

A nested case-control analysis of self-reported physical functioning after total knee replacement surgery in the 45 and Up Study Cohort

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ABSTRACT

Objectives: The rate of total knee arthroplasty surgery (TKA) is rising in Australia despite varying impacts of TKA on physical function (PF) in population-based studies. There are potentially modifiable risk factors that could enhance PF after TKA, so we evaluated (1) the levels of PF in persons with TKA and the rest of the population, (2) potentially modifiable characteristics of those reporting poor PF after TKA.

Design: Nested case-control study.

Setting: Population-based cohort study in New South Wales, Australia.

Participants: Members of a large (n=267 151) cohort study recruited by a self-completed, mailed questionnaire from 2006 to 2008. After exclusions (for hip arthroplasty, partial TKA, missing important variables and mismatching TKA status between self-reported and hospital record data), this study included 205 148 participants.

Primary and secondary outcomes: Primary outcome, Medical Outcomes Study Physical Function scale (MOS-PF). Secondary outcome, dispensings of analgesics or anti-inflammatory drugs.

Results: We found 2916 TKA participants and 202 232 participants with no TKA (confirmed across datasets). Persons with TKA had a lower MOS-PF (59.9, 95% CI 58.5 to 60.6) than those without TKA (83.8, 95% CI 83.7 to 83.9). In the matched analysis, the TKA group had a lower MOS-PF (59.9, 95% CI 59.9 to 62.4) than those without TKA (68.4, 95% CI 67.8 to 69.0). In persons with TKA, lower levels of MOS-PF were associated with low self-rated health, high psychological distress, comorbidity, greater age, recent treatment for osteoarthritis and use of paracetamol. Women had an MOS-PF that was 11.6 points (95% CI 9.5 to 13.8) lower than men.

Conclusions: Several modifiable risk factors have been identified to influence PF in persons receiving TKA, with notable differences between sexes. The importance of these risk factors should be examined in incident TKA to test if early identification and intervention for individuals can improve outcomes.

ARTICLE SUMMARY

Article focus

- The rate of total knee arthroplasty (TKA) has risen in Australia despite variation in the effectiveness of this procedure.
- There are potentially a range of modifiable risk factors for poor physical function (PF) after TKA.
- We evaluated levels of PF in persons with TKA and the rest of the population, and also risk factors that could be amenable to intervention to improve PF.

Key messages

- Persons with TKA had much lower levels of PF than those who had not had TKA, even after matching on the propensity score.
- Women with TKA had a much lower level of PF than men, even after adjusting for confounders.
- Lower PF after TKA is associated with low self-rated health, high psychological distress, comorbidity, greater age and recent use of paracetamol.

Strengths and limitations of this study

- A large population-based study that uses the participant's hospital and medicine dispensing data.
- Confounding minimised by use of matching on propensity score.
- No direct measure of pain—indirect measures (analgesic and anti-inflammatory use) used instead to provide evidence of pain management needs.

INTRODUCTION

Total knee arthroplasty (TKA) rates are rising in Australia,¹ reflecting in part the high community burden of osteoarthritis. Studies have shown meaningful gains in functional status and pain reduction compared with matched controls,² but there is a subgroup with continuing pain and poor physical functioning. Population-based approaches, compared with single-site studies, have the advantage of heterogeneity in individuals, care settings and

outcomes, and have the potential to offer insights into a range of factors associated with variations in outcomes.³ Studies of functioning after TKA have produced variable and divergent results, partly attributable to differences in study design,⁴ which can be categorised as single-site clinical studies (involving one hospital or surgeon,⁵ population-based studies that are typically within specific populations (eg, male veterans, Medicare recipients, older people). A minority of studies have used an internal control or comparison group.² Population-based studies can be further grouped into those that have a specific focus on osteoarthritis, and general population-based studies that have less characterisation of osteoarthritis, but the advantages mentioned above. The 45 and Up Study includes participants from rural and regional areas, and also includes all types of health insurance coverage.

Very few studies have examined aspects of health-related quality of life (HRQOL) of people with prevalent TKA in a community setting with comparison to the general population. A study of US veterans with TKA compared with a control veteran population found significant physical HRQOL deficits in the veteran TKA group.⁴ The health-care system contact associated with surgery and recovery offers an opportunity to identify and potentially intervene further in this subgroup. There may be opportunities to enhance outcomes by specifically addressing modifiable factors associated with physical functioning. In this study, we addressed the following questions:

- A. What is the self-reported physical functioning and healthcare use in community-living people who have had knee replacement surgery and how does it compare with the rest of the population?
- B. What are the characteristics of those reporting poor physical functioning after knee replacement surgery?

METHODS

Data sources

The 45 and Up Study is a large cohort study of healthy ageing involving 267 151 men and women aged 45 years and over from the general population of New South Wales (NSW).⁶ Individuals 45 years and over were sampled from the Medicare Australia database and joined the study by completing a postal questionnaire (baseline questionnaire, BQ) and providing written consent to follow their health through repeat questionnaires and linkage to health records. Recruitment began in February 2006 with these analyses using information from the 241 949 participants who joined the study before July 2008. The response rate at this stage of recruitment was 19%.

