Patient-Reported Outcomes Following Total Hip Arthroplasty Stratified by Body Mass Index

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Abstract: Obese patients undergoing total hip arthroplasty have been shown to have less functional recovery. This study prospectively compared temporal trends in patient-reported outcomes and activity levels between patients with a body mass index (BMI) of less than 30, 30 to 35, and 35 to 40 kg/m² after total hip arthroplasty. Patients were evaluated via the Harris Hip Score, Lower Extremity Activity Scale, and Short Form-12 physical and mental components. The results suggest that patients with BMIs of 35 to 40 kg/m² might have poorer functional outcomes preoperatively, with function returning more slowly or poor function being sustained and their not reaching other cohorts’ levels. Surgeons must counsel these patients regarding functional expectations and the potential for slower functional returns.


Total hip arthroplasty (THA) has been shown to be one of the most successful surgical interventions in medicine, having excellent long-term implant survivorship rates across multiple studies.¹⁻⁴ In 2005, an estimated 208,600 primary THAs were performed in the United States, and this is expected to increase to 572,000 by 2030. Not surprisingly, the total number of total hip revisions is also expected to significantly increase by 137%, from 40,800 cases in 2005 to 96,700 in 2030.⁵ Despite the reported excellent long-term implant survivorship rates, the functional outcomes are not as well described, especially in the obese population.

Obesity has long been shown to be detrimental to overall health and has become a global epidemic. Flegal et al⁶ recently reported that the mean age-adjusted body mass index (BMI) was 28.7 kg/m² in the United States and that 35.5% of adult men and 35.8% of adult women were classified as “obese.” In addition, obese patients have been shown to be at an increased risk for requiring both total knee and hip arthroplasty.⁷⁻⁸ The reported relative risk of women who have a BMI of 30 kg/m² or greater requiring hip arthroplasty is 2.47 (95% confidence interval, 2.25 to 2.71). Bourne et al⁷ found that patients who had a BMI of greater than 40 kg/m² were 8.5 times more likely to require a THA compared with nonobese individuals. Furthermore, obese patients who undergo lower extremity total joint arthroplasty often present at a younger age than nonobese patients who present for the same procedure.⁹,¹⁰ More recently, results of “super-obese” patients (BMI > 50 kg/m²) undergoing total hip and knee arthroplasty have been described as being suboptimal.¹¹,¹² Currently, many hip surgeons are reluctant to operate on patients who are obese for fear of an increased risk of perioperative complications, including infection,¹³ thromboembolic disease,¹⁴ revision surgery,¹⁵ dislocation,¹⁶ com-
ponent malposition,\textsuperscript{17} aseptic loosening,\textsuperscript{18} and prolonged hospital stay.\textsuperscript{19} However, an accepted “cut-off” BMI currently does not exist among hip surgeons. More recently, functional and clinical outcomes have emerged as an important standard for determining the relative success of the procedure. With the demand for THA expected to increase during the next several decades along with the scrutiny on postoperative outcomes, hip surgeons must be able to identify risk factors that may portend poor prognoses and functional outcomes.

The purpose of this study was to analyze the effects of BMI on patient-reported outcomes after THA. Specifically, the authors assessed the changes in (1) pain, (2) function and range of motion, (3) activity levels, (4) physical health status, and (5) mental health status. Additionally, the authors stratified these outcomes according to BMI. The authors hypothesized that an increasing BMI would have a negative effect on patient-reported outcomes.

**Materials and Methods**

In this study, the authors prospectively collected and analyzed data from 11 institutions (12 surgeons) between January 2006 and December 2009. A total of 61 men and 127 women were enrolled in the study (188 patients, 194 THAs). All THAs were performed for primary degenerative joint disease of the hip using the same prosthesis (Acclade TMZF; Stryker, Mahwah, New Jersey). Patients were stratified by their BMI into 1 of 3 groups: less than 30 kg/m\(^2\) (group A), 30 to 35 kg/m\(^2\) (group B), and greater than 35 to 40 kg/m\(^2\) (group C). Body mass index was calculated by dividing patients’ weight in kilograms by their height in meters squared (Table).

Group A consisted of 115 patients (118 THAs) who had a mean BMI of 25.8 kg/m\(^2\) (range, 19.8-29.9 kg/m\(^2\)). There were 32 men and 83 women in this cohort who had a mean age of 70 years (range, 48-88 years) (Table).

Group B consisted of 52 patients (55 THAs) who had a mean BMI of 32 kg/m\(^2\) (range, 30.1-35 kg/m\(^2\)). There were 22 men and 30 women in this cohort who had a mean age of 70 years (range, 47-85 years) (Table).

