15)

(Please check the best description of how often you participate in this activity.)

12. I am up and about at will in my house and outside. I also participate in vigorous physical activity such as competitive level sports
- ☐ occasionally (2-3 times per month) (16)
- ☐ 2–3 times per week (17)
- ☐ daily (18)

(Please check the best description of how often you participate in this activity.)

* actual score obtained is specified in parentheses at end of whichever statement is chosen

Fig. 1. The lower-extremity activity scale (LEAS) from Saleh KJ et al. Development and validation of a lower-extremity scale. Use for patients treated with revision total knee arthroplasty. *J Bone Surg Am* (2005;87:1985-1994). Reprinted with permission from The Journal of Bone and Joint Surgery, Inc.

that morbidly obese women, who were advised by a physician to lose weight and were counseled by a dietician, had no sustained weight loss, and 24% gained weight after TKA.

These previous studies of weight change in TKA patients were limited by small samples and lack of data on change in physical activity and change in BMI. The study reported here prospectively examined change in weight among overweight or obese American patients after primary TKA. We also investigated whether preoperative physical activity was associated with weight/BMI change in these patients after arthroplasty.

Materials and Methods

Patients

We prospectively followed 188 consecutive overweight or obese patients after they underwent primary TKA performed by one surgeon at a university medical center between May 1998 and December 2003. Patients with BMI less than 25 kg/m^2 (n = 31) were not included in the study because it would be undesirable for normal weight or underweight patients to lose weight after TKA. If a patient with staged bilateral arthroplasties had both operations during the 5-year study period,

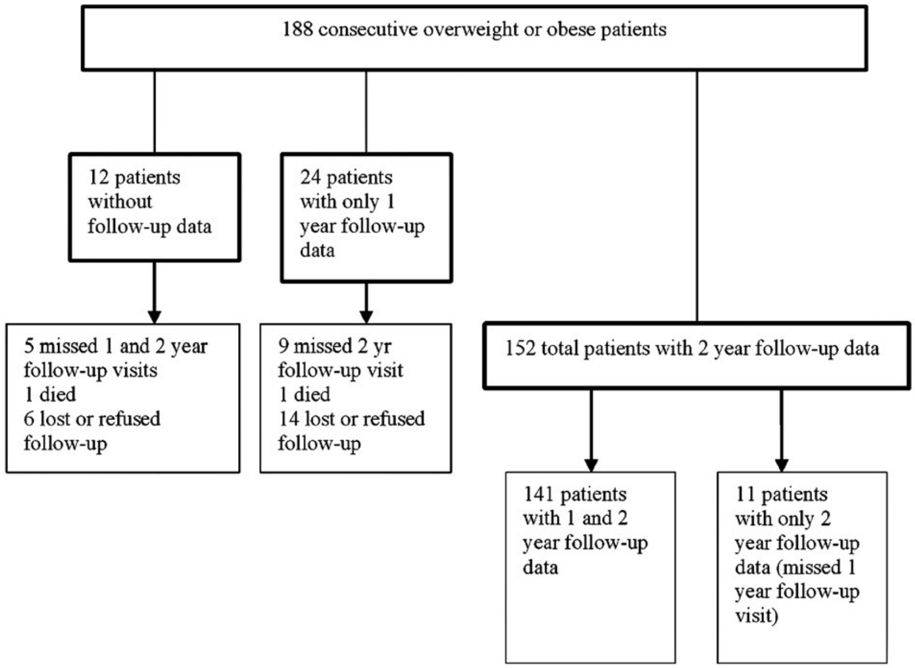

Fig. 2. Study flow chart.

only the data collected after the second operation were analyzed. All charts were reviewed, and data were collected by one investigator (A.L.). The research protocol was reviewed and approved by the university institutional review board.

Procedures and Data Collection

Patient height and weight, with clothing and shoes, were recorded preoperatively and at 1- and 2-year follow-up visits by 1 of 2 nursing personnel using a scale (Scale-tronix 6002; Scale-tronic, Wheaton, Ill) accurate to one tenth of a pound. Weight and height were converted to BMI defined by the ratio of body weight in kilograms divided by the height in meters squared (kg/m^2) [22]. Patients were classified by preoperative BMI as overweight (25.0-29.9 kg/m^2) or obese ($\geq$30.0 kg/m^2) [23].

Data on several patient characteristics and demographic variables were collected preoperatively, including age, sex, and orthopedic diagnosis. Preoperatively and at 1 and 2 years of follow-up, data were also collected on arthritic comorbidities and typical physical activity.

