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Functional Outcomes After Total Shoulder Arthroplasty in Obese Patients

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Background: Obesity is increasingly prevalent in the United States. There are several reports of outcomes in obese patients after total knee or hip replacement. The purpose of this study was to compare the functional outcomes and complications of obese patients undergoing shoulder arthroplasty with those of overweight or normal-weight patients.

Methods: Seventy-six patients who underwent primary total shoulder arthroplasty were grouped according to body mass index. The groups were classified as: normal, which was denoted by a body mass index of <25 kg/m² (twenty-six patients); overweight, which was denoted by a body mass index of 25 to 29.9 kg/m² (twenty-five patients); and obese, which was denoted by a body mass index of ≥ 30 kg/m² (twenty-five patients). Preoperative demographics and perioperative and postoperative complications were recorded. The American Shoulder and Elbow Surgeons score, Short Form-36, and visual analog scale pain and fatigue scores were evaluated at baseline and at the two-year follow-up visit.

Results: In the normal group, the mean scores (and standard deviation) improved for the American Shoulder and Elbow Surgeons score from 38.4 ± 15.5 points preoperatively to 80.2 ± 19.4 points at two years postoperatively ($p < 0.001$) and for the Short Form-36 Physical Component Summary score from 38.3 ± 6.5 points preoperatively to 53.7 ± 11.3 points at two years postoperatively ($p < 0.001$); the visual analog scale pain scores decreased from a mean score of 62 points preoperatively to 12 points at two years postoperatively ($p < 0.001$). In the overweight group, the mean scores (and standard deviation) improved for the American Shoulder and Elbow Surgeons score from 37.4 ± 18.1 points preoperatively to 75.2 ± 24.9 points at two years postoperatively ($p < 0.001$) and for the Short Form-36 Physical Component Summary score from 36.1 ± 8.0 points preoperatively to 39.8 ± 12.2 points at two years postoperatively ($p = 0.21$); the visual analog scale pain scores decreased from 68 points to 18 points ($p < 0.001$). In the obese group, the mean scores (and standard deviation) improved for the American Shoulder and Elbow Surgeons score from 35.8 ± 12.5 points preoperatively to 80.0 ± 20.6 points at two years postoperatively ($p < 0.001$) and for the Short Form-36 Physical Component Summary score from 36.3 ± 8.4 points preoperatively to 40.7 ± 12.4 points at two years postoperatively ($p = 0.15$); the visual analog scale pain scores decreased from 66 points preoperatively to 11 points at two years postoperatively ($p < 0.001$). There was one deep infection in the overweight group that required surgical irrigation and debridement. Two revisions of the components were required in the normal group.

Conclusions: Obesity did not have a detrimental effect on the improvement of short-term shoulder function. However, the overall physical function of obese and overweight patients does not significantly improve after total shoulder arthroplasty. In the normal body mass index group, patients did improve overall physical function after total shoulder arthroplasty.

Level of Evidence: Prognostic Level II. See Instructions for Authors for a complete description of levels of evidence.

Obesity is a cause of patient morbidity and mortality in many areas of medicine¹. There is a high prevalence of obesity in the United States and the rate continues to

increase²⁻⁴. According to the World Health Organization, obesity can be classified according to body mass index (BMI), the body weight in kilograms divided by the height in meters squared.

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Individuals with a BMI of $<25 \text{ kg/m}^2$ are classified as normal weight, those with a BMI of 25 to 29.9 kg/m^2 are classified as overweight, those with a BMI of 30 to 39.9 kg/m^2 are classified as obese, and those with a BMI of $\geq 40 \text{ kg/m}^2$ are classified as morbidly obese^{5,6}. Furthermore, the World Health Organization has categorized obesity into three classes: Class I is a BMI of 30 to 34.9 kg/m^2 with a moderate risk of patient morbidity or mortality, Class II is a BMI between 35 and 39.9 kg/m^2 with a high risk of patient morbidity or mortality, and Class III is defined as a BMI of $\geq 40 \text{ kg/m}^2$ with a very high risk of patient morbidity or mortality⁷⁻⁹. Obesity has burdensome economic consequences for the individual, physician, and society^{4,10}.

