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Association Between Body Mass Index Change and Outcome in the First Year After Total Knee Arthroplasty

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ABSTRACT

There is an association between obesity, osteoarthritis and total knee arthroplasty (TKA), but little is known about how postoperative weight change influences outcomes. Primary TKA patients were identified from an institutional arthroplasty registry. BMI and patient reported outcome measures (PROMs, specifically WOMAC and SF36) were recorded for 1545 patients preoperatively and up to 3 years postoperatively. Mixed effects modelling showed postoperative BMI change had no impact on postoperative WOMAC scores. However, weight gain over 10% had a negative impact on SF36 pain and functional scores although postoperative weight loss was not associated with improved PROMs. Men showed greater improvement in postoperative SF36 function and pain scores, whilst older patients were slower to improve. Postoperative weight gain has a negative association with SF36 pain and function.

High body mass index (BMI) is associated with higher prevalence of knee osteoarthritis (OA) and reduced reported mobility [1]. Furthermore, it has been linked to poorer outcomes after total knee arthroplasty (TKA) [2,3] including reduced survival because of aseptic loosening [4]. The crucial barriers to weight loss after surgery remain unclear [5]. Increases in BMI in the general population mean there is an increasing awareness of the need to manage weight and interest in how this might be achieved [6]. When patients undergo knee arthroplasty there is a timely opportunity to address comorbidities including obesity. However, there remains little evidence-based guidance for such patients after knee arthroplasty.

Given the recognised associations between BMI, knee arthritis and surgical outcomes, we were interested in exploring the impact of BMI change after surgery on patient reported outcomes in an institutional registry, and what advice we might therefore offer patients. Specifically, we were interested in how postoperative BMI change is related to SF36 and WOMAC scores at a year after surgery. Our null hypothesis was that a significant change in postoperative BMI (arbitrarily taken as $\pm$10% body weight or BMI) would not influence patient reported outcomes.

Patients and Methods

The Freeman Joint Registry (FJR) was set up in July 2003 as an ongoing institutional audit of patient outcomes following hip or knee arthroplasty. It is registered with and has approval from the institutional research and development board (Project ID number: 3290). Inclusion in the FJR requires informed consent preoperatively for the collection, storage and analysis of data. The study was conducted in accordance with the declaration of Helsinki and the guidelines for good clinical practise.

This study was therefore a retrospective comparative cohort study from a single centre institutional arthroplasty registry using anonymised data. Data items used in this study were preoperative patient demographics including; age, gender, comorbidities and self reported height and weight. Patient reported outcomes included the Western Ontario and McMaster University Osteoarthritis Index (WOMAC), and Medical Outcomes Trust Short Form-36 (SF36) [7–10]. Preoperative assessment was undertaken within 6 weeks of surgery and postoperative analysis was performed annually out to 3 years using both WOMAC and SF36 scores. Years 1 and 2 data are collected in out patients; year 3 data are collected using a postal survey.

For the purposes of this analysis, we selected patients who underwent primary TKA over a five year period from April 2004 to March 2009 to allow for the collection of follow up data. All patients underwent cemented TKA using either Press Fit Condylar (PFC) (Depuy, Warsaw, Indiana, USA) or Triathlon (Stryker, Marwah, New Jersey, USA) knee implants. No distinction was made between these

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Table 1
Explanatory Variables Used in the Models.

Fixed Effects	Definition
Sex	Categorical
Age	Continuous
BMI preop	Preoperative body mass index; continuous
SF36-FUNC preop	Preoperative SF36 physical function; continuous
SF36-PAIN preop	Preoperative SF36 bodily pain; continuous
W-FUNC preop	Preoperative WOMAC functionality; continuous
W-PAIN preop	Preoperative WOMAC pain; continuous
10% change BMI preop	Change in BMI from preoperative assessment, divided into three categories: gain (of ≥10% preoperative BMI), loss (of ≥10% preoperative BMI), no change (<10% gain or loss)
Year of assessment	Ordinal
Random Effects	**Definition**
ID	Anonymised identification code; categorical
Age category	30–34.9 35–39.9, …, 90–94.9; ordinal

implants are both are modern generation cruciateretaining minimally constrained. All implants were cemented in place.

We used linear mixed effects models (LMEs) for this analysis to investigate the role of key variables (Table 1) in explaining the variation in each of the response variables. LMEs were used because they account for repeated measures on the same individuals by including the unique ID of each patient as a random effect. Each unique ID is fitted in the model with a different gradient; with the aim of reducing the residual error of the model by allowing each individual to improve at his or her own rate, rather than assuming that everyone improves at the same rate. All analyses were performed using the 'nlme' package in the R statistical language [11,12], and pseudo-R-squared values generated using the 'MuMIn' package [13]. Marginal R^2 calculated by the latter represents the variance explained by fixed effects, whereas conditional R^2 is interpreted as the variance explained by both fixed and random effects. Variance attributable to the random effect is therefore the difference between the two.