Comorbidities potentially affecting mobility were assessed preoperatively and at 1- and 2-year follow-up visits using the 3 patient classifications described by Charnley [24], which we modified for knees. Class A patients had unilateral knee arthroplasty and no other problems limiting ambulation. Class B patients had bilateral knee arthroplasty or unilateral knee arthroplasty and arthritis in the contralateral knee severe enough to limit ambulation. Class C patients had unilateral or bilateral knee arthroplasty and multiple arthritic problems or other conditions directly impeding ambulation, such as rheumatoid arthritis, neurologic conditions, or lumbosacral arthritis. Although the Charnley patient classification scheme has never been systematically validated, it has been used by convention for over 2 decades to describe ambulatory function in lower extremity arthroplasty patients. The classification scheme was originally designed for use with patients undergoing total hip arthroplasty but has been modified for use with knee arthroplasty patients [19,25-27].

Patient physical activity was assessed preoperatively and at 1- and 2-year follow-up visits with the Lower Extremity Activity Scale (LEAS) [28] used in the medical center since September 1998 (Fig. 1). The LEAS is a linear 12-item scale scored from 1 to 18 with a score of 1 describing the lowest activity and 18 the highest activity. This self-administered scale reflects an individual's typical daily activity, including frequency and intensity. The LEAS is well suited to measure activity change in total hip or knee arthroplasty patients because, although other commonly used activity instruments measure maximum capability, the LEAS describes actual

Table 1. Preoperative Patient Characteristics (n = 188)

	Mean (range)	%
Age (y)	70.9 (41-89)	
% Female		74
Weight (kg)	84.9 (54.4-117.0)	
Height (m)	1.66 (1.45-2.01)	
BMI (kg/m^2)	30.8 (25-42.1)	
BMI classification		
Overweight (25.0-29.9 kg/m^2)		53
Obese (≥30.0 kg/m^2)		47
LEAS score	7.9 (2-17)	
Charnley		
Class A		23
Class B		42
Class C		35
Staging		
Unilateral		65
One-stage bilateral		26.5
Staged bilateral		8.5
Diagnosis		
Osteoarthritis		85
Rheumatoid arthritis		5
Other		10

activity [28]. The validity and reliability of this instrument were assessed using pedometer readings, next-of-kin proxy measurements, and 2-week-retest scores in a population of volunteers that included 45 arthroplasty patients, 15 of whom underwent primary TKA [28,29]. In addition, the LEAS was validated in a consecutive series of 297 revision TKA patients by evaluating its correlation with Western Ontario and McMaster Universities Osteoarthritis Index scores [28].

Statistical Methods

Univariate statistics were used to describe the study variables and to examine the distribution of continuous variables for all patients. The preoperative characteristics of patients who were included in the analyses were compared with those of patients who had incomplete data at 1 or 2 years of follow-up using 2-sample *t* tests for continuous variables and Pearson χ^2 tests for categorical variables.

The percentages of patients who gained, lost, or had no change in weight from preoperative assessment to the 2-year follow-up were calculated. The US Food and Drug Administration considers a 5% reduction in weight to be a clinically significant weight loss [30]. Therefore, patients whose weight decreased by 5% or more were considered to have lost weight. Patients whose weight increased by 5% or more were considered to have gained weight, and all other patients were classified as having no significant weight change.

The mean change in weight, height, BMI, and LEAS score from preoperative to 1 and 2 years of follow-up was analyzed using a paired *t* test. We examined the mean changes for the entire sample as well as the subgroups when the sample was stratified by sex and by preoperative BMI as either overweight (25-29.9 kg/m^2) or obese (≥ 30 kg/m^2)

Bivariate analyses were performed to examine the associations between weight/BMI at 2 years and all the other study variables, to examine the unadjusted associations between preoperative LEAS score and patient characteristics, and to test for colinearity. The 2-sample *t* test was used for variables in 2 categories, one-way analysis of variance for variables with more than 2 categories and Pearson correlation for continuous variables. Analyses for BMI were repeated using the Wilcoxon rank sum test for variables in 2 categories, the Kruskal-Wallis test for variables with more than 2 categories and the Spearman correlation for continuous variables.

Multiple linear regression was used to examine the relationship between preoperative LEAS score and weight/BMI at 2-year follow-up. The primary outcomes, weight and BMI, were all treated as continuous variables. Preoperative LEAS score failed to meet the linearity assumption as a continuous variable, and scores were therefore divided into 4 categories: "minimally active" (score, 0-6), "somewhat active" (score, 7-8), "moderately active" (score, 9-11), and "extremely active" (score, 12-18). Preoperative weight/BMI, age, sex, and preoperative Charnley class were included in both regression models.

All *P* values were 2 sided, and $P < .05$ was considered statistically significant. Stata Statistical Software version 9.0 [31] (Stata Corp, College Station, Tex) was used for all analyses.