Although obese patients undergo a disproportionately high number of elective orthopaedic procedures², there is a paucity of outcome data on those undergoing total shoulder arthroplasty¹¹. Several studies on patients who have undergone total hip arthroplasty or total knee arthroplasty have shown increased cost, perioperative complications, infection, and revision rates associated with obesity¹²⁻²¹. However, the literature is divided over the contribution of obesity on the overall functional outcome in patients who undergo total hip arthroplasty or total knee arthroplasty. Some reports have found similar outcomes between obese and non-obese patients²²⁻²⁵, whereas other authors have found obesity to be a negative influence on the final outcome^{12-14,21,26}. These reports cite altered biomechanics and systemic factors as causes for the increased complications^{13,14,22,24,26-28}. Furthermore, a higher body weight will significantly increase the stress load transferred to implant bone interfaces of both total hip replacements and total knee replacements, which may contribute to higher failure rates^{26,27,29}. To our knowledge, there is only one reported case series that examined the results, complications, and failure rates of shoulder arthroplasty in morbidly obese patients³⁰ and there are no studies in the literature comparing functional outcomes among obese, overweight, and normal-weight patients who undergo shoulder arthroplasty.

Given the evidence that obesity is a predisposing factor for increased complications and adverse functional outcomes following total hip arthroplasty or total knee arthroplasty, we hypothesized that obesity would have a similar negative impact on outcomes following total shoulder arthroplasty. The purpose of this study was to compare the short-term functional outcomes and the perioperative and postoperative complications among obese, overweight, and normal-weight patients undergoing total shoulder arthroplasty.

Materials and Methods

A total of 234 patients had unconstrained anatomic total shoulder replacements in our hospital between January 1, 2009, and January 31, 2010. Of these 234 patients, seventy-six were enrolled into the prospective total total shoulder registry, were grouped according to BMI, and were followed prospectively for two years. These data were obtained from the total shoulder registry and multiple surgeons at our institution performed the shoulder replacements reported in this study. Approval for this study was obtained from our institutional review board and all patients in the study provided written informed consent. All patients with the diagnosis of osteoarthritis, rheumatoid arthritis, or posttraumatic arthritis who underwent a total shoulder arthroplasty as the primary procedure were included in the study. Patients were excluded if they had undergone a hemiarthroplasty, a reverse shoulder ar-

throplasty, or any revision surgery as the index procedure. According to the World Health Organization classifications, the three groups were classified as: normal, which was denoted as a BMI of $<25 \text{ kg/m}^2$ (twenty-six patients); overweight, which was denoted as a BMI of 25 to 29.9 kg/m^2 (twenty-five patients); and obese, which was denoted as a BMI of $\geq 30 \text{ kg/m}^2$ (twenty-five patients). Studies in the hip and knee arthroplasty literature evaluating obesity and functional outcomes have used similar methods in separating patients according to their BMI^{12,13}.

Preoperative demographics, age, comorbidities, and postoperative complications were recorded. More specifically, comorbidities recorded in this study included hypertension, diabetes, cancer, and cardiac, pulmonary, psychiatric, neurological, and vascular disease. Perioperative operating room and hospital data were also analyzed from the anesthesia records and inpatient hospital charts. These included the American Society of Anesthesiologists (ASA) classification, surgical time from incision to closure as documented by the anesthesia records, intraoperative complications, length of total hospital stay, postoperative blood transfusion, and discharge home or to a rehabilitation facility. Postoperative hospital complications were also reported along with any complications from the time of the hospital discharge to the two-year postoperative clinic visit. These data were obtained from both the shoulder registry questionnaire (mailed or given to all patients at the six-month postoperative follow-up to record all complications during this time period) and the medical records and clinic notes up to the two-year follow-up visit. Functional outcome measurements including the American Shoulder and Elbow Surgeons (ASES) score, Short Form-36 (SF-36) Physical Component Summary (PCS) and Mental Component Summary (MCS) scores, and visual analog scale (VAS) pain and fatigue scores were evaluated at baseline and at the two-year follow-up visit. The VAS scores for both components was a horizontal line that is 10 cm in length and is anchored by two verbal descriptors, one for each symptom extreme.