The Department of Human Services processes claims for subsidised pharmaceuticals through the Pharmaceutical Benefits Scheme (PBS). The Australian PBS entitles residents with access to subsidised prescription medicines, where a copayment is made towards the cost of each item dispensed at the point of sale and the remaining cost of

the medicine is covered by PBS. Social security beneficiaries (eg, aged pensioners, individuals with disabilities, the unemployed and other low income earners) pay a lower copayment than the remainder of the community ('general' beneficiaries). In 2008, copayments were \$A5.00 for social security beneficiaries and \$31.30 for general beneficiaries. Approximately 85% of subsidised prescriptions in Australia go to social security beneficiaries. Where the cost of the prescription medicines is lower than the copayment, beneficiaries pay the lower amount, but the data are not recorded in PBS. All drugs considered 'necessary' for treatment of medical conditions are included in PBS, which includes analgesics (opioids, aspirin, paracetamol) and non-steroidal anti-inflammatory drugs (Ibuprofen, Naproxen, Celebrex, etc). Small pack sizes of less expensive drugs (eg, paracetamol) would typically be below the copayment threshold for social security beneficiaries, but more expensive drugs (eg, Celebrex) and larger packs (eg, 100 tablets) of less expensive drugs will be above the copayment threshold and appear in the PBS data. PBS data include date of service, item and Anatomical Therapeutic Code (ATC).

The NSW Admitted Patient Data Collection (APDC) includes records for all admissions from all NSW hospitals and day procedure centres. This study used APDC data from July 2000 to June 2009. Data used include patient demographics and procedures coded according to the Australian modification of the International Statistical Classification of Diseases and Related Problems, 10th revision (ICD-10-AM).

Data linkage

Linkage of the 45 and Up Study to PBS data was accomplished by a deterministic link established between the 45 and Up Study and Medicare Australia during recruitment into the 45 and Up Study. Medicare Australia included a scrambled identification number on BQs, which is capable of being linked back to MBS and PBS data. This number was captured during data entry, and allows MBS and PBS records to be linked directly to 45 and Up data. The linkage of 45 and Up Study and APDC data was performed by the Centre for Health Record Linkage⁷ using probabilistic methods⁸ and ChoiceMaker software.⁹ CHeReL creates MLK using probabilistic linkage of personal information (including full name, date of birth, sex and address) and ChoiceMaker software. Evaluation of the accuracy of the linkage was determined by clerical review of samples of matched records, with false-positive and false-negative rates of 0.4% and <0.1%, respectively.

Selection of participants—exclusions

Participants were included if their BQ response included self-reported physical function (PF) data (see below) and their TKA status could be verified against APDC records. Persons were excluded when there was an APDC record of hip replacement surgery (see web appendix A for ICD10 codes) or a self-report of hip

replacement surgery in BQ; an APDC record of TKA after baseline recruitment; an APDC record or self-report of TKA less than 1 year prior to recruitment to the 45 and Up Study or the participant had an APDC record of revision or replacement without a previously verified TKA. One hundred and seventy-four participants had APDC records of TKA within 6 months of baseline recruitment, and another 148 had records between 6 months and 1 year prior to baseline recruitment. A minimum 1 year gap was chosen on the basis of estimates of the time to recovery of stable levels of physical functioning.¹⁰ We tested this assumption by conducting a sensitivity analysis where we changed the gap period to 6 months. Participants with TKA between 6 months and 1 year had greatly reduced levels of PF relative to those with TKA of more than 1 year; this confirmed that a 1 year gap criterion was justified. The effect of time since surgery was also tested and found to be not significant.

Measures used knee replacement surgery

Identification of participants who had undergone knee replacement surgery was based on self-report to the item 'Knee replacement surgery' in The 45 and Up Study BQ to the item: 'Have you ever had any of the following operations?' Participants were also asked to record the age at which they had the operation.

Self-report of TKA was then compared with NSW APDC data to verify that the participant had undergone TKA. Records from the APDC data ranged from July 2000 to June 2008, for 8 years of complete records. A participant was considered to have a verified TKA if they had a full TKA and self-report of TKA (web appendix A). Participants with a record of bilateral TKA were classified as those having simultaneous bilateral knee replacement procedure and that both knee joints were replaced. Participants with a record of simultaneous bilateral knee replacement or records of two separate unilateral procedures were classified as having both knee joints replaced. ICD10 codes were derived from those used by the Australian National Joint Replacement Registry.¹

Physical functioning

The Medical Outcomes Study Physical Functioning Scale (MOS-PF) from the 45 and Up Study BQ was used to ascertain physical functioning.^{11 12} MOS-PF is a 10-item scale included in full in BQ and covers physical activities ranging from vigorous activities to those associated with basic activities of daily living (dressing and bathing). It includes items that are particularly relevant to knee functioning (climbing one or several flights of stairs, kneeling or stooping, lifting groceries). Participants were asked to rate their current degree of limitation in performing each activity on a three-point Likert scale (limited not at all/a little bit/a lot). The MOS-PF score was calculated by averaging responses across the 10

items and transforming the score to a 0–100 scale where higher scores indicate better physical functioning.

The MOS-PF scale has a relatively high rate of missing items; the standard approach is to allow for up to 5 missing items (of 10), with the mean of the non-missing items imputed into the missing values.¹¹ An additional strategy for imputing values based on similar items within the scales was developed. There were several items with an ordinal scale such as walking ('Walking 1 km', 'Walking half a km', 'Walking 100 m'), climbing stairs ('Climbing several flights of stairs', 'Climbing one flight of stairs'), levels of activity ('Vigorous activities', 'Moderate activities') where a greater level of PF would be needed to complete the first item than the next or subsequent items. If the item was answered indicating no limitations at the highest functional level (eg, Walking 1 km), and the rest of the related items were missing, then the rest of the items (eg, Walking half a km) were considered to be able to be completed with no physical limitations. Conversely, when an item at the lowest functional level (eg, Walking 100 m) was answered as 'limited a lot' or 'limited a little' and related items with higher functional requirements were missing (eg, Walking 1 km), then the level of physical limitation in the lower item was imputed to the item with the higher physical requirement.

