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Body Mass Index ⩾35 kg/m² and Early Postoperative Complications After Primary Hip and Knee Arthroplasty: A Retrospective Cohort Study

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Abstract

Background and objective

Higher body mass index (BMI) has been associated with complications following total joint arthroplasty. However, the clinical value of a fixed BMI cutoff remains uncertain. This study assessed whether BMI ⩾35 kg/m² was associated with early complications after primary total hip arthroplasty (THA) and total knee arthroplasty (TKA).

Methodology

This retrospective cohort study included elective primary THA and TKA operations performed at a regional orthopaedic centre in the United Kingdom between January 2017 and December 2018. Operations were grouped as BMI <35 kg/m² and BMI ⩾35 kg/m². The primary outcome was any documented early postoperative complication. Modified Poisson regression with patient-clustered robust standard errors was used to adjust for age, ASA grade and procedure type. BMI threshold performance and receiver operating characteristic analysis were also assessed.

Results

A total of 466 operations were included, comprising 368 (79.0%) in the BMI <35 kg/m² group and 98 (21.0%) in the BMI ⩾35 kg/m² group. Postoperative complications occurred in 39 (10.6%) operations in the BMI <35 kg/m² group and 14 (14.3%) in the BMI ⩾35 kg/m² group (RR, 1.35; 95% CI, 0.76-2.38; p=0.307). After adjustment for age, American Society of Anesthesiologists (ASA) grade, and procedure type, BMI ⩾35 kg/m² was not significantly associated with postoperative complications (adjusted relative risk (RR), 1.33; 95% confidence interval (CI), 0.73-2.44; p=0.352). ASA III was associated with a higher risk of complications (adjusted RR, 1.85; 95% CI, 1.05-3.27; p=0.034). BMI ⩾35 kg/m² was not significantly associated with hospital stay (IRR, 1.01; 95% CI, 0.88-1.15; p=0.921), blood transfusion (RR, 0.79; 95% CI, 0.29-2.13; p=0.639), or haemoglobin reduction (p=0.848). BMI alone showed poor discriminatory ability with an area under the curve of 0.558 (95% CI: 0.472-0.645). These findings indicate limited discriminatory performance; clinical utility cannot be established from ROC analysis alone.

Conclusion

BMI ⩾35 kg/m² was associated with a higher observed complication rate, but it was not an independent predictor. BMI alone had limited discriminatory performance for individual risk classification. Preoperative decisions should consider overall clinical status rather than a fixed BMI cutoff alone.

Categories: Orthopedics
Keywords: body mass index, obesity, risk assessment, total hip arthroplasty, total knee arthroplasty

Introduction

Total hip arthroplasty (THA) and total knee arthroplasty (TKA) are commonly performed for advanced degenerative joint disease. Obesity is frequently present among patients undergoing these procedures. Higher body mass index (BMI) may increase operative difficulty and may affect wound healing, infection risk, and perioperative recovery. Long-term registry data have shown that obesity remains associated with adverse outcomes after TKA, particularly periprosthetic joint infection [1]. The risk may also increase progressively with increasing BMI rather than at a single fixed cutoff [2].

BMI thresholds are often considered during preoperative risk assessment. However, the most appropriate cutoff remains uncertain. Dash et al. [3] reported a higher complication rate among patients with BMI above 35 kg/m² undergoing anterior-based THA. These patients still achieved clinically meaningful improvement after surgery. DeMik et al. [4] found that lower BMI cutoffs could prevent some complications after TKA. However, these cutoffs would also restrict surgery in many patients expected to have an uncomplicated outcome. Giori et al. [5] reported a similar trade-off between risk reduction and access to joint replacement.

BMI also has limitations as an individual risk marker. It does not measure fat distribution, muscle mass, metabolic health, or local soft-tissue thickness around the operative site. Heifner et al. [6] found that BMI did not adequately represent peri-incisional adiposity in patients undergoing primary joint arthroplasty. Pavlovic et al. [7] also found no clear association between preoperative BMI or modest preoperative weight reduction and postoperative outcomes after THA or TKA. These findings suggest that BMI should be considered alongside age, comorbidity burden, ASA grade, and procedure type.

There is limited evidence on the clinical utility of a BMI cutoff of 35 kg/m² in predicting early complications after combined primary THA and TKA. The present study compared early postoperative complications between patients with BMI < 35 kg/m² and BMI > 35 kg/m². It also assessed whether BMI > 35 kg/m² was independently associated with complications after adjustment for age, ASA grade, and type of arthroplasty. The aims of this study were therefore twofold. First, to compare the occurrence of early postoperative complications between patients with BMI < 35 kg/m² and those with BMI ⩾ 35 kg/m² undergoing primary THA or TKA. Second, to determine whether BMI ⩾ 35 kg/m² is independently associated with early postoperative complications after adjustment for age, ASA grade, and type of arthroplasty. The objectives were to estimate the unadjusted and adjusted relative risk of any early postoperative complication associated with BMI ⩾ 35 kg/m², to describe the distribution of individual complication types by BMI group, and to evaluate the discriminatory performance of BMI and of commonly used BMI thresholds (30, 35, and 40 kg/m²) for predicting early postoperative complications. The primary outcome was the occurrence of any documented postoperative complication during the index admission or within 30 days of surgery. The early postoperative period was therefore defined as the index admission plus 30 days following surgery; complications occurring after 30 days were not included in the primary outcome.