Results

Preoperative data were recorded for 188 overweight or obese patients (Fig. 2). Patients were then followed for a mean of 21 months. Data were

Table 2. Patient Weight Change at 2 Years Postoperatively*

	2 y postoperatively (n = 152)
% Lost weight	17
% No weight change	60
% Gained weight	23

* Weight change is ≥5% or ≤5% of weight from preoperatively.

Table 3. Comparison of Weight, BMI, and Activity for Patients With 2 Years of Follow-up

	n	Preoperatively	At 2 y	*P**
All patients				
Mean weight (kg)	152	85.5	85.4	.80
Mean height (cm)	152	166.4	165.1	<.001
Mean BMI (kg/m^2)	152	30.9	31.3	.049
Mean LEAS score (1-18)	92	8.0	9.9	<.001
Overweight patients				
Mean age (y), range	100	73.5,49–89		
Mean weight (kg)	78	78.0	78.1	.85
Mean height (cm)	78	167.5	165.6	<.001
Mean BMI (kg/m^2)	78	27.7	28.4	.008
Mean LEAS score (1-18)	42	7.9	9.7	<.001
Obese patients				
Mean age (y), range	88	68.0,41–52		
Mean weight (kg)	74	93.5	93.0	.67
Mean height (cm)	74	165.3	164.6	.05
Mean BMI (kg/m^2)	74	34.2	34.4	.63
Mean LEAS score (1-18)	50	8.0	9.9	<.001

* Significance test for comparisons based on the Paired *t* test.

available at 1 year of follow-up for 165 patients (87.8%): 12 patients had no follow-up data and 11 had only 2-year follow-up data. Data were available at 2 years for 152 patients (80.9%): 12 patients had no follow-up data and 24 had only 1 year of follow-up data. Lack of follow-up data was due to death, untimely follow-up, refusal to return for follow-up, or loss to follow-up. No significant differences were found in the characteristics of patients who were included in the analyses and those patients who lacked data at 1 or 2 years of follow-up.

Preoperatively, all patients were classified by BMI as either overweight or obese (Table 1). One hundred twenty-two (65%) patients had a unilateral arthroplasty, 50 (26.5%) had one-stage bilateral arthroplasty, and 16 (8.5%) had staged bilateral arthroplasty. One hundred forty patients (74%) were female and 48 (26%) were male. Their mean age was 71 years (range, 41-89). The preoperative orthopedic diagnosis was osteoarthritis in 160 patients (85%); rheumatoid arthritis in 10 (5%); psoriatic arthritis in 5 (3%); osteonecrosis in 4 (2%); traumatic arthritis in 4 (2%); and a variety of other diagnoses in 5 (3%). When the sample was stratified by sex, female patients had significantly lower weight ($P < .001$), greater BMI ($P = .03$), and lower physical activity ($P = .002$) preoperatively than did male patients. Males and females did not differ significantly on other preoperative characteristics (data not shown).

At 2-year follow-up, 17% of patients had lost ≥5% of body weight, 23% had gained ≥5% of body weight, and 60% showed <5% change in weight (Table 2). These percentages did not differ by sex or preoperative weight status (data not shown).

The mean postoperative weight loss at 2 years was 0.14 kg ($P = .80$), which was not significant (Table 3). Furthermore, at 2 years, mean BMI had increased by 0.46 kg/m^2, with borderline significance ($P = .049$). Among patients with only 1-year follow-up data, no significant weight or BMI changes were detected (data not shown). Interestingly, mean height also decreased significantly from preoperatively to 2 years ($P < .001$).

Mean changes were also examined with patients stratified by sex and by preoperative BMI. When patients were stratified by sex, no significant mean weight or BMI changes were detected (data not shown). When patients were stratified by preoperative BMI as overweight (25.0-29.9 kg/m^2) or obese (≥30 kg/m^2), no significant weight loss was found. Body mass index increased significantly among overweight patients but not among obese patients (Table 3).

Lower Extremity Activity Scale scores were available preoperatively and at both 1 and 2 years for 87 patients (46%), preoperatively and at 1 year for 116 patients (62%), and preoperatively and at 2 years for 92 patients (49%). The mean LEAS score increased significantly by 1.8 points ($P < .001$) from preoperative assessment to 2 years (Table 3). Significant changes in mean physical activity were also found among patients with only 1 year of follow-up, among both female and male patients (data not shown), and among both overweight and obese patients (Table 3).

Age and preoperative weight were positively correlated with postoperative weight ($P < .001$).

Table 4. Adjusted Comparisons Between Preoperative LEAS Score and 2-Year Weight (kg) and BMI (kg/m^2) (N = 109)

Preoperative LEAS score	Adjusted* mean 2-y weight	*P*	Adjusted** mean 2-y BMI	*P*
0-6, minimally active	86.8	.47	31.9	.51
7-8, somewhat active	87.3		32.2	
9-11, moderately active	84.5		30.9	
12-18, extremely active	89.2		32.1	

* Based on the predicted means from the multiple linear regression model, adjusted for preoperative weight, age, sex, and preoperative Charnley classification.

