# Should a Patients BMI Status be Used to Restrict Access to Total Hip and Knee Arthroplasty? Functional Outcomes of Arthroplasty Relative to BMI - Single Centre Retrospective Review

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**Abstract:** We reviewed the experience of a dedicated orthopaedic elective service to determine whether we could establish a BMI group where arthroplasty was no longer effective as assessed by the patient's functional outcome. This was a prospective observational study with retrospective analysis of data collected on 1439 total hip arthroplasty, 934 total knee arthroplasty and 326 unicompartment knee arthroplasty patients. Functional scores (WOMAC, Oxford hip and knee scores and HAAS) were obtained preoperatively and at 12 months post op. Patients had their BMI recorded at the preoperative assessment and were divided into BMI groups (BMI<25, BMI 25-30, BMI 30-35 and BMI > 35).

Patients with a BMI of ≤ 30 had significantly better functional scores at 12 months post op compared to those with a BMI of > 35. The absolute gain in functional scores from pre op to 12 months post op did not differ significantly between BMI groups, the only significant difference we found for absolute gain showed patients with a BMI of > 35 have a greater increase in HAAS scores following total hip arthroplasty compared to patients with a BMI of 30 or less (p = 0.0435).

Our patients with higher BMI's had worse preoperative and post operative functional scores but their benefit from surgery measured by the change in functional scores showed no difference compared to patients with lower BMI. We could find no reason on the basis of the 12-month results to limit surgery to obese patients because of an expected poorer functional outcome.

**Keywords:** Arthroplasty, BMI, Functional scores, Oxford scores, WOMAC scores, HAAS scores.

## INTRODUCTION

Obesity has become a major health concern throughout the developed world with a recent nutritional survey in New Zealand revealing that one in four adults over the age of 15 was classed as obese [1] which was disproportionately represented in our Maori and Pacific populations. The overall rates of obesity in New Zealand have dramatically increased since 1997 from 17% to 27.7% in men and 20.6% to 27.8% in women [1].

Obesity has been significantly associated with multiple co- morbidities including type II diabetes, cancers and cardiovascular diseases [2]. There has been a strong association of obesity with osteoarthritis [3] and with obesity increasing worldwide this is likely to result in a disproportionately high number of obese and overweight patients seeking arthroplasty surgery.

To date the orthopaedic literature has been conflicting with regard to the risks of arthroplasty surgery in obese patients. A number of articles have found no difference or even improved functional outcomes in obese patients [4-6]. Many others have shown increased peri-operative morbidity, complications and poorer functional outcomes in obese patients [7-11]. As a result of poorer outcomes several institutions have put Body Mass Index (BMI) restrictions on access to arthroplasty surgery. Given the increasing prevalence of obesity and the ageing population this is likely to become a more contentious issue. Many patients assume the reason they cannot loose weight is due to an inability to exercise because of arthritis. Studies have disproven this theory with a number of patients both obese and of normal weight shown to gain weight post-operatively [12].

BMI is a crude measure of body fat as it does not distinguish between fat and muscle bulk but it has been shown to be an accurate estimate of those at risk of health related conditions associated with obesity. We reviewed the experience of a dedicated orthopaedic elective service to determine whether we could establish a BMI group where arthroplasty was no longer effective as assessed by the patient's functional outcome.

## METHODS

This was a prospective observational study with retrospective analysis of the data collected for all patients who underwent a total hip arthroplasty (THA), total knee arthroplasty (TKA) or unicompartment knee arthroplasty (UKA) at a single dedicated elective hospital between May 2005 and April 2012.