To provide some external comparison, we used findings from The Hertfordshire Cohort Study,¹³ a population-based cohort study which compared SF-36 Physical Functioning Scale scores with objectively measured physical performance to establish cut-off values on the SF-36 score that were associated with the lowest quintile of performance on a battery of physical performance tests measuring mobility disability (grip strength, timed up and go test, walking speed, chair rise, timed one leg balance and supine quadriceps torque). The age range for the Hertfordshire study cohort was 59–72 years, and thus when applying, the PF score cut-offs analyses were restricted to 45 and Up participants of comparable age when they completed BQ. The cut-off values were a score of 60 or less for men, and 75 or less for women.

Other self-report measures

Age, sex, educational qualifications, income, health insurance status,¹⁴ number of falls in the last year, disability status, physical activity and self-rated health status were classified according to the groupings in table 1. The number of sessions of physical activity (metabolically adjusted) was used in place of time spent in physical activity, as this can be harmonised across different versions of The 45 and Up Study Questionnaire and has been shown to validly represent time spent in physical activity in the 45 and Up Study.¹⁵ Psychological distress was measured using the Kessler-10 score.¹⁶ Kessler-10 scores were classified into three groups: low psychological distress (score 10–15), moderate psychological distress (score 16–21), high psychological distress (score

Table 1 Characteristics of participants by verified self-report of knee replacement surgery

Variable	TKA	No TKA
Age (years)		
45–49	20 (0.7%)	28 985 (14.3%)
50–54	60 (2.1%)	35 560 (17.6%)
55–59	168 (5.8%)	36 796 (18.2%)
60–64	362 (12.4%)	31 346 (15.5%)
65–69	500 (17.1%)	24 788 (12.3%)
70–74	546 (18.7%)	16 741 (8.3%)
75–79	493 (16.9%)	11 443 (5.7%)
80–84	572 (19.6%)	11 797 (5.8%)
85+	195 (6.7%)	4 776 (2.4%)
Mean	72.6	61.7
Sex		
Male	1397 (46.9%)	94 847 (47.8%)
Female	1519 (53.1%)	107 385 (52.2%)
Education level		
Some high school	1319 (46.2%)	64 554 (32.3%)
High school	243 (8.5%)	19 970 (10.0%)
Post school qualification	947 (33.2%)	65 373 (32.7%)
University degree	347 (12.1%)	49 741 (24.9%)
Income/year		
<\$20k	953 (34.8%)	36 717 (18.7%)
\$20–50k	814 (29.7%)	51 051 (26.0%)
\$50–70	170 (6.2%)	22 623 (11.5%)
\$70k+	230 (8.4%)	52 793 (26.9%)
Rather not say	575 (21.0%)	33 036 (16.8%)
Self-rated health		
Excellent or Good	2109 (74.3%)	173 391 (87.0%)
Poor or very poor	729 (25.7%)	25 834 (13.0%)
Number of chronic conditions		
No conditions	277 (9.5%)	51 722 (25.6%)
1 health condition	675 (23.1%)	61 802 (30.6%)
2 health conditions	762 (26.1%)	45 717 (22.6%)
3 health conditions	617 (21.2%)	24 922 (12.3%)
4+ health conditions	585 (20.1%)	18 069 (8.9%)
Treated for osteoarthritis in last month		
No	2100 (72.0%)	189 079 (93.5%)
Yes	816 (28.0%)	13 153 (6.5%)
Private health insurance status		
Private	1874 (64.3%)	131 417 (65.0%)
DVA	140 (4.8%)	3,002 (1.5%)
None	902 (30.9%)	67 813 (33.5%)
Used paracetamol in last 2 weeks		
No	1794 (61.5%)	155 382 (76.8%)
Yes	1122 (38.5%)	46 850 (23.2%)
Psychological distress		
Low distress	2202 (78.2%)	154 867 (78.0%)
Moderate distress	406 (14.4%)	29 758 (15.0%)
High/very high distress	209 (7.4%)	14 010 (7.1%)
BMI categories		
Underweight (<18.5)	17 (0.6%)	2499 (1.3%)
Healthy weight (18.5–<25)	463 (17.5%)	70 580 (37.5%)
Overweight (25–<30)	1040 (39.4%)	74 754 (39.7%)
Obese (30+)	1119 (42.4%)	40 334 (21.4%)
Physical activity sessions		
0–3 sessions/week	642 (22.0%)	30 842 (15.3%)
4–9 sessions/week	1053 (36.1%)	70 002 (34.6%)
10–17 sessions/week	830 (28.5%)	63 373 (31.3%)
18+ sessions/week	391 (13.4%)	38 015 (18.8%)

Continued

Table 1 Continued

Variable	TKA	No TKA
Broken bone in last year		
No	2457 (86.6%)	175 655 (88.7%)
Yes	381 (13.4%)	22 299 (11.3%)
Falls in last 12 months		
0	1 932 (68.8%)	163 172 (83.4%)
1 or more	875 (31.2%)	32 581 (16.6%)
Total	2916	202 232

BMI, body mass index; TKA, total knee arthroplasty.

22 or higher) and very high psychological distress (score 30 or higher). Body mass index (BMI) was calculated from self-reported height and weight. Recent paracetamol use was based on self-reported use of the medication for most of the 4 weeks prior to the survey. Presence of osteoarthritis was based on reporting treatment by a doctor for osteoarthritis in the 4 weeks prior to the survey. The number of comorbidities was calculated from the self-report of selected conditions (treated in the last month) including cancer, heart attack, heart disease, high blood pressure, blood clots, asthma, thyroid conditions, osteoporosis, depression and anxiety.

