Published in final edited form as:

JAMA. 2016 April 5; 315(13): 1362–1371. doi:10.1001/jama.2016.3010.

Change in Pain and Physical Function Following Bariatric Surgery for Severe Obesity

Wendy C. King, PhD, **Jia-Yuh Chen, MS**, **Steven H. Belle, PhD**, **Anita P. Courcoulas, MD, MPH**, **Gregory F. Dakin, MD**, **Katherine A. Elder, PhD**, **David R. Flum, MD, MPH**, **Marcelo W. Hinojosa, MD**, **James E. Mitchell, MD**, **Walter J. Pories, MD**, **Bruce M. Wolfe, MD**, and **Susan Z. Yanovski, MD**

University of Pittsburgh, Graduate School of Public Health, Pittsburgh, Pennsylvania (King, Chen, Belle); University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania (Courcoulas);Weill Cornell Medical Center, New York, New York (Dakin); Oregon Health and Science University, Portland (Elder, Wolfe); Now with Pacific University, Forest Grove, Oregon, and the Oregon Health and Science University, Portland (Elder); University of Washington, Seattle (Flum, Hinojosa); Neuropsychiatric Research Institute, Fargo, North Dakota (Mitchell); Brody School of Medicine, East Carolina University, Greenville, North Carolina (Pories); National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, Maryland (Yanovski).

Abstract

IMPORTANCE—The variability and durability of improvements in pain and physical function following Roux-en-Y gastric bypass (RYGB) or laparoscopic adjustable gastric banding (LAGB) are not well described.

OBJECTIVES—To report changes in pain and physical function in the first 3 years following bariatric surgery, and to identify factors associated with improvement.

Corresponding Author: Wendy C. King, PhD, Epidemiology Data Center, Room 105, 130 DeSoto St, University of Pittsburgh, Graduate School of Public Health, Pittsburgh, PA 15261 (kingw@edc.pitt.edu).

Author Video Interview and JAMA Report Video at jama.com

Supplemental content at jama.com

Author Contributions: Drs King and Chen had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: King, Mitchell, Pories, Wolfe.
Acquisition, analysis, or interpretation of data: All authors.
Drafting of the manuscript: King.
Critical revision of the manuscript for important intellectual content: King, Chen, Belle, Courcoulas, Dakin, Elder, Flum, Hinojosa, Mitchell, Pories, Wolfe, Yanovski.
Statistical analysis: King, Chen, Wolfe.
Obtained funding: Belle, Flum, Mitchell, Pories, Wolfe.
Administrative, technical, or material support: Belle, Courcoulas, Dakin, Flum, Wolfe.
Study supervision: Wolfe, Yanovski.

Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Dr Coucourlas reports receipt of research grants from Covidien, Ethicon, Nutrisystem, and PCORI; and consultant fees from Apollo Endosurgery. Dr Dakin reports receipt of consultant fees from Covidien. Dr Pories reports receipt of research grants from Johnson & Johnson Janssen Pharmaceuticals. Dr Wolfe reports receipt of consultant fees from EnteroMedics. Dr Flum reports having had an advisor role with Pacira Pharmaceuticals, providing expert testimony for Surgical Consulting LLC, and receiving travel expenses from PCORI. The other authors report no disclosures.

DESIGN, SETTING, AND PARTICIPANTS—The Longitudinal Assessment of Bariatric Surgery-2 is an observational cohort study at 10 US hospitals. Adults with severe obesity undergoing bariatric surgery were recruited between February 2005 and February 2009. Research assessments were conducted prior to surgery and annually thereafter. Three-year follow-up through October 2012 is reported.

EXPOSURES—Bariatric surgery as clinical care.

MAIN OUTCOMES AND MEASURES—Primary outcomes were clinically meaningful presurgery to postsurgery improvements in pain and function using scores from the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) (ie, improvement of ≥5 points on the norm-based score [range, 0–100]) and 400-meter walk time (ie, improvement of ≥24 seconds) using established thresholds. The secondary outcome was clinically meaningful improvement using the Western Ontario McMaster Osteoarthritis Index (ie, improvement of ≥9.7 pain points and ≥9.3 function points on the transformed score [range, 0–100]).

RESULTS—Of 2458 participants, 2221 completed baseline and follow-up assessments (1743 [78.5%] were women; median age was 47 years; median body mass index [BMI] was 45.9; 70.4% underwent RYGB; 25.0% underwent LAGB). At year 1, clinically meaningful improvements were shown in 57.6% (95% CI, 55.3%-59.9%) of participants for bodily pain, 76.5% (95% CI, 74.6%-78.5%) for physical function, and 59.5% (95% CI, 56.4%-62.7%) for walk time. Additionally, among participants with severe knee or disability (633), or hip pain or disability (500) at baseline, approximately three-fourths experienced joint-specific improvements in knee pain (77.1% [95% CI, 73.5%-80.7%]) and in hip function (79.2% [95% CI, 75.3%-83.1%]). Between year 1 and year 3, rates of improvement significantly decreased to 48.6% (95% CI, 46.0%-51.1%) for bodily pain and to 70.2% (95% CI, 678%-72.5%) for physical function, but improvement rates for walk time, knee and hip pain, and knee and hip function did not (*P* for all ≥. 05). Younger age, male sex, higher income, lower BMI, and fewer depressive symptoms presurgery; no diabetes and no venous edema with ulcerations postsurgery (either no history or remission); and presurgery-to-postsurgery reductions in weight and depressive symptoms were associated with presurgery-to-postsurgery improvements in multiple outcomes at years 1,2, and 3.

CONCLUSIONS AND RELEVANCE—Among a cohort of participants with severe obesity undergoing bariatric surgery, a large percentage experienced improvement, compared with baseline, in pain, physical function, and walk time over 3 years, but the percentage with improvement in pain and physical function decreased between year 1 and year 3.

TRIAL REGISTRATION—clinicaltrials.gov Identifier: NCT00465829

Severe obesity is associated with significant joint pain and impaired physical function (ability to bend, lift, carry, push, and walk).[1,2] Excess weight bearing can lead to joint damage and pain, resulting in activity restriction and walking limitations.[3] Obesity can also contribute to pain and physical limitations through factors such as impaired cardiorespiratory function,[4] systematic inflammation,[5] reduced flexibility of movement,[6] low strength per body mass,[5] and depression.[7]

Bariatric surgery is effective at achieving and maintaining weight loss, and inducing remission or reducing severity of many comorbidities such as type 2 diabetes mellitus,

hypertension, dyslipidemia, and depression.[8,9] Although evidence of improvements in pain and physical function following bariatric surgery is increasing, the variability and durability of improvement have not been well described—with most studies limited by small sample size and follow-up of 1 year or less or by the study of obsolete surgical procedures.[10–12]

This report examines pain and physical function outcomes in a large multisite cohort study with annual follow-up. The aim of the study was to evaluate changes in bodily and joint-specific pain and physical function, including perceived and objectively measured walking capacity in the first 3 years following bariatric surgery, and to identify factors associated with presurgery-to-postsurgery improvements.

Methods

Participants

The Longitudinal Assessment of Bariatric Surgery-2 (LABS-2) study is an observational study of 2458 adults who underwent an initial bariatric surgical procedure between March 14, 2006, and April 24, 2009, at 1 of 10 hospitals at 6 US clinical centers.[13,14] The institutional review boards at each center and the data coordinating center approved the protocol and all participants provided written informed consent.

LABS-2 had a target sample size of 2400 participants, based on anticipated loss to follow-up of 17% to 25% and the desire to detect small effect sizes for continuous outcomes (requires ≤1800 participants) and odds ratios (ORs) of at least 2.0 for categorical outcomes with 90% power (requires ≤2000 participants) for discrete outcomes in most circumstances.

Assessments were conducted by trained personnel within 30 days prior to scheduled surgery and annually following surgery. To be included, participants had to complete the baseline and at least 1 follow-up assessment within the first 3 post-surgery years (2221 participants; 91% with baseline data), with data collection ending October 2012 (Figure 1).