Group C consisted of 21 patients (21 THAs) who had a mean BMI of 37.1 kg/m\(^2\) (range, 35.2-38.9 kg/m\(^2\)). There were 7 men and 14 women in this cohort who had a mean age of 64 years (range, 47-80 years). All patients had a minimum follow-up of 2 years and a final mean follow-up of 5 years (Table).

Preoperatively, patient demographics (age and gender), BMI, and medical comorbidities were carefully evaluated and recorded for all patients. In addition, Harris Hip Score (HHS)\textsuperscript{20} and Lower Extremity Activity Scale (LEAS) score were calculated for each patient prior to THA. Patients were also asked to complete the Short-Form 12 health survey (SF-12) during their preoperative office visit.

The HHS, a questionnaire completed by both the patient and the surgeon, takes into consideration aspects of pain, level of function and activity, and range of motion. A point total is generated at the end of the questionnaire depending on the answers given, with a score between 0 and 100 points possible. A successful result is defined as an increase of greater than 20 points with a radiographically stable implant. This outcome measure has been shown to be both valid and reliable in assessing clinical outcome after THA.\textsuperscript{21}

The LEAS is a self-administered outcome measure tool consisting of 18 levels, or activity statements. Patients choose the one statement that best describes their self-perceived activity level and are assigned a point value from 1 to 18 (1=bedbound, 18=daily rigorous physical activity, competitive sports). This outcome measure was developed for patients undergoing lower extremity total joint arthroplasty and has the advantage of being able to monitor for change between pre- and postoperative activity levels. It is easy to administer and score and has been shown to be both valid and reliable for these patients.\textsuperscript{22}

The SF-12 is an outcome measurement tool commonly used to assess the physical and mental well-being of patients.
across various medical subspecialties. It is a 12-item, self-administered questionnaire that assesses self-perceived physical and mental health status, activity level, and pain. The questionnaire can be further broken down into physical and mental components. It has been used to assess clinical outcome among patients undergoing lower extremity total joint arthroplasty and has been shown to be reliable and valid.23-25

The HHS was recorded at 6 weeks, 6 months, 1 year, 2 years, 3 years, and 5 years postoperatively. The LEAS and SF-12 scores were recorded at 6 months, 1 year, 2 years, 3 years, and 5 years postoperatively. The results of the HHS, LEAS, and SF-12 were compared pre- and postoperatively, as well as between each follow-up period.

All data were prospectively recorded and stored within a Structured Query Language server (Stryker), and statistical analyses were conducted using SigmaStat version 3.0 software (Systat Inc, San Jose, California). Cohorts were compared using the Student’s t test. A P value of less than .05 was used to determine significance.

RESULTS
A total of 194 hips (188 patients) were included in this study. Prior to the 5-year follow-up, 5 patients died due to reasons unrelated to the surgery. An additional 2 patients required component revision. One patient underwent revision surgery secondary to an acetabular periprosthetic fracture at 45 days after the index arthroplasty. The patient subsequently developed a periprosthetic joint infection and required revision of both the acetabular and the femoral components. Another patient underwent revision of the femoral stem and head at approximately 2 years postoperatively secondary to trochanteric bursitis and groin pain after a fall. Both of these patients had a BMI of less than 30 kg/m². An additional 2 patients did not reach a minimum 2-year follow-up. Another patient died 19 months postoperatively, with cause of death unknown. This left 187 hips (181 patients) available for evaluation at a minimum follow-up of 5 years.

Harris Hip Score
The mean preoperative HHSs in the patient cohorts with a BMI of less than 30 kg/m², between 30 and 35 kg/m², and greater than 35 to 40 kg/m² were 53, 49, and 45 points, respectively. A significant difference was found in scores between those whose BMI was less than 30 kg/m² and those whose BMI was greater than 35 to 40 kg/m² (P=.02). All 3 patient cohorts had significant increases from their mean preoperative HHSs at the 6-week follow-up (P=.0001). For groups A, B, and C, their mean HHSs increased from 53 to 80 points, 49 to 78 points, and 45 to 86 points, respectively. Groups A and B had further significant improvements in their mean HHSs from 6 weeks to 6 months (group A, 80 to 89 points; group B, 78 to 89 points; P=.0003). Conversely, no significant difference in scores was noted in group C after 6 weeks of follow-up through to 5 years postoperatively (P>.05); however, from preoperatively to 6 months, this cohort had the greatest delta change in improvement. In all groups, significant improvements in mean HHSs were seen between 6 weeks and 6 months (P≤.0003). Thus, using the HHS as an outcome measure, it appears that patients across all 3 cohorts reached a “steady-state” after 6 months (Figure 1).