In total there were 2699 (1439 THA, 934 TKA and 326 UKA patients) consecutive patients (Table **1**) who underwent a preoperative and 12 month assessment using the Oxford (hip and knee) scores, High-Activity Arthroplasty Score (HAAS) and Western Ontario and McMasters

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**Table1. Patient Demographics for Each Arthroplasty Grouping**

| | THA | TKA | UKA |
|---|---|---|---|
| Number of Patients | 1439 | 934 | 326 |
| Average Age | 67.5 | 70.6 | 67.2 |
| Age Range | 22-94 | 44-90 | 39-86 |
| Female% | 56.6% | 57.7% | 52.3% |
| Average BMI | 28.49 | 30.79 | 30.0 |
| BMI range | 13-54 | 19-53 | 19-49 |

Universities Osteoarthritis Index (WOMAC) for the THA and TKA groups and the Oxford knee score for the UKA group. Response rates were calculated for both the preoperative and 12 month post op assesments. At the 12 month assesment this was based on the percentage of patients with available scores as not all patients had reached the 12 months post op mark for scoring (Table **2**).

of early revision [13]. The Oxford hip and knee questionnaires contain 12 questions, each with five options scoring from 0 to 4, all related to pain and function. The best possible score is 48 and the worst is zero [14].

The High-Activity Arthroplasty Score (HAAS) was developed to assess subtle differences in functional outcomes in lower limb arthroplasty, particularly in those high demand patients. It has been shown to have a wider range of activities assessed than other functional scores, thus is a more sensitive measure of difference following lower limb arthroplasty [15]. The HAAS score contains 4 questions and assesses function across walking, stair climbing, running and recreational activities. The best possible score is 18 and the worse is zero [15].

The Western Ontario and McMasters Universities Osteoarthritis Index (WOMAC) is a self assessed, disease specific measure for patients with hip and knee osteoarthritis. It assesses three variables including pain, stiffness and physical function in a 24 question survey. It is a widely used, sensitive assessment that has been used in clinical trials. The best possible score is 68 and the worst is zero [16].

**Table 2. Percentage Response Rate of Available Patients According to Functional Score Used**

| | Oxford | | | WOMAC | | HAAS | |
|---|---|---|---|---|---|---|---|
| | UKA | THA | TKA | THA | TKA | THA | TKA |
| **Preop** | 97.9% 319/326 | 99.9% 1438/1439 | 99.8% 932/934 | **61.3% 882/1439** | **55.5% 518/934** | 99.9% 1437/1439 | 99.7% 931/934 |
| **12 months** | 85.3% 278/326 | 79.7% 886/1111 | 83% 614/740 | 79.4% 882/1111 | 83.0% 614/740 | 79.7% 885/1111 | 83.0% 614/740 |

Note: The 12 month response rate is based on the percentage of patients with available scores at time of processing data for this study. Not all patient had reached the 12 month post op mark for scoring.

Each arthroplasty group was divided into one of 4 BMI groups (<25, 25-30, 31-35 and >35) in accordance with the World Health Organisation's classification of normal weight (<25), overweight (25-30), class 1 obese (31-35) and (>35) morbidly obese (Table **3**). There were no underweight patients. For the statistical analysis the normal weight (BMI < 25)and overweight (BMI 25-30)groups were combined. For each arthroplasty group comparison of outcome scores was made among the BMI groups. The absolute gain in functional scores was also calculated for those patients who had scores at both preop and 12 months, this was compared among the BMI groups.

**Table 3. BMI Breakdown for Each Arthroplasty Group**

| | THA | % | TKA | % | UKA | % |
|---|---|---|---|---|---|---|
| BMI <25 | 299 | 20.78 | 105 | 11.24 | 41 | 12.58 |
| BMI 25-30 | 686 | 47.67 | 396 | 42.40 | 145 | 44.48 |
| BMI 31-35 | 310 | 21.54 | 280 | 29.98 | 99 | 30.37 |
| BMI >35 | 144 | 10.01 | 153 | 16.38 | 41 | 12.58 |
| Total | 1439 | | 934 | | 326 | |

The Oxford hip (OHS) and knee scores (OKS) are patient generated scores that have been shown to effectively assess a patient's early functional status as well as predict the likelihood

## RESULTS

For the three joint replacement groupsthe patient demographics and BMI groups are shown in Tables **1-3**. The average 12 month functional scores for all three joint replacement groups are listed in Table **4** and the average absolute change in functional scores for all arthroplasty groups are listed in Table **7**.