Measures

The Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) is a generic measure of functional health and wellbeing with proven validity, reliability, and sensitivity to change.[15] Two domain scores were examined: bodily pain, composed of 2 items that assess the magnitude of bodily pain and how much it interferes with activities; and physical function, composed of 10 items that assess whether health limits various activities. Norm-based methods were used to transform the scores to a mean (SD) of 50 (10) in the general US population.[16] Higher SF-36 scores indicate less pain or better function. An increase of at least 5 points represents a clinically important improvement.[17] The 3 items specific to walking limitations were also examined.

The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) measures symptoms of hip and knee osteoarthritis. It has demonstrated reliability and validity and is sensitive to preintervention-to-postintervention changes.[18] This analysis used 2 scores per joint: pain, composed of 5 items that assess pain level during various activities; and function, composed of 17 items that assess difficulty performing various activities. Scores were

transformed to a scale (0–100; lower scores indicate less pain and better function).[19] A decrease of at least 9.7 pain points and at least 9.3 function points represents a clinically important improvement.[20]

Participants reported history of back, hip, knee, and ankle surgery; use of pain medication (prescription or over-the-counter) for back, hip(s), knee(s), or ankle(s), in the past week; the effects and level of dissatisfaction or satisfaction with back or leg pain; use of a mobility aid; and severe walking limitation (inability to walk 61 m unaided).[13]

The 400-m Long-Distance Corridor Walk (LDCW) was used to objectively measure walking capacity.[21,22] To minimize risk, participants were instructed to walk the 400-m course at their usual pace and to wear a heart rate monitor. After completion, participants were asked if they experienced back, hip, knee, or foot pain during the LDCW. Testing could be terminated prior to completion for safety reasons. Participants were ineligible to attempt the LDCW if they had a contraindication to exertion, had any of several cardiovascular risk factors (eg, hospitalized for myocardial infarction, underwent angioplasty, or saw a clinician for new or worsening chest pain in the past 3 months), needed a mobility aid other than a straight cane, or reported feeling unsafe. Participants were categorized as having a mobility deficit if they met the LDCW exclusion criteria or stopping criteria or exceeded 7 minutes to walk 400 m (which equates to a cardiorespiratory fitness level of <12 mL oxygen/kg/min, the minimal level deemed necessary to safely cross a traffic intersection).[23] A decrease of at least 24 seconds indicates a substantial improvement.[24]

Heart rate, measured after a minimum of 5 minutes of seated rest, was used as a proxy for cardiovascular fitness.

Primary end points were clinically meaningful presurgery-to-postsurgery improvements in pain and function scores from the SF-36 Health Survey and 400-m walk time. Secondary end points were clinically meaningful improvements in the WOMAC and remission of mobility deficit.

Anthropometrics, Socio demographics, and Health Indicators—Anthropometric measurements followed standardized protocols.[8] Sociodemographics and smoking status were self-reported. Race was set to missing for participants who did not self-report as one or more of the following: white/Caucasian, black/African American, Asian, American Indian/Alaska Native, Native Hawaiian/other Pacific Islander. β-Blocker use was determined from the therapeutic class of self-reported prescribed medications. Diabetes and history of stroke, cardiovascular disease (CVD), asthma, sleep apnea, and venous edema with ulcerations were determined using laboratory values (eg, hemoglobin A_{1c}), physical examination measures (eg, blood pressure), patient-reported medication use, comorbidity diagnoses from clinicians, and medical records review using standard definitions.[14] Due to lack of sleep studies following surgery, only baseline sleep apnea status was used in this analysis. Depressive symptoms in the past week were assessed using the Beck Depression Inventory (BDI) version 1.[25] Higher BDI scores (range, 0–63) indicate greater depressive symptomatology.

Statistical Analysis

Analyses were conducted using SAS version 9.3. Potential selection bias was examined by comparing preoperative characteristics and presurgery-to-postsurgery percent weight loss of LABS-2 participants in the analysis sample (n = 2221) to those excluded (n = 237) using the Pearson χ^2 test for categorical variables and the Wilcoxon rank-sum test for continuous variables. Baseline characteristics were summarized with frequencies and percentages for categorical data and median plus interquartile (IQR) ranges for continuous data.

Longitudinal analyses was performed with mixed models (eAppendix 1 [Supplement]) using all available data, with control for age and site, which were associated with missing follow-up data (eTable 1 [Supplement]). Sensitivity analyses, performed to examine the robustness of results with respect to the missing at random assumption, indicated that missing follow-up data was not related to outcomes (eAppendices 1–2, eTable 1 [Supplement]).

Evaluating Change Over Time—Mixed models were used to estimate and test changes in pain and physical function over time. Poisson mixed models with robust error variance were used for binary measures (eg, mobility deficit); mixed-effects multinomial logistic regression models for nominal categorical measures (eg, LDCW status); mixed-effects ordinal logistic regression models for ordinal measures (eg, degree to which pain interfered with work); and linear mixed models for continuous measures (eg, SF-36 score). Analysis of WOMAC scores was limited to participants with symptoms indicative of osteoarthritis (severe or extreme rating on ≥1 item in the relevant joint [26]) at baseline. Analysis of pain during the LDCW excluded participants who did not start, and LDCW completion time excluded those who did not complete the LDCW. Analysis of heart rate excluded those who reported taking β-blockers. Pairwise comparisons were made between baseline and each follow-up and between years 1 and 3. The 4 comparisons were tested using the t statistic with *P* values adjusted to control for overall type I error (eAppendix 3 [Supplement]).[27]

The proportions of participants with clinically meaningful presurgery-to-postsurgery improvements based on SF-36 scores (among the total sample),WOMAC scores, and the LDCW time (among subgroups previously described) were calculated using established thresholds [17,20,24] with Poisson mixed models with robust error variance. An additional 12 to 23 patients whose baseline WOMAC scores did not meet the thresholds for clinically important improvement were excluded. Post-surgery remission of mobility deficit (among patients with a presurgery mobility deficit) was also calculated. Year-1 and year-3 proportions were compared using t statistic (eAppendix 4 [Supplement]).

Modeled percentages or means and 95% CIs, are reported. Summary statistics of observed data are reported online (eTables 2–3 [Supplement]).

Identifying Factors Related to Improvement—Poisson mixed models with robust error variance were used to identify factors related to clinically important presurgery-to-postsurgery improvements in SF-36 and WOMAC scores, LDCW time, and remission of mobility deficit in years 1, 2, and 3. Sex, race, baseline age, household income, body mass index (BMI; calculated as weight in kilograms divided by height in meters squared), depressive symptoms, surgical procedure, presurgery-to-postsurgery smoking status, change

in depressive symptoms, and percent weight change were included in all models as independent variables, with control for site. Baseline and presurgery-to-postsurgery change in bodily pain were also included as independent variables in models of physical function and LDCW outcomes. Baseline sleep apnea status, history of stroke, and postsurgery status of diabetes, asthma, venous edema with ulcerations, and CVD symptoms with consideration for baseline status (ie, current vs remitted/no symptoms in past 12 months, and no history) were also considered as independent variables and retained if statistically significant ($P < .05$). Adjusted relative risks (RRs), 95% CIs, and P values are reported. All reported P values are 2-sided; $P < .05$ was considered to be statistically significant.

Results

Participant Characteristics

This report includes 2221 of 2428 study participants (91%) with baseline data (Figure 1; Table 1). Pain and function data were obtained in 2042 (84%) participants at year 1, 1794 (74%) at year 2, and 1724 (72%) at year 3. Participants who were excluded (n = 237) vs included (n = 2221) from the analysis sample were younger (median age, 41 vs 47 years) and had a lower household income, a higher proportion of current smokers (22% vs 12%), and a lower proportion of sleep apnea (43% vs 54%) (P value for all <.05). There was also a significant difference in site representation between participants who were excluded vs included. There were no other statistically significant differences in baseline characteristics, or in percent of weight loss from baseline at year 1, year 2, or year 3, controlling for baseline characteristics that differed by group (P value for all ≥.05).

