



Original Article

Patient factors associated with weight gain and weight loss after knee or hip arthroplasty



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ARTICLE INFO

Article history:

Received 31 January 2019

Received in revised form 7 May 2019

Accepted 10 May 2019

Keywords:

Arthroplasty, knee

Arthroplasty, hip

Obesity

Weight loss

ABSTRACT

Objectives: Following total knee or total hip arthroplasty (TKA, THA), up to 31% of recipients experience significant weight gain while up to 14% experience significant weight loss. Factors associated with significant weight change ($\geq 5\%$ of baseline weight) have not been comprehensively explored. This study aimed to identify pre- and post-surgical (including current) patient factors associated with significant weight change three years after surgery.

Methods: A pre-existing nationally-acquired cohort who underwent TKA or THA for osteoarthritis participated in 3-year telephone follow-up. Updated weight, comorbidity, and complication data were collected along with ongoing index joint problems and other patient-reported outcomes including global improvement. These data, along with body mass index (BMI) pre-surgery and post-surgery rehabilitation received, were incorporated into two multivariable logistic regression models to determine separately the factors associated with $\geq 5\%$ weight gain and $\geq 5\%$ loss at 3-years post-surgery.

Results: 73.4% (1289/1757) participated in the follow-up; 1191 (n = 663 TKA) provided updated weight data. Patterns of weight change were similar for both surgeries (TKA: 16.1% gained $\geq 5\%$, 19.6% lost $\geq 5\%$; THA: 15.8% gained $\geq 5\%$, 17.8% lost $\geq 5\%$). In multivariable modelling, younger age and lower pre-surgery BMI were significantly associated with weight gain; female gender and an absence of ongoing index joint issues were associated with weight loss.

Conclusion: Different mechanisms are likely associated with significant weight gain or loss at 3-years post-surgery. Cogent weight management entails consideration of both outcomes. Many post-surgical factors appear not to be importantly associated with weight change.

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Introduction

Osteoarthritis (OA) is the most common precipitant of total knee or hip arthroplasty (TKA, THA) surgery [1], and excess weight and obesity are known risk factors for development of both knee and hip OA [2,3] and progression of knee OA [4,5]. Consequently, overweight and obesity are commonly observed characteristics in people awaiting knee or hip arthroplasty [1,6–8]. To date, numerous studies have reported that despite significant improvements in joint symptoms and mobility, the majority of people do not experience significant weight loss (typically defined as $>5\%$ [9]) after

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TKA or THA [10–17]. Results vary, but as little as 14% of patients appear to experience significant weight loss [11,13,14]. Estimates for weight gain also vary; up to 31% experience $\geq 5\%$ weight gain 1–5 years following surgery [11–14,16,17]. The proportion who gain $\geq 5\%$ weight over five years following TKA (30%) or THA (31%) has been observed to be greater than the proportion who significantly gain weight amongst age- and gender-matched controls over the same time period (20%) [16,17]. These findings stand out given that weight loss is [18] or is thought to be [10] an important goal of surgery for many patients awaiting arthroplasty, and given their comorbid profile [8,10–17], this patient population have much to gain from losing weight to prevent worsening of extant chronic conditions.

There may be numerous reasons why the majority of overweight or obese people do not experience weight loss following TKA or THA. It has been observed that overweight and obese people with knee OA ascribe their weight issues to unmodifiable factors such as genetics and metabolism [19]. Such beliefs may represent inadequate patient buy-in and knowledge about the importance of adopting healthy lifestyle changes to improve joint symptoms pre-surgery, as well as to improve joint outcomes and morbidity once surgery is undertaken. Further, though often not to the same extent as their non-obese counterparts, those who are obese experience significant improvement in patient-reported outcomes post-surgery [12–14,20,21]. Thus, there may be a lack of patient motivation to lose weight for the sake of good outcomes. Past failed attempts to lose weight may also undermine a patient's motivation to lose weight post-surgery [22]. Finally, it may be related to the fact that physical activity – a common strategy used to assist weight loss – does not appear to increase sufficiently post-surgery for it to be a useful adjunct for weight loss [23–25].

