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ORIGINAL STUDY

Is high body mass index a potential risk factor for poor outcome after hip arthroplasty? A cohort study of 98 patients 1 year after surgery

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The association between obesity and outcome after hip arthroplasty is controversial. We investigated whether there was an association between the preoperative body mass index in primary total hip arthroplasty patients and their quality of life and physical function 1 year after surgery.

98 patients were included in the study. The results were adjusted for age, sex, and comorbidities. The obese group had an increased risk of obtaining a worse physical score and a lower activity in daily living score at the 1-year follow-up than compared with the normal-weight group. In addition, the obese patients' hospitalization was 1 day longer than that of the normal-weight patients. However, the overweight patients accomplished the largest improvement of general health and hip-related health compared with the normal-weight group.

Keywords : Obesity ; total hip arthroplasty ; HOOS ; SF-36 ; body composition ; QoL.

INTRODUCTION

The association between obesity, morbidity, as well as peri- and postoperative complications after primary total hip arthroplasty (THA) has been clarified in several studies. Obese THA patients occupy more intraoperative time (total room time, anesthesia induction time, surgery time) than normal-weight patients, which reflects the burden obesity poses to the hospitals; *(24,21)* and obesity increases the length of admission *(22,16)* and direct medical costs *(16)*. Moreover, obesity is independently associated with a high risk of prosthetic joint infection (PJI), *(9,3,10)* thromboembolic complications, *(10,2)* and risk of dislocation; *(10,8,11,15,23)* and increasing body mass index (BMI) is associated with superficial infection *(6)*.

The association between obesity and physical functioning and quality of life (QoL) after THA is, however, controversial. One study showed that obese patients experienced a reduction in pain and improvement in function after THA comparable to that of non-obese patients *(7)*. McCalden et al. suggested that obese and non-obese patients enjoyed similar improvements in performance assessed by the Western Ontario and McMaster Universities Arthritis Index (WOMAC), the Harris Hip Score (HHS), and the Short-Form 12 (SF-12) in a 2-year

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follow-up study *(18)*. Jones et al. documented that severe obesity was a statistically significant risk factor for worse pain and functional recovery measured with the WOMAC at 6 months, but no longer at 3 years after THA *(13)*. A cohort study with 653 patients *(24)* showed that overweight and obesity were statistically significantly associated with general health measured with the SF-12. Davis et al. also found that obesity was associated with poorer HHS and SF-36 scores at 5 years after THA. In addition, obese subjects had a lesser range of motion (ROM) than non-obese subjects after THA, even when the implant positioning was performed correctly *(11)*. In the present study, we investigated whether there was an association between the preoperative BMI of patients who underwent THA and their QoL, physical function, and body composition before surgery and 1 year after surgery. Our hypothesis was that a high BMI increases the risk of poor physical function and poor QoL after THA.

PATIENTS AND METHODS

Study design and setting

The study was a prospective cohort study with a 1-year follow-up conducted at the Department of Orthopedics, Hospital of Southern Jutland, Denmark. ClinicalTrials.gov identifier: NCT01496716. The Local Committee on Biomedical Research Ethics approved the study on 6 September 2011; Journal number: S-201110124.

Patients

103 consecutive hip osteoarthritis (OA) patient scheduled for primary THA were recruited between December 2011 and May 2012. Among these, 1 patient did not want to participate at follow-up, 1 patient was seriously ill (not related to THA), and 3 patients THA was cancelled or postponed. Thus, 98 patients completed the 1-year follow-up. Exclusion criteria were rheumatoid arthritis.