PBS dispensing records

The 45 and Up Study BQ contains no direct pain measures, so linked PBS data were used to estimate pain-related prescribed medication use in TKA and non-TKA participants. Dispensation of analgesic or anti-inflammatory drugs in the year after completing BQ was derived from linked PBS data. The ATC of the item was used to identify analgesic or anti-inflammatory (ATCs: N01/N02 and M01/M02) drugs. Items priced below the copayment threshold (\$5.00/\$31.30 in June 2010 for concessional/general users) do not appear in the PBS data, so the use of analgesics or anti-inflammatory drugs may not be completely recorded in these data.

Statistical analysis

Characteristics of TKA and non-TKA groups

The self-reported characteristics of participants from the 45 and Up Study BQ were compared according to the verified TKA status. The overall MOS-PF and each individual item (where the participant reported being "Limited a lot") were also summarised according to the TKA status. The rate of dispensation of analgesics and anti-inflammatory drugs under PBS was estimated with a log-binomial model with propensity score-matched data (see web appendix B), with the record of dispensing as the outcome.

Predictors of physical function in the TKA and non-TKA groups

The first analysis examined predictors of self-reported physical functioning in persons with and without TKA. The MOS-PF score ranges from 0 to 100 and the ceiling

and floor effects are commonly found,¹⁷ so Tobit regression¹⁸ was used to account for this censoring (web appendix B). Goodness-of-fit was assessed by calculating Efron's pseudo r^2 .¹⁹ Tobit regression models were estimated for MOS-PF, using PROC QLIM in SAS/ETS (SAS V.9.1, SAS Institute, Cary, North Carolina, USA).

Difference in physical function between the TKA and non-TKA groups

Matching by propensity score and by age, sex and osteoarthritis status was used to adjust for differences between the TKA and non-TKA groups (ratio 1 TKA:5 non-TKA). Numerous factors including age, gender, paracetamol use and self-rated health were found to be associated with TKA. A full list of the information used to create the propensity score can be found in web appendix B. Tobit regression was used to estimate the effect of TKA on MOS-PF. For age-sex-osteoarthritis matching, additional predictor variables were used in the model using the same strategy as above. An additional dichotomous outcome of low-PF was also analysed in a conditional logistic regression, similarly with verified TKA status as the predictor variable, with the matched group (consisting of one TKA and five matched non-TKA) as a cluster.

The 45 and Up Study has approval from the University of NSW Ethics Committee, and this study was approved by The NSW Population and Health Services Research Ethics Committee and the Department of Health and Ageing Departmental Ethics Committee.

RESULTS

Participant selection and validation of TKA

Linked data for 241 949 45 and Up Study participants were available at the time of this analysis in March 2009 (figure 1). Approximately 90% of participants (218 237) had completed enough items to calculate a valid MOS-PF score. Of these participants, 6889 were excluded because they either self-reported or had a hospital record of hip replacement surgery. A further 826 participants were excluded for self-report of TKA or an APDC record of TKA that occurred less than 1 year before recruitment into the 45 and Up Study, and 1237 participants were excluded because they had a hospital

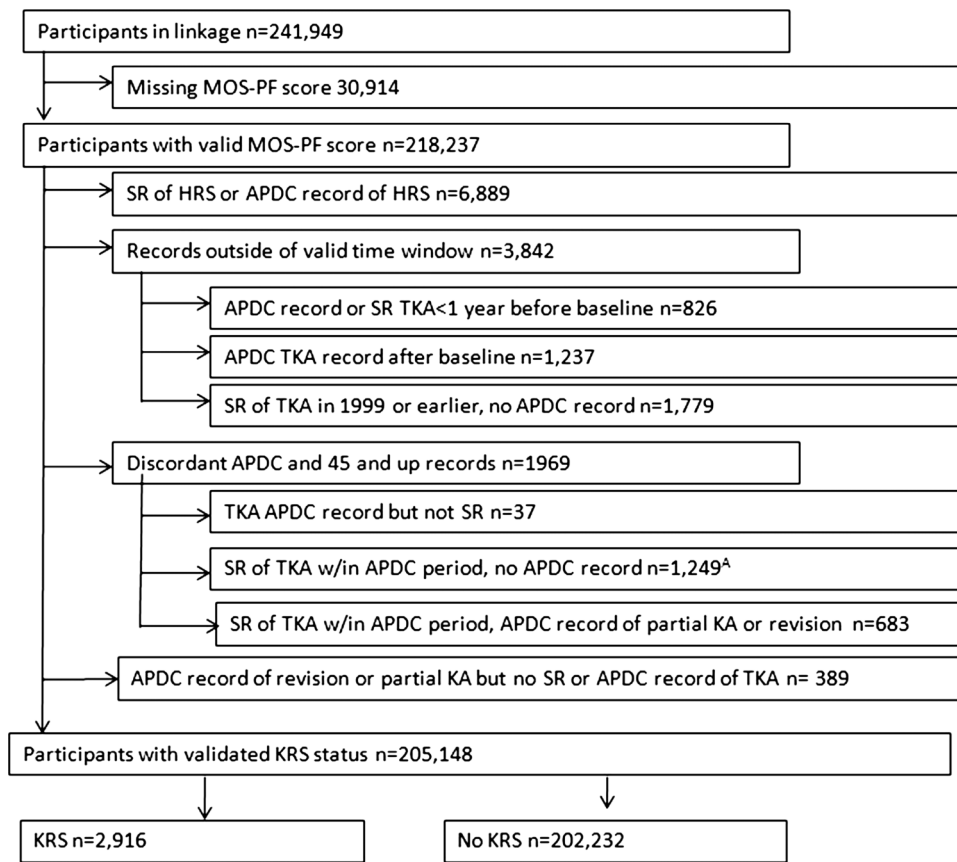


Figure 1 Details of inclusion and exclusion of participants in study. A 45.1% (n=563) self-reported a knee replacement in 2000 or 2001 (most proximate years to the beginning of the hospital data).

record of TKA after recruitment into the 45 and Up Study cohort.