Several studies document patient factors associated with weight change after TKA or THA [10–17]. Recurring themes are the importance of age and pre-surgical weight or body mass index (BMI) [11,12,16,17] with younger age and lower BMI associated with a greater risk of weight gain. Female gender is associated with weight loss [11,12]. To the best of our knowledge, no study to date has examined the potentially important post-surgical patient factors such as rehabilitation pathway, concomitant lower-limb or back problems affecting mobility, or presence of specific ongoing index joint issues as additional associated factors. These are arguably relevant given that different rehabilitation pathways with different levels of clinician oversight or the presence of ongoing index joint or other joint problems may in turn influence an individual's motivation or ability to participate in physical activity.

The aims of this study were to i) describe patterns of weight change three years after surgery in people who have undergone primary THA or TKA, and; ii) identify pre- and post-surgical patient factors associated with weight gain ($\geq 5\%$) or weight loss ($\leq 5\%$) three years post-surgery including under-explored and potentially modifiable factors. Comprehensive knowledge of factors associated with weight change will inform weight loss or maintenance strategies pre- and post-surgery as well as be used to alert those at high risk for weight gain.

Methods

Setting, participants and ethical approval

This study describes secondary analysis of a prospective study capturing 3-year outcomes in a multicentre cohort of people who had primary TKA or THA [26]. Ethical approval for the follow-up study was obtained from a lead health sector (Hunter New England Human Research Ethics Committee (HREC), 16/07/20/5.05) and university ethics committee (Macquarie University HREC, Ref.

5201600658). The original cohort collected data prospectively on 1900 people presenting for surgery secondary to OA at one of 19 hospitals (10 public, nine private) from five Australian States between August 2013 and January 2015 [27].

Of the 1837 participants reached for follow-up at one year in the original study, 1773 provided verbal consent to be contacted for future follow-up. Just prior to their 3-year arthroplasty anniversary (between August 2016 to January 2018), patients were sent a letter informing them of the follow-up and the focus of the interview. Each was free to opt-out via mailed letter, email or telephone. People who had died since the 1-year follow-up were excluded and those with dementia (as reported to researchers by a carer) were subsequently deemed ineligible as they were not able to respond or reliably respond to interviewer questions. Those unable to be contacted were deemed lost to follow-up. Those who consented to participate when telephoned completed an interview with researchers.

Follow-up outcomes

The interview entailed collection of multiple variables aside from updated weight. Several patient-reported outcomes including 3-year Oxford Knee or Hip Scores (OKS, OHS) [26] and the EuroQol (EQ) 'today' health score [26] were administered. The OKS and OHS report joint-specific pain and function over the past month and are scored out of 48 (higher score reflects better pain and functioning). The EQ score asks participants to rate their health 'today', all things considered, out of 100 (100 equals best score). Prior to surgery, the baseline score was collected using a visual analogue scale as baseline data were collected face-to-face. At follow-up the score was obtained verbally, an approach that has been shown to be equivalent to the visual approach in people awaiting TKA or THA [28].

In addition to the above, current self-reported weight was obtained along with details about major joint-related complications occurring between 1–3 years (deep infection, further or revision surgery, dislocation, instability), new health issues (comorbidities) that had arisen since the index surgery, ongoing index joint problems (e.g. ongoing pain, instability, major stiffness, major muscle weakness), and further (new) arthroplasty surgery. A global improvement question was also asked whereby participants had to rate their improvement since surgery as 'much better', 'slightly better', 'same', 'slightly worse', 'much worse'.

Data collected during the original study period

Alongside the follow-up data, other data incorporated into the analysis included patient-related data collected during the original study period. This included information about pre-surgery (baseline) comorbidity, major joint-related complications up to 1-year post-surgery, and the rehabilitation pathway. These variables are defined in Table 1.

