

The Effect of Obesity on Theatre Utilisation Time During Primary Hip and Knee Replacements

Seif Sawalha^{*1}, Peter Ralte¹, Carol Chan¹ and Prakash Chandran²

¹Orthopaedic Surgery, Mersey Deanery, Liverpool, UK

²Warrington and Halton Hospitals NHS Trust, UK

Abstract: *Introduction:* The aim of this study is to assess the effect of body mass index (BMI) and body weight on theatre utilisation time during primary total hip (THR) and knee replacements (TKR).

Methods: A total of 1859 cases were included (820 THR and 1039 TKR). Patients were divided into groups based on BMI and body weight. The time interval from 'starting anaesthesia' to 'transfer back to recovery' was used as total theatre time. Hierarchical regression analysis was then used to study the effect of BMI and body weight while controlling the effect of any confounding variables.

Results: In THR cases, the median theatre time was significantly different between BMI and body weight subgroups ($p=0.001$). In TKR cases, the median theatre time was more significantly different between weight subgroups ($p<0.001$) than BMI subgroups ($p=0.021$). Regression analysis showed that only weight remained a significant predictor ($p=0.018$) of theatre time in THR cases after controlling for other variables. In TKR cases, body weight and BMI were not predictors of theatre time after controlling for other variables.

Conclusion: Body weight is a significant predictor of theatre time during THR. Neither weight nor BMI predicted theatre time during TKR.

Keywords: body mass index, body weight, hip replacement, knee replacement, obesity, theatre time.

INTRODUCTION

The estimated duration of time required to complete an operation is an important factor in planning theatre lists [1]. Identifying patient factors that can predict increased operation time can improve theatre list management by avoiding list over-running and unplanned cancellations. There are also financial implications for increased theatre time utilisation in a specific subgroup of patients [2].

In the National Health Service (NHS) in England, 39% of patients who underwent primary hip replacements and 56% of those who underwent knee replacements in 2012 were obese [3]. Given that high proportion of obese patients, clarifying the relation between obesity and theatre utilisation is important.

Several publications have suggested that the operative time for hip and knee arthroplasty is increased in obese patients [4-8]. Other researchers reported no significant difference between obese and non-obese patients [9, 10]. There are limitations to the current available evidence. Some of these studies did not control the effect of confounding variables or relied on data from a single surgeon and included very small number of obese and morbidly obese patients. In addition, most studies relied on the body mass

index (BMI) alone as a measure of obesity although it doesn't reflect the patient morphology [11].

The aim of this study is to assess the effect of BMI and patient body weight on theatre utilisation time during primary hip and knee replacements.

METHODS

A list of all primary total hip (THR) and knee replacement (TKR) cases performed in the hospital during the study period was retrieved from the electronic theatre management system. As the study involved retrospective review of electronic records, ethical approval was not required but the project was approved by the local audit department in our hospital. We identified 2016 consecutive cases of THR and TKR (956 THR and 1060 TKR) performed between April 2009 and July 2013. Fig. (1) shows the flow diagram of patients in the study. After excluding patients who were admitted acutely for fractures, metastasis or fixation failure and those with incomplete data on BMI or theatre time, the remaining 820 THR and 1039 TKR patients were included.

Demographics, height and weight, and ASA grade were retrieved from preoperative assessment clinic records. Operative details and times were retrieved from electronic theatre records. We used the time interval (in minutes) from starting anaesthesia till transferring the patient back from theatre to recovery room as the dependent variable. Patients were divided into groups based on the WHO classification of

*Address correspondence to this author at the Arrowe Park Hospital, Wirral, UK; Tel: 00441512363739; E-mail: seifsawalha1@nhs.net

obesity but underweight and normal weight patients were analysed in one group as the number of underweight patients was very small. Patients were also stratified into weight groups; <69.99kg, 70-89.99kg, 90-109.9kg and >110kg.