RYGB was the most common surgical procedure (70.4%); one-fourth (25.0%) of patients underwent LAGB; and less than 5% underwent another procedure (sleeve gastrectomy, banded gastric bypass, or biliopancreatic diversion with duodenal switch). Median (IQR) percentage weight loss of baseline weight at year 1 was 30.5% (21.3%-37.5%), at year 2 it was 30.5% (21.3%-38.5%), and at year 3 it was 28.2% (19.8%-36.4%) overall. Following RYGB, percentage weight loss at year 1 was 34.1% (28.7%-39.2%), at year 2 it was 34.1% (27.7%-40.3%), and at year 3 it was 31.5% (24.8%-8.4%). Following LAGB, percentage weight loss at 1 year was 14.0% (9.7%-19.7%), at year 2 it was 16.1% (9.4%-23.0%), and at year 3 it was 16.2% (8.1%-23.1%).

Presurgery-to-Postsurgery Change in Pain and Physical Function

Following surgery, SF-36 scores were significantly higher for bodily pain (baseline, 39.9 [95% CI, 39.5–40.3] to 44.8 [95% CI, 44.3–45.3] at year 3) and for physical function (baseline, 36.5 [95% CI, 36.1–37.0] to 47.8 [95% CI, 47.4–48.3] at year 3). WOMAC scores were significantly lower for knee pain (baseline, 46.5 [95% CI, 44.9–48.1] to 26.2 (95% CI, 24.1–28.2] at year 3), hip pain (baseline, 47.4 [95% CI, 45.6–49.2] to 25.7 [95% CI, 23.4–28.0] at year 3), knee function (baseline, 48.6 [95% CI, 47.2–50.0] to 24.6 [95% CI, 22.7–26.6] at year 3), and hip function (baseline, 46.7 [95% CI, 45.0–48.3] to 22.2 [95% CI, 20.0–24.4] at year 3), indicating improvements in the entire sample and specifically among participants with severe knee or hip pain or disability at baseline (Table 2). The degree to which back or leg pain interfered with work and level of dissatisfaction with current back or

leg pain symptoms also improved postsurgery (Figure 2; eTable 4 [Supplement]). Likewise, at follow-up, a smaller percentage of participants reported medication use for leg or back pain, leg or back pain during the LDCW, back or leg pain that prevented going to work or school, health limitations that impeded walking and mobility aid use, and were measured to have a mobility deficit, reflecting a higher percentage of participants able to complete the LDCW and faster LDCW completion time. Resting heart rate also improved (Table 2). In contrast, the prevalence of severe walking limitations at year 3 was not significantly different from baseline.

At year 1, the majority of participants had clinically meaningful presurgery-to-postsurgery improvements for bodily pain (57.6% [95% CI, 55.3%-59.9%]), physical function (76.5% [95% CI, 74.6%-78.5%]), and walk time (59.5% [95% CI, 56.4%-62.7%]). Additionally, the majority of participants with severe knee or hip pain or disability at baseline experienced joint-specific improvements (for knee pain, 77.1% [95% CI, 73.5%-80.7%]; hip pain, 74.1% [95% CI, 69.7%-78.4%]; hip physical function, 79.2% [95% CI, 75.3%-83.1%]), and the majority of participants with a mobility deficit at baseline experienced remission by year 1 (55.6% [95% CI, 52.0%-59.3%]) (Table 3).

Durability of Improvement

Rates of improvement in LDCW time, knee and hip pain, knee and hip function, and mobility deficit remission did not significantly differ between year 1 and year 3 (Table 3). However, by year 3, rates were significantly lower vs year 1 for bodily pain (48.6% [95% CI, 46.0%-51.1%]) and physical function (70.2% [95% CI, 67.8%-72.5%]) (Table 3). Likewise, the prevalence of medication use for pain, back pain during the LDCW, health limitations to walking, and mobility aid use postsurgery increased during follow-up (Table 2). Despite these postsurgery deteriorations in improvement, year-3 status was significantly better than baseline status.

Factors Related to Improvement in Pain, Walking Capacity, and Physical Function

Associations between sociodemographics and clinical characteristics with clinically meaningful improvements in bodily pain (SF-36 score), physical function (SF-36 score), walking capacity(LDCW completion time),and knee pain (WOMAC score) are shown in Table 4. Associations with additional clinically meaningful improvements in hip pain, knee function and hip function (WOMAC scores), and no longer having a mobility deficit are provided in eTable 5 (in the Supplement). Younger age, higher household income, and fewer depressive symptoms presurgery, greater presurgery-to-postsurgery percent weight loss, decline in depressive symptoms, and remission or no history of diabetes were associated with greater likelihood of clinically meaningful improvements in most measures of pain and physical function. Additionally, men, as compared with women, had greater likelihood of improvement in joint-specific and bodily pain, while lower BMI and less bodily pain presurgery, greater presurgery-to-postsurgery decline in bodily pain, and remission or no history of venous edema with ulcerations were associated with greater likelihood of improvement in multiple measures of physical function. More pain presurgery was associated with higher likelihood of improvement in pain, and worse function presurgery was associated with higher likelihood of improvement in function. Type of surgical

procedure (RYGB, LAGB, and other) was not related to any outcomes. The numbers of participants with clinically meaningful improvements by year, outcome, and categorical variables in Table 4 and eTable 5 (Supplement) are reported in eTable 6 and eTable7 (Supplement) .

Postsurgery Hip, Knee, Ankle, and Back Procedures

The incidence of past-year hip, knee, or ankle surgery in year 1 was 3.7% (95% CI, 2.9%-4.6%), for year 2 it was 4.9% (95% CI, 2.9%-4.6%), and for year 3 it was 4.6% (95% CI, 3.6%-5.6%); the majority of which were knee surgeries (eTable 8 [Supplement]). Past-year back surgery incidence ranged from a year-1 level of 1.5% (95% CI, 0.9%-2.0%) to a year-3 level of 2.3% (95% CI, 1.5%-3.1%).

Discussion

The primary findings of this study are that through 3 years of follow-up: (1) approximately 50% to 70% of adults with severe obesity who underwent bariatric surgery experienced clinically significant improvements in perceived bodily pain and physical function and in objectively measured walking capacity; and (2) approximately three-fourths of participants with severe knee and hip pain or disability at baseline experienced clinically significant improvements in symptoms indicative of osteoarthritis. Additionally, results of this study suggest that, while response to surgery was variable, there were several presurgery factors and postsurgery changes that were consistently associated with improvements in pain and physical function following bariatric surgery.

Changes in SF-36 and WOMAC pain scores observed in this study indicate that following bariatric surgery, the majority of patients initially experience clinically meaningful improvements in bodily and joint-specific pain, although the percentage with improvement in pain and function, as measured by the SF-36, decreased from year 1 to year 3. Additionally, the findings that following surgery, a smaller percentage of patients had back or leg pain that prevented them from going to work or school and that the degree to which back or leg pain interfered with work improved suggest that bariatric surgery may lead to improvements in work productivity and related costs. However, when considering the clinical implications of bariatric surgery on pain, it is important to note that bariatric surgery patients, as a group, continue to have more pain following surgery than the general US population, as indicated by the mean standardized SF-36 bodily pain score.[16] Additionally, at year 3, approximately 1 in 3 participants took pain medication within the prior week for back pain or leg pain and were dissatisfied with their level of back or leg pain.