Four response variables were considered in the model: improvement of function score and improvement of pain score from the preoperative assessment, using two different scales: the Western Ontario and McMaster Universities Arthritis Index (WOMAC) and the Short Form (36) Health Survey (SF36). High WOMAC scores reflect poorer outcomes, whereas higher SF36 scores are associated with better outcomes. The following explanatory variables (Table 1) were identified; age, preoperative BMI, sex, SF36 and WOMAC pain and function, and postoperative weight loss or gain (greater or equal to 10%). Percentage weight change was calculated by the difference of postoperative BMI in relation to the preoperative value for each individual patient.

Results

There were 1902 patients in the original dataset, however, after accounting for missing data on variables of interest (age, sex, BMI, PROMS for pain and functionality) there were records for 1821 individuals. Of these, 276 without follow up data were excluded, leaving a sample size of 1545. There were 865 women and 680 men in this dataset, with a median age of 69.8 years (IQR 62.3–75.8). In addition to preoperative data, data were available for three (not necessarily consecutive) annual follow-up assessments in 812 (52.6%), two in 446 (28.9%) and one in 287 patients (18.6%).

All individuals exhibited postoperative improvements in SF36/WOMAC function and pain scores, whilst allowing for the different rates of improvements for each individual (i.e. the random effect of patient ID). However, the rate of improvement was significantly affected by covariates included in the LMEs.

There was no significant increase in the rate of in SF36 function score improvement in patients who lost 10% or more of preoperative BMI over those whose weight did not change postoperatively. However, patients who gained 10% or more of their preoperative BMI following total knee arthroplasty had significantly smaller improvements in physical function ($t = -2.67$, $P = 0.008$, Fig. 1). Increasing age and increasing preoperative BMI were associated with slower improvements in the SF36 function score ($t = -5.71$, $P \leq 0.001$ and $t = -4.25$, $P \leq 0.001$). Male patients had a significantly larger improvement in SF36 function score than female patients ($t = 3.52$, $P \leq 0.001$). Recovery of SF36 function score was positively related to preoperative assessment of pain ($t = 7.02$, $P \leq 0.001$), and negatively associated with preoperative SF36 function score ($t = -13.83$, $P \leq 0.001$). Overall, the random effect of patient ID accounted for 58.5% of the variance in the model (conditional $R^2 = 0.704$, marginal $R^2 = 0.119$).

Improvement of WOMAC function score was significantly related to preoperative BMI ($t = -2.13$, $P = 0.033$) and preoperative WOMAC function score ($t = -15.74$, $P \leq 0.001$). Both these associations were negative, indicating that patients who had a high preoperative BMI and/or a high preoperative WOMAC function score showed a smaller improvement in WOMAC function score than patients with lower preoperative BMI or WOMAC function scores (Fig. 2). The random effect of patient ID accounted for 64.9% of the variance in the model (conditional $R^2 = 0.782$, marginal $R^2 = 0.133$).

Individuals who gained more than 10% of their preoperative BMI following a total knee arthroplasty showed a significant reduction in the rate of improvement of SF36 pain score ($t = -2.58$, $P = 0.01$) compared to those whose weight remained the same or decreased. Weight gain of less than 10% of preoperative BMI was not associated with less improvement in SF36 pain (Fig. 3). Unlike improvements in SF36 function score, age was not a significant predictor of improvement in SF36 pain score. Male patients had a significantly larger improvement in pain score than female patients ($t = 3.20$, $P = 0.001$). Preoperative BMI was negatively associated with the rate of improvement ($t =$

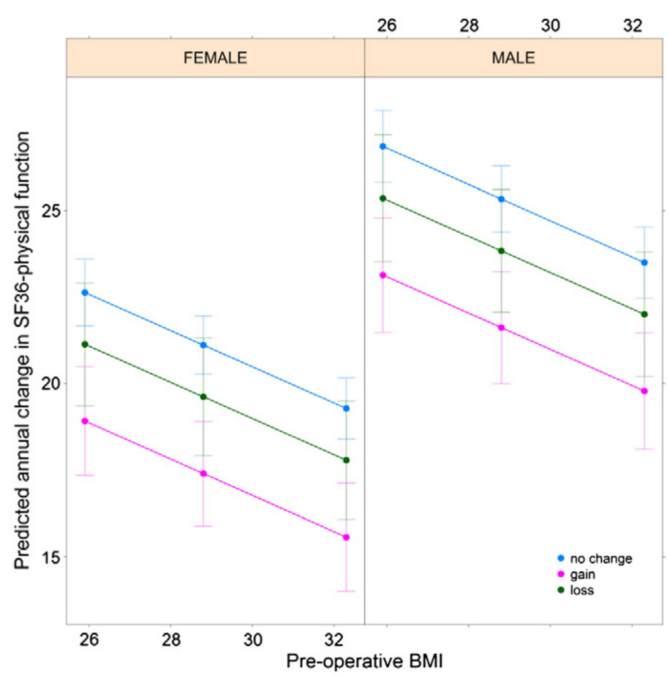

Fig. 1. Predicted annual change in physical function (as measured by SF36), as affected by sex of patient (left = female, right = male), preoperative BMI (x-axis), and change in BMI of at least 10% (coloured groups). Predictions are for individuals at the median age and median initial SF36 scores for pain and physical functioning. For example, a female patient with a preoperative BMI of 30 can expect an annual improvement in SF36-physical function of 20.5 points if she has not gained weight since TKA, but only 16.8 points if she has gained weight.