Data analyses

Descriptive statistics were used to describe the participant groups based on weight change. Weight change at three years was dichotomised in two ways; firstly, as a weight gain $\geq 5\%$ or not (i.e. weight gain of $< 5\%$, no change in weight, or any weight loss), then secondly, as a weight decrease $\geq 5\%$ or not. The 5% threshold was based on a recommended threshold for clinically important weight change [9]. Although this threshold is recognised as somewhat arbitrary [9], for comparison with other studies, it was necessary to use the threshold commonly used by other investigators in this field [10–17].

Table 1
Patient-related variables collected pre-surgery and up to 1-year post-surgery.

Variable	Coding
<i>Pre-surgery (baseline)</i>	
Weight	kg; used to calculate body mass index
Height	m; used to calculate body mass index
Body mass index (BMI)	kg/m ² ; categorised as <25 (normal weight); ≥25 <30 (overweight); ≥30 <35 (obese); ≥35 (morbidly obese)
Presence of comorbidity requiring daily medication	Categorical – Yes/No; includes cardiovascular, renal, respiratory, endocrine, liver, central and peripheral nervous systems, current cancer, and excludes other lower-limb or back problems limiting mobility or past arthroplasty.
Presence of other lower limb or back problems limiting mobility	Categorical – Yes/No; includes arthritis, limb fracture, lumbar spine issues
Previous or additional knee or hip arthroplasty	Categorical – Yes/No
Insurance status	Categorical – public (medicare) or private (self-funded, compensation, Department of Veterans Affairs cover, private cover)
Education level	Categorical – ≤year 8; years 9–10; years 11–12; degree qualified),
Oxford Knee or Hip Score	Continuous variable (baseline not used – 3-year used)
EuroQol 'health' score	Continuous variable (baseline not used – 3-year used)
<i>Acute-care period</i>	
American Society of Anesthesiologists (ASA)	Categorical – I = normal, healthy; II = mild systemic disease; III = severe systemic disease; IV = severe systemic disease that is a constant threat to life (categories V and VI not applicable here). For analysis, class I and II were combined, as were class III and IV.
<i>Across first year</i>	
Rehabilitation pathway in first three post-operative months	Categorical based on level of supervision received – inpatient rehabilitation plus ongoing outpatient (community-based) rehabilitation; inpatient rehabilitation only; community-based only; monitored home program (up to three visits with a physical therapist); and unmonitored home program. Community program included treatment by a physical therapist in a private or public clinic, in the home, in day hospital, and included supervised hydrotherapy sessions
Major joint-related complication	Categorical – Yes/No: deep infection, re-operation, clinical instability, wound dehiscence, intra- or post-operative fracture, dislocation

The investigative team identified, a priori, factors previously shown or hypothesised to be, associated with weight change. These included age, baseline BMI, index joint (knee or hip), education level, American Society of Anaesthesiologists (ASA) score, insurance status, global improvement, rehabilitation pathway in the first three months post-surgery, presence of other lower limb or back problems limiting mobility at three years, experience of a major joint complication within the first three years, life-time history of >1 lower limb arthroplasty, presence of comorbidity requiring daily medication, and presence of ongoing index joint issues (whether or not it was associated with a diagnosed complication) at three years. Current (3-year) Oxford and EQ 'today' scores were utilised in the model in preference to pre-surgery scores. We reasoned that current joint and general health status may be more relevant to the weight outcome at 3-years.

Because a major joint complication could either resolve without ongoing joint issues or an ongoing issue could occur in the absence of a diagnosed joint complication, these two variables were combined and collapsed as follows: ongoing index joint issue regardless of the presence or absence of a major joint complication; no ongoing index joint issue regardless of presence or absence of a major joint

complication. In this regard, our analysis examined the association of ongoing index joint issues rather than a major joint complication per se on weight change.

For ease of interpretation, several variables were reclassified. Age was categorised by quartile. BMI was categorised as per [Table 1](#) as was ASA score. Global improvement was collapsed into two categories: 'much better', 'other'.