This study revealed substantial improvements in joint-specific and general measures of function. The mean standardized SF-36 physical function score improved approximately 1 standard deviation following surgery, such that it was close to that of the general US population at year 3 (48 vs 50).[16] Improvements in resting heart rate and LDCW walking time and the related improvement (decrease) in the proportion of patients with an objectively defined mobility deficit are also noteworthy—as walking capacity is a strong predictor of incident mobility limitations and all-cause mortality. Still, at year 3, approximately one-fourth of patients self-reported limitations with walking several blocks and exhibited

evidence of an objectively measured mobility deficit, indicating that a sizable portion of postsurgery patients may have walking limitations that hinder ability to follow physical activity recommendations for weight loss maintenance.[28]

The findings from this study reinforce shorter-term results from studies that have reported significant improvements in SF-36 bodily pain and physical function scores,[29–32] WOMAC scores,[29,33,34] walking capacity (as measured by the LDCW or the 6-minute walk test),[30,31,35,36] resting heart rate,[35,36] or other measures of pain and function [10–12] in the first 3 to 12 months following RYGB or LAGB. Few studies have reported on pain and function from longer-term follow-up of these procedures. In a cross-sectional analysis, Sanchez-Santos et al [37] reported that a smaller percentage of adults at least 5 years after RYGB (22% [50]) had difficulty with mobility when compared with controls matched on presurgery characteristics (55%; $P < .01$). Likewise, Raoof et al [38] reported that mean (SD) scores for bodily pain and physical function on the SF-36 were better 12 (3) years post-RYGB when compared with those of morbidly obese controls who were awaiting surgery (matched on age and sex). Another study,[39] which provided follow-up for 145 LAGB patients for 3 to 8 years, reported that fewer patients had significant knee pain at follow-up vs baseline (38% vs 47%; $P < .01$). The authors speculated that the majority of patients may not have experienced a clinical improvement because of irreversible degenerative joint damage.

In the Swedish Obesity Study, which primarily studied vertical banded gastroplasty, a smaller percentage of male and female surgical patients reported pain in most body parts (neck, back, hip, knee, and ankle) 2 years following surgery vs non-surgical controls. However, most comparisons were not statistically significant at 6-year follow-up, despite substantial (albeit smaller) differences in 6-year weight change (mean difference >20 kg in both men and women).[40] Given that we detected deteriorations in some measures of pain and function between year 1 and year 3, evaluating longer-term follow-up will be important for elucidating the durability of surgery-induced improvements and examining how weight regain, which becomes common 2 or more years following RYGB and LAGB,[8] and other factors (such as physical activity participation) may explain deteriorations.

This study identifies several baseline characteristics such as younger age, higher household income, fewer depressive symptoms, and no history of diabetes related to improvements in pain and physical function following surgery, as well as presurgery-to-postsurgery changes associated with improvements in pain and function. Similar to 2 previous studies, degree of weight loss was consistently related to improvement,[29,40] while surgical procedure, independent of weight loss, was not. However, contrary to a previous study,[29] which did not find an association between resolution of comorbid medical conditions and improvements in SF-36 or WOMAC scores 6 to 12 months following RYGB (N = 48), our data suggest that change in several comorbidities was associated with changes in pain and function. Specifically, patients who had remission of diabetes, remission of venous edema with ulcerations, and no symptoms of cardiovascular disease in the past 12 months had greater improvements in either pain, function, or both than patients who continued to have each condition and/or symptoms, respectively. Also, improvement in depressive symptoms was related to 7 of 8 outcomes. Although this association may be bidirectional, the finding that having fewer presurgery depressive symptoms was associated with improvements in pain

suggests amelioration of depressive symptoms may contribute to postsurgery pain perception. Less bodily pain presurgery and presurgery-to-postsurgery decline in bodily pain were associated with improvements in physical function and walking capacity, after controlling for factors related to both pain and function. Thus, effective pain management may help postsurgical patients improve their physical function and walking capacity.

Limitations of this study include the lack of a nonsurgical control group, precluding us from establishing that surgery caused observed changes in pain and physical function. Additionally, we do not know whether knee or hip pain reflected osteoarthritis pain or widespread chronic pain, and we did not assess abdominal pain, which may affect perceived joint or bodily pain, or the number of years of obesity and severe obesity, which might affect likelihood of improvement. Missing follow-up data are also a concern because they can affect statistical power or bias the findings. However, the initial sample size and retention rate were adequate to ensure sufficient power for the analyses; all longitudinal analyses controlled for baseline factors (age and site) related to missing follow-up data; and the sensitivity analysis showed that those missing pain or function outcomes at 1, 2, or 3 years vs those not missing these data had similar improvement rates at the other follow-up time points, indicating the missing data have a minimal affect on the results. The current study's large geographically diverse sample, inclusion of multiple validated measures of pain and physical function, longitudinal design, and follow-up through 3 years make it one of the most informative studies of pain and function following RYGB and LAGB to date.

Conclusions

Among a cohort of patients with severe obesity undergoing bariatric surgery, a large percentage experienced improvement compared with baseline in pain, physical function, and walk time over 3 years. However, the percentage with improvement in pain and physical function decreased between year 1 and year 3 following surgery.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding/Support: LABS-2 was a cooperative agreement funded by the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). Grant numbers: Data Coordinating Center-U01 DK066557; Columbia University Medical Center-U01-DK66667 (in collaboration with Cornell University Medical Center CTRC, grant UL1-RR024996); University of Washington-U01-DK66568 (in collaboration with CTRC, grant M01RR-00037); Neuropsychiatric Research Institute-U01-DK66471; East Carolina University-U01-DK66526; University of Pittsburgh Medical Center-U01-DK66585 (in collaboration with CTRC, grant UL1-RR024153); Oregon Health & Science University-U01-DK66555.

Role of the Sponsor: The NIDDK scientists contributed to the design and conduct of the study, which included collection and management of data. The project scientist from the NIDDK served as a member of the steering committee, along with the principal investigator from each clinical site and the data coordinating center. The data coordinating center housed all data during the study and performed data analyses according to a prespecified plan developed by the data coordinating center biostatistician and approved by the steering committee and independent data and safety monitoring board. The decision to publish was made by the LABS-2 steering committee, with no restrictions imposed by the sponsor. As a coauthor, an NIDDK scientist contributed to the interpretation of the data and preparation, review, or approval of the manuscript.