### Unicompartmental Knee Joint Replacement

The OKS from preop and 12 months post op were compared across BMI groups. Patients in the > 35 BMI group had significantly lower preoperative OKS ($p = 0.0048$) and 12 month OKS ($p = 0.0017$) when compared to patients with a BMI of ≤ 30 (Tables **5** and **6**). Patients in the 31-35 BMI group had lower but non significant OKS compared to patients with a BMI of ≤ 30 (preop ($p = 0.1091$) and 12 months ($p = 0.0511$)) (Tables **5** and **6**). The OKS for the > 35 BMI group did not differ significantly from the OKS for the 31-35 BMI group (preop ($p = 0.0905$) and 12 months ($p = 0.1466$)).

The absolute gain in the OKS from preop to 12 months when compared across the BMI groups did not differ significantly between patients with a BMI of ≤ 30 and BMI 31-35 ($p = 0.4717$) or BMI ≤ 30 and BMI >35 ($p = 0.1449$) (Table **8**).

**Table 4. Summary of 12 Month Oxford, WOMAC and HAAS Scores for Each Arthroplasty Group According to BMI Grouping**

| Oxford Scores | THA | | | TKA | | | UKA | | |
|---|---|---|---|---|---|---|---|---|---|
| | BMI < 30 | BMI 31-35 | BMI > 35 | BMI < 30 | BMI 31-35 | BMI > 35 | BMI < 30 | BMI 31-35 | BMI > 35 |
| Mean score at 12 months | 42.00 | 40.76 | 39.75 | 38.58 | 36.99 | 36.01 | 41.03 | 39.06 | 36.44 |
| SD | 6.52 | 6.92 | 7.03 | 7.32 | 8.71 | 8.53 | 6.99 | 8.47 | 9.26 |
| Number | 630 | 175 | 81 | 336 | 178 | 100 | 158 | 88 | 32 |

| WOMAC Scores | THA | | | TKA | | |
|---|---|---|---|---|---|---|
| | BMI < 30 | BMI 31-35 | BMI > 35 | BMI < 30 | BMI 31-35 | BMI > 35 |
| Mean score at 12 months | 82.78 | 79.06 | 77.54 | 78.78 | 77.28 | 75.03 |
| SD | 13.51 | 14.27 | 15.92 | 14.51 | 16.73 | 16.95 |
| Number | 627 | 174 | 81 | 336 | 178 | 100 |

| HAAS Scores | THA | | | TKA | | |
|---|---|---|---|---|---|---|
| | BMI < 30 | BMI 31-35 | BMI > 35 | BMI < 30 | BMI 31-35 | BMI > 35 |
| Mean score at 12 months | 10.51 | 10.17 | 10.46 | 9.78 | 9.35 | 8.93 |
| SD | 2.08 | 2.32 | 1.92 | 2.34 | 2.79 | 2.96 |
| Number | 629 | 175 | 81 | 336 | 178 | 100 |

