Improvements in physical function and pain sustained for up to 10 years after knee or hip arthroplasty irrespective of mental health status before surgery

9,737 middle-aged and 9,292 older women from the Australian Longitudinal Study on Women's Health and National Joint Replacement Registry

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Background and purpose — **There are concerns that mental health (MH) may influence outcomes of total knee arthroplasty (TKA) or total hip arthroplasty (THA). We examined effects of poor MH before surgery on long-term outcomes of osteoarthritis-related TKA or THA in women.**

Patients and methods — **The data were from 9,737 middle-aged participants (47–52 years) and 9,292 older participants (73–78 years) in the Australian Longitudinal Study on Women's Health who completed surveys between 1998 and 2013. Dates of arthroplasties were obtained from the Australian Orthopaedics Association National Joint Replacement Registry. Participants without procedures were matched with participants with procedures. Trajectories of the Short-Form 36 scores for physical functioning, bodily pain, social functioning, and mental health based on mixed modeling were plotted for participants with and without surgery (stratified according to mental health, separately for TKA and THA, and for middle-aged and older participants).**

Results — **In middle-aged women with poor and good MH, TKA improved physical function and reduced bodily pain, with improvements sustained up to 10 years after surgery. TKA contributed to restoration of social function in women with good MH, but this was less clear in women with poor MH. In both MH groups, mental health appeared to be unaffected by TKA. Similar patterns were observed after THA, and in older women.**

Interpretation — **Recovery of physical and social function and reductions in pain were sustained for up to 10 years after surgery. Improvements in physical function and pain were also observed in women with poor mental health. Thus, in our view poor mental health should not be a contraindication for arthroplasty.**

Joint arthroplasty is offered to improve function and relief of pain for patients with degenerative joint disease. Previous studies have shown that improved function and pain relief after arthroplasty lead to better physical and psychological well-being after surgery (Jones et al. 2000, Montin et al. 2008, Papakostidou et al. 2012). A systematic review involving 31 studies showed that preoperatively to 6–8 months after hip arthroplasty (THA), there were improvements of 50–80% for physical function and 70–80% for functional capacity (Vissers et al. 2011). Only 5 of these studies had follow-up durations of 2 years or more (Brown et al. 1980, McBeath et al. 1980, Laupacis et al. 1993, Huber et al. 2006, Busija et al. 2008); the longest duration of follow-up was 5 years (Busija et al. 2008). Moreover, few studies have examined changes in well-being from before until after surgery over longer periods of time, and few have compared the course of well-being from before until after surgery with those in people who have not had arthroplasty.

There are concerns that pre-surgical mental health may influence post-surgical outcomes. A systematic review of 35 studies that examined psychological factors affecting outcomes of knee arthroplasty (TKA) and THA found that poor mental health before surgery did have an influence on long-term (i.e. > 1-year) post-surgical functioning after TKA, but not after THA (Vissers et al. 2012). Studies published after that review found that patients with psychological distress, depression, anxiety, or poor mental health before surgery had poorer functioning and quality of life 1 year after surgery, and that they were less satisfied with the outcome of the surgery up to 1 year after surgery (Clement et al. 2013, Duivenvoorden et al. 2013, Hanusch et al. 2014, Utrillas-Compaired et al. 2014) or 2–5 years after surgery (Singh and Lewallen 2014).

The aims of this study were (1) to examine the long-term consequences of primary osteoarthritis-related TKA and THA for physical and social functioning, pain, and mental health in middle-aged and older women, and (2) to examine the effect of poor mental health before surgery on post-surgical recovery. The course of these outcomes was examined from before to after surgery in 4 groups according to arthroplasty (yes/no) and mental health status (poor/good), and analyzed for TKA and THA separately.

Patients and methods

Participants

The Australian Longitudinal Study on Women's Health (ALSWH) is an ongoing study of factors affecting the health and well-being of 3 population-based cohorts of women born in the periods 1973–1978, 1946–1951, and 1921–1926. Recruitment, data collection procedures, and attrition have been described in detail elsewhere (Lee et al. 2005). In 1996, women were selected randomly from the national Medicare health insurance database, which includes all Australian citizens and permanent residents. Apart from over-representation of Australian-born and university-educated women, the sample was otherwise representative of the general population of Australian women (Lee et al. 2005). For this study, the data were from the 1946–1951 cohort (middle-aged women, n = 13,715) and 1921–1926 cohort (older women, n = 12,432). Data from the 1973–1978 cohort were not included, as too few TKA and THA procedures occurred in this sample during follow-up. In the middle-aged cohort, data were included in the analyses from 12,338 women who returned the 1998 survey (response rate is 90% of the 1996 sample). Subsequent surveys were completed in 2001, 2004, 2007, 2010, and 2013. In the older cohort, data were included from 10,434 women who returned the 1999 survey (response rate is 84% of the 1996 sample). Subsequent surveys were completed in 2002, 2005, 2008, and 2011.