Variables

Outcome measures: At baseline, preoperatively and at the 1-year follow-up, self-reported health status was measured by the Short-Form 36 (SF-36) version 2 acute (1-week recall) (primary outcome) and the Hip disability and Osteoarthritis Outcome Score 2.0 (HOOS). The SF-36 includes 8 health domains, and 2 component scores aggregate the 8 sub-domains into 2 component scales: physical component (PCS) and mental component (MCS) *(1)*. For registration and calculation of the SF-36 score, we used the Quality Metric Health Outcomes Scoring Software 4.5. The HOOS includes 5 health domains: Function in daily living (ADL), hip-related quality of life (QoL), pain, symptoms, function in sport and recreation (Sport/Rec) *(19)*. Each SF-36 and HOOS score is transformed into a 0–100 scale with higher scores indicating better status. In addition, body composition (fat mass, muscle and bone mass), bone mineral content (BMC), and bone mineral density (BMD) were measured with dual energy X-ray absorptiometry (DXA). The length of hospital stay in days was recorded. Height and weight were measured at baseline and generated to BMI (kg/m2), the exposure variable. BMI is categorized according to the World Health Organizations (WHO) BMI classification: < 18.5 kg/m2 (underweight), > 18.5 – 24.9 kg/m2 (normal-weight), > 25 – 29.9 kg/m2 (overweight), > 30 - 34.9 kg/m2 (obese), > 35 – 39.9 kg/m2 (morbid obese). In this paper, obese and morbid obese are consider as one group: obese. Blood pressure and heart rate were measured at baseline.

Demographic characteristics were recorded: Educational level, working status (yes/no), living alone (yes/no), smoking (yes/no), and alcohol status (female > 7 units per week yes/no, male > 14 units per week yes/no (1 unit = 1 beer/1 glass of wine)). Known confounder variables *(14)* were collected at baseline: sex, date of birth, and comorbidities (heart disease, hypertension, diabetes, respiratory disease, digestive disease, psychiatric disease). Potential confounder variables were collected from the patient records: Operating surgeon (8 staff surgeons), type of prosthesis (uncemented (Corail stem and Pinnacle cup)/ cemented (Exeter stem and cup, Palacos cement with gentamycin), perioperative complication (yes/ no), in-hospital complications before discharge (yes/no), complications after discharge (yes/no), and other knee or hip replacement (yes/no) (data not shown). At follow-up, the patients were asked if they were doing daily exercise (yes/no) (data not shown). All surgical procedures were performed using a posterior approach with the patient in lateral position. The main author, AL, performed all variable measurements and registration.

Statistics

The ordinal logistic regression (proportional odds model (POM)) was applied for the patient-reported outcomes. All the response variables (SF-36, HOOS) and the exposure variable (BMI) were continuous, but a linear regression analysis could not be performed since there were ceiling-effects for several of the response variables or because they were not consistent with a normal distribution of residuals. The POM gives a little more information than the binary logistic regression method that applies when we have a categorical response of the simplest possible form - dichotomous. In our POM, all continuous response variables (SF-36, HOOS) were generated to 4 ordered categorical variables. In the POM, logistic regressions were made corresponding to the internal cut-points made for the response variables. The estimates from the regression models were then pooled to provide just one set of estimates, presented as odds ratios (OR) and their 95% confidence intervals (CI). The POM assumption that the relationship between any 2 pairs of response variable groups is statistically the same was tested using a log likelihood test.

Analysis of variance (one-way ANOVA) was used for comparison of mean body composition between the BMI groups. Before the ANOVA test, the assumptions of the model were tested. A normal distribution of the residual for each BMI group was checked with a histogram, and a probability plot and a Bartlett's test were performed for homogeneity of variance. For non-parametric statistics, Kruskal-Wallis test was used for comparison of mean admission days between the BMI groups. The assumption: identically shaped and scaled distribution for each group was tested with a histogram and a probability plot. All the observations in the sample (n) were independent and had the same probability of events. A priori power analysis was performed to determine the sample size (n) required to detect a 5% difference in PCS in patients with a difference in BMI of 1 kg/m2. To achieve a power of 80%, it was determined that 80 patients would be required in the study group. For the statistical analysis, the Stata 12 software was used. All p-values < 0.05 were considered statistically significant.

RESULTS

Patients

Patient characteristics are shown in Table I. Women were overrepresented in the underweight group and underrepresented in the obese group. In all groups, the mean age was 70-73 years.

Patient-reported outcome

The results in Table II show the OR in proportion to the normal-weight BMI group and each of the groups: underweight, overweight, and obese. The results were adjusted for known confounders: age, gender, and comorbidities. Hence, the results show the odds between 2 THA patients of the same age, same sex, and both patients with or without comorbidities and with the difference that one patient is of normal-weight and the other patient is underweight, overweight or obese. The analytical model was tested for other potential confounders (educational level, working status, living alone, smoking, alcohol status, weight at follow-up, work status, surgeon, type of prosthesis, perioperative complication, in-hospital complications before discharge, complications after discharge, other knee or hip replacement, and daily exercise), but these adjustments did not affect the results of the analyses (data not shown).