There were 1969 participants who self-reported TKA within 1 year of the APDC data becoming available, but who did not have any record of this in their hospital data. These excluded participants had either a record of a partial TKA or revision (683 for both types) or had self-reported TKA occurring in 2000 or 2001, close to the lower limits of the available data. Another 37 participants had a record of TKA in the APDC data but did

not report any TKA in their 45 and Up BQ. Many participants with a self-report of TKA but no matching record (1249) had self-reported TKA reported 1 year or more before the available APDC data starting in 2000 (1779). All these participants (3842 in total) were excluded. Participants with an APDC record of a partial KA or a revision who were unable to validate a TKA were then excluded (389). A total of 2916 participants had self-reported TKA and a hospital record of full knee replacement; these were considered to have a verified

Table 2 Proportion of participants reporting limited a lot for each item in MOS-PF by TKA (unmatched) status

Item	TKA (%)	No TKA (%)
Vigorous activities	2042 (72.4)	60 897 (30.7)
Moderate activities	582 (21.1)	13 657 (6.9)
Lift/carry shopping	473 (16.8)	12 269 (6.1)
Climb several flights of stairs	858 (30.2)	20 317 (10.1)
Climb 1 flight of stairs	421 (15.3)	8492 (4.3)
Walk 1 km	842 (29.8)	16 337 (8.2)
Walk 0.5 km	590 (21.7)	11 410 (5.8)
Walk 100 m	269 (10.2)	5774 (2.9)
Bend/kneel/stoop	1209 (42.2)	16 944 (8.5)
Bathing/dressing	104 (3.8)	2888 (1.5)
MOS-PF score (95% CI)	59.9 (58.5 to 60.6)	83.8 (83.7 to 83.9)

MOS-PF, Medical Outcomes Study Physical Function; TKA, total knee arthroplasty.

Table 3 PBS item use in persons with TKA vs no TKA in year prior to recruitment

PBS items	TKA	No TKA
Analgesic (ATC: N02A/N02B)	43.8% (41.2–45.2)	33.7% (32.9–34.4)
Anti-inflammatory (ATC: M01/M02)	36.3% (34.6–38.2)	25.7% (25.0–26.4)

ATC, Anatomical Therapeutic Code; PBS, Pharmaceutical Benefits Scheme; TKA, total knee arthroplasty.

procedure. A further 202 232 participants had no self-report or hospital record of any joint replacement procedure, and these formed the verified control group. There were 205 148 persons with verified TKA status available for analysis.

Participants with a mismatching self-report and hospital records were similar to participants with verified TKA status with respect to age, MOS-PF score and self-report of treatment for osteoarthritis (web appendix C). Participants with an APDC record but no self-report were older and had lower MOS-PF scores than those with verified knee-replacement procedure, but they were still more similar to the verified TKA group than those in the verified control group.

Characteristics of the TKA and non-TKA groups

TKA participants differed from those without TKA across demographic and health status variables (table 1). The TKA group had a lower proportion of men (47.8%). Those who had received TKA were older, less educated and had lower household income levels. They also reported more chronic conditions, poorer self-rated health and were more likely to have recently used paracetamol or to have been treated recently for osteoarthritis. The number of falls reported by TKA participants was greater, and a higher proportion were either overweight or obese (81.8%).

The poorer overall health of TKA participants was reflected by the much lower MOS-PF: the average MOS-PF score was 59.9 (table 2) compared with 83.8 in those with no TKA. Given the mean age of the surgery and comparison groups, the expected score based on the Australian population normative data would be 66.2 and 76.1, respectively.²⁰ As with any population-based cohort study, participants may be, on average, healthier than the general population. TKA participants were more likely to report a high level of limitation in most MOS-PF items, particularly for limitations in climbing stairs and bathing/dressing.

TKA participants had substantially higher rates of use of PBS analgesic and anti-inflammatory items than propensity score-matched non-TKA participants in the year prior to participating in the 45 and Up Study (table 3).

Difference in PF between the TKA and non-TKA groups

Covariate balance was closer in the propensity score-matched group than in the groups matched by age, sex and self-report of osteoarthritis (table 6). The estimated difference in MOS-PF between the TKA and non-TKA participants was similar between matching methods once additional regression adjustment was used for the groups matched by age, sex and osteoarthritis status (table 4). Individuals with TKA had lower levels of PF than very similar (matched) individuals who had not had TKA.

To provide context, we applied the verified PF score cut-offs corresponding to poorly assessed physical functioning obtained from the Hertfordshire study (see Methods section) to the subset of the cohort meeting the age range inclusion criteria for the Hertfordshire study. For this subset, 30.7% of men with TKA had a PF score that may indicate poor physical functioning, compared with 60.5% of women. By contrast, in participants without TKA, 10.6% of men and 22.5% of women had a PF score below the cut-point for poorly assessed physical functioning as defined in the Hertfordshire Study. The odds of poor PF were 1.6 times greater (propensity score matched) in the group with TKA than in the group without TKA.