Univariate analysis was undertaken first to identify which variables were independently associated with significant weight gain or loss post-surgery. Correlation between independent variables was assessed to identify collinearity. No correlation exceeded 0.5, and most (64%) were less than 0.1. Multivariable logistic regression modelling was undertaken to determine the significance of each of these variables (regardless of their whether they were significantly associated in univariate analysis) whilst controlling for others. All other variables were coded as described above. No imputation was undertaken for missing data (4% in multiple regression models). p-Values <0.05 were deemed significant.

Data were stored in RedcapTM and analysed using SAS 9.4 (SAS Institute, Cary NC, USA).

Results

Of the 1773 participants who provided verbal consent to be contacted again after the 1-year follow-up, 16 were subsequently excluded due to death (n = 14) or dementia (n = 2). Of the remaining cohort (1757), 1289 (73%) were included while 468 were lost-to-follow-up (n = 278 uncontactable; n = 190 declined). Of the 1289 respondents, 98 were unable to provide an updated weight on the day; thus, 1191 respondents (n = 663 TKA) from 19 hospitals are included in these analyses. As detailed elsewhere [26], characteristics of those retained compared to those lost were similar for 11 characteristics and dissimilar for two (a greater proportion of the retained cohort were younger and privately insured).

Mean weight of the overall cohort did not change over the study period regardless of joint (TKA: 89.1 (SD 18.1) at baseline vs 88.7 (18.9) kg at three years, p = 0.235; THA: 83.8 (18.7) vs 83.4 (19.5) kg, p = 0.25; All 86.7 (18.5) vs 86.4 (19.3) kg, p = 0.10), though individual changes were evident. For the entire cohort, 16.0% (190/1191) gained ≥5% of their baseline weight at three years and 18.8% (224/1191) lost ≥5%. The percentages were similar regardless of surgery type (TKA: 19.6% lost, 16.1% gained; THA: 17.8% lost, 15.8% gained).

[Table 2](#) summarises the characteristics between those who gained ≥5% weight and those who did not, and those who lost ≥5% weight and those who did not. Univariate analyses revealed that those in the >5% weight gain group had greater proportions of people in the 'normal weight' category, younger age categories, who were publicly insured, and who had ongoing joint issues. The >5% weight gain group also had a significantly lower 3-year Oxford score (indicating a poorer patient-reported outcome) and a lower proportion reporting to be 'much better'. Only female gender and the absence of ongoing index joint issues were significantly associated with ≥5% weight loss.

Multivariable logistic regression modelling revealed older age and higher BMI at the time of surgery were significantly associated with decreased odds of weight gain ≥5% by 3-years post-surgery ([Table 3](#)). Those in the upper quartiles for age (3rd quartile [68 to <73 years], OR 0.56, p = 0.02; 4th quartile [>73 years], OR 0.46, p = 0.004) had a decreased adjusted odds of weight gain ≥5% compared to the those in the lower quartile (age <61 years). Those who were overweight (OR 0.43, p = 0.0007), obese (OR 0.52, p = 0.01) or morbidly obese (OR 0.34, p = 0.0003), were less likely to gain weight compared to those of 'normal' weight. A degree qualification was

Table 2
Characteristics of those who gained or lost $\geq 5\%$ weight compared to those who did not.