Primary outcome: SF-36

All BMI groups had a 47-84% increased risk (Table II) of obtaining a worse PCS at the 1-year follow-up than the normal-weight group. The increased risk was statistically significant for the obese patients. The underweight and the obese groups had a 13-17% increased risk of achieving a smaller, statistically non-significant difference in PCS from baseline to the 1-year follow-up than

Table I.— Demographics and baseline characteristics of the study population before total hip arthroplasty

	Underweight BMI <18.5 (n=13)	Normal BMI (≥18.5) (n=49)	Overweight BMI (≥25) (n=27)	Obese (≥30) (n=9)
Woman, n (%)	11 (85)	27 (55)	12 (44)	2 (22)
Age, years	73 (9.3)	71 (9.4)	70 (8.3)	70 (7.1)
Weight, kg	57 (4.9)	74 (7.8)	93 (7.5)	112 (12.0)
Android fat%	21.7 (8.2)	41.9 (8.8)	46.7 (6.9)	52.1 (5.1)
Gynoid fat%	40.5 (9.4)	37.6 (9.8)	38.6 (9.7)	45.8 (8.4)
Bone mineral content (BMC), g	2137.9 (505.0)	2722.7 (585.2)	3229.9 (520.0)	3205.8 (702.6)
Bone mineral density (BMD), g/cm2	1.05 (0.13)	1.16 (0.13)	1.28 (0.10)	1.30 (0.14)
Systolic blood pressure, mm/Hg	155 (23.9)	152 (20.9)	153 (16.9)	142 (17.9)
Diastolic blood pressure, mm/Hg	77 (13.8)	84 (9.8)	85 (10.1)	81 (6.1)
Hearth rate, rate/min	77 (13.7)	72 (12.3)	69 (12.5)	78 (16.5)
Comorbidity, n (%)	5 (38)	24 (49)	18 (67)	8 (89)
Education, n (%)				
Unskilled worker	3 (23)	23 (47)	9 (33)	4 (44)
Skilled worker	3 (23)	16 (33)	12 (44)	3 (33)
Bachelor/master degree	7 (54)	10 (20)	6 (22)	2 (22)
Working, n (%)	0 (0)	7 (14)	6 (22)	2 (22)
Living alone, n (%)	6 (46)	16 (33)	10 (37)	4 (44)
Smoking, n (%)	3 (23)	3 (6)	2 (7)	0 (0)
Alcohol, n (%)	3 (23)	7 (18)	2 (10)	1 (17)

Values are means and the numbers in parentheses indicate the standard deviation (SD), unless otherwise indicated

other subjects. In addition, the obese group had a 75% increased risk of obtaining a worse MCS at the 1-year follow-up than the normal-weight group. Moreover, from baseline to the 1-year follow-up, the change in MCS was 14% lower in the obese group than in the normal-weight group ($p = 0.81$). The overweight group had an increased likelihood of achieving a larger, but non-statistically significant improvement in PCS (44%) and MCS (99%) than the normal-weight group.

HOOS

The risk of obtaining a worse ADL score at follow-up was increased by 77% for the obese group ($p = 0.04$) (Table II) compared with the normal–weight group. In addition, the difference in Sport/Rec. score from baseline to follow-up was statistically significantly lower in the obese group than in the normal–weight group. The obese group had an 82% risk of improving less than the normal-weight group ($p = 0.03$). For all other HOOS results, ORs < 1 were found; a 6-75% increased risk of obtaining a worse score for the obese group compared with the normal–weight group was seen. The overweight group had an increased, non-statistically significant likelihood of 22-85% of achieving a larger improvement in scores than normal-weight patients'.

Body composition

The patients' body composition at the 1-year follow-up is shown in Table III. As expected, an increase was observed in weight, fat percentage, fat mass, and muscle mass between the BMI groups. The lowest values were seen in the underweight group and the highest values in the obese group.