Predictors of PF by TKA status

In a fully adjusted Tobit model, multiple factors were related to levels of PF (table 5). Factors most strongly associated with lower PF scores were poorer self-rated health, high levels of psychological distress, female gender, increasing number of comorbidities and increasing age. Recent treatment for osteoarthritis and recent use of paracetamol were also associated with lower PF scores. The number of physical activity sessions per week

Table 4 Comparison of MOS-PF score and OR of low MOS-PF score between TKA and non-TKA participants

Type of matching	MOS-PF, no TKA group	MOS-PF, TKA group	OR of low MOS-P, TKA compared with no TKA group
Matched by age, sex, osteoarthritis	76.5 (75.9–77.1)	61.1 (59.0–62.2)	2.3 (2.2–2.6)
+Regression adjustments	75.5 (75.9–77.1)	64.3 (62.5–65.7)	2.3 (2.2–2.6)
Matched on propensity score	68.4 (67.8–69.0)	59.9 (58.4–62.4)	1.6 (1.4–1.7)

MOS-PF, Medical Outcomes Study Physical Function; TKA, total knee arthroplasty.

Table 5 Factors associated with poor self-reported Physical Functioning in TKA participants (verified)

	Difference in MOS-PF from reference
Age (years)	
45–54	Reference
55–64	–2.1 (–8–3.9)
65–74	0.5 (–5.4–6.4)
75–84	–5.5 (–11.5–0.6)
85+	–17.4 (–24.7–10.2)
Sex	
Male	Reference
Female	–11.6 (–13.8–9.5)
Education level	
Less than high school	Reference
High school	–0.2 (–3.9–3.5)
Trade/apprenticeship	0.1 (–2.2–2.4)
University degree	4.2 (0.9–7.5)
Income/year	
<\$20k	Reference
\$20–49k	2.5 (–0.1–5)
\$50–69k	4 (–0.4–8.3)
\$70k+	2.7 (–1.4–6.7)
Rather not say	2 (–0.9–4.8)
Self-related health	
Excellent or good	Reference
Fair or poor	–20 (–22.5–17.5)
Number of conditions	–1.6 (–2.2–0.9)
Private health insurance status	
None	Reference
Private w/extras	0.7 (–2.9–4.3)
Private no extras	–0.9 (–4.9–3.2)
DVA healthcare	–10.5 (–16.2–4.9)
Health care	–4.7 (–8.6–0.8)
Used paracetamol in the last week	
No	Reference
Yes	–5.1 (–7.2–3)
Level of psychological distress (K10)	
Low	Reference
Moderate	–5.7 (–8.6–2.8)
High/very high	–10.6 (–14.6–6.5)
Treated for osteoarthritis in last month	
No	Reference
Yes	–6.4 (–8.7–4.1)
BMI category	
Healthy weight	Reference
Underweight (<18.5)	–10.6 (–23.4–2.3)
Overweight (25–29)	–0.6 (–3.4–2.3)
Obese (30+)	–6.3 (–9.2–3.4)
PA sessions/week	
0–3 sessions	Reference
4–9 sessions	12.7 (9.9–15.5)
10–17 sessions	17.4 (14.5–20.3)
18+ sessions	19 (15.5–22.6)
Time since TKA	
1	Reference
2	–1.8 (–6–2.5)
3	–4 (–8.2–0.2)
4	–2.4 (–6.8–2)
5	–2.5 (–7–2)

Continued

Table 5 Continued

	Difference in MOS-PF from reference
6+	–5.5 (–9.5–1.5)
Model fit	
Pseudo R ²	0.627
Summary	
N	2916
n at lower bound (0)	72
n at upper bound (100)	108

BMI, body mass index; PA, physical activity; TKA, total knee arthroplasty.

was strongly and incrementally associated with higher PF scores. This model had a pseudo-r² value of over 0.6, indicating reasonable ability to predict PF.

DISCUSSION

This study was motivated by recent findings of variability in health outcomes following TKA.³ It should be emphasised that the intention of this study is not to assess whether knee replacement surgery is an efficacious intervention; it would be inappropriate to draw inferences about this from our study. We were interested in identifying factors associated with poorer functioning that may be potentially amenable to intervention. This is important because suboptimal function leads to continuing demands on support/health services. Conversely, targeted interventions can potentially improve the quality of life and reduce costs. Population-based studies with broad heterogeneity in exposures and outcomes are useful in this context.

We compared self-reported physical functioning in community-dwelling people with prevalent TKA to their peers using data from a large cohort study linked to routinely collected administrative health records, and identified a range of factors associated with differential self-reported physical functioning. This is the first study of its type in Australia, and the first to use data linkage and sophisticated statistical techniques (propensity-score matching) to match ‘cases’ (people who have had TKA) to ‘controls’ (people who have not had TKA) who were otherwise similar. There are only two previous studies of this type internationally, both much smaller in size and only one of which used propensity scoring.²¹ The use of propensity score matching to compare groups based on TKA status within one study population is an additional methodological feature of our study. We found that this approach led to a better balance of covariates in the matched sample than simply matching on a few variables (web appendix B). To our knowledge, this is the first study to use the MOS-PF scale with a Tobit model that implicitly accounts for floor and ceiling effects,²² which can otherwise underestimate the effect size of explanatory variables (web appendix B).²³

Table 6 Covariate balance (self-reported information from the 45 and Up Study baseline questionnaire) by TKA status and type of matching