	Gained $\geq 5\%$, n = 190*	Did not gain $\geq 5\%$ n = 1001*	p-Value	Lost $\geq 5\%$, n = 224*	Did not lose $\geq 5\%$, n = 967*	p-Value
TKA	107 (56.3)	557 (55.6)	0.86	130 (58.0)	534 (55.2)	0.44
Unilateral surgery	177 (93.7)	947 (94.8)	0.52	211 (94.2)	913 (94.7)	0.76
Female	109 (57.4)	540 (54.0)	0.39	137 (61.2)	512 (53.0)	0.026
ASA-III and IV combined	52 (28.1)	309 (31.3)	0.39	71 (32.0)	290 (30.5)	0.67
Age quartile (year)			0.004			0.16
<61	59 (31.1)	240 (24.0)		64 (28.6)	235 (24.3)	
61 to <68	59 (31.1)	238 (23.8)		55 (24.6)	242 (25.0)	
68 to <73	37 (19.5)	261 (26.1)		44 (19.6)	254 (26.3)	
≥ 73	35 (18.4)	262 (26.2)		61 (27.2)	236 (24.4)	
Body mass index, time of surgery			0.01			0.05
$\geq 18 < 25$ (normal weight)	46 (24.2)	148 (14.8)		30 (13.4)	164 (17.0)	
$\geq 25 < 30$ (overweight)	54 (28.4)	359 (35.9)		73 (32.6)	340 (35.2)	
$\geq 30 < 35$ (obese)	51 (26.8)	273 (27.3)		57 (25.5)	267 (27.6)	
≥ 35 (morbidly obese)	39 (20.5)	221 (22.1)		64 (28.6)	196 (20.3)	
Education			0.28			0.66
\leq Year 8 (nil or junior level)	21 (11.2)	73 (7.3)		18 (8.0)	76 (7.9)	
Year 9/10 (middle level)	102 (55.1)	570 (57.2)		125 (55.8)	548 (57.1)	
Year 11/12 (senior level)	24 (12.8)	117 (11.8)		32 (14.3)	109 (11.4)	
Degree	39 (20.9)	236 (23.7)		49 (21.9)	226 (23.8)	
Privately insured	100 (52.6)	609 (60.8)	0.03	130 (58.0)	579 (59.9)	0.61
Rehabilitation pathway post-surgery			0.28			0.46
-Unmonitored home program	32 (17.0)	204 (20.4)		53 (23.7)	183 (19.0)	
-Monitored home program	36 (19.2)	203 (20.3)		44 (19.6)	195 (20.2)	
-Outpatient only	67 (35.6)	277 (27.7)		57 (25.5)	287 (29.8)	
-Inpatient only	12 (6.4)	67 (6.7)		17 (7.6)	62 (6.4)	
-Inpatient plus outpatient	41 (21.8)	249 (24.9)		53 (23.7)	237 (24.6)	
3-year 'global improvement (much better)'	153 (81.8)	869 (88.4)	0.01	197 (89.1)	825 (86.9)	0.37
3-year 'other lower limb or back problems'	103 (54.2)	513 (51.2)	0.45	113 (50.5)	503 (52.0)	0.67
3-year daily medications for comorbidities#	122 (64.2)	656 (65.5)	0.73	143 (63.8)	635 (65.7)	0.61
3-year EQ today score	75.7 (17.1)	78.1 (15.6)	0.05	76.8 (18.2)	77.9 (15.2)	0.36
3-year Oxford score,	40.5 (8.8)	42.3 (7.1)	0.002	41.7 (7.6)	42.1 (7.4)	0.51
3-year ongoing joint issues (\pm defined complication)	33 (17.4)	116 (11.6)	0.03	17 (7.6)	132 (13.7)	0.014
3-year > 1 arthroplasty (lifetime)	70 (36.8)	426 (42.6)	0.14	94 (42.0)	402 (41.6)	0.91

Legend: Those who did not lose or gain $\geq 5\%$ = those who remained the same weight or gained or lost $< 5\%$. Data are count (%) or mean (sd). TKA = total knee arthroplasty; yr = year; ASA = American Society of Anaesthesiologists; #Comorbidity included any conditions of the cardiovascular, renal, respiratory, endocrine, liver, central and peripheral nervous systems, and excluding other musculoskeletal conditions; *maximum sample possible for each variable.

protective against weight gain compared to low-level education, but overall education status was not significant.

Multivariable logistic regression modelling found both female gender and ongoing joint issues were significantly associated with weight loss $\geq 5\%$ (Table 3). Females (OR 1.48, $p = 0.02$) were more likely to lose weight $\geq 5\%$ while those with ongoing joint issues (OR 0.49, $p = 0.01$) were less likely. Participation in outpatient-based rehabilitation was associated with reduced odds for weight loss $\geq 5\%$ compared to participation in an unmonitored home program, but overall the rehabilitation variable was not significant.