Materials And Methods

Study design and setting

This retrospective observational cohort study was conducted at Dumfries and Galloway Royal Infirmary, a regional orthopaedic centre in Scotland, United Kingdom. The hospital serves a mixed urban and rural population and provides elective primary hip and knee arthroplasty services for the region. All elective primary total hip arthroplasty (THA) and total knee arthroplasty (TKA) operations performed between January 2017 and December 2018 were reviewed. The study was undertaken as a service evaluation using routinely collected clinical data.

All records were anonymised before analysis. The project was conducted as a service evaluation using data collected during routine clinical care. The study was reviewed by the local Clinical Governance and Audit Department at Dumfries and Galloway Royal Infirmary, which determined that formal research ethics approval was not required under NHS Scotland service evaluation governance arrangements. This determination was based on the use of routinely collected anonymised data for service improvement purposes. The study was conducted in accordance with the Declaration of Helsinki and local data protection regulations.

Study population

All consecutive patients aged 18 years or above who underwent elective primary THA or TKA during the study period were eligible. Revision arthroplasty and arthroplasty involving joints other than the hip or knee were excluded. Consecutive case selection was used to reduce selection bias.

A total of 630 operations were identified during the study period. Of these, 466 operations from 443 patients had complete BMI and postoperative complication data and were included in the primary complete-case analysis. Twenty-three patients underwent two operations during the study period. The remaining 164 operations (26.0%) were excluded from the primary analysis. Reasons for exclusion were: missing BMI data (n=89), missing complication status (n=42), and missing both BMI and complication data (n=33). Missing data were more prevalent during the later study period (2018) due to changes in electronic record documentation. A comparison of included versus excluded operations is presented in the supplementary table in the Appendices. A STROBE-style flow diagram illustrating patient identification, exclusion, and inclusion is presented in Figure *1*.

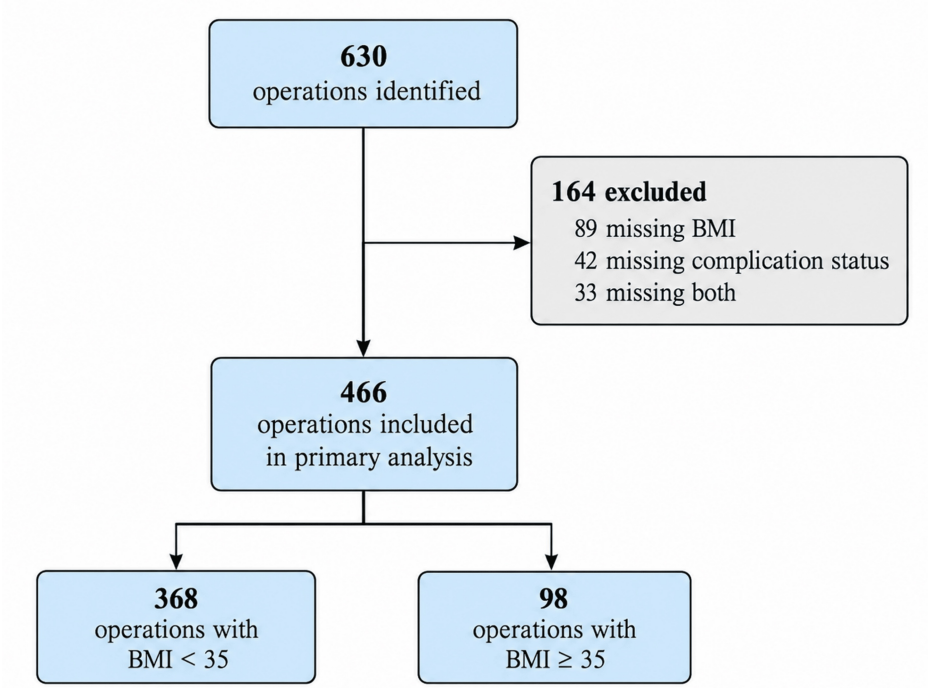


FIGURE 1: STROBE flow diagram

Data collection

Data were obtained from electronic patient records and inpatient documentation. The variables collected were age, BMI, American Society of Anesthesiologists (ASA) grade [8], type of arthroplasty, hospital stay, preoperative haemoglobin, postoperative haemoglobin, blood transfusion and postoperative complications.