Variable	Unmatched			Propensity score matched		Age, sex, arthritis matched	
	TKA	No TKA	No TKA-TKA (%)	No TKA	No TKA-TKA	No	
						No TKA	TKA-TKA
Age (years)							
45–49	20 (0.7%)	28 985 (14.3%)	–13.6	117 (0.8%)	–0.1	100 (0.7%)	0
50–54	60 (2.1%)	35 560 (17.6%)	–15.5%	282 (2.0%)	0.1%	300 (2.1%)	0%
55–59	168 (5.8%)	36 796 (18.2%)	–12.4%	780 (5.4%)	0.4%	840 (5.8%)	0%
60–64	362 (12.4%)	31 346 (15.5%)	–3.1%	1761 (12.2%)	0.2%	1810 (12.4%)	0%
65–69	500 (17.1%)	24 788 (12.3%)	4.8%	2564 (17.7%)	–0.6%	2500 (17.1%)	0%
70–74	546 (18.7%)	16 741 (8.3%)	10.4%	2776 (19.2%)	–0.5%	2730 (18.7%)	0%
75–79	493 (16.9%)	11 443 (5.7%)	11.2%	2389 (16.5%)	0.4%	2465 (16.9%)	0%
80–84	572 (19.6%)	11 797 (5.8%)	13.8%	2829 (19.6%)	0%	2860 (19.6%)	0%
85+	195 (6.7%)	4,776 (2.4%)	4.3%	956 (6.6%)	0.1%	975 (6.7%)	0%
Sex							
Male	1468 (50.3%)	94847 (47.8%)	–0.9%	7369 (51.0%)	–0.7%	7340 (50.3%)	0%
Female	1448 (49.7%)	107385 (52.2%)	0.9%	7085 (49.0%)	0.7%	7240 (49.7%)	0%
Education level							
Less than high school	1319 (46.2%)	64 554 (32.3%)	13.9%	6622 (46.8%)	–0.6%	5964 (41.7%)	4.5%
High school	243 (8.5%)	19 970 (10.0%)	–1.5%	1216 (8.6%)	–0.1%	1355 (9.5%)	–1%
Post high school	947 (33.2%)	65 373 (32.7%)	0.5%	4616 (32.6%)	0.6%	4444 (31.1%)	2.1%
University degree	347 (12.1%)	49 741 (24.9%)	–12.8%	1701 (12.0%)	0.1%	2542 (17.8%)	–5.7%
Income/year							
<\$20k	953 (34.8%)	36 717 (18.7%)	16.1%	4629 (34.0%)	0.8%	4470 (32.5%)	2.3%
\$20–50k	814 (29.7%)	51 051 (26.0%)	3.7%	4097 (30.1%)	–0.4%	4199 (30.5%)	–0.8%
\$50–70	170 (6.2%)	22 623 (11.5%)	–5.3%	871 (6.4%)	–0.2%	1006 (7.3%)	–1.1%
\$70k+	230 (8.4%)	52 793 (26.9%)	–18.5%	1114 (8.2%)	0.2%	1448 (10.5%)	–2.1%
Rather not say	575 (21.0%)	33 036 (16.8%)	4.2%	2894 (21.3%)	–0.3%	2646 (19.2%)	1.8%
Self-rated health							
Excellent or Good	2109 (74.3%)	173391 (87.0%)	–12.7%	10535 (75.0%)	–0.7%	11281 (79.4%)	–5.1%
Poor or very poor	729 (25.7%)	25 834 (13.0%)	12.7%	3516 (25.0%)	0.7%	2922 (20.6%)	5.1%
Number of chronic Conditions							
No conditions	277 (9.5%)	51 722 (25.6%)	–16.1%	1481 (10.2%)	–0.7%	2037 (14.0%)	–4.5%
1 health condition	675 (23.1%)	61 802 (30.6%)	–7.5%	3301 (22.8%)	0.3%	3746 (25.7%)	–2.6%
2 health conditions	762 (26.1%)	45 717 (22.6%)	3.5%	3822 (26.4%)	–0.3%	3747 (25.7%)	0.4%
3 health conditions	617 (21.2%)	24 922 (12.3%)	8.9%	2810 (19.4%)	1.8%	2611 (17.9%)	3.3%
4+ health conditions	585 (20.1%)	18 069 (8.9%)	11.2%	3040 (21.0%)	–0.9%	2439 (16.7%)	3.4%
Recent osteoarthritis							
No	2100 (72.0%)	189 079 (93.5%)	–21.5%	10711 (74.1%)	–2.1%	10500 (72.0%)	0%
Treatment							
Yes	816 (28.0%)	13 153 (6.5%)	21.5%	3743 (25.9%)	2.1%	4080 (28.0%)	0%
Private health insurance							
Private	1874 (64.3%)	131 417 (65.0%)	–0.7%	9250 (64.0%)	0.3%	8420 (57.8%)	6.5%
Status							
DVA	140 (4.8%)	3,002 (1.5%)	3.3%	653 (4.5%)	0.3%	585 (4.0%)	0.8%
None	902 (30.9%)	67 813 (33.5%)	–2.6%	4551 (31.5%)	–0.6%	5575 (38.2%)	–7.3%
Use paracetamol in Last 2 weeks							
No	1794 (61.5%)	155382 (76.8%)	–15.3%	9038 (62.5%)	–1%	10369 (71.1%)	–9.6%
Yes	1122 (38.5%)	46 850 (23.2%)	15.3%	5416 (37.5%)	1%	4211 (28.9%)	9.6%
Psychological							
Low	2202 (78.2%)	154867 (78.0%)	0.2%	10884 (78.0%)	0.2%	11391 (80.6%)	–2.4%