Discussion

Consistent with previous studies, at a time when recovery is considered stable, we found no meaningful change in mean weight post-TKA or -THA compared to pre-surgery [11–17,29], though a small minority (16–19%), regardless of surgery type, gained or lost 5% or more of their baseline weight. Also consistent with previous studies, weight gain was associated with younger age [11,12,16,17] and lower pre-surgery BMI [12,17], whilst weight loss was associated with female gender [11,12]. Unique to this study, we found that the absence of ongoing joint issues was associated with weight loss.

Our prospective and interview-based approach allowed us to explore factors that have not been previously explored. Consistent with our hypothesis, several post-surgical factors were associated with significant weight change in univariate analysis – the presence of ongoing index joint issues, global improvement, and

current Oxford score. We found no significant univariate associations between weight change and rehabilitation received or other lower-limb or back problems. Furthermore, when considered together in a multivariable model, none of these post-surgical variables, except for ongoing index joint issues, were significantly associated with weight change. It appears then that post-surgical and 'current' factors, as well as many pre-surgical factors, may not be associated with the risk of gaining weight post-surgery or, conversely, the achievement of weight loss.

The identification of different factors associated with weight gain and loss – and this too has been shown by others [11,12] – suggests that the underlying processes are likely to be different. The fact that women are more likely to lose weight does not mean men are more likely to gain weight. Whilst ongoing index joint issues may prevent weight loss, their presence may not necessarily contribute to weight gain. Clinicians need to be cognisant of these nuances if their conversations with patients about weight management are to be helpful.

Here we observed that weight loss is not realised for most, but equally concerning is that studies that have collected data across several time points suggest greater numbers of people manifest significant weight gain from the 1st to 5th years [16,17]. These longitudinal studies (at five years, $n = 590$ TKA [16]; $n = 348$ THA [17]) propose that this is due in part to people undergoing further arthroplasties and experiencing surgical complications after the subsequent surgery. These propositions were not supported by our data, which were derived from slightly larger samples at an earlier follow-up period. In the current study, we also captured

Table 3
Multivariable logistic regression determining the factors associated with significant weight gain or weight loss of $\geq 5\%$ at 3-years post-surgery.

Variable	Weight gain $\geq 5\%$ compared to did not			Weight loss $\geq 5\%$ compared to did not				
	OR	95% CI	p-Value	OR	95% CI	p-Value		
TKA vs THA	1.07	0.72	1.58	0.738	1.23	0.87	1.76	0.25
Bilateral vs unilateral	1.14	0.55	2.36	0.721	0.88	0.43	1.80	0.72
Female vs male	1.01	0.72	1.43	0.936	1.48	1.07	2.03	0.02
ASA III and IV combined vs I and II combined	0.87	0.57	1.31	0.496	0.95	0.66	1.38	0.80
Age, yr								
<61	Reference				Reference			0.003
61 to <68	1.02	0.66	1.58	0.933	0.86	0.56	1.32	0.50
68 to <73	0.56	0.34	0.92	0.021	0.63	0.40	1.00	0.05
≥ 73	0.46	0.27	0.78	0.004	1.10	0.70	1.73	0.69
Pre-surgery BMI								0.001
Normal	Reference				Reference			
Overweight	0.43	0.26	0.70	0.0007	1.21	0.74	1.98	0.44
Obese	0.52	0.31	0.86	0.010	1.26	0.75	2.11	0.38
Morbidly obese	0.34	0.19	0.61	0.0003	1.77	1.02	3.09	0.04
Education				0.224				0.82
\leq Year 8	Reference				Reference			
Year 9/10	0.58	0.32	1.05	0.074	1.04	0.58	1.87	0.91
Year 11/12	0.67	0.32	1.39	0.282	1.27	0.63	2.54	0.51
Degree	0.49	0.24	0.99	0.046	1.0	0.51	1.94	0.99
Insurance – private vs public	0.79	0.52	1.21	0.285	1.02	0.69	1.52	0.91
Rehabilitation post-surgery				0.665				0.17
Unmonitored	Reference				Reference			
Monitored home program	1.05	0.58	1.89	0.870	0.65	0.39	1.10	0.11
Outpatient only	1.41	0.83	2.41	0.205	0.56	0.35	0.91	0.02
Inpatient only	1.26	0.57	2.84	0.551	0.86	0.44	1.65	0.63
Inpatient plus outpatient	1.18	0.67	2.10	0.565	0.64	0.40	1.04	0.07
3-year global improvement 'much better' vs 'other'	1.07	0.59	1.97	0.817	0.90	0.49	1.64	0.74
3-year other lower limb or back problems	1.10	0.78	1.55	0.581	0.85	0.62	1.17	0.32
3-year requirement for daily medication for comorbidity	1.05	0.72	1.52	0.808	0.86	0.61	1.20	0.38
3-year EQ 'today' health score	0.99	0.98	1.00	0.404	1.00	0.99	1.01	0.65
3-year Oxford score	0.98	0.95	1.01	0.176	0.98	0.96	1.01	0.25
3-year ongoing joint problem (with or without diagnosed joint complication)	1.15	0.65	2.04	0.632	0.49	0.24	0.84	0.01
3-year >1 arthroplasty (lifetime)	0.92	0.65	1.31	0.655	0.92	0.67	1.28	0.64