**Table 5. Difference in Mean Functional Scores of ≤ 30 BMI Group *vs* Higher BMI Groups at Pre Op**

| THA Group | Oxford | | WOMAC | | HAAS | |
|---|---|---|---|---|---|---|
| | BMI 31-35 | BMI > 35 | BMI 31-35 | BMI > 35 | BMI 31-35 | BMI > 35 |
| Difference in mean score of ≤30 BMI group compared to higher BMI groups | 1.86 | 2.7 | 3.36 | 4.03 | 0.53 | 0.56 |
| 95% Confidence interval | 1.04 - 2.68 | 1.58 - 3.82 | 1.07 - 5.65 | 0.41- 7.65 | 0.28 - 0.78 | 0.25 - 0.91 |
| P value | <0.0001 | <0.0001 | 0.0041 | 0.0157 | <0.0001 | 0.0008 |
| **TKA Group** | **Oxford** | | **WOMAC** | | **HAAS** | |
| | **BMI 31-35** | **BMI > 35** | **BMI 31-35** | **BMI > 35** | **BMI 31-35** | **BMI > 35** |
| Difference in mean score of ≤30 BMI group compared to higher BMI groups | 0.14 | 2.1 | 3.02 | 3.5 | 0 | 0.77 |
| 95% Confidence interval | -0.79 - 1.07 | 0.99 - 3.21 | 0.30 - 5.74 | -0.32 - 7.32 | -0.30 - 0.30 | 0.41 - 1.13 |
| P value | 0.7553 | 0.0002 | 0.0304 | 0.0729 | 0.9649 | <0.0001 |
| **UKA Group** | **Oxford** | | | | | |
| | **BMI 31-35** | **BMI > 35** | | | | |
| Difference in mean score of ≤30 BMI group compared to higher BMI groups | 1.27 | 3.19 | | | | |
| 95% Confidence interval | -036 - 2.90 | 0.97 - 5.41 | | | | |
| P value | 0.1091 | 0.0048 | | | | |

## Total Hip Arthroplasty

The OHS, WOMAC and HAAS scores from preoperative and 12 months were compared across BMI groups. When the ≤30 BMI group was compared to both the 31-35 and >35 BMI groups there was significantly higher preoperative scores in the OHS (p = < 0.0001 for both 31-35 and >35 BMI), WOMAC (p = 0.0041 for 31-35 BMI and p = 0.0157 for>35 BMI) and HAAS scores (p = 0.0001 for 31-35 BMI and p = 0.0008 for>35 BMI) (Tables **5** and **6**). At 12 months the scores continued to be significantly higher for the OHS (p = 0.0282 for 31-35 BMI and p = 0.0039 for >35BMI) and WOMAC (p = 0.0016 for 31-35 BMI and 0.0014 for >35

**Table 6. Difference in Mean Functional Scores of ≤ 30 BMI Group *vs* Higher BMI Groups at 12 Month Post Op**

| **THA Group** | **Oxford** | | **WOMAC** | | **HAAS** | |
|---|---|---|---|---|---|---|
| | **BMI31-35** | **BMI> 35** | **BMI31-35** | **BMI> 35** | **BMI31-35** | **BMI> 35** |
| Difference in mean score of ≤30 BMI group compared to higher BMI groups | 1.24 | 2.25 | 3.72 | 5.24 | 0.34 | 0.05 |
| 95% Confidence interval | 0.13 - 2.35 | 0.72 - 3.78 | 1.42 - 6.02 | 2.04 - 8.44 | -0.02 - 0.70 | -0.04 - 0.05 |
| P value | 0.0282 | 0.0039 | 0.0016 | 0.0014 | 0.0658 | 0.836 |
| **TKA Group** | **Oxford** | | **WOMAC** | | **HAAS** | |
| | **BMI 31-35** | **BMI> 35** | **BMI31-35** | **BMI> 35** | **BMI 31-35** | **BMI> 35** |
| Difference in mean score of ≤30 BMI group compared to higher BMI groups | 1.59 | 2.57 | 1.5 | 3.75 | 0.43 | 0.85 |
| 95% Confidence interval | 0.16 - 3.02 | 0.87 - 4.27 | -1.29 - 4.29 | 0.37 - 7.13 | -0.03 - 0.89 | 0.29 - 1.41 |
| P value | 0.029 | 0.0032 | 0.2916 | 0.0298 | 0.0641 | 0.003 |
| **UKA Group** | **Oxford** | | | | | |
| | **BMI31-35** | **BMI> 35** | | | | |
| Difference in mean score of ≤30 BMI group compared to higher BMI groups | 1.97 | 4.59 | | | | |
| 95% Confidence interval | -0.01 - 3.95 | 1.76 - 7.42 | | | | |
| P value | 0.0511 | 0.0017 | | | | |

BMI) but not for the HAAS (p = 0.0659 for 31-35 BMI and 0.836 for >35 BMI) (Tables **5** and **6**).