Statistical Analysis

One-way analysis of variance (ANOVA) was used to compare attributes between the cohort groups, while repeated-measures ANOVA was used to compare the change in subjective outcome scores between cohort groups. For all analysis, two-sided hypothesis testing and significance were set to $\alpha = 0.05$ (the Bonferroni technique was also used to adjust for multiple comparisons).

Source of Funding

There was no external source of funding for this project.

Results

Demographics

The patient population in our study consisted of seventy-six patients (twenty-seven male patients and forty-nine female patients). The average age (and standard deviation) was 71 ± 9 years in the normal group, 71 ± 11 years in the overweight group, and 68 ± 8 years in the obese group. The normal group had nine male patients and seventeen female patients, the overweight group had ten male patients and fifteen female patients, and the obese group had eight male patients and seventeen female patients. The mean number of comorbidities was 2.07 for the normal group, 1.80 for the overweight group, and 2.12 for the obese group; there were no statistically significant differences among the three groups (Table I).

Operating Room and Hospital Data

In the twenty-six patients in the normal group, two were in ASA class I, seventeen were in ASA class II, and seven were in ASA class III; the average surgical time from incision to closure was 108 minutes; there were no intraoperative complications; and the average hospital stay was 2.4 days, with all patients discharged to home. In the twenty-five patients in the overweight group, one was in ASA class I, twenty were in ASA class II, and four were in

TABLE I Demographics of the Patient Population in Our Study
Among the Three BMI Groups*

Demographics	BMI Group		
	Normal	Overweight	Obese
Sex†			
Male	9	10	8
Female	17	15	17
Age‡ (yr)	71 ± 9	71 ± 11	68 ± 8
Preoperative comorbidities per patient			
Mean	2.07	1.80	2.12
Total	56	45	53

*There were no significant p values for any of the comparisons.
†The values are given as the number of patients. ‡The values are given as the mean and the standard deviation in years.

ASA class III; the average surgical time from incision to closure was 116 minutes; there was one intraoperative complication (a glenoid fracture); the average hospital stay was 2.6 days; and three patients (12%) were discharged to an inpatient rehabilitation facility. In the twenty-five patients in the obese group, one was in ASA class I, seventeen were in ASA class II, and seven were in ASA class III; the average surgical time from incision to closure was 120 minutes; there were no intraoperative complications; the average hospital stay was 2.4 days; and one patient (4%) was discharged to an inpatient rehabilitation facility. In-hospital data

showed no perioperative medical complications and minimal blood transfusion was needed in all three groups (see Appendix).

Functional Outcome (ASES and SF-36)

In the normal group, the mean scores (and standard deviation) improved from 38.4 ± 15.5 points preoperatively to 80.2 ± 19.4 points at two years postoperatively ($p < 0.001$) for the ASES, from 38.3 ± 6.5 points preoperatively to 53.7 ± 11.3 points at two years postoperatively ($p < 0.001$) for the SF-36 PCS (a 100-point scale), and from 47.4 ± 14.3 points preoperatively to 52.8 ± 10.0 points at two years postoperatively ($p = 0.12$) for the SF-36 MCS (also a 100-point scale). Two patients required revision of components at the two-year follow-up. One patient had a revision for glenoid loosening and the other patient had a conversion of the failed total shoulder arthroplasty to a reverse shoulder arthroplasty.