REFERENCES

1. Garver MJ, Focht BC, Dials J, et al. Weight status and differences in mobility performance, pain symptoms, and physical activity in older, knee osteoarthritis patients. Arthritis. 2014:375909. [PubMed: 24963401]
2. Hergenroeder AL, Wert DM, Hile ES, Studenski SA, Brach JS. Association of body mass index with self-report and performance-based measures of balance and mobility. Phys Ther. 2011; 91(8):1223–1234. [PubMed: 21680770]
3. Hills AP, Hennig EM, Byrne NM, Steele JR. The biomechanics of adiposity—structural and functional limitations of obesity and implications for movement. Obes Rev. 2002; 3(1):35–43. [PubMed: 12119658]
4. Hulens M, Vansant G, Lysens R, Claessens AL, Muls E. Exercise capacity in lean versus obese women. Scand J Med Sci Sports. 2001; 11(5):305–309. [PubMed: 11696216]
5. Vincent HK, Heywood K, Connelly J, Hurley RW. Obesity and weight loss in the treatment and prevention of osteoarthritis. PMR. 2012; 4(5 suppl):S59–S67.
6. de Souza SA, Faintuch J, Valezi AC, et al. Gait cinematic analysis in morbidly obese patients. Obes Surg. 2005; 15(9):1238–1242. [PubMed: 16259878]
7. Zdziarski LA, Wasser JG, Vincent HK. Chronic pain management in the obese patient. J Pain Res. 2015; 8:63–77. [PubMed: 25709495]
8. Courcoulas AP, Christian NJ, Belle SH, et al. Longitudinal Assessment of Bariatric Surgery (LABS) Consortium. Weight change and health outcomes at 3 years after bariatric surgery among individuals with severe obesity. JAMA. 2013; 310(22):2416–2425. [PubMed: 24189773]
9. Mitchell JE, King WC, Chen JY, et al. Course of depressive symptoms and treatment in the longitudinal assessment of bariatric surgery (LABS-2) study. Obesity (Silver Spring). 2014; 22(8): 1799–1806. [PubMed: 24634371]
10. Steele T, Cuthbertson DJ, Wilding JP. Impact of bariatric surgery on physical functioning in obese adults. Obes Rev. 2015; 16(3):248–258. [PubMed: 25580667]
11. Speck RM, Bond DS, Sarwer DB, Farrar JT. A systematic review of musculoskeletal pain among bariatric surgery patients. Surg Obes Relat Dis. 2014; 10(1):161–170. [PubMed: 24182448]
12. Gill RS, Al-Adra DP, Shi X, et al. The benefits of bariatric surgery in obese patients with hip and knee osteoarthritis. Obes Rev. 2011; 12(12):1083–1089. [PubMed: 21883871]
13. Belle SH, Berk PD, Courcoulas AP, et al. Longitudinal Assessment of Bariatric Surgery Consortium Writing. Group Safety and efficacy of bariatric surgery. Surg Obes Relat Dis. 2007; 3(2):116–126. [PubMed: 17386392]
14. Belle SH, Berk PD, Chapman WH, et al. LABS Consortium. Baseline characteristics of participants in the Longitudinal Assessment of Bariatric Surgery-2 (LABS-2) study. Surg Obes Relat Dis. 2013; 9(6):926–935. [PubMed: 23602493]
15. Frendl DM, Ware JE Jr. Patient-reported functional health and well-being outcomes with drug therapy. Med Care. 2014; 52(5):439–445. [PubMed: 24714581]
16. Ware, JE., Jr; Kosinski, M.; Keller, SK. SF-36 Physical and Mental Health Summary Scales: A User's Manual. Boston, MA: The Health Institute; 1994.
17. Norman GR, Sloan JA, Wyrwich KW. Interpretation of changes in health-related quality of life. Med Care. 2003; 41(5):582–592. [PubMed: 12719681]
18. McConnell S, Kolopack P, Davis AM. The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC): a review of its utility and measurement properties. Arthritis Rheum. 2001; 45(5):453–461. [PubMed: 11642645]
19. Bellamy N. The WOMAC Knee and Hip Osteoarthritis Indices: development, validation, globalization and influence on the development of the AUSCAN Hand Osteoarthritis Indices. Clin Exp Rheumatol. 2005; 23(5)(suppl 39):S148–S153. [PubMed: 16273799]
20. Ehrich EW, Davies GM, Watson DJ, et al. Minimal perceptible clinical improvement with the Western Ontario and McMaster Universities osteoarthritis index questionnaire and global assessments in patients with osteoarthritis. J Rheumatol. 2000; 27(11):2635–2641. [PubMed: 11093446]

21. Lange-Maia BS, Newman AB, Strotmeyer ES, Harris TB, Caserotti P, Glynn NW. Performance on fast- and usual-paced 400-m walk tests in older adults. Aging Clin Exp Res. 2015; 27(3):309–314. [PubMed: 25373610]
22. Rolland YM, Cesari M, Miller ME, et al. Reliability of the 400-m usual-pace walk test as an assessment of mobility limitation in older adults. J Am Geriatr Soc. 2004; 52(6):972–976. [PubMed: 15161464]
23. Simonsick EM, Newman AB, Visser M, et al. Health, Aging and Body Composition Study. Mobility limitation in self-described well-functioning older adults. J Gerontol A Biol Sci Med Sci. 2008; 63(8):841–847. [PubMed: 18772472]
24. Perera S, Studenski S, Newman A, et al. Health ABC Study. Are estimates of meaningful decline in mobility performance consistent among clinically important subgroups? J Gerontol A Biol Sci Med Sci. 2014; 69(10):1260–1268. [PubMed: 24615070]
25. Beck AT, Steer RA, Garbin MG. Psychometric properties of the Beck Depression Inventory. Clin Psychol Rev. 1998; 8:77–100.
26. Jinks C, Jordan K, Croft P. Measuring the population impact of knee pain and disability with the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). Pain. 2002; 100(1–2):55–64. [PubMed: 12435459]
27. Edwards D, Berry JJ. The efficiency of simulation-based multiple comparisons. Biometrics. 1987; 43(4):913–928. [PubMed: 3427176]
28. King WC, Bond DS. The importance of pre and postoperative physical activity counseling in bariatric surgery. Exerc Sport Sci Rev. 2012; 41(1):26–35. [PubMed: 22710705]
29. Hooper MM, Stellato TA, Hallowell PT, et al. Musculoskeletal findings in obese subjects before and after weight loss following bariatric surgery. Int J Obes (Lond). 2007; 31(1):114–120. [PubMed: 16652131]
30. Josbeno DA, Jakicic JM, Hergenroeder A, Eid GM. Physical activity and physical function changes in obese individuals after gastric bypass surgery. Surg Obes Relat Dis. 2010; 6(4):361–366. [PubMed: 18996771]
31. Tompkins J, Bosch PR, Chenowith R, Tiede JL, Swain JM. Changes in functional walking distance and health-related quality of life after gastric bypass surgery. Phys Ther. 2008; 88(8):928–935. [PubMed: 18583427]
32. Vincent HK, Ben-David K, Conrad BP, et al. Rapid changes in gait, musculoskeletal pain, and quality of life after bariatric surgery. Surg Obes Relat Dis. 2012; 8(3):346–354. [PubMed: 22336495]
33. Edwards C, Rogers A, Lynch S, et al. The effects of bariatric surgery weight loss on knee pain in patients with osteoarthritis of the knee. Arthritis. 2012:504189. [PubMed: 23243506]
34. Richette P, Poitou C, Garnero P, et al. Benefits of massive weight loss on symptoms, systemic inflammation and cartilage turnover in obese patients with knee osteoarthritis. Ann Rheum Dis. 2011; 70(1):139–144. [PubMed: 20980288]
35. de Souza SA, Faintuch J, Fabris SM, et al. Six-minute walk test: functional capacity of severely obese before and after bariatric surgery. Surg Obes Relat Dis. 2009; 5(5):540–543. [PubMed: 19656738]
36. Maniscalco M, Zedda A, Giardiello C, et al. Effect of bariatric surgery on the six-minute walk test in severe uncomplicated obesity. Obes Surg. 2006; 16(7):836–841. [PubMed: 16839479]
37. Sanchez-Santos R, Del Barrio MJ, Gonzalez C, et al. Long-term health-related quality of life following gastric bypass: influence of depression. Obes Surg. 2006; 16(5):580–585. [PubMed: 16687025]
38. Raoof M, Näslund I, Rask E, et al. Health-Related Quality-of-Life (HRQoL) on an average of 12 years after gastric bypass surgery. Obes Surg. 2015; 25(7):1119–1127. [PubMed: 25566743]
39. Korenkov M, Shah S, Sauerland S, et al. Impact of laparoscopic adjustable gastric banding on obesity co-morbidities in the medium- and long-term. Obes Surg. 2007; 17(5):679–683. [PubMed: 17658030]
40. Peltonen M, Lindroos AK, Torgerson JS. Musculoskeletal pain in the obese: a comparison with a general population and long-term changes after conventional and surgical obesity treatment. Pain. 2003; 104(3):549–557. [PubMed: 12927627]