Measurements

Outcome scores for physical function, bodily pain, social function, and mental health were calculated from subscales of the Medical Outcomes Survey 36-item Short-Form measure (SF-36) (McCallum 1995). Subscale scores were calculated in accordance with the SF-36 manual for these domains (range 0–100, with 100 indicating optimal well-being). These 4 subscales were selected because they were the SF-36 outcomes expected to be most affected by TKA and THA, while at the same time measuring distinct domains of well-being.

Arthroplasty data were provided by the Australian Orthopaedic Association National Joint Replacement Registry (AOAN-JRR). Staged implementation of the AOANJRR data collection began in September 1999, and became national during 2002. Full national data were available from 2003 (Graves et

al. 2004). Using probabilistic linkage based on name, address, address history, and date of birth, participants in the ALSWH study with records in the AOANJRR were identified. The linkage was limited to primary knee and hip procedures for patients with a diagnosis of osteoarthritis. Only the first procedure for each joint was included in the analyses.

In this study, the term mental health (MH) refers to the combined states of anxiety and depression as measured by the 10-item Center for Epidemiology Studies Depression (CESD-10) scale in middle-aged participants (range 0–30). Participants who scored 10 points or more were classified as having poor MH (Radloff 1977). This cutoff point has been found to have high accuracy in detection of major depression (sensitivity = 0.97, specificity = 0.84) (Irwin et al. 1999). The CES-D10 was not used in the older participants; therefore, an SF-36 mental health subscale score of ≤ 52 was used as a marker of poor MH in this cohort (Strand et al. 2003, Friedman et al. 2005).

Sample characteristics

The following variables were included as potential confounders: age at time of surgery, level of education, body mass index (BMI), number of chronic conditions, physical activity, and smoking status. BMI was calculated based on self-reported weight and height. Participants were asked to indicate which of the following chronic conditions they had been diagnosed with or treated for in the previous 3 years: diabetes, heart disease, hypertension, stroke, lung disease, osteoporosis, and cancer. Physical activity was assessed using the modified Active Australia questionnaire (Brown et al. 2008). The number of minutes in the previous week spent walking and in moderate and vigorous leisure-time activities were multiplied by a metabolic equivalent (MET) score (i.e. walking = 3, moderate = 4.5, vigorous = 7) (Ainsworth et al. 2011) then summed as MET.min/week and categorized as: inactive (0–40), low (40–599), moderate (600–1,200), or high (> 1,200).