Comparison of the absolute gain in the OHS and WOMAC scores from preoperative to 12 months showed no significant difference between patients with a BMI of ≤ 30 and patients in higher BMI groups (Table **8**). The > 35 BMI group did show a significantly larger increase in HAAS functional scores from preoperative to 12 months compared to the patients with a BMI ≤ 30 groups (p = 0.0435) but the 31-35 BMI group did not differ significantly from the ≤ 30 BMI group (p = 0.3881) (Table **8**).

### Total Knee Athroplasty

The OHS, WOMAC and HAAS scores from preoperative and 12 months were compared across BMI groups. When the ≤ 30 BMI group was compared to the >35 BMI group there was significantly higher OKS and HAAS and higher but not significant WOMAC scores preoperatively (p = 0.0002 for OKS, p = 0.0729 for WOMAC and p < 0.0001 for HAAS) with all scores being significantly higher at 12 months (p = 0.0032 for OKS, p = 0.0298 for WOMAC and p = 0.003 for HAAS) (Tables **5** and **6**).

Preoperatively the 31-35 BMI group had similar OKS and HAAS (p = 0.7553 for OKS and p = 0.9649 for HAAS) but significantly lower WOMAC (p = 0.0304) scores compared to the ≤ 30 BMI group but by 12 months only the OKS was significantly different (p = 0.029 for OKS, p = 0.2916 for WOMAC and p = 0.0641 for HAAS) (Tables **5** and **6**).

Comparison of the absolute gain in functional scores from preoperative to 12 months showed no significant difference between the ≤ 30 BMI patients and patients with a BMI > 35 (p = 0.9236 for OKS, p = 0.6848 for WOMAC and p = 0.9621 for HAAS) (Table **8**), whereas there was significantly less improvement in the OKS comparing the 31-35 BMI group to the ≤ 30 BMI group (p = 0.0194) (Table **8**).

## DISCUSSION

Our study showed that with increasing BMI patients have poorer functional scores preoperatively. For all three forms of arthroplasty those with a BMI above 30 had poorer functional outcome scores than those with a BMI of less than 30. These results are similar to Busato *et al.* [17]. Patients with a BMI of ≤ 30 had significantly better functional scores at 12 months than those with a BMI of > 35 and this was true for all types of functional scores we assessed. This difference was more than the minimal clinically important difference of 2 for the Oxford score [14] and 0.75 for the WOMAC scores [18]. The results for the 31-35 BMI group demonstrated lower scores when compared to the ≤ 30 BMI group but this was only significant with the Oxford scores and trending towards significance with the HAAS scores. However when we assessed the absolute gain from preoperative to 12 month score across all BMI groups we found no significant difference between the BMI groups. This result suggests that although patients with higher BMI's start at a lower functional level compared to normal patients the overall improvement following hip and knee arthroplasty is similar which confirms the findings of others [4, 19].

The only significant differences we found with regards the absolute change in scores was in the HAAS score change in the THA group where the > 35 BMI group did significantly better than patients with a BMI ≤ 30 groups (p = 0.0435). This result may reflect the better early results often seen with THA compared to TKA and the fact that patients with larger BMI's patients are significantly restricted in higher physical activities, such as walking and running. The HAAS scoring system is designed for younger patients, our average age for all 2699 patients was 68.5 years and this may have affected our HAAS results.