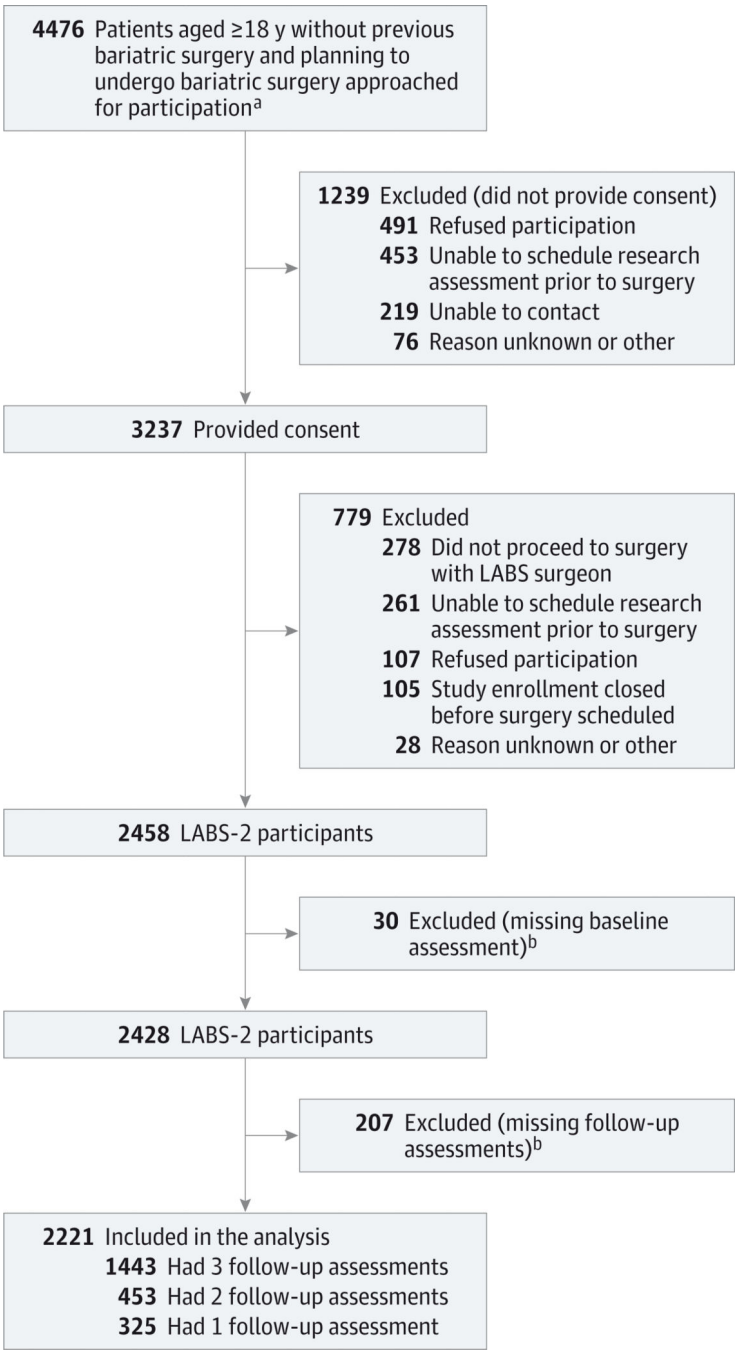

Figure 1. Longitudinal Assessment of Bariatric Surgery-2 (LABS-2) Study Flow From Approached Patients to Analysis Sample

[a] The number of patients initially screened for eligibility was not recorded. [b] Indicates that all pain and function measures may not have been completed.

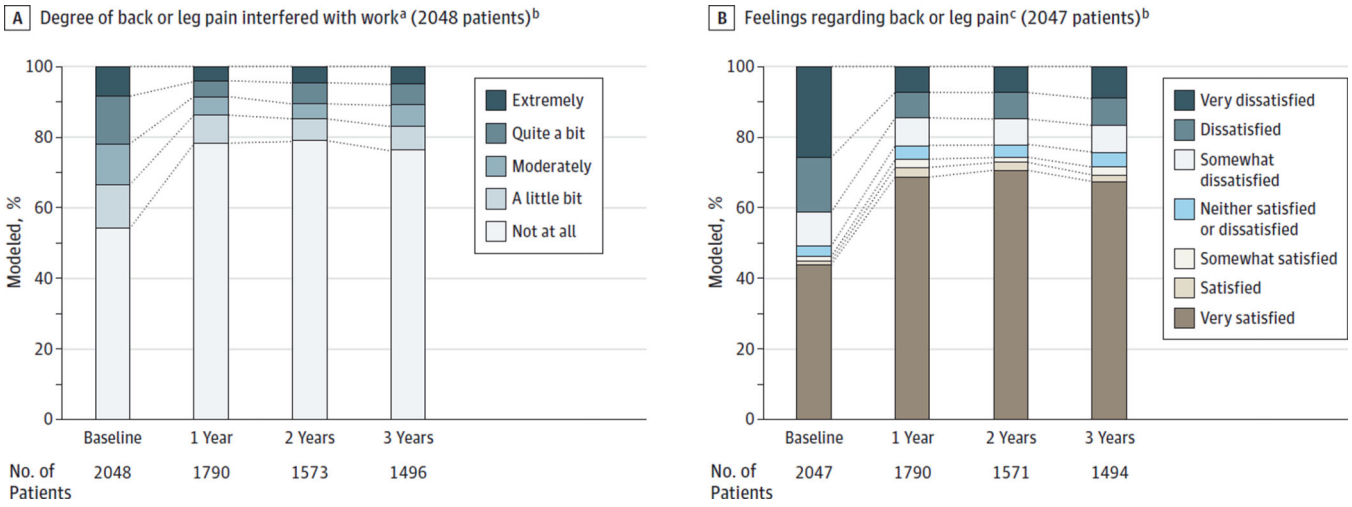

Figure 2. Back and Leg Pain Before and After Bariatric Surgery

Observed data are reported in eTable 2.

[a] Patients were asked, “In the past 4 weeks, how much did pain interfere with your normal work, including both work outside the home and house work?” Those who reported having no back or leg pain to the preceding question were grouped with those reporting “not at all.”

[b] Sample size of model. Modeled data, adjusted for age and site are shown.

[c] Patients were asked, “If you had to spend the rest of your life with the symptoms you have right now, how would you feel about it?” Those who reported no back or leg pain to the preceding question were grouped with those reporting “very satisfied.”

Table 1

Demographic and Clinical Characteristics of Adults Prior to Bariatric Surgery (N = 2221)[a]

Characteristic	No. (%)[b]
Women	1743 (78.5)
Age, y	
Median (IQR)	47 (37–55)
Range	18–78
Race	(n = 2199)
White	1903 (86.5)
Black	232 (10.6)
Other[c]	64 (2.9)
Hispanic/Latino ethnicity, No./total (%)	104/2219 (4.7)
Household income, US $	(n = 2039)
<25 000	369 (18.1)
25 000–49 000	526 (25.8)
50 000–74 999	469 (23.0)
75 000–99 999	333 (16.3)
≥100 000	342 (16.8)
Weight, kg	
Median (IQR)	128.6 (115.0–147.3)
Range	75.0–289.5
Body mass index[d]	
Median (IQR)	45.9 (41.7–51.4)
Range	33.0–94.3
Current or recent smoker, No./total (%)	273/2217 (12.3)
Beck Depression Inventory score[e]	(n = 2078)
Median (IQR)	6 (3–11)
Range	0–44
Comorbidity, No./total (%)	
Cardiovascular disease	170/2182 (7.8)
Stroke	22/2219 (1.0)
Diabetes	708/2106 (33.6)
Sleep apnea	1188/2220 (53.5)
Asthma	554/2175 (25.5)
Venous edema with ulcerations	161/2220 (7.3)
Functional status, No./total (%)	
Severe or extreme knee pain or function	633/1685 (37.6)
Severe or extreme hip pain or function	500/1684 (29.7)
Completed the LDCW	1481/2089 (70.9)

Characteristic	No. (%)[b]
Mobility disability	836/2089 (42.7)
History of back surgery	178/2073 (8.6)
History of hip, knee, or ankle surgery	526/2072 (25.4)
Hip surgery	69/2069 (3.3)
Knee surgery	425/2072 (20.5)
Ankle surgery	126/2072 (6.1)

Abbreviations: IQR, interquartile range; LDCW, Long-Distance Corridor Walk.

[a] Denominators shift between variables because of missing data.

[b] Data are reported as No. (%) unless otherwise indicated.

[c] Combined due to small numbers: Asian, American Indian/Alaska Native, Native Hawaiian/other Pacific Islander, multiple races.

[d] Calculated as weight in kilograms divided by height in meters squared.

[e] Score ranges from 0 to 63, with a higher score indicating greater severity.

JAMA. Author manuscript; available in PMC 2016 October 05.