BMI was calculated using the latest height and weight recorded during preoperative assessment. Operations were divided into two groups: BMI <35 kg/m² and BMI ⩾35 kg/m². The cutoff of 35 kg/m² was selected because it is commonly considered during risk stratification and eligibility assessment for elective arthroplasty. This threshold was prespecified before data analysis based on its widespread use in institutional protocols and its inclusion in previous studies of arthroplasty outcomes [3,4,9,10]. The threshold was not selected based on the current dataset.

All operations were performed by or under the supervision of consultant orthopaedic surgeons. Standard perioperative protocols were followed. These included antibiotic prophylaxis (typically a single dose of intravenous cefazolin or teicoplanin for penicillin-allergic patients), venous thromboembolism prophylaxis (aspirin or low molecular weight heparin according to local guidelines), and early mobilisation with physiotherapy on the first postoperative day. These protocols were consistent throughout the study period.

Outcome measures

The primary outcome was the occurrence of any documented postoperative complication during the index admission or within 30 days of surgery (early postoperative period). Complications were identified from electronic patient records, inpatient documentation, and readmission records. Pre-specified complication categories included: (1) wound complications (wound leakage, cellulitis requiring antibiotics, superficial or deep wound infection); (2) thromboembolic complications (deep vein thrombosis, pulmonary embolism); (3) mechanical complications (prosthetic joint dislocation); and (4) other documented complications (including nonspecific records where a complication was noted without a clear subtype). Complications were adjudicated by two independent reviewers (SSJ and RNK), with discrepancies resolved by consensus. Nonspecific complication records were retained in the composite primary outcome but were not classified into a specific clinical category.

Complications were defined using standardized criteria as follows: wound leakage (persistent drainage from the surgical wound requiring dressing changes beyond 72 hours postoperatively); cellulitis (erythema, warmth, and tenderness requiring antibiotic therapy); deep wound infection (infection involving the deep tissues, confirmed by culture or requiring surgical intervention); deep vein thrombosis (confirmed by Doppler ultrasound or venography); pulmonary embolism (confirmed by CT pulmonary angiography or ventilation-perfusion scanning); and prosthetic joint dislocation (confirmed by radiography). Nonspecific complications were those where a complication was documented in the medical record without sufficient

detail to classify into a specific category.

Other medical or surgical complications, including urinary tract infection, pneumonia, cardiovascular events, readmission, and mortality, were not reliably captured in the source records and were therefore not included in the primary outcome. This is acknowledged as a limitation.

Secondary outcomes included hospital stay, blood transfusion and postoperative haemoglobin reduction. Haemoglobin reduction was calculated by subtracting postoperative haemoglobin from preoperative haemoglobin. The clinical performance of BMI thresholds of 30, 35 and 40 kg/m² was also assessed. Sensitivity, specificity, positive predictive value, negative predictive value and likelihood ratios were calculated. BMI discrimination was assessed using receiver operating characteristic analysis, with BMI treated as a continuous variable. The ROC analysis evaluates discrimination only and does not establish clinical utility.

Statistical analysis

Continuous variables were presented as mean with standard deviation when the distribution was approximately symmetrical, or as median with interquartile range when the distribution was skewed. The choice between these summary measures was determined by visual inspection of histograms and by formal assessment of skewness, with a skewness value outside the range of −1 to +1 (or a ratio of skewness to its standard error exceeding 2) taken to indicate meaningful departure from normality. The same distributional assessment determined the choice of statistical test: Welch's t-test was used for approximately symmetrical variables, and the Wilcoxon rank-sum test was used for skewed variables. Categorical variables were presented as number and percentage. The chi-square test and Fisher's exact test were used for categorical variables. The unadjusted association between BMI ⩾35 kg/m² and complications was reported as relative risk with 95% confidence interval. Absolute risk difference was also calculated.

Modified Poisson regression with a log link was used for the main adjusted analysis. Robust standard errors were clustered by patient to account for patients who underwent more than one operation. The model included BMI group, age per 10-year increase, ASA III or above and procedure type. THA was used as the reference procedure. Covariates were selected a priori based on clinical relevance and previous literature. Age was included as a continuous variable per 10-year increase because of its established association with postoperative complications. ASA grade was included as a marker of overall comorbidity burden, which has been shown to outperform individual comorbidity measures in arthroplasty populations [11-14]. Procedure type was included because previous studies have demonstrated differential effects of BMI on outcomes after THA versus TKA [9]. Sex, diabetes, smoking status, and other individual comorbidities were not reliably available in the dataset and could not be included; this is acknowledged as a limitation and may result in residual confounding.

BMI was also analysed as a continuous variable per 5 kg/m² increase. Logistic regression was performed as a sensitivity analysis. In an exploratory analysis, a quadratic BMI term was used to assess nonlinearity; this analysis was limited by the small number of events and should be considered hypothesis-generating. An interaction term between BMI group and procedure type was used to assess whether the association differed between THA and TKA; this analysis was also exploratory and underpowered.