In the overweight group, the mean scores (and standard deviation) improved from 37.4 ± 18.1 points preoperatively to 75.2 ± 24.9 points at two years postoperatively ($p < 0.001$) for the ASES, from 36.1 ± 8.0 points preoperatively to 39.8 ± 12.2 points at two years postoperatively ($p = 0.21$) for the SF-36 PCS, and from 49.7 ± 11.6 points preoperatively to 51.7 ± 11.5 points at two years postoperatively ($p = 0.54$) for the SF-36 MCS. One patient had deep infection that required surgical irrigation and debridement. One patient had an intraoperative glenoid fracture. No patients required revision of the components at the two-year follow-up.

In the obese group, the mean scores (and standard deviation) improved from 35.8 ± 12.5 points preoperatively to 80.0 ± 20.6 points at two years postoperatively ($p < 0.001$) for the ASES, from 36.3 ± 8.4 points preoperatively to 40.7 ± 12.4 points at two

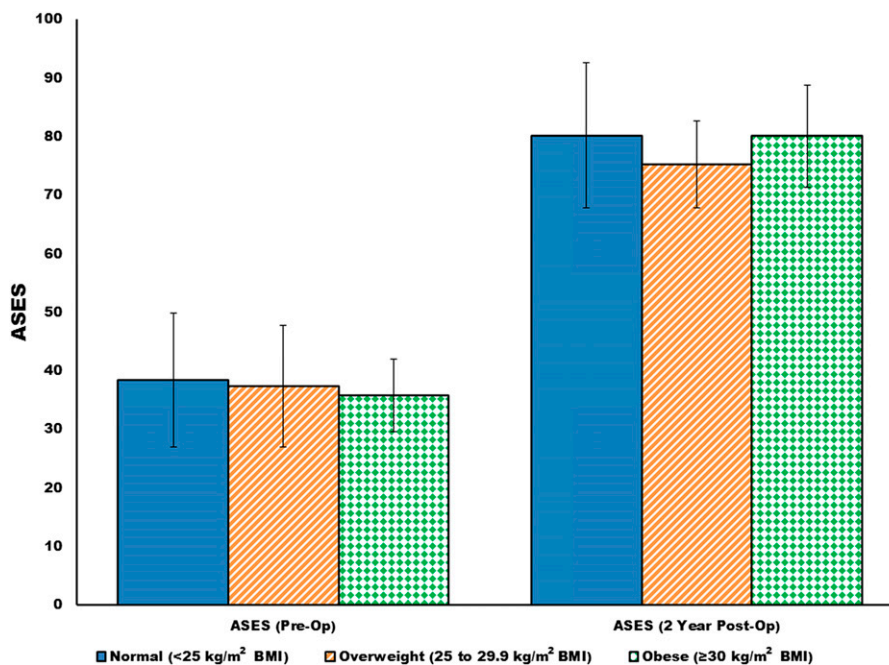


Fig. 1

Bar graph showing the three BMI groups with both preoperative and two-year postoperative ASES functional outcome scores after total shoulder arthroplasty. Error bars indicate 95% confidence intervals.