Table 2

Pain and Physical Function Before and After Bariatric Surgery

	Model-Based Estimates[a]								Adjusted *P* Value[b]			
	Baseline		Year 1		Year 2		Year 3		Baseline vs Year			Year 1 vs Year 3
	No.	Estimate	No.	Estimate	No.	Estimate	No.	Estimate	1	2	3	
SF-36 Scores, Mean (95% CI)[c]												
Bodily pain	2093	39.9 (39.5–40.3)	1839	47.3 (46.9–47.8)	1646	46.1 (45.6–46.7)	1553	44.8 (44.3–45.3)	<.001	<.001	<.001	<.001
Physical function	2094	36.5 (36.1–37.0)	1841	49.2 (48.8–49.6)	1649	48.8 (48.3–49.2)	1565	47.8 (47.4–48.3)	<.001	<.001	<.001	.06
Objective Walking Test												
LDCW status, % (95% CI)	2089		1754		1450		1390					
Ineligible		18.8 (17–20.6)		14.5 (12.7–16.3)		17.6 (15.4–19.8)		14.9 (12.8–16.9)	<.001	.03	<.001	.99
Refused		5.4 (4.4–6.3)		4.5 (3.6–5.5)		3.8 (2.8–4.7)		4.3 (3.3–5.4)				
Stopped		3.0 (2.3–3.7)		0.6 (0.2–0.9)		0.5 (0.1–0.8)		0.5 (0.2–0.9)				
Completed 400 m		72.9 (70.6–75.1)		80.4 (78.3–82.5)		78.1 (75.7–80.6)		80.3 (78.0–82.7)				
Time to complete walk, mean (95% CI), s[d]	1205	381.6 (378.0–385.2)	911	344.5 (341.3–347.6)	722	337.5 (334.2–340.8)	674	340.4 (337.0–343.7)	<.001	<.001	<.001	.07
Mobility deficit, % (95% CI)	2089	43.7 (41.5–45.8)	1754	26.3 (24.3–28.3)	1450	27.3 (25.1–29.5)	1390	26.0 (23.8–28.3)	<.001	<.001	<.001	.99
WOMAC Scores, Mean (95% CI)[e]												
Knee pain[f]	629	46.5 (44.9–48.1)	496	25.0 (23.1–26.9)	488	25.1 (23.1–27.1)	452	26.2 (24.1–28.2)	<.001	<.001	<.001	.66

	Model-Based Estimates[a]								Adjusted *P*Value[b]			
	Baseline		Year 1		Year 2		Year 3		Baseline vs Year			Year 1 vs Year 3
	No.	Estimate	No.	Estimate	No.	Estimate	No.	Estimate	1	2	3	
Hip pain[g]	499	47.4 (45.6–49.2)	399	25.0 (22.8–27.3)	389	24.8 (22.5–27.2)	358	25.7 (23.4–28.0)	<.001	<.001	<.001	.92
Knee physical function[h]	627	48.6 (47.2–50.0)	489	23.8 (21.9–25.6)	483	22.9 (21.0–24.7)	447	24.6 (22.7–26.6)	<.001	<.001	<.001	.78
Hip physical function[i]	493	46.7 (45.0–48.3)	396	21.2 (19.2–23.2)	387	21.4 (19.2–23.7)	356	22.2 (20.0–24.4)	<.001	<.001	<.001	.71
Pain Medication, % (95% CI)												
For leg pain, past week	2040	38.2 (36.1–40.2)	1860	25.3 (23.4–27.1)	1614	27.1 (25.1–29.1)	1544	29.4 (27.3–31.5)	<.001	<.001	<.001	<.001
For back pain, past week	2067	34.5 (32.5–36.5)	1890	28.0 (26.1–30.0)	1663	28.0 (26.0–30.0)		31.0 (28.9–33.1)	<.001	<.001	.03	.03
Back or Leg Pain, % (95% CI)												
Could not go to work or school (back or leg pain), past 4 weeks	1762	7.7 (6.5–8.9)	1615	3.8 (2.9–4.7)	1397	4.1 (3.1–5.0)	1314	4.2 (3.1–5.3)	<.001	<.001	<.001	.92
Leg pain during LDCW[j]	1168	39.9 (37.2–42.6)	1006	15.4 (13.2–17.5)	792	15.3 (13.0–17.6)	750	18.7 (16.0–21.3)	<.001	<.001	<.001	.09
Back pain during LDCW[j]	1168	15.9 (13.9–17.9)	1005	4.5 (3.3–5.7)	792	4.5 (3.2–5.8)	750	7.5 (5.7–9.3)	<.001	<.001	<.001	<.01
Self-Reported Walking, % (95% CI)												
Severe walking limitation	2044	7.1 (6.1–8.2)	1731	4.9 (4.0–5.9)	1524	5.1 (4.1–6.0)	1471	5.8 (4.7–6.8)	<.001	<.001	.07	.28
Mobility aid use	2045	14.7 (13.3–16.1)	1750	9.8 (8.5–11.0)	1473	10.9 (9.5–12.3)	1321	12.3 (10.8–13.9)	<.001	<.001	.01	<.01
Health Limits Ability to												
Walk 1 block	2077	38.4 (36.3–40.4)	1828	10.1 (8.8–11.4)	1625	11.8 (10.3–13.2)	1544	13.6 (12.0–15.2)	<.001	<.001	<.001	<.001

JAMA. Author manuscript; available in PMC 2016 October 05.

	Model-Based Estimates[a]								Adjusted *P*Value[b]			
	Baseline		Year 1		Year 2		Year 3		Baseline vs Year			Year 1 vs Year 3
	No.	Estimate	No.	Estimate	No.	Estimate	No.	Estimate	1	2	3	
Walk several blocks	2089	63.5 (61.5–65.5)	1833	18.7 (17.0–20.4)	1631	20.4 (18.6–22.2)	1544	23.5 (21.5–25.4)	<.001	<.001	<.001	<.001
Walk >1 mile	2083	80.0 (78.3–81.7)	1830	30.2 (28.2–32.2)	1630	30.4 (28.4–32.5)	1544	34.2 (32.0–36.4)	<.001	<.001	<.001	<.01
Fitness Proxy, Mean (95% CI)												
Resting heart rate, beats/min[k]	1683	79.2 (78.6–79.7)	1506	69.3 (68.7–69.8)	1338	70.1 (69.5–70.8)	1266	71.2 (70.5–71.8)	<.001	<.001	<.001	<.001

Abbreviations: LDCW, Long-Distance Corridor Walk; SF-36, Medical Outcomes Study Short-Form 36 Health Survey; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

[a] Adjusted for site and age (see observed data in eTable 2 [Supplement]).

[b] *P* values were adjusted using simulation.

[c] Norm-based methods were used to transform scores (mean [SD], 50 [10]) in the general US population. Higher scores indicate less pain or better function.

[d] N = 1205; excludes 276 of 1481 who did not complete the LDCW at baseline due to ineligibility, refusal, or meeting LDCW stopping criteria LDCW at ≥1 follow-up.

[e] Lower scores indicate less pain and better function on a 0- to 100-point scale.

[f] Excludes 4 of 633 due to missing baseline knee pain score.

[g] Excludes 1 of 500 due to missing baseline hip pain score.

[h] Excludes 6 of 633 due to missing baseline knee function score.

[i] Excludes 7 of 500 due to missing baseline hip function score.

[j] N = 1168; excludes participants who missed LDCW (n = 132), were ineligible or refused LDCW(n = 540), or did not answer pain questions following LDCW (n = 85) at baseline, or at ≥1 follow-up (n = 296).

[k] N = 1683; excludes 538 taking β-blockers at ≥ 1 follow-up.