Continued

Table 6 Continued

Variable	TKA	Unmatched		Propensity score matched		Age, sex, arthritis matched	
		No TKA	No TKA-TKA (%)	No TKA	No TKA-TKA	No TKA	No TKA-TKA
Distress							
Moderate	406 (14.4%)	29 758 (15.0%)	-0.6%	2068 (14.8%)	-0.4%	1883 (13.3%)	1.1%
High or very high	209 (7.4%)	14 010 (7.1%)	0.3%	1009 (7.2%)	0.2%	854 (6.0%)	1.4%
BMI categories							
Underweight (<18.5)	17 (0.6%)	2,499 (1.3%)	-0.7%	74 (0.6%)	0%	235 (1.8%)	-1.2%
Healthy (18.5-25)	463 (17.5%)	70 580 (37.5%)	-20%	2368 (18.2%)	-0.7%	5264 (39.3%)	-21.8%
Overweight (25-30)	1040 (39.4%)	74 754 (39.7%)	-0.3%	5239 (40.2%)	-0.8%	5315 (39.6%)	-0.2%
Obese (30+)	1119 (42.4%)	40 334 (21.4%)	21%	5345 (41.0%)	1.4%	2595 (19.4%)	23%
Physical activity							
0-3 sessions/week	642 (22.0%)	30 842 (15.3%)	6.7%	3231 (22.4%)	-0.4%	2675 (18.3%)	3.7%
Sessions							
4-9 sessions/week	1053 (36.1%)	70 002 (34.6%)	1.5%	5208 (36.0%)	0.1%	5127 (35.2%)	0.9%
10-17 sessions/week	830 (28.5%)	63 373 (31.3%)	-2.8%	3967 (27.4%)	1.1%	4451 (30.5%)	-2%
18+ sessions/week	391 (13.4%)	38 015 (18.8%)	-5.4%	2048 (14.2%)	-0.8%	2327 (16.0%)	-2.6%
Broken bone in last Year							
No	2457 (86.6%)	175655 (88.7%)	-2.1%	12120 (86.4%)	0.2%	12132 (86.1%)	0.5%
Yes	381 (13.4%)	22,299 (11.3%)	2.1%	1905 (13.6%)	-0.2%	1962 (13.9%)	-0.5%
Falls in last 12 Months							
0	1932 (68.8%)	163172 (83.4%)	-14.6%	9658 (69.4%)	-0.6%	10765 (76.6%)	-7.8%
1 or more	875 (31.2%)	32 581 (16.6%)	14.6%	4264 (30.6%)	0.6%	3291 (23.4%)	7.8%
Total	2916	202232		14580		14580	

BMI, body mass index; TKA, total knee arthroplasty.

Self-reported physical functioning was lower in the TKA group compared with the matched controls using two different matching methods. There were also differences in use of prescribed anti-inflammatory and analgesic medications between the two groups. These results can be contextualised in two ways. First, prior studies have used the criterion of a minimal clinically important difference (MCID) between groups in domain scores to interpret differences in self-reported physical functioning.²⁴ Using this (ie, MCID of a 5-10 change in score), lower PF scores were strongly associated with fair/poor self-rated health, female gender, moderate-to-high levels of psychological distress and increasing age, and to a lesser extent with obesity, underweight (possibly due to frailty and related sarcopenia), health insurance status, length of time since surgery and recently reported treatment for osteoarthritis. Higher physical functioning scores were positively associated with levels of physical activity. Taken together, these findings suggest that interventions aimed at incremental improvements in physical functioning need to be carefully targeted. Second, our findings were also contextualised

using an external source of comparison, showing a marked gender difference. Poorer outcomes in women have been found elsewhere,¹⁰ although the reasons for this are not clear and need further investigation. It has been identified that women are less likely to be offered knee joint replacement surgery,²⁵ which may in part explain poorer function if they have more advanced disease and disability before surgery. Further investigation is recommended for this gender difference in outcomes. As this is a cross-sectional study, no inferences can be made about the causal nature or directionality. However, the results suggested here show the potential for further improvements in outcomes, particularly for women. In this context, Maly²⁶ identified age, female gender and BMI as predictors of adverse change in SF-36 physical functioning scores over time in a clinical cohort (median length of follow-up, 6.9 years).

Recent papers have identified factors including age, gender, PF status, pain from other arthritic joints and comorbidities as predictors for patients who are more likely to benefit from TKA.²⁷ We acknowledge our lack of

preoperative information as a limitation in this analysis but have been able to adjust for analgesic use (previously shown in another Australian population-based study to correlate strongly with pain and distress scores²⁸) and comorbidities in our propensity scoring analysis. There were no knee-specific outcome measures in this study, so the extent to which poorer self-reported physical functioning was due to osteoarthritis at other sites, or other causes, is unclear. There is considerable debate about how to best assess physical functioning and physical performance, and a recognition that different measures map to different domains of functioning.^{26–29} Direct measures of pain and related coping strategies and disability were not available or measures of sites affected by arthritis or disease severity; instead, we compared the use of prescribed analgesics and anti-inflammatory medications in the TKA group and propensity-matched controls. This provided strong indirect evidence of higher pain management needs in the TKA group, although the reason for this difference cannot be attributed to surgery. Another limitation is the lack of data on social support. Despite model testing indicating a reasonable ability to predict PF, like all observational studies, there is the likelihood of residual potential confounding.

In conclusion, we have identified a broad range of factors associated with self-reported physical functioning after surgery, some of which are modifiable; the findings of differential functional status in women are striking. We will be examining whether these same factors are identified in a prospective analysis of incident TKA within the 45 and Up Study cohort, to see how early identification of at-risk groups could occur. This could potentially be the foundation for testing cointerventions that reduce distress, improve pain management and reduce obesity.

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Contributors FMB, KDR, LMM and LJ conceived the idea of the study and were responsible for the design of the study. KDR was responsible for the

data analysis and produced the tables and figures. FMB and LMM provided input into the data analysis. The initial draft of the manuscript was initially prepared by FMB and KDR and circulated repeatedly among all authors for critical revision. KDR was responsible for the acquisition of the data and FMB, KDR, LMM and LJ all contributed to the interpretation of results. All authors read and approved the final manuscript.

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