Sensitivity analyses were performed after excluding source-conflict records, including only the first operation per patient, and restricting the study period to June 2018. Source-conflict records were defined as operations where the electronic patient record and inpatient documentation contained discrepant information regarding the presence or absence of a postoperative complication. These records were identified during data collection and were excluded in a sensitivity analysis to assess the robustness of the primary findings. The June 2018 cutoff was selected because a transition in electronic documentation occurred in mid-2018, which may have affected data completeness and complication ascertainment. This sensitivity analysis was performed to assess whether the main findings were robust to this potential source of bias.

Separate subgroup analyses were performed for THA and TKA. Hospital stay was analysed using negative binomial regression because of overdispersion. Transfusion was analysed using modified Poisson regression adjusted for procedure type and preoperative haemoglobin. Haemoglobin reduction was analysed using linear regression adjusted for age, ASA grade, procedure type and preoperative haemoglobin. A two-sided p-value below 0.05 was considered statistically significant. Analysis was performed using R version 4.5.2 (R Foundation for Statistical Computing, Vienna, Austria).

The study had limited statistical power to detect moderate associations. With 53 total complications and 14 complications in the BMI ⩾35 kg/m² group, the study was underpowered to detect a relative risk below approximately 2.0. A formal post-hoc power calculation indicated that the study had approximately 30% power to detect a relative risk of 1.35 at a two-sided alpha of 0.05.

Results

The study included 466 operations, with 368 (79.0%) in the BMI <35 kg/m² group and 98 (21.0%) in the BMI ⩾35 kg/m² group. Patients in the BMI ⩾35 kg/m² group were younger than those in the BMI <35 kg/m² group (66.05 ± 10.48 vs. 70.87 ± 9.77 years; p<0.001). Total knee arthroplasty was more frequent in the BMI ⩾35 kg/m² group, occurring in 64 (65.3%) operations compared with 161 (43.8%) in the BMI <35 kg/m² group (p<0.001). ASA grade also differed between the groups (p=0.007), with ASA III recorded in 25 (25.5%) operations in the BMI ⩾35 kg/m² group compared with 53 (14.4%) in the BMI <35 kg/m² group. Preoperative haemoglobin levels were similar between the groups (p=0.178) (Table *1*). A complete breakdown of individual complications by BMI group is presented in Table *2*.

Characteristic	BMI <35 kg/m² (n=368)	BMI ≥35 kg/m² (n=98)	Test statistics	p-value
Age, years	70.87 ± 9.77[1]	66.05 ± 10.48	t=4.10, df=145, Cohen's d=0.4	<0.001
BMI, kg/m²	28.46 ± 3.69	37.71 ± 2.50	t=−29.14, df=222, Cohen's d=−2.66	<0.001
Procedure				
Total hip arthroplasty	207 (56.3)	34 (34.7)	χ^2=14.40, df=1, Cramér's V=0.18	<0.001
Total knee arthroplasty	161 (43.8)	64 (65.3)		
ASA grade				
ASA I	42 (11.4)	4 (4.1)	χ^2=10.07, df=2, Cramér's V=0.15	0.007
ASA II	273 (74.2)	69 (70.4)		
ASA III	53 (14.4)	25 (25.5)		
Preoperative haemoglobin	134.80 ± 13.17[2]	132.98 ± 11.48	t=1.35, df=171, Cohen's d=0.14	0.178

TABLE 1: Baseline and operative characteristics by BMI group

Data are presented as mean ± standard deviation or number (percentage). Categorical variables were compared using the chi-square test. Continuous variables were compared using Welch's t-test.
[1]Age was available for 364 operations in the BMI <35 group.
[2]Preoperative haemoglobin was available for 367 operations in the BMI <35 group.

ASA: American Society of Anesthesiologists [8].

Complication type	BMI <35 kg/m² (n=368)	BMI ≥35 kg/m² (n=98)	Total (n=466)
Wound complications	18 (4.9)	7 (7.1)	25 (5.4)
Wound leakage	10 (2.7)	4 (4.1)	14 (3.0)
Cellulitis requiring antibiotics	6 (1.6)	2 (2.0)	8 (1.7)
Deep wound infection	2 (0.5)	1 (1.0)	3 (0.6)
Thromboembolic complications	8 (2.2)	2 (2.0)	10 (2.1)
Deep vein thrombosis	6 (1.6)	1 (1.0)	7 (1.5)
Pulmonary embolism	2 (0.5)	1 (1.0)	3 (0.6)
Mechanical complications	5 (1.4)	2 (2.0)	7 (1.5)
Prosthetic joint dislocation	5 (1.4)	2 (2.0)	7 (1.5)
Nonspecific complications	8 (2.2)	3 (3.1)	11 (2.4)
Total complications	39 (10.6)	14 (14.3)	53 (11.4)

TABLE 2: Individual complications by BMI group

Data are presented as number (percentage). Some operations had more than one complication. Nonspecific complications were those where a complication was documented without a clear subtype.