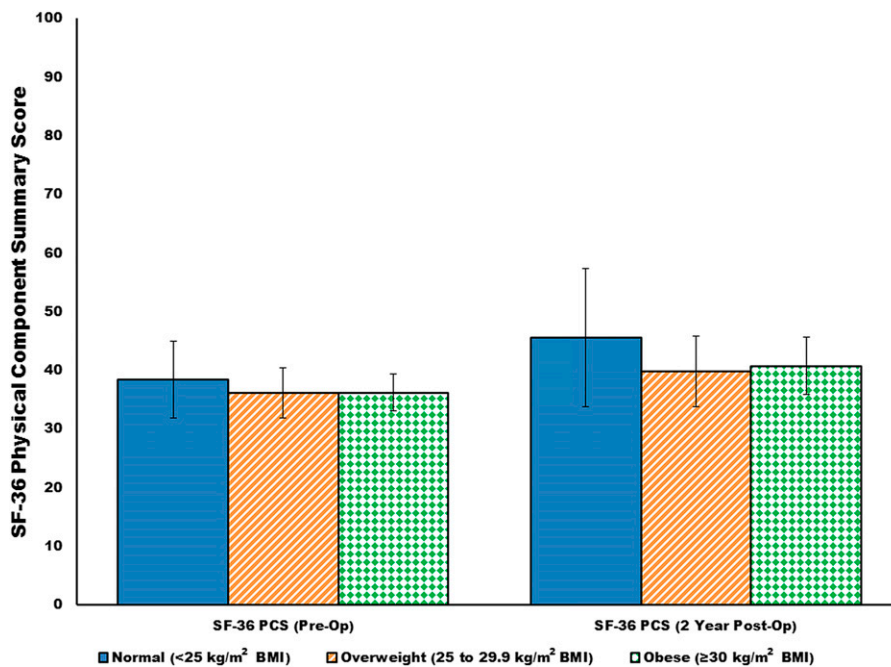


Fig. 2-A

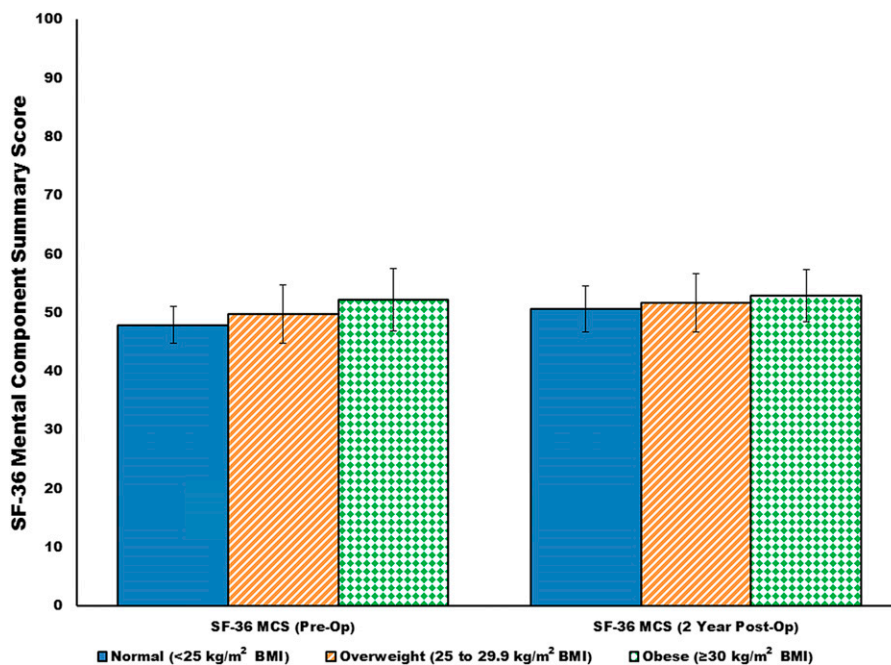


Fig. 2-B

years postoperatively ($p = 0.15$) for the SF-36 PCS, and from 51.5 ± 12.5 points preoperatively to 52.9 ± 11.6 points at two years postoperatively ($p = 0.68$) for the SF-36 MCS. No intra-operative complications were reported and no patients required revision surgery at the two-year follow-up time frame.

Statistical analysis showed significant differences in the mean SF-36 PCS scores (and standard deviation) at the two-year follow-up between both the overweight group (39.8 ± 12.2 points) and the obese group (40.7 ± 12.4 points) compared

with the normal group (53.7 ± 11.3 points). Overall, patients in the normal group had a mean SF-36 PCS score improvement of 13.9 points when compared with those in the overweight group and 13.0 points when compared with those in the obese group ($p < 0.05$). No statistically significant difference was seen among the three groups with the SF-36 MCS scores and pain and fatigue VAS scores. See Figure 1 for the ASES scores and Figure 2 for the SF-36 PCS and MCS scores for the three groups.