Table 3

Proportion of Patients With Clinically Important Improvements in Pain and Physical Function Following Bariatric Surgery

		Model-Based Estimates, % (95% CI)[a]						P Value
		Year 1		Year 2		Year 3		
	No.[b]	No.	Estimate	No.	Estimate	No.	Estimate	Year 1 vs Year 3
SF-36: minimal clinically important improvement[c]								
Bodily pain	2093	1755	57.6 (55.3–59.9)	1576	53.5 (51.0–56.0)	1487	48.6 (46.0–51.1)	<.001
Physical function	2094	1760	76.5 (74.6–78.5)	1578	74.2 (72.0–76.4)	1502	70.2 (67.8–72.5)	<.001
LDCW time: substantial improvement[d]	1205	911	59.5 (56.4–62.7)	722	63.0 (59.6–66.5)	674	60.1 (56.5–63.7)	.77
WOMAC: minimal perceptible clinical improvement								
Knee pain[e]	614	481	77.1 (73.5–80.7)	471	73.6 (69.6–77.5)	437	73.4 (69.3–77.5)	.11
Hip pain[e]	477	381	74.1 (69.8–78.4)	371	74.0 (69.7–78.4)	341	73.6 (69.0–78.2)	.88
Knee physical function[f]	621	479	78.6 (75.1–81.1)	476	78.7 (75.1–82.4)	439	74.8 (70.8–78.8)	.12
Hip physical function[f]	485	384	79.2 (75.3–83.1)	375	79.9 (75.9–83.9)	344	78.5 (74.2–82.7)	.77
Mobility deficit: remission	836	650	55.6 (52.0–59.3)	542	55.8 (51.9–59.8)	499	56.5 (52.5–60.5)	.68

Abbreviations: LDCW, Long-Distance Corridor Walk; SF-36, Medical Outcomes Study Short-Form 36 Health Survey; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

[a] All models were adjusted for site and age. Observed data are reported in eTable 3 (Supplement).

[b] Improvement in bodily pain and physical function was evaluated among the entire cohort; LDCW time improvement was evaluated among participants who were not ineligible, refused participation, or noncompleters at any time point; improvement in knee or hip pain and function was evaluated among those with severe pain or disability at baseline; remission of mobility deficit was evaluated among those with a mobility deficit at baseline.

[c] Scores indicate improvement (increase) ≥5 points on the norm-based scores.

[d] Scores indicate improvement (decrease) of at least 24 seconds.

[e] Scores indicate improvement (decrease) of at least 9.7 pain points. Fifteen of 629 patients with severe or extreme knee pain or disability at baseline and 22 of 499 patients with severe or extreme hip pain or disability at baseline were excluded from analysis because their baseline score was less than 9.7 points.

[f] Scores indicate reduction of at least 9.3 function points. Six of 627 patients with severe or extreme knee pain or disability at baseline and 8 of 493 patients with severe or extreme hip pain or disability at baseline were excluded from analysis because their baseline score was below 9.3 points.

Table 4

Associations With Clinically Meaningful Presurgery-to-Postsurgery Improvements in Bodily Pain, Physical Function, Walking Capacity, and Knee Pain in Years 1, 2, and 3 Following Bariatric Surgery[a]

	Clinically Meaningful Improvement							
	Bodily Pain (n = 1245)[b]		Physical Function (n = 1470)[b]		LDWC Completion Time (n = 821)[c]		Knee Pain (n = 490)[d]	
	ARR (95%CI)	*P* Value	ARR (95%CI)	*P* Value	ARR (95%CI)	*P* Value	ARR (95%CI)	*P* Value
Presurgery								
Age, per 10 y younger	1.05 (1.01–1.10)	.03	1.05 (1.02–1.08)	<.001	1.02 (0.97–1.07)	.39	1.09 (1.05–1.14)	<.001
Men (vs women)	1.16 (1.05–1.28)	<.01	1.02 (0.96–1.09)	.52	1.08 (0.98–1.20)	.14	1.10 (1.01–1.20)	.03
Race (vs black)								
White	1.00 (0.82–1.23)	.77	1.03 (0.91–1.15)	.90	1.10 (0.87–1.39)	.48	1.19 (0.98–1.44)	<.01
Other	1.10 (0.80–1.52)		1.04 (0.83–1.30)		0.93 (0.63–1.40)		1.47 (1.15–1.89)	
Annual household income, $ (vs <25 000)								
25000-<50000	1.23 (1.07–1.41)	<.01	1.09 (1.00–1.19)	<.01	0.96 (0.83–1.12)	.04[e]	1.18 (1.02–1.35)	<.01
≥50 000	1.25 (1.09–1.43)		1.14 (1.05–1.24)		1.10 (0.95–1.27)		1.25 (1.09–1.43)	
BMI, per 10 kg[f]	1.05 (0.98–1.11)	.14	1.04 (1.01–1.08)	.02	1.04 (0.96–1.12)	.32	1.04 (0.99–1.10)	.10
Fewer depressive symptoms, per 10 BDI points	1.61 (1.43–1.81)	<.001	1.05 (0.99–1.11)	.09	1.07 (0.97–1.18)	.15	1.21 (1.09–1.34)	<.001
Less bodily pain, per 10 SF-36 points	NA		1.13 (1.08–1.17)	<.0001	0.96 (0.90–1.02)	.22	NA	
Worse value of the outcome, per 10 points	1.45 (1.38–1.52)	<.001	1.28 (1.24–1.33)	<.001	1.04 (1.03–1.05)	<.001	1.06 (1.04–1.08)	<.001
Presurgery-to-Postsurgery Improvement								
Decrease in depressive symptoms, per −10 BDI points	1.69 (1.49–1.91)	<.001	1.14 (1.08–1.20)	<.001	1.00 (0.91–1.10)	.98	1.27 (1.16–1.40)	<.001
Decrease in bodily pain, per 10 SF-36 points	NA		1.18 (1.15–1.21)	<.001	1.04 (0.99–1.09)	.07	NA	
Weight loss, per 5%	1.05 (1.02–1.07)	<.001	1.01 (1.00–1.03)	.06	1.06 (1.03–1.09)	<.001	1.04 (1.02–1.06)	<.001
Presurgery-to-Postsurgery Comorbidity Status								
Cardiovascular disease (vs current symptoms)								

	Clinically Meaningful Improvement							
	Bodily Pain (n = 1245)[b]		Physical Function (n = 1470)[b]		LDWC Completion Time (n = 821)[c]		Knee Pain (n = 490)[d]	
	ARR (95%CI)	*P* Value	ARR (95%CI)	*P* Value	ARR (95%CI)	*P* Value	ARR (95%CI)	*P* Value
No history	2.16 (1.46–3.20)	<.001		[g]		[g]		[g]
History, no symptoms Past 12 mo	1.82 (1.20–2.76)							
Diabetes (vs current symptoms)								
No history	1.31 (1.13–1.53)	<.01	1.15 (1.04–1.26)	.01		[g]		[g]
Remitted	1.17 (0.99–1.38)		1.15 (1.04–1.27)					
Venous edema with ulcerations (vs current symptoms)								
No history		[g]	1.22 (1.04–1.43)	.046	1.22 (0.88–1.69)	.049		[g]
Remitted			1.21 (1.02–1.44)		1.46 (1.02–2.07)			

Abbreviations: ARR, adjusted relative risk; BDI, Beck Depression Inventory; BMI, body mass index; NA, not applicable; SF-36, Medical Outcomes Study Short-Form 36 Health Survey.

[a] All 4 models controlled for site. Models also controlled for surgical procedure and presurgery and postsurgery smoking status, which were forced in the models but were not significantly associated with any of the outcomes. Observed data are reported in eTable 6 (Supplement).

[b] Values indicate minimal clinically important improvement (increase of ≥5 points) on norm-based SF-36 scores.

[c] Values indicate substantial improvement (decrease of ≥24 seconds).

[d] Values indicate minimal perceptible clinical improvement (reduction of ≥9.7 pain points) on the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC).

[e] For the household income category comparing $50 000 or greater vs $25 000 to less than $50 000, the ARR is 1.15 (95% CI, 1.03–1.28).

[f] BMI was calculated as weight in kilograms divided by height in meters squared.

[g] The ARR (95% CI) is not reported for variables that were not retained in the model due to lack of significance (*P*≥ .05 overall).