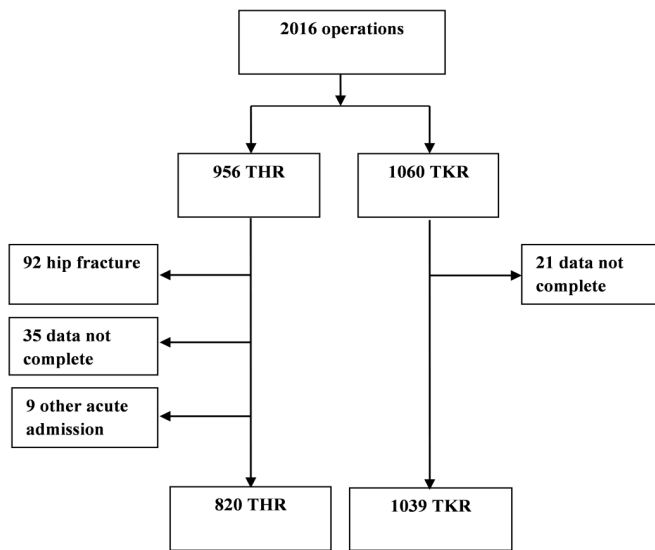


Fig. (1). Flow diagram of patients in the study.

Statistical Analysis

Statistical analysis was performed with IBM SPSS 20.0 statistics software (Armonk, NY: IBM Corp). Patient body weights, BMI and theatre times did not follow a normal distribution and were skewed to the right. A non-parametric approach to analysis was used. Data on continuous variables was presented using medians and interquartile ranges (IQR). The BMI and weight subgroups were compared using Kruskal-Wallis test. A p-value < 0.05 was considered to be statistically significant.

A hierarchical linear regression model was used to control for the effects of confounding variables (gender, ASA grade, surgeon, type of operation and theatre suite used) on theatre times. Hierarchical regression analysis was used because it allows us to specify a fixed order of entry of variables to the model and evaluate the contribution of the variables of interest (BMI and body weight) above and beyond control variables. As the theatre time, body weight and BMI values were skewed to the right, a natural log transformation (log-10) of the variables was used for regression analysis. Age was not entered as a variable in the model as its effect on theatre time is through the associated comorbidities which are reflected in the ASA grade. As body weight and BMI are related, we tested multicollinearity in the model by measuring tolerance and variance inflation factor (VIF) of the variables. The tolerance values were > 0.1 and VIF <10

for all variables indicating minimal multicollinearity.

RESULTS

Table 1 summarises baseline data for patients in the study. The proportion of obese patients (BMI ≥30) was 55.2% in TKR cases and 39.2% in THR cases.

Table 1. Baseline data for patients in the study.

Continuous Variables (Median, IQR 25 th -75 th Percentile)	THR	TKR
	n=820	n= 1039
Median age (years)	69 (61-75.8)	68 (62-75)
Gender		
male (n, %)	356 (43.4%)	488 (47%)
female (n, %)	464 (56.6%)	551 (53%)
Median body weight (kg)	80 (67.6-93)	86 (75-98)
Median BMI	28.4 (25-32.8)	30.86 (27.13-35.12)
Median theatre time (min)	143.5 (118-167)	136 (120-155)
ASA (n, %)		
I	160 (19.5%)	157 (15.1%)
II	488 (59.5%)	731 (70.4)
III	170 (20.7%)	150 (14.4%)
IV	2 (0.3%)	1 (0.1%)
Operation (n, %)		
Cemented	572 (69.7%)	1020 (98.2%)
Uncemented	94 (11.4%)	N/A
Hybrid	89 (10.8%)	N/A
Reverse hybrid	61 (7.7%)	N/A
Nonspecified	4 (0.4%)	19 (1.8%)

Tables 2 and 3 show theatre times in patients undergoing THR stratified by BMI and weight into subgroups. The differences between BMI and weight subgroups were statistically significant (p=0.001, Kruskal-Wallis test).