**Table 7. Summary of the Absolute Change in Oxford, WOMAC and HAAS Scores from Preop to 12 Months Post Op Across all BMI Groups**

| Oxford Scores | THA | | | TKA | | | UKA | | |
|---|---|---|---|---|---|---|---|---|---|
| | BMI < 30 | BMI 31-35 | BMI > 35 | BMI < 30 | BMI 31-35 | BMI > 35 | BMI < 30 | BMI 31-35 | BMI > 35 |
| Change in score | 23.64 | 24.44 | 24.6 | 18.91 | 17.02 | 19 | 20.47 | 19.59 | 17.92 |
| SD | 8.64 | 8.95 | 8.9 | 8.1 | 9.68 | 9.47 | 8.17 | 10.36 | 12.05 |
| Number | 629 | 175 | 81 | 335 | 177 | 100 | 154 | 86 | 32 |

| WOMAC Scores | THA | | | TKA | | |
|---|---|---|---|---|---|---|
| | BMI < 30 | BMI 31-35 | BMI > 35 | BMI < 30 | BMI 31-35 | BMI > 35 |
| Change in score | 46.39 | 44.04 | 46.95 | 39.83 | 41.23 | 38.3 |
| SD | 17.38 | 18.55 | 17.37 | 17.71 | 19.37 | 24.85 |
| Number | 332 | 96 | 42 | 162 | 77 | 30 |

| HAAS Scores | THA | | | TKA | | |
|---|---|---|---|---|---|---|
| | BMI < 30 | BMI 31-35 | BMI > 35 | BMI < 30 | BMI 31-35 | BMI > 35 |
| Change in score | 7.07 | 7.28 | 7.74 | 5.76 | 5.32 | 5.78 |
| SD | 2.84 | 2.96 | 2.69 | 2.84 | 3.33 | 3.15 |
| Number | 627 | 175 | 81 | 335 | 177 | 100 |

A limitation of this study was the poor return of the preoperative WOMAC scores with only approximately 60% return rate compared to >97% for all other scores (Table **2**). This no doubt influenced the WOMAC results especially on the absolute gain results. This low response rate makes it difficult to draw definitive conclusions from the WOMAC results alone. Other limitations to the study include a lack of presurgical severity diagnosis and the potential confounders of age and gender which were not included in our analysis.

In summary patient with higher BMI's have worse preoperative and post operative functional score but their

**Table 8. Comparison of Absolute Functional Score Gains for Patient with a BMI ≤ 30 Compared to Patients with Higher BMI (31-35 and > 35)**

| **Oxford Scores** | | | | | |
|---|---|---|---|---|---|
| | BMI≤ 30 | BMI 31-35 | BMI≤30 *vs* 31-35 p Value | BMI > 35 | BMI≤30 *vs* >35 p Value |
| **THA** | 23.64 | 24.44 | 0.2841 | 24.6 | 0.3473 |
| **TKA** | 18.91 | 17.02 | 0.0194 | 19 | 0.9236 |
| **UKA** | 20.47 | 19.59 | 0.4717 | 17.92 | 0.1449 |
| **WOMAC Scores** | | | | | |
| | BMI≤ 30 | BMI 31-35 | BMI≤30 *vs* 31-35 p Value | BMI > 35 | BMI≤30 *vs* >35 p Value |
| **THA** | 46.39 | 44.04 | 0.2506 | 46.95 | 0.8447 |
| **TKA** | 39.83 | 41.23 | 0.58 | 38.3 | 0.6848 |
| **HAAS Scores** | | | | | |
| | BMI≤ 30 | BMI 31-35 | BMI≤ 30 *vs* 31-35 p Value | BMI > 35 | BMI≤30 *vs* >35 p Value |
| **THA** | 7.07 | 7.28 | 0.3881 | 7.74 | 0.0435 |
| **TKA** | 5.76 | 5.32 | 0.1157 | 5.78 | 0.9621 |

benefit from surgery as measured by these functional scores was no different to patients with a lower BMI. This study did not look at complications following joint replacement in patients with a high BMI, which in itself may be a justification to limit access to surgery, however we could find no reason on the basis of the 12 month results to limit surgery to obese patients because of an expected poorer functional outcome.

## CONFLICT OF INTEREST

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


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