Lower Extremity Activity Scale
The mean preoperative LEAS scores in groups A, B, and C were 8.9, 7.9, and 8.5 points, respectively. At the 6-month mean follow-up, the scores improved to 10.4, 10.3, and 10.1 points, respectively, with a significant difference in group A (8.9 to 10.4 points) and group B (7.9 to 10.3 points; P=.0004). No significant improvements in LEAS scores were noted in group C across any of the follow-up periods (P>.05). Although the scores continued to trend upward throughout the 5-year follow-up across all 3 cohorts, the mean differences from each follow-up period did not reach statistical significance (Figure 2).

Short-Form 12
The mean SF-12 physical component scores significantly increased at 6 months from the preoperative values. Groups A, B, and C had improvement in their scores from 33.3 to 47.6 points, 32.3 to 45.5 points,
and 30 to 46.6 points, respectively (P=.0001) (Figure 3). Although slight improvements were noted across the 3 cohorts during the remainder of the follow-up period up to 5 years, the improvements did not reach significance (P>.05). The mean SF-12 mental component scores significantly improved at the 6-month follow-up compared with the preoperative values for group A and group B only. Mental component scores increased from 50.1 to 54.6 points for group A and from 50.2 to 55.3 points for group B (P<0.02). Group C showed improvement in their reported scores from 48.2 to 54.2 points, which trended toward significance (P=.07) (Figure 4). Despite not reaching significance, group C had the greatest delta change and might have been limited by the cohort size.

**DISCUSSION**

Obesity has reached epidemic proportions worldwide. With obesity rates on the rise, along with the projected number of THAs to be performed in the near future, the need to understand how this multisystem disease affects clinical outcomes cannot be overstated. Surgeons have long been hesitant to perform THA for obese patients for fear of an increased risk of perioperative complications and decreased implant survivorship. Overall, the current authors’ results showed significantly improved patient-reported outcomes (HHS, SF-12 physical component) up to 6 months postoperatively. Beyond this point, the results reached a steady-state up to the final mean follow-up at 5 years. The HHS in group C plateaued after just 6 weeks with no further significant improvements. The results remained stable from this point up to the final follow-up. However, the authors found those with a BMI of greater than 35 to 40 kg/m² to have less consistent improvements in their scores. It is concerning that patients with BMIs greater than 35 to 40 kg/m² had no significant increase in LEAS score postoperatively. This serves as another reason to counsel patients regarding their functional expectations postoperatively. The absence of significant improvement in SF-12 mental scores is difficult to explain, although obesity can be associated with several concomitant medical comorbidities that may have contributed to this.

Several limitations were identified in this study. Body mass index has long been criticized as an inaccurate measure. Also, differing distributions in fat across genders and various ethnic groups, along with an inability to distinguish between adipose and muscle weight, make BMI an imperfect measurement of obesity. No patient in this study had a BMI above 39 kg/m² (maximum, 38.9 kg/m²). As alluded to previously, the results from the “obese” patient cohort may not be applicable to all patients who had a BMI of greater than 30 kg/m² because class III obese (BMI > 40 kg/m²) and “super-obese” (BMI > 50 kg/m²) patients may be subject to their own unique set of risks and complications. In addition, in this study, the BMI of 35 to 40 kg/m² group had a smaller cohort compared with the other groups, which might have limited their improvements to reach significance. This was a multicenter study involving different surgeons with different surgical approaches and postoperative protocols, which may have affected postoperative pain and functional outcomes. However, the same cementless total hip prosthesis was used, which eliminated this confounding variable encountered in studies in which prostheses by different manufacturers were used. Additionally, although the authors’ data were collected prospectively, they concluded at 5 years; thus, no long-term conclusions can be reached from this study. Finally, the authors did not have a case-matched cohort to allow for the performance of subgroup analyses.

Currently, there is controversy regarding the role of obesity in postoperative functional outcomes, with several studies reporting poorer postoperative pain levels, function, and activity levels. Haverkamp et al evaluated 411 patients (489 hips) who underwent THA. At a minimum follow-up of 10 years, they reported significantly lower HHSs among patients who had a BMI of
greater than 30 kg/m² when compared with patients who had a BMI between 25 and 30 kg/m² and a BMI of less than 25 kg/m² (84 vs 87 vs 92 points, respectively; \( P = .02 \)). Additionally, in a study of 800 patients undergoing cemented THA, Moran et al.\(^{26} \) noted lower HHSs in the obese cohort at 6 and 18 months postoperatively. The difference was small, but significant \((P < .05)\).

Furthermore, Tai et al.\(^{27} \) also noted overall lower mean preoperative HHSs between their obese and nonobese cohorts \((P = .006)\). The reasons for this were likely multifactorial, with the additional medical and physical comorbidities including, but not limited to, hypertension, diabetes mellitus, obstructive sleep apnea, and coronary artery disease. These results are consistent with the current authors’ findings, which revealed that patients with a BMI of greater than 35 kg/m² showed less consistent improvements in their scores and had overall lower preoperative mean HHSs.