Postoperative complications occurred in 39 (10.6%) operations in the BMI <35 kg/m² group and 14 (14.3%) in the BMI ⩾35 kg/m² group. The relative risk was 1.35 (95% CI, 0.76-2.38), with an absolute risk difference of 3.69 percentage points (95% CI, −3.92 to 11.30). The difference between the groups was not statistically significant (p=0.307) (Table *3*).

BMI group	No complication, n	Complication, n (%)	Relative risk (95% CI)	Risk difference, percentage points (95% CI)	p-value
BMI <35 kg/m²	329	39 (10.6)	Reference	Reference	0.307
BMI ≥35 kg/m²	84	14 (14.3)	1.35 (0.76–2.38)	3.69 (−3.92 to 11.30)	
Total	413	53 (11.4)			

TABLE 3: Postoperative complications by BMI group

CI: confidence interval. The p-value was calculated using the Pearson chi-square test. Fisher's exact test gave p=0.370

After adjustment for age, ASA grade, and procedure type, BMI ⩾35 kg/m² was not significantly associated with postoperative complications (adjusted RR, 1.33; 95% CI, 0.73-2.44; p=0.352). ASA III was associated with a higher risk of postoperative complications (adjusted RR, 1.85; 95% CI, 1.05-3.27; p=0.034). Age and total knee arthroplasty were not significantly associated with postoperative complications. A 5 kg/m² increase in BMI was also not significantly associated with complications (adjusted RR, 1.16; 95% CI, 0.90-1.49; p=0.265) (Table *4*).

Predictor	Adjusted relative risk	95% CI	p-value
BMI ≥35 versus BMI <35 kg/m²	1.33	0.73–2.44	0.352
Age, per 10-year increase	1.09	0.81–1.46	0.578
ASA III versus ASA I–II	1.85	1.05–3.27	0.034
Total knee versus total hip arthroplasty	1.02	0.61–1.72	0.929
BMI, per 5 kg/m² increase[1]	1.16	0.90–1.49	0.265

TABLE 4: Adjusted analysis of postoperative complications

Modified Poisson regression was used with robust standard errors clustered by patient. The primary model included 462 operations with complete covariate data.

[1]The continuous BMI estimate was obtained from a separate model adjusted for age, ASA grade and procedure type.

Median hospital stay was 4 days (IQR, 3-5) in both BMI groups, with no significant difference between groups (p=0.597). Blood transfusion occurred in 27 (7.3%) operations in the BMI <35 kg/m² group and 5 (5.1%) in the BMI ⩾35 kg/m² group (p=0.437). After adjustment, BMI ⩾35 kg/m² was not significantly associated with hospital stay (IRR, 1.01; 95% CI, 0.88-1.15; p=0.921) or blood transfusion (RR, 0.79; 95% CI, 0.29-2.13; p=0.639). Haemoglobin reduction was similar between the groups (21.35 ± 9.42 vs. 21.14 ± 9.69; p=0.848) (Table 5).

Outcome	BMI <35 kg/m²	BMI ≥35 kg/m²	Unadjusted p-value	Adjusted BMI effect (95% CI)	Adjusted p-value
Hospital stay, days, median (IQR)	4 (3–5), n=367	4 (3–5), n=98	0.597	IRR 1.01 (0.88–1.15)	0.921
Blood transfusion, n (%)	27/368 (7.3)	5/98 (5.1)	0.437	RR 0.79 (0.29–2.13)	0.639
Haemoglobin reduction, mean ± SD	21.35 ± 9.42, n=366	21.14 ± 9.69, n=96	0.848	MD −0.17 (−2.62 to 2.29)	0.895

TABLE 5: Secondary perioperative outcomes by BMI group

CI: confidence interval; IQR: interquartile range; IRR: incidence rate ratio; MD: mean difference; RR: relative risk; SD: standard deviation

At the BMI ⩾35 kg/m² threshold, sensitivity was 26.4%, specificity was 79.7%, positive predictive value was 14.3%, and negative predictive value was 89.4%. The BMI ⩾30 kg/m² threshold showed higher sensitivity (64.2%) but lower specificity (50.6%). At BMI ⩾40 kg/m², sensitivity was 3.8% and specificity was 95.4%. The area under the curve was 0.558 (95% CI, 0.472-0.645). These findings indicate limited discriminatory performance; clinical utility cannot be established from ROC analysis alone (Table 6).