Tables 4 and 5 show theatre times in patients undergoing TKR stratified by BMI and weight into subgroups. Kruskal-Wallis test showed that the differences between weight subgroups were significant (p<0.001) but BMI subgroups were much less significantly different (p=0.021).

Regression Analysis

Tables 6 and 7 show the correlation between all independent variables entered in the regression model and THR &

Table 2. Theatre time in THR patients stratified by BMI.

Group	Under- & Normal Weight	Overweight	Obese Class I	Obese Class II	Obese Class III
Number of cases	198	298	200	82	42
Median time (min)	139	140	145	152	147
IQR	115-161	115-164	124-173	125-180	112-165

Table 3. Theatre time in THR patients stratified by body weight.

Group	<70kg	70-90kg	90-110kg	>110kg
Number of cases *	240	326	185	63
Median time (min)	139	142	148	156
IQR	115-162	118-163	124-177	115-190

*Weight not available for 6 cases.

Table 4. Theatre time in TKR patients stratified by BMI.

Group	Under- & Normal Weight	Overweight	Obese Class I	Obese Class II	Obese Class III
Number of cases	117	348	308	180	86
Median time (min)	134	133.5	137.5	140	140
IQR	115-150	117-152	120-155	124-158	120-165

Table 5. Theatre time in TKR patients stratified by body weight.

Group	<70kg	70-90kg	90-110kg	>110kg
Number of cases*	160	449	304	123
Median time (min)	130	134	140	148
IQR	115-149	118-150	122-159	128-168

*Weight not available for 3 cases.

TKR theatre time, respectively. Tables 8 and 9 show the contribution of all variables to the variance in the final model in THR & TKR groups, respectively.

Table 6. Correlation between all variables and THR theatre time.

Variable	Pearson Correlation	P Value
Gender	-0.073	0.018
Operation	0.137	< 0.001
Theatre	-0.399	< 0.001
Surgeon	0.043	0.110
ASA	0.105	0.001
Log10-BMI	-0.227	< 0.001
Log10-weight	0.144	< 0.001

In THR group, regression analysis showed that log10-weight was a significant predictor of log10-theatre time after controlling for ASA, gender, surgeon, operation, theatre suite and log10-BMI (overall model fit $R^2 = 0.212$, $p = 0.017$). Log10-BMI was not a significant predictor after controlling for the other variables ($p = 0.519$). In the final model, other control variables were also statistically significant predictors. Based on β values, the order of contribution of variables is; surgeon, log10-weight, theatre and operation. The unstandardised coefficient B for log10-weight was 0.231. As both weight and time are log10 transformed, a 10% increase in weight would result in 2.31% increase in THR theatre time.

Table 7. Correlation between all variables and TKR theatre time.

Variable	Pearson correlation	P Value
Gender	0.080	0.005
Operation	0.011	0.367
Theatre	0.250	< 0.001
Surgeon	-0.101	0.001
ASA	0.008	0.398
Log10-BMI	0.086	0.003
Log10-weight	0.122	< 0.001

Table 8. Final hierarchal regression model of THR theatre time.

Variable	Unstandardised Coefficient B	Standardised Coefficient β	P Value
Gender	0.003	0.011	0.801
Operation	-0.013	-0.112	0.001
Theatre	0.039	0.159	<0.001
Surgeon	-0.020	-0.358	<0.001
ASA	-0.001	-0.006	0.852
Log10-BMI	-0.067	-0.049	0.519
Log10-weight	0.231	0.199	0.017

Table 9. Final hierarchical regression model of TKR theatre time.

Variable	Unstandardised Coefficient B	Standardised Coefficient β	P Value
Gender	0.008	0.042	0.309
Operation	0.002	0.006	0.835
Theatre	0.046	0.234	<0.001
Surgeon	-0.003	-0.064	0.035
ASA	-0.005	0.029	0.344
Log10-BMI	0.002	0.002	0.982
Log10-weight	0.111	0.099	0.166

In TKR cases, neither log10-BMI nor log10-weight was significant a predictor of log10-theatre time after controlling for other variables. The regression model did not explain the variance of data well ($R^2 = 0.081$).