** Based on the predicted means from the multiple linear regression model, adjusted for preoperative BMI, age, sex, and preoperative Charnley classification.

Similarly, age and preoperative BMI were positively correlated with postoperative BMI ($P < .001$). Males were more likely to have higher weights after 2 years ($P < .001$). Females tended to have higher BMI after 2 years, but this was not statistically significant when BMI was assumed to have a nonparametric distribution ($P = .07$). Preoperative LEAS score was significantly higher among males than females ($P = .002$) and was positively correlated with LEAS at 1 and 2 years postoperatively ($P < .001$).

Multiple linear regression was used to examine the relationships between preoperative LEAS score and weight/BMI at 2 years, adjusted for covariates. The models included preoperative LEAS score in 4 categories (minimally active, somewhat active, moderately active, and extremely active patients), preoperative weight or BMI, age, sex, and preoperative Charnley classification as covariates. Preoperative LEAS score was not associated with weight or BMI at 2 years postoperatively (Table 4).

Discussion

Two years after primary TKA, this cohort of overweight and obese patients experienced no change in mean weight, but an increase in mean BMI, despite an apparent increase in physical activity. However, 17% of patients did lose a notable amount of weight 2 years after TKA (≥5% of body weight). It is not clear whether this is higher or lower than the percentage of all overweight or obese adults aged 41 to 89 years who experience weight loss over 2 years. Total knee arthroplasty may allow some overweight/obese patients to lose weight more easily than they would otherwise. However, this question is beyond the scope of our study.

Our results are similar to those found in previous studies of weight change among TKA patients. Neither Woodruff and Stone [18], following 68 knee patients, nor Heisel et al [19], examining 45 knee patients, found a significant change in mean weight. Similarly, Pritchett and Bortel [21] found that 45 morbidly obese women had no sustained weight loss after arthroplasty.

Unlike these previous studies of knee arthroplasty patients, however, we also examined change in BMI, and BMI increased, with borderline significance ($P = .049$). Often, studies of weight change among adults do not include BMI because adult height generally remains constant. However, decreasing height with age is well-documented [32], and we found that 74 (39%) of our patients lost at least 1.27 cm (0.5 in) of height over the 2-year period. Thus, the increase in BMI is likely to represent an artifact of height reduction rather than a true increase in adiposity.

We examined preoperative LEAS scores in an attempt to identify which patients were most likely to experience weight or BMI change 2 years after arthroplasty. However, preoperative LEAS score was not significantly associated with weight or BMI change at 2 years, and the relationship between weight and activity remains unclear. Elia et al [33,34] found no relationship between physical activity energy expenditure and BMI in subjects older than 65 years, and Saleh et al [28] noted that weight and BMI did not correlate well with average daily steps measured by a pedometer. In contrast, McClung et al [27] reported that lower activity measured by a pedometer was associated with a higher BMI among 209 individuals, including 151 hip or knee arthroplasty patients. Voorrips et al [35] found this same association among 50 elderly women. Although LEAS score is highly correlated with pedometer measurements [28], this disagreement may result from biases in the tools used to measure typical activity. The association between weight and activity may also vary among different populations, and more research is needed to clarify this relationship.

This study has several limitations. Although it was prospective, the case series design increased the potential for both confounding and selection bias. Furthermore, while we examined the relationship between preoperative LEAS score and weight at 2 years, Jain et al [20], who surveyed total hip arthroplasty patients about their weight postoperatively, reported that many factors influence postoperative weight change, including illness, change in diet, and enjoyment of food. Although we analyzed comorbidities limiting ambulation, using a modified Charnley classification, we did not identify all comorbidities that may have affected weight change in this sample.

In addition, only 81% of patients had weight/BMI data at 2 years, and only 49% of patients completed the LEAS both preoperatively and at 2 years. Although no significant differences in preoperative characteristics were detected between patients who were included and excluded in weight/BMI and LEAS analyses, unknown differences may have existed between the patients who returned for follow-up and those who were not interviewed at follow-up or between patients who completed the LEAS and those who failed to do so.

Nevertheless, the validity of the findings is strengthened by our large consecutive sample with a robust follow-up percentage. One surgeon interviewed and operated on all patients, and 2 trained personnel performed all weight and height measurements. Unlike previous studies, we limited our population to overweight and obese primary TKA patients and followed the patients until 2 years postoperatively. Finally, the characteristics of our population are comparable to those of most patients undergoing primary TKA in the United States [2].

The findings of this study have important implications for patient expectations and counseling before primary TKA. Although increased patient weight does not prevent a successful surgical outcome, overweight and obese patients should not expect TKA alone to result in weight loss.

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