Table II. — Normal-weight THA patients' self-reported outcome compared with underweight, overweight, and obese patients' outcomes. Scores for 1-year follow-up and scores for the difference between preoperative and the 1-year follow-up scores are presented for the Short Form 36 (SF-36) and the Hip disability and Osteoarthritis Outcome Score (HOOS)

	BMI group	1-year follow-up score OR adjusted (95% CI)	P-value	Difference in score OR adjusted (95% CI)	p-value
SF-36					
PCS	1	1.00		1.00	
	2	0.42 (0.13-1.32)	0.14	0.83 (0.25-2.74)	0.76
	3	0.53 (0.22-1.27)	0.16	1.44 (0.23-3.29)	0.41
	4	0.16 (0.04-0.65)	0.01	0.87 (0.23-3.29)	0.84
MCS	1	1.00		1.0	
	2	1.16 (0.35-3.87)	0.81	0.62 (0.21-1.84)	0.39
	3	1.52 (0.65-3.54)	0.33	1.99 (0.82-4.81)	0.13
	4	0.25 (0.06-1.01)	0.05	0.86 (0.25-2.98)	0.81
HOOS					
ADL	1	1.00		1.00	
	2	1.39 (0.41-4.66)	0.59	1.58 (0.48-5.19)	0.45
	3	0.74 (0.32-1.71)	0.48	1.55 (0.65-3.69)	0.32
	4	0.23 (0.06-0.97)	0.04	0.71 (0.19-2.67)	0.61
QoL	1	1.00		1.00	
	2	0.84 (0.27-2.61)	0.77	0.75 (0.26-2.14)	0.58
	3	1.70 (0.71-4.05)	0.23	2.04 (0.84-4.98)	0.12
	4	0.54 (0.14-2.89)	0.39	0.80 (0.19-3.37)	0.76
Pain	1	1.00		1.00	
	2	1.60 (0.48-5.39)	0.45	1.10 (0.36-3-33)	0.97
	3	0.91 (0.40-2.09)	0.83	1.85 (0.77-4.45)	0.17
	4	0.54 (0.13-2.24)	0.40	0.90 (0.24-3.37)	0.87
Symptom	1	1.00		1.00	
	2	0.70 (0.21-2.31)	0.56	0.81 (0.28-2.41)	0.71
	3	0.84 (0.36-1.96)	0.68	1.22 (0.52-2.87)	0.64
	4	0.41 (0.11-1.49)	0.18	0.94 (0.26-3.42)	0.92
Sport/Rec	1	1.00		1.00	
	2	0.90 (0.30-2.73)	0.86	0.97 (0.33-2.80)	0.95
	3	0.69 (0.29-1.61)	0.39	1.40 (0.58-3.38)	0.46
	4	0.25 (0.06-1.03)	0.05	0.18 (0.04-0.86)	0.03

BMI groups: 1= normal weight, 2=underweight, 3=overweight, 4=obese. The patient-reported outcome measures are presented as odds ratios (OR) and their 95% confidence intervals (CI); calculated using the proportional odds analysis adjusted for age, gender, and comorbidity

Unlike muscle mass, the body muscle percentage decreased statistically significantly between the groups. The mean muscle percentage was highest in the underweight group and lowest in the obese group at the 1-year follow-up.

The obese group had a mean weight loss from baseline to the 1-year follow-up of -3.17kg (Table III). For all other BMI groups, the weight increased < 1kg from baseline to the 1-year follow-up. All groups experienced an increase in body fat percentage from baseline to follow-up, and all groups experienced a decrease in body muscle percentage that matched their increase in body fat percentage. The obese group had the largest reduction of muscle mass of -2.4kg from baseline to follow-up. There was no statistically significant difference between the groups.