Fig. 2-A Bar graph showing the three BMI groups with both preoperative and two-year postoperative SF-36 PCS scores after total shoulder arthroplasty. Error bars indicate 95% confidence intervals. **Fig. 2-B** Bar graph showing the three BMI groups with both preoperative and two-year postoperative SF-36 MCS scores after total shoulder arthroplasty. Error bars indicate 95% confidence intervals.

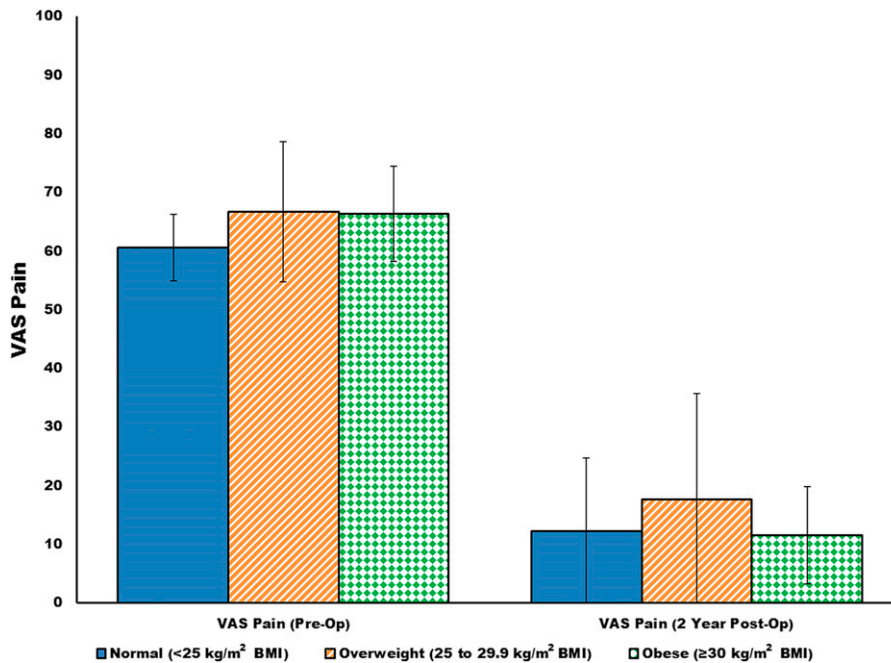


Fig. 3-A

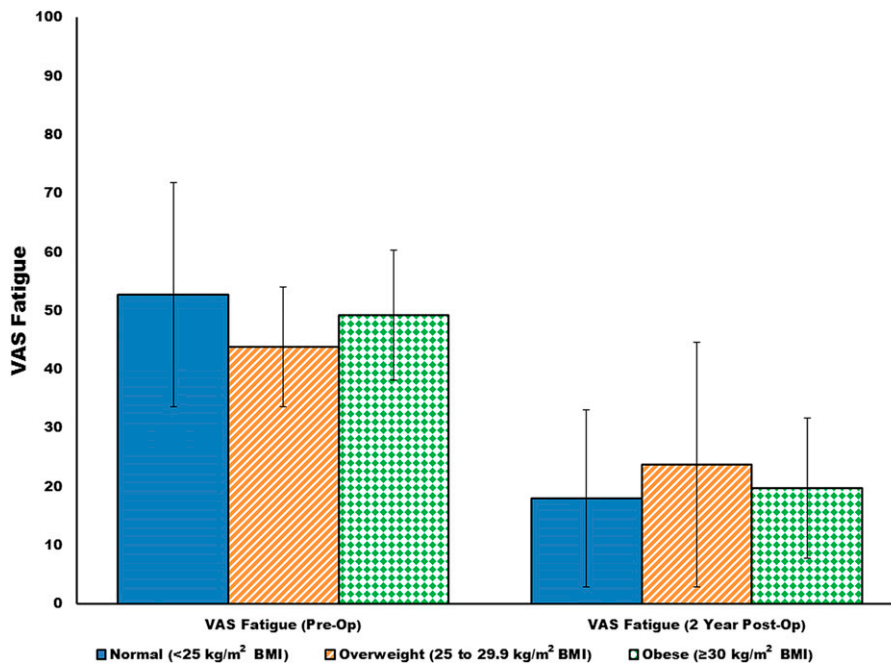


Fig. 3-B

Fig. 3-A Bar graph showing the three BMI groups with both preoperative and two-year postoperative visual analog scale (VAS) scores for pain after total shoulder arthroplasty. Error bars indicate 95% confidence intervals. **Fig. 3-B** Bar graph showing the three BMI groups with both preoperative and two-year postoperative VAS scores for fatigue after total shoulder arthroplasty. Error bars indicate 95% confidence intervals.

Visual Analog Scale Scores: Pain and Fatigue

The VAS scores are depicted in Figure 3. In all three cohort groups, there was a significant decrease ($p < 0.001$) in the VAS score in pain and fatigue between the preoperative and two-year postoperative time points after total shoulder arthroplasty. However, there was no significant difference when comparing

the two VAS components among the three groups. In the normal group, the VAS pain score decreased from 62 points to 12 points and the VAS fatigue score decreased from 52 points to 21 points. In the overweight group, the VAS pain score also decreased from 68 points to 18 points and the VAS fatigue score decreased from 44 points to 24 points. In the obese group, the

VAS pain score also decreased from 66 points to 11 points and the VAS fatigue score decreased from 49 points to 19 points.

Discussion

BMI is reported to be a predictor of patient morbidity and mortality because of the association with chronic diseases, such as diabetes, cardiovascular disease, peripheral vascular disease, and stroke³¹⁻³³. In contrast to the total hip and knee arthroplasty literature, to our knowledge, few studies show the complication rate and functional outcomes in the obese patient population after total shoulder arthroplasty. Linberg et al.