BMI threshold	Patients above threshold, n	Sensitivity, % (95% CI)	Specificity, % (95% CI)	PPV, % (95% CI)	NPV, % (95% CI)	LR+ / LR−
≥30 kg/m²	238	64.2 (49.8–76.9)	50.6 (45.7–55.5)	14.3 (10.1–19.4)	91.7 (87.3–94.9)	1.30 / 0.71
≥35 kg/m²	98	26.4 (15.3–40.3)	79.7 (75.5–83.4)	14.3 (8.0–22.8)	89.4 (85.8–92.4)	1.30 / 0.92
≥40 kg/m²	21	3.8 (0.5–13.0)	95.4 (92.9–97.2)	9.5 (1.2–30.4)	88.5 (85.2–91.3)	0.82 / 1.01

TABLE 6: Performance of BMI thresholds for postoperative complications

CI: confidence interval; LR+: positive likelihood ratio; LR−: negative likelihood ratio; NPV: negative predictive value; PPV: positive predictive value

The sensitivity analyses showed results similar to those of the primary analysis. After excluding source-conflict records, complications occurred in 38 (10.5%) operations in the BMI <35 kg/m² group and 13 (13.4%) in the BMI ⩾35 kg/m² group (RR, 1.27; 95% CI, 0.71-2.29; p=0.424). In the first-operation-only analysis, complications occurred in 37 (10.5%) and 13 (14.1%) operations, respectively (RR, 1.34; 95% CI, 0.74-2.42; p=0.333). For operations performed through June 2018, complications occurred in 39 (10.7%) and 14 (14.4%) operations, respectively (RR, 1.35; 95% CI, 0.77-2.39; p=0.299). In the procedure-specific analyses, complications occurred in 21 (10.1%) versus 6 (17.6%) total hip arthroplasty operations (RR, 1.74; 95% CI, 0.76-4.00; p=0.199) and 18 (11.2%) versus 8 (12.5%) total knee arthroplasty operations (RR, 1.12; 95% CI, 0.51-2.44; p=0.780). The BMI-by-procedure interaction was not statistically significant (p=0.672) (Table 7).

Analysis	BMI <35 kg/m², n/N (%)	BMI ≥35 kg/m², n/N (%)	Relative risk (95% CI)	p-value
Primary complete-case analysis	39/368 (10.6)	14/98 (14.3)	1.35 (0.76–2.38)	0.307
Source-conflict records excluded	38/361 (10.5)	13/97 (13.4)	1.27 (0.71–2.29)	0.424
First operation per patient only	37/351 (10.5)	13/92 (14.1)	1.34 (0.74–2.42)	0.333
Operations through June 2018	39/366 (10.7)	14/97 (14.4)	1.35 (0.77–2.39)	0.299
Total hip arthroplasty	21/207 (10.1)	6/34 (17.6)	1.74 (0.76–4.00)	0.199
Total knee arthroplasty	18/161 (11.2)	8/64 (12.5)	1.12 (0.51–2.44)	0.780

TABLE 7: Sensitivity and subgroup analyses of postoperative complications

CI: confidence interval; THA: total hip arthroplasty; TKA: total knee arthroplasty

Exploratory analyses of individual complication categories showed that wound complications occurred in 7.1% of operations in the BMI ⩾35 kg/m² group versus 4.9% in the BMI <35 kg/m² group (RR: 1.45, 95% CI: 0.62-3.38, p=0.389). Thromboembolic complications occurred in 2.0% versus 2.2% (RR: 0.93, 95% CI: 0.20-4.32, p=0.928). Mechanical complications occurred in 2.0% versus 1.4% (RR: 1.50, 95% CI: 0.30-7.57, p=0.623). These exploratory analyses were limited by the small number of events in each category and should be interpreted cautiously.

Discussion

The present study included 466 complete operations from 443 patients. Postoperative complications occurred in 14.3% of operations in the BMI ⩾35 kg/m² group and 10.6% in the BMI <35 kg/m² group. The unadjusted relative risk was 1.35, and the absolute risk difference was 3.69 percentage points. However, the association was not statistically significant. After adjustment for age, ASA grade, and procedure type, BMI ⩾35 kg/m² remained nonsignificant, with an adjusted relative risk of 1.33. These findings indicate a higher observed complication rate in the higher-BMI group; however, no statistically significant independent association was detected. The 95% confidence interval (0.73-2.44) remains compatible with a clinically meaningful increase in risk, and the study may have been underpowered to detect a moderate association.

Previous studies have shown variable findings. Li et al. [9] found no significant increase in complications

among patients with obesity undergoing primary TKA, although hospital stay and rehabilitation were longer. Abdulla et al. [10] found that the effect of BMI varied by procedure and outcome, with adverse medical and infection-related outcomes more evident after THA. Differences between studies may be related to sample size, BMI classification, follow-up duration, and the complications included in the outcome.

Some studies have reported a clearer increase in risk above BMI 35 kg/m². Luger et al. [11] found that BMI ⩾35 kg/m² was associated with higher rates of general surgical complications, periprosthetic joint infection, and early revision after THA. Dash et al. [3] also reported a higher complication rate after anterior-based THA in patients with BMI above 35 kg/m², although these patients still achieved clinically meaningful improvement. These studies were procedure- and approach-specific, and their findings may not be directly comparable with a combined THA and TKA cohort having a broader composite outcome.