Table III. — Comparison of body composition at the 1-year follow-up and the difference in body composition from preoperative examination to 1-year follow-up, between the 4 BMI groups

	BMI group	1-year follow-up Mean (SD)	p-value	Difference Mean (SD)	p-value
Body composition					
Total body weight (kg)	1 2 3 4	75.7 (8.0) 58.8 (6.1) 93.3 (11.0) 109.0 (15.3)	<0.001	0.77 (1.9) 0.73 (3.5) 0.06 (7.2) -3.17 (8.2)	0.13
Total body fat %	1 2 3 4	34.2 (8.2) 33.3 (8.4) 37.6 (7.5) 44.5 (5.2)	0.004	0.35 (1.8) 1.78 (1.8) 0.22 (2.1) 0.17 (3.3)	0.28
Total body muscle%	1 2 3 4	62.2 (8.0) 63.1 (8.0) 59.0 (7.2) 52.5 (4.7)	0.005	-0.3 (1.8) -1.8 (1.8) -0.2 (2.1) -0.5 (3.2)	0.27
Fat body mass (kg)	1 2 3 4	25.1 (6.5) 19.0 (5.6) 34.9 (6.9) 46.9 (8.9)	<0.001	3.1 (1.8) 1.2 (1.4) 4.7 (2.7) -1.3 (5.6)	0.69
Muscle body mass (kg)	1 2 3 4	45.8 (8.1) 35.9 (5.5) 55.2 (9.5) 55.0 (7.4)	<0.001	-0.2 (1.5) -0.7 (1.1) 0.1 (2.2) -2.4 (3.3)	0.73
Bone body mass (kg)	1 2 3 4	2.7 (0.6) 2.0 (0.4) 3.2 (0.5) 3.1 (0.6)	<0.001	-0.02 (0.1) 0.01 (0.1) -0.03 (0.1) 0.06 (0.2)	0.36

BMI groups: 1= normal weight, 2=underweight, 3=overweight, 4=obese. Body composition is presented as means and standard deviation (SD) For p-value, one-way-ANOVA analysis of variance was performed

Admission

Table IV, shows the number of admission days. There were statistically significant differences between the groups' mean number of admission days in relation to the THA surgery. Hospitalization was shortest for the normal-weight group and longest for the obese group.

Table IV. —Comparison of admission days between the 4 BMI groups

	BMI group	Mean (SD)	p-value
Admission days	1 2 3 4	3.2 (0.7) 3.5 (0.5) 3.7 (1.2) 4.3 (1.6)	0.02

BMI groups: 1= normal weight, 2=underweight, 3=overweight, 4=obese. Admission days are presented as means and standard deviation (SD). For p-value, Kruskal-Wallis test was used

DISCUSSION

The literature is unanimous that obesity is a risk factor for several complications during primary THA. Contrary to this, it is unclear whether obese patients achieve a boost in health-related QoL and physical function similar to that of normal-weight THA patients and if they therefore experience good effect of THA treatment, despite their increased risk of complications. Our results indicate that obese patients do not obtain the same physical function and QoL as normal-weight patients 1 year after surgery, and they do not achieve the same improvement as the normal-weight group.

These results are consistent with other studies that have used patient-reported, general-health, and hip-related health outcomes *(22,6,13,24,4)*. Additionally, obesity is associated with longer hospital stays and higher costs of THA, even among patients without comorbidities *(16)*. In our study, we demonstrated comparable results. The obese patients' hospitalization was 1 day longer than that of normal-weight patients.

General-health score

In our study, the obese group had a statistically significantly increased risk of obtaining a worse PCS than normal-weight patients, and they had an increased, statistically non-significant risk of achieving a smaller change in PCS. A cohort study of 1,617 primary THA patients reported that in all the SF-36 domains (8 sub-domains) other than mental health, the scores decreased statistically significantly with increasing BMI 5 years after surgery *(6)*. As in our analysis model, these results were adjusted for age, sex, and comorbidities. Rajgopal et al. demonstrated similar results in super-obese THA patients (BMI > 50kg/m2) who were compared with normal-weight patients. The former had a statistically significantly lower postoperative SF-12 PCS and smaller change in score from pre- to postoperative examination compared with the normal-weight patients *(22)*. In our study, also the underweight group had an increased risk of not achieving the same change in score as the normal-weight group. The overweight group experienced the largest improvement in PCS and MCS from pre-surgery to post-surgery and hence experienced a larger relative improvement in physical and mental health hence outperformed than all other groups in the present study.