A recent American Association of Hip and Knee Surgeons workgroup\(^{27} \) recommended that patients with a BMI of greater than 40 kg/m² be encouraged to undergo a weight-loss program prior to THA due to these more inconsistent functional and clinical outcomes reported in the literature. However, despite the lower scores, all 3 patient cohorts in the current study reported significant improvements at 6 weeks postoperatively.

Singh and Lewallen\(^{28} \) evaluated the effect of a raised BMI (between 30 and 40 kg/m²) on pain and activity outcomes following THA. They noted that obesity significantly correlated with moderate to severe pain at 2- and 5-year follow-up as well as moderate to severe activity limitations. Additionally, Michalka et al.\(^{25} \) prospectively evaluated 191 THAs. They reported a significantly decreased walking distance achieved in the 6-minute-walk-test in a morbidly obese (BMI \( \geq 35 \) kg/m²) cohort compared with obese and nonobese cohorts who had a BMI of less than 35 and 30 kg/m², respectively \((P = .028)\).

Furthermore, Chee et al.\(^{15} \) reported on physical function and activity among 106 nonobese and morbidly obese (BMI \( > 40 \) kg/m²) patients following THA. They noted that in the morbidly obese group, preoperative SF-36 scores were significantly poorer, particularly in the pain and physical functioning domains \((P < .05)\). Similar to the current study, they noted a “ceiling effect” and found HHSs and SF-36 scores to improve significantly following THA but to reach a peak at 6 months and continue out to 5 years. This may simply reflect the patients’ experiencing clinical gains back to their premorbid or pre-arthritic functional status. This information can be useful to counsel patients on the continued physical, functional, and mental recovery that can be seen up to 1 year out. However, as with the current study’s findings, obese patients with a BMI of greater than 35 kg/m² may not experience the same functional and mental gains as those with a BMI of less than 35 kg/m².

Conversely, evidence in the literature suggests that obesity may have no effect on outcomes, or patients may experience surgical satisfaction despite their numerical scores. For example, McLaughlin and Lee\(^{29} \) studied 285 uncemented THAs (260 patients) and stratified them into obese (\( \geq 30 \) kg/m²) and nonobese (<30 kg/m²) cohorts. Using revision as an end point, the authors did not find a statistically significant difference in implant survivorship or clinical outcome as measured by HHS between the 2 groups at a final mean follow-up of 14 years.

Yeung et al.\(^{30} \) reported comparable satisfaction scores between obese (BMI \( \geq 30 \) kg/m²) and nonobese (BMI < 30 kg/m²) patient cohorts, despite a significantly lower postoperative HHS in the obese group (89.9 vs 93.2 points, \( P < .001 \)) at a mean follow-up of 6.3 years (SD, 2.5 years). Also, McCalden et al.\(^{24} \) found no significant difference in the change of Western Ontario and McMaster Universities Osteoarthritis Index scores and HHSs from pre- to postoperative levels in obese and nonobese patients despite overall lower actual scores preoperatively in the obese cohort.

Additionally, some studies reported no difference in physical or mental health state outcomes. Because they could not identify an influence of obesity on SF-36 scores or perioperative complication rates, Moran et al.\(^{26} \) concluded that there was no reason to withhold THA from obese patients. Moreover, in an analysis of outcomes among nonobese, obese, and morbidly obese patients following THA, Michalka et al.\(^{25} \) noted that all patients experienced an improvement in SF-36 physical and mental assessments, but no significant difference was noted between groups. The current study’s results showed comparable magnitudes of improvement and levels of patient satisfaction between obese and nonobese cohorts.

**Conclusion**

The exact role that obesity plays in patient-reported outcomes is difficult to ascertain because it is likely multifactorial. In addition, heterogeneity in patient cohorts and surgical technique across multiple studies makes it difficult to draw conclusions. However, with the demand for THA set to exponentially increase in the next few decades and the rates of obesity on the rise, hip surgeons must be able to identify potential negative predictors of functional outcome, especially because of the current outcome-driven federal mandates. Given the current study’s findings, it is imperative that surgeons preoperatively counsel patients regarding their expected postoperative outcomes and functional expectations based on the current literature. Obese patients with a BMI of between 30 and 35 kg/m² were shown to experience similar improvements in their patient-reported outcomes when compared with nonobese patients. These functional gains ap-
peared to plateau after 6 months and continued out to final follow-up at 5 years. Patients with a BMI of greater than 35 kg/m² may be at an increased risk for a slower functional return when compared with non-obese patients and thus may require extra counseling preoperatively and a personalized rehabilitation regimen postoperatively. Prospectively designed studies are needed to define the role of obesity, morbid obesity, and super-obesity in functional outcomes after THA.

REFERENCES