The effect of BMI may become more evident at extreme levels of obesity. Palmer et al. [12] reported higher risks of periprosthetic joint infection, pulmonary embolism, wound dehiscence, and acute renal failure among patients with BMI ⩾50 kg/m² undergoing primary TKA. Only 21 operations in the present study involved patients with BMI ⩾40 kg/m², which may partly explain the smaller observed association.

BMI was also assessed as a continuous variable. Each 5 kg/m² increase was associated with an adjusted relative risk of 1.16, but this was not statistically significant. In an exploratory analysis, the quadratic term in BMI was also nonsignificant. This analysis was limited by the small number of events (n=53) and should be considered hypothesis-generating. Telang et al. [2] reported a nonlinear association between BMI and periprosthetic joint infection after TKA, with risk increasing more clearly above a BMI of approximately 31 kg/m². Uvodich et al. [1] found that improvement in infection-related outcomes was less evident among patients with obesity over 30 years. The present study included only 53 complications, which was insufficient to identify a reliable outcome-specific BMI change point.

The association was numerically stronger in the THA subgroup than in the TKA subgroup. The relative risk was 1.74 after THA and 1.12 after TKA. Neither association was statistically significant, and the BMI-by-procedure interaction was also nonsignificant. However, only 34 THAs were performed in the BMI ⩾35 kg/m² group, with only six complications. This subgroup analysis is therefore likely underpowered and should be considered exploratory. Schmerler et al. [13] found that patients with morbid obesity were more likely to undergo revision for periprosthetic joint infection than normal-weight patients, supporting a possible stronger infection-related effect in hip arthroplasty.

ASA grade III was the only covariate significantly associated with postoperative complications in the main model, with an 85% higher risk. However, this comparison should be interpreted cautiously. Statistical significance does not establish that ASA III is a stronger predictor than BMI, particularly given the limited number of events. Gronbeck et al. [14] found that ASA classification was associated with most assessed postoperative outcomes and performed better than several individual comorbidity measures. Clement et al. [15] found that increasing ASA grade was associated with longer hospital stay and higher risks of readmission and mortality. These findings support assessment of overall comorbidity burden rather than reliance on BMI alone.

Hospital stay was similar between the two BMI groups, with a median of four days in each. Blood transfusion was required in 5.1% of operations in the BMI ⩾35 kg/m² group and 7.3% in the BMI <35 kg/m² group. Mean hemoglobin reduction was also comparable. Similar perioperative pathways and the small number of patients with extreme obesity may have reduced differences in these secondary outcomes.

The threshold analysis was clinically important. BMI ⩾35 kg/m² had a sensitivity of 26.4% and a positive predictive value of 14.3%, identifying only 14 of the 53 operations with complications. Specificity was 79.7%. BMI alone showed poor discriminatory ability with an area under the curve of 0.558 (95% CI: 0.472-0.645). These findings indicate limited discriminatory performance; clinical utility cannot be established from ROC analysis alone. A BMI cutoff may identify a group with a somewhat higher average risk; however, it performs poorly as an individual prediction tool. These findings should not be interpreted as evidence that BMI has no role in multivariable risk assessment.

Roth et al. [16] also found limited clinical value for fixed BMI thresholds after TKA. DeMik et al. [4] showed that lower BMI cutoffs could prevent more complications but would also restrict many patients expected to undergo complication-free surgery. Giori et al. [5] reported that a BMI cutoff of 40 kg/m² would have denied 1,148 patients an operation free of major complications while potentially avoiding 83 major complications. DeMik et al. [17] reported a similar trade-off between complication reduction and access to surgery in their THA study. These findings suggest that a fixed BMI cutoff may reduce some adverse outcomes but may also unnecessarily restrict access to arthroplasty.

Surgical approach may modify the effect of obesity on wound outcomes. Salmons et al. [18] reported that wound complication risk increased most clearly above a BMI of approximately 33 kg/m² in both approach groups. Acuña et al. [19] found no significant increase in early postoperative instability after THA across matched BMI categories. Obesity may therefore have a stronger relationship with infection and wound

complications than with early mechanical instability. In the present study, the composite primary outcome combined biologically distinct complications, which may have diluted associations specific to particular complication types. Exploratory analyses showed that wound complications occurred in 7.1% of operations in the BMI ⩾35 kg/m² group versus 4.9% in the BMI <35 kg/m² group (RR: 1.45, 95% CI: 0.62-3.38). These exploratory analyses were limited by the small number of events and should be interpreted cautiously.

Patients with obesity may still obtain clinically important functional improvement after arthroplasty. Sobba et al. [20] found that the degree of improvement after surgery was comparable across BMI groups. The role of preoperative weight reduction remains uncertain. LaValva et al. [21] found that meaningful BMI reduction before surgery was not associated with fewer 90-day complications. Spezia et al. [22] reported a more selective benefit, with reduction of BMI below 45 kg/m² associated with lower infection risk among patients with extreme obesity. Preoperative optimization may therefore be more useful at extreme BMI levels.