Hip-related health score

Our study also demonstrates that the obese group had a statistically significantly increased risk of obtaining a lower ADL 1 year after THA than the normal-weight group. Additionally, they had an increased risk of lower hip-related QoL, more pain, more hip symptoms, and lower function in sports and recreation. The obese group had an increased risk of a smaller improvement in HOOS score than the normal-weight group. As far as we know, none of the studies that have investigated the relationship between obesity and the effect after THA have used HOOS as an outcome measure, whereas the WOMAC score is commonly used. Jones et al. found statistically significantly lover pain scores and function scores in morbidly obese patients than in a non-obese group at the 6-month follow-up, but no statistically significant differences between different BMI groups at the 3-year follow-up *(13)*. In a 2-year follow-up study, McCalden et al. (2011) found that morbidly obese patients did not differ statistically significantly in mean postoperative WOMAC scores from underweight/normal-weight patients. Thus, this group had the largest change in WOMAC score compared with the non-morbidly obese groups *(18)*. Like the SF-36 results for overweight patients in our study, overweight patients had the largest improvement in all HOOS scores; this indicates that the overweight group achieved a larger improvement in hip-related physical and mental health than all other BMI groups.

Body composition

At follow-up, the obese group had accomplished a mean weight loss of 3.17 kg. In the non-obese group, the weight had increased < 1 kg. One obese patient had a large weight loss of 23.8 kg and this person's weight loss alone increased the average weight loss of the group by 1.7 kg. Similarly, one patient in the obese group had a large weight loss of 33.3kg which reduced the average weight gain in the group by 1.3 kg. Paans et al. concluded that no clinically relevant reduction of weight occurred 1 year after THA *(20)*. Our study indicates that the THA treatment has no clinically relevant effect on body composition 1 year after surgery. In a systematic review, no conclusive evidence was found that weight or body composition (weight and BMI) increase, decrease or remain the same after THA *(12)*. Additionally, Wolf et al. recognized no changes in muscle mass or fat mass 3 months, 1 year, and 5 years after THA *(26)*.

Limitations

We acknowledge certain limitations in our study. Some of groups categorized according to BMI were very small. The underweight group comprised only 13% of the cohort population, the obese group only 9%. This might indicate that the study sample size was too small and that the strength of the study was not optimal. On the other hand, all the results in the obese group point in the same direction and indicate a link between obesity and poorer physical function and QoL compared with normal–weight patients; hence, OR <1 for all outcomes. It is known that underweight THA patients *(17)* and hip fracture patients *(5)* are at increased risk of complications, which is the reason why we chose to use BMI as a categorical variable. Underweight is apparently not considered a risk factor for hip-related QoL and physical function in other studies. Several studies placed underweight and normal-weight patients in the same category, *(18)* used BMI to dichotomize patients into an obese and a non-obese group, *(4)* or used BMI as a continuous variable *(24)*. This introduces the possibility that the underweight group pulls the results against the 0 hypothesis.

The study population was consecutive included in the study, and only 2 patients did not participate in the follow-up and were therefore excluded from the study. Both patients were normal-weight. We do not expect that there is any selection bias in the population. All patients answered standardized questionnaires; height and weight were measured and DXA scans performed with the same apparatuses and the same staff (AL) at baseline and at follow-up. We therefore assess that there is no information bias in the study.

In conclusion, our results suggest that obesity increases the risk of poor general-health and hip-related health 1 year after THA, and obesity retards improvement in general health and QoL during the first year after surgery. In addition, the obese patients' hospitalization was 1 day longer than that of the normal-weight patients. Considering this knowledge and the existing knowledge about the association between obesity and the complications in relation to THA, obese patients should be made aware of the increased risk of THA. Furthermore, obese patients should be encouraged to reduce weight before surgery. However, the overall results indicate that the overweight BMI group accomplished the largest improvement of physical and mental general health and hip-related health compared with the normal-weight group. This suggests that overweight patients have much to gain from primary THA. There is a need for further studies examining whether underweight is a risk factor for patient-reported QoL and physical function after THA. THA treatment has no clinically relevant effect on body composition1 year after surgery.

Contribution of authors

KS and IM conceived the study. All authors contributed to the design of the study, the interpretation of the data, and revision of the final manuscript. AL performed the clinical controls, collected data, analyzed the data, and drafted the paper. The analyses of data were supervised by IM.

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