DISCUSSION

This is one of the largest studies that assess the effect of obesity on theatre utilisation time in THR and TKR. We used the time interval between starting anaesthesia until the patient leaves theatre room to recovery as the dependent variable. This period represents the actual operation time and covers all steps that are likely to be influenced by the patient's size; anaesthetic time, patient positioning, preparation, draping, surgical time and transferring the patient from theatre table to recovery room.

The proportion of obese patients was higher in the TKR group and the mean BMI and body weight were higher than the THR group. Similar observations are reported in the National Joint Registry [3]. The mean theatre time was shorter for TKR cases and the vast majority of TKR cases were cemented compared to about 70% of THR cases.

We have shown that patients' body weight independently predicted theatre time during hip but not knee replacement. The probable explanation is that heavier patients would require longer time to perform every step during a hip replacement as opposed to a knee replacement. All hip replacements were performed in lateral decubitus position whereas knee replacements were performed in supine position and therefore, positioning time is more likely to be increased in hip replacements. In addition, surgical approach to the knee is less likely to be influenced by patients' weight or size compared to the approach to the hip due to the nature of surgical approach [10, 11].

Very few papers assessed the relation between body weight and theatre time during hip and knee replacements. We assessed the effect of body weight as well as BMI on theatre time because of our observation that taller and heavier patients, who may have a normal BMI, still required longer time to perform joint replacements. Our literature search identified one earlier study that used body weight to stratify patients and reported no difference in operative time

during hip replacement between patients with body weight <80kg and >80kg [12].

Our initial comparison showed that theatre time significantly increased with BMI during hip more than knee replacements. However, after controlling for other confounding variables, the BMI did not predict theatre time during both operations. Similar results were not reported before although Lozano *et al.* found no relation between BMI and tourniquet time during TKR in morbidly obese patients [11]. They recommended using anthropometric measures (suprapatellar index) as it reflected patient's morphology and fat distribution around the knee. Michalka *et al.* reported no difference in operative time only between three groups of patients undergoing THR and classified according to their BMI [9].

Our results contradict previous findings of increased utilisation of theatre time in obese patients during hip and knee replacements [4-6]. None of previous studies attempted to control the effect of confounding variables. Two studies from the same institution reported longer total theatre time in both hip and knee replacements [5, 6]. All the operations were performed by a single surgeon and therefore reflect a specific surgeon's experience and their results cannot be generalised. Bradley *et al.* analysed theatre time except anaesthetic time in a group of patients undergoing THR and TKR and concluded that theatre time increased with increasing BMI [4]. However, the effect of confounding variables like type of implant or operating surgeon was not considered.

There are limitations to our study. This is a retrospective study which comes with all the limitations of retrospectively collected data. Data on the type of anaesthesia or seniority of anaesthetist is not recorded electronically and was not available. However, the standard practice in our unit is spinal anaesthesia and all joint arthroplasty lists are routinely performed by a consultant anaesthetist. As the same anaesthetist would usually work with each surgeon, any confounding effect would be controlled by regression analysis. We did not have data on the diagnosis and pathologic condition of end-stage arthritis (e.g. genu valgus or varum). We did not have accurate data on surgical starting time ('knife to skin') as a prospective pilot audit performed previously in our department showed this time is not accurately recorded in many cases whereas anaesthetic start time and transfer to recovery were accurate. The aim of our study was to assess total theatre utilisation time so that theatre list planning could be improved and in that context, surgical time in isolation is not an essential variable.

CONCLUSION

Patient's body weight, rather than BMI, is an independent predictor of theatre utilisation time during THR and should be taken into account when planning theatre lists. Body weight and BMI didn't influence theatre utilisation time during TKR.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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