³⁰ reported that shoulder arthroplasty in the morbidly obese patient population was associated with long-term improvement in pain, elevation, external rotation, and internal rotation. However, their study did not use any validated functional outcome measurements and did not include a comparison group. To our knowledge, this is the first series comparing functional outcomes after total shoulder arthroplasty among the obese, overweight, and normal-weight patient populations. We found comparable and significant improvement in the ASES scores at the two-year follow-up after total shoulder arthroplasty for all three groups. The preoperative and postoperative ASES scores in this study were similar to results from a multicenter study (133 patients who have undergone a total shoulder arthroplasty)³⁴. Likewise, quality-of-life scores for VAS pain and fatigue both improved significantly for each BMI category with no statistical differences between each group.

Although preoperative SF-36 PCS scores were similar across all groups, there was only significant improvement in the normal-weight patient population. The obese and overweight groups failed to achieve the amount of physical function improvement (SF-36 PCS) seen in the normal group after total shoulder arthroplasty despite significant improvement in overall shoulder function (ASES). In contrast, the normal group showed significantly greater improvement in the SF-36 PCS postoperatively in addition to the ASES score. The likely explanation is that in normal-weight patients, the overall function of their shoulder prior to surgery placed a limitation on their overall physical function. Total shoulder arthroplasty resulted in a significant decrease in overall pain and improvement in upper-extremity function that allowed the patients in the normal-weight group to return to their active lifestyle. Although total shoulder arthroplasty provides similar shoulder functional improvements to patients with above-normal BMI compared with those with normal BMI, it does not significantly improve the SF-36 PCS scores, which is likely dependent on factors other than upper-extremity function.