Legend: For dichotomous comparisons, the reference group is the second variable. OR = odds ratio; 95% CI = 95% Wald confidence limits; TKA = total knee arthroplasty; THA = total hip arthroplasty; vs = versus; yr = year; ASA = American Society of Anaesthesiologists; EQ – EuroQol.

>1 arthroplasty across the lifetime (any previous arthroplasty as well as any up to the point of final follow-up) and not just in the period of follow-up as was the case in the latter two studies, so methodological differences may contribute to the discordance.

Even though excess weight and obesity do not preclude significant improvements in patient-reported outcomes and physical performance post-surgery [12–14,20,21] – and here we found global improvement was not associated with weight change – that does not mean more healthy weights should not be encouraged for those affected. We observed – and it has been reported elsewhere [1] – that most TKA and THA recipients are overweight or obese at the time of surgery. Excess weight and obesity are associated with many chronic conditions and early mortality, thus, it seems to be a missed opportunity that TKA and THA recipients are not taking advantage of their improved symptomatic and functional status, and 'shedding' the excess weight. A recent systematic review concluded that little is known about best strategies to achieve weight-loss prior to TKA or THA surgery [30], though a small pilot study concluded a dietitian-led weight management program could be feasible prior to surgery [31]. Similarly, we have not found high-level evidence regarding effective strategies to reduce weight or maintain weight following TKA or THA, though preliminary work suggests strategies centred around patient preferences could be helpful [29]. The lack of evidence aside, it appears younger age at the time of surgery and a 'normal' pre-surgery BMI may be associated with increased odds of weight gain, with male gender associated with a decreased odds of weight loss, thus, we can at

least target those considered to be most at risk and, conveniently, this can be done prior to surgery. Post-surgery, there may also be a role for rehabilitation providers. Though we did not observe any overall significant associations between the type of rehabilitation pathway followed (ranging from no clinician oversight [unmonitored home program] to intense oversight [inpatient followed by outpatient rehabilitation]) and weight change, this may reflect that (anecdotally at least) rehabilitation providers in Australia do not typically incorporate weight management into their programs. Alternatively, if the more intense programs do address weight management, it may be that the effects, if any, are not sustained years after surgery.