BMI does not distinguish adipose tissue from muscle mass and does not measure metabolic health or local adiposity around the operative site. Heifner et al. [6] found that BMI did not adequately represent peri-incisional adiposity in patients undergoing primary joint arthroplasty. Pavlovic et al. [7] found no clear association between preoperative BMI or modest preoperative weight reduction and outcomes up to six months after THA or TKA. Other factors, such as comorbidity burden, nutritional status, and local soft-tissue characteristics, may therefore provide additional risk information.

The findings remained similar after excluding source-conflict records, including only the first operation per patient, and restricting the study period to June 2018. Relative risks remained between 1.27 and 1.35 across these analyses, and the confidence intervals included 1 in every analysis. The study should therefore be interpreted as showing an uncertain increase in risk rather than proof of no association.

The study also has several strengths. Relative risks and absolute risk differences were reported with confidence intervals, allowing the magnitude and precision of the observed association to be assessed directly. Repeated operations in the same patient were addressed using patient-clustered robust standard errors, accounting for within-patient correlation. BMI was analysed as both a categorical and a continuous variable, and the prespecified 35 kg/m² threshold was selected before data analysis on the basis of its use in institutional protocols and previous literature rather than on the current dataset. Threshold performance was evaluated using sensitivity, specificity, predictive values, and likelihood ratios, and discrimination was assessed by receiver operating characteristic analysis. Several sensitivity analyses - excluding source-conflict records, including only the first operation per patient, and restricting the study period to June 2018 - were performed, and the findings were consistent across these analyses. Completeness of the core surgical and outcome variables, the use of standardized complication definitions, and adjudication of complications by two independent reviewers with consensus resolution further support the internal validity of the findings. However, these strengths should be considered in the context of the study's limitations.

This study has several limitations. First, it was retrospective, and 164 of the 630 identified operations (26.0%) lacked complete BMI and complication data, raising concern for selection bias. Missing data were mainly present during the later study period. Complete-case analysis may have introduced bias if missingness was related to both BMI and complication status. Second, the primary outcome was a composite measure of complications, which may have diluted associations specific to particular complication types. Third, the number of events was limited (n = 53), particularly in the BMI ⩾ 35 kg/m² THA subgroup. A formal post-hoc power calculation indicated that the study had approximately 30% power to detect a relative risk of 1.35. The nonsignificant findings should therefore be interpreted as indicating uncertainty rather than absence of association. Fourth, sex, diabetes, smoking status, and other individual comorbidities were not available, resulting in potential residual confounding. Fifth, follow-up was limited to 30 days, and longer-term complications were not assessed. Sixth, the study was conducted at a single institution, which may limit generalizability.

Overall, BMI ⩾35 kg/m² was associated with a higher observed complication rate, but no statistically significant independent association was detected after adjustment. ASA grade III was significantly associated with postoperative risk. BMI ⩾35 kg/m² also had low sensitivity and poor discriminatory performance. BMI should remain part of preoperative counseling and optimization but should not be used as the sole criterion for determining eligibility for primary hip or knee arthroplasty.

Conclusions

The complication rate was higher in operations involving patients with BMI ⩾35 kg/m², but the difference was not statistically significant. BMI ⩾35 kg/m² was not significantly associated with complications after adjustment for age, ASA grade and procedure type; however, the confidence interval remains compatible with a clinically meaningful increase in risk. ASA grade III was significantly associated with postoperative complications, although this comparison should be interpreted cautiously given the limited event count. BMI alone had poor discriminatory performance and the cutoff of 35 kg/m² had low sensitivity. In this single-centre retrospective cohort, BMI should be considered during counselling and preoperative optimisation, but it should not be used as the only criterion for accepting or refusing primary hip or knee arthroplasty. These findings should be interpreted in the context of the study's limitations, including the

relatively small sample size, missing data, and the 2017-2018 study period. Larger, prospective studies with standardised complication definitions and longer follow-up are needed to confirm these findings and to better define the role of BMI in preoperative risk assessment.

Appendices

Characteristic	Included (n=466)	Excluded (n=164)	p-value
Age, years	**69.85 ± 10.12**	**68.92 ± 11.34**	**0.312**
BMI, kg/m²	30.41 ± 5.52	31.02 ± 6.18	0.228
Procedure, n (%)			0.187
Total hip arthroplasty	241 (51.7)	76 (46.3)	
Total knee arthroplasty	225 (48.3)	88 (53.7)	
ASA grade, n (%)			0.421
ASA I	46 (9.9)	14 (8.5)	
ASA II	342 (73.4)	118 (72.0)	
ASA III	78 (16.7)	32 (19.5)	
Calendar period, n (%)			<0.001
January–December 2017	289 (62.0)	42 (25.6)	
January–December 2018	177 (38.0)	122 (74.4)	

TABLE 8: Comparison of included versus excluded operations

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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