In contrast to our study, literature in the lower-extremity arthroplasty shows changes in physical function (SF-36 PCS scores) in the obese patient population after either total knee arthroplasty or total hip arthroplasty. One study found marked improvement in the quality-of-life scores in both non-obese and obese patients after total hip arthroplasty with no significant difference between the two groups³⁵. Another study

showed that obese patients attained as much improvement and satisfaction as non-obese patients after lower-extremity joint replacements. The authors found no differences between the changes in SF-36 PCS scores for the different BMI groups³⁶. In contrast, Chee et al.¹² reported significant postoperative improvement in the SF-36 score for morbidly obese and non-obese patients who underwent total hip arthroplasty, but when compared with each other, the morbidly obese group had significantly poorer scores for both preoperative and postoperative physical functioning. Regardless of the absolute magnitude of change in physical functioning, the overall trend in these studies appears to show that lower-extremity arthroplasty offers a significant improvement in the overall physical function and general health for every BMI category³⁷. This is likely the result of improvements in patients' ability to walk. However, in terms of upper-extremity arthroplasty, in our study, patients in the overweight and obese groups did not have as much improvement in their overall SF-36 physical function compared with the normal group after total shoulder arthroplasty. The consequence of these findings has implications for counseling patients according to their BMI about postoperative expectations. Patients should be counseled that they could expect major improvement in shoulder function, pain, and general health after total shoulder arthroplasty. However, improvement in overall physical function for overweight and obese patients is less likely and expectations should be tempered accordingly.

In addition to improved shoulder outcome measures and general health, our study also showed that total shoulder arthroplasty in overweight and obese patients is a procedure associated with low complications in the short term. The operative times for overweight and obese patients were slightly longer, which may be a reflection of the degree of difficulty in achieving adequate exposure. Also, the differences in the operative time could also be related to the differences in individual surgeons. There were no anesthetic complications or perioperative medical complications in any of the groups. Furthermore, the average number of perioperative blood transfusions and the length of stay did not differ across all groups. All of the patients in the normal group were discharged to home after surgery. However, several patients in the overweight group (12%) and the obese group (4%) required placement into rehabilitation facilities. Revisions during the two-year follow-up period were uncommon; two revisions of the components were done in the normal group, one for loosening and the other for conversion of the total shoulder arthroplasty to a reverse shoulder arthroplasty for instability. During this follow-up period, no revision of the components was seen in either the overweight group or the obese group. In contrast, Singh et al.³⁸ reported obesity as a risk factor for higher revision rates after humeral head replacements after following a group of patients with >1400 shoulders in a twenty-year follow-up study.

The major limitation of our study was the small number of subjects with a low prevalence of complications. Post hoc power analysis was performed for this study and indicated that

we were underpowered to detect the observed differences. The sample sizes that we had, even with the cohort divided into two groups (obese and non-obese), were powered for effect sizes that are larger than those reported in the literature for the ASES and both the SF-36 component scores. The short-term follow-up of this study was also an important limitation. Further investigation with more patients and longer follow-up are needed to determine if above-normal BMI affects long-term outcome. This study also included primary diagnoses other than osteoarthritis (rheumatoid arthritis and posttraumatic arthritis), which may also affect the overall outcomes. Lastly, the fact that multiple surgeons performed the total shoulder replacements in our study population introduced bias that might affect outcomes independent of patient BMI. However, the aggregation of outcomes from multiple surgeons could potentially show the generalizability of the findings.

In conclusion, total shoulder arthroplasty in patients with above-normal BMI is associated with significant improvements in ASES scores and a decrease in overall pain. Although our sample size numbers were limited, our results suggest that above-normal BMI does not have a detrimental effect on short-term, shoulder-specific functional outcomes. In contrast, patients in the overweight and obese groups had significantly less overall physical function improvements (SF-36 PCS scores) compared with patients in the normal group.

Appendix

eA Tables showing perioperative operating room data and in-hospital perioperative data are available with the online version of this article as a data supplement at jbjs.org. ■

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