Our findings should be considered in light of the strengths and weaknesses of this study. Given that this study was based on prospectively collected data from a large, national sample, our study should have a lower level of bias compared to the retrospective studies which occupy much of this space [11,12,15–17]. In addition, the national-level sample allows for generalisability to privately and publicly insured recipients. Further, we included many patient variables not yet explored in this area of research, providing insight into the potential importance of these post-surgical and 'current' factors. Participant weight at three years was self-reported whilst baseline weight was objectively measured. While self-report is not unique to our study [10,12], there remains a possibility that weight was incorrectly reported at follow-up. We did, however, alert people to the pending follow-up and excluded participants who were unsure of their weight at the time of inter-

view. Further, that our results align with studies where weight was objectively measured suggests our method of recording has not generated spurious results. We did not include an objective measure of participation in regular physical activity, thus, we are unable to assess the association between current volume of physical activity undertaken and weight change. We note, however, that levels of physical activity post-TKA or -THA are known to be sub-optimal [23–25] and, as such, will typically be insufficient to generate significant weight loss. We also do not have any detail about weight loss in the year prior to surgery which has been shown to be a predictor of weight gain post-surgery [11,16,17]. We did not include a concurrent age-matched ‘control’ group so we are unable to compare patterns of weight change to what may be expected in an ageing population in the absence of surgery. We note, however, that prior studies have observed that weight gain across two years in TKA and THA cohorts exceeds that observed in non-surgical controls [32], or at least, a greater proportion of arthroplasty patients exhibit significant weight gain over a five-year period compared to controls [16,17]. Finally, we did not ask participants about whether they had tried to lose or maintain their weight since surgery or were encouraged to do so by their rehabilitation provider, thus, we have no insights about who was motivated to or not in this regard.

Implications for future research

Future research should identify how best to achieve and maintain weight loss or maintain healthy weights in TKA and THA recipients. Reference to what has been shown to be cost-effective in patients with OA [33] or other patient populations – such as behaviour change interventions addressing diet and physical activity [34], or strict caloric restriction alone [35] – would be a useful place to start. Incorporating weight loss or weight maintenance strategies and targets into rehabilitation pathways would also be reasonable to explore, and understanding the barriers and enablers of weight loss in this group would also appear to be essential.

Conclusion

Weight loss is uncommon after TKA or THA surgery with a similar small percentage either losing or gaining 5% weight or more three years after surgery. While factors associated with weight loss are different from those associated with weight gain, post-surgical or current factors such as the rehabilitation pathway, concurrent back or lower limb problems or patient-perceived improvement measured globally or via index joint recovery measures do not appear to be associated with weight change in any direction whilst ongoing index joint problems are relevant to weight loss.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Ethics statement

For the manuscript – “Patient factors associated with weight gain and weight loss after knee or hip arthroplasty”

As stated in the manuscript, ethical approval for the study was provided by two HREC – HNE HREC, 16/07/20/5.05 and Macquarie University HREC, Ref. 5201600658.

The study was undertaken according to the Australian Code for the Conduct of Research.

All patient participants provided verbal consent to participate at the time of telephone follow-up. They were free to decline at

the time of the telephone contact or via email or letter. All participants provided written, informed consent when recruited into the original study.

Declaration of interest

The authors have no conflicts of interest to declare.

CRedit authorship contribution statement

Justine M. Naylor: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Writing - original draft, Writing - review & editing. **Kathryn Mills:** Conceptualization, Data curation, Investigation, Methodology, Writing - review & editing. **Natasha Pocovi:** Data curation, Investigation, Methodology, Writing - review & editing. **Sarah Dennis:** Conceptualization, Investigation, Methodology, Writing - review & editing. **Danella Hackett:** Conceptualization, Investigation, Methodology, Writing - review & editing. **Leanne Hassett:** Conceptualization, Investigation, Methodology, Writing - review & editing. **Bernadette Brady:** Conceptualization, Investigation, Methodology, Writing - review & editing. **Adriane M. Lewin:** Conceptualization, Visualization, Writing - original draft, Writing - review & editing. **Sam Adie:** Conceptualization, Investigation, Methodology, Writing - review & editing. **Wei Xuan:** Formal analysis, Investigation, Methodology, Validation, Writing - original draft, Writing - review & editing.

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