Statistics

To examine the course of the outcomes over time, a time variable was created to indicate the year of survey relative to the year of surgery. Time of survey was anchored on time of surgery by subtracting the date of surgery from the date of survey return. This could be done for participants with a TKA or THA. To compare those with a TKA or THA with those without a TKA or THA, participants were group-matched based on pattern of survey return (i.e. matched participants had to have returned and not returned exactly the same surveys), number of chronic conditions, and age (< 50 or ≥ 50 years in 1998 for middle-aged women and < 75 or ≥ 75 in 1999 for older women). Participants without TKA or THA were then assigned the same timing of surveys as their matched participants with TKA or THA. As there were few participants with data for the extreme years, i.e. < −13 and > +10 years in middle-aged women and < −10 and > +8 years in older
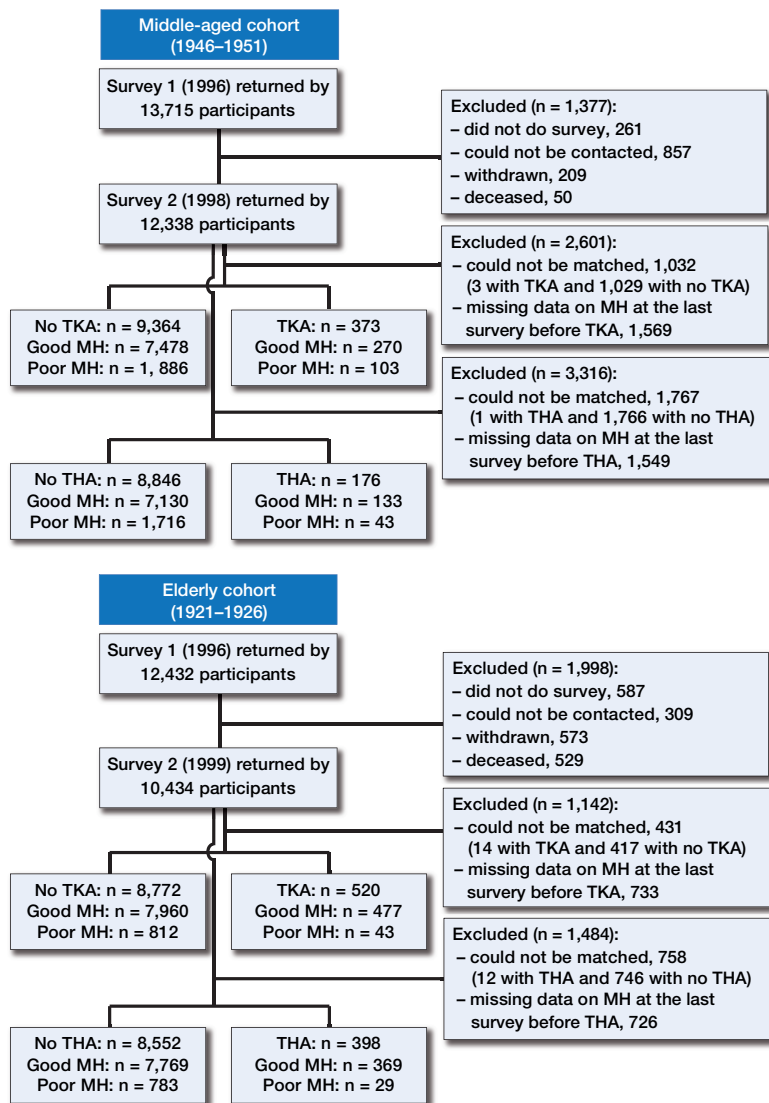
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Middle-aged cohort
(1946–1951)

Survey 1 (1996) returned by        Excluded (n = 1,377):
13,715 participants                – did not do survey, 261
                                   – could not be contacted, 857
                                   – withdrawn, 209
                                   – deceased, 50

Survey 2 (1998) returned by        Excluded (n = 2,601):
12,338 participants                – could not be matched, 1,032
                                     (3 with TKA and 1,029 with no TKA)
                                   – missing data on MH at the last
No TKA: n = 9,364   TKA: n = 373     survey before TKA, 1,569
Good MH: n = 7,478  Good MH: n = 270
Poor MH: n = 1,886  Poor MH: n = 103  Excluded (n = 3,316):
                                   – could not be matched, 1,767
                                     (1 with THA and 1,766 with no THA)
                                   – missing data on MH at the last
No THA: n = 8,846   THA: n = 176     survey before THA, 1,549
Good MH: n = 7,130  Good MH: n = 133
Poor MH: n = 1,716  Poor MH: n = 43

Elderly cohort
(1921–1926)

Survey 1 (1996) returned by        Excluded (n = 1,998):
12,432 participants                – did not do survey, 587
                                   – could not be contacted, 309
                                   – withdrawn, 573
                                   – deceased, 529

Survey 2 (1999) returned by        Excluded (n = 1,142):
10,434 participants                – could not be matched, 431
                                     (14 with TKA and 417 with no TKA)
                                   – missing data on MH at the last
No TKA: n = 8,772   TKA: n = 520      survey before TKA, 733
Good MH: n = 7,960  Good MH: n = 477
Poor MH: n = 812    Poor MH: n = 43  Excluded (n = 1,484):
                                   – could not be matched, 758
                                     (12 with THA and 746 with no THA)
                                   – missing data on MH at the last
No THA: n = 8,552   THA: n = 398      survey before THA, 726
Good MH: n = 7,769  Good MH: n = 369
Poor MH: n = 783    Poor MH: n = 29
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Figure 1. Flow charts for the middle-aged and elderly cohorts. MH: mental health.

relative-to-time-of-surgery was included to estimate the mean scores at each time point. Adjustment was made for age at the time of surgery, level of education, BMI, and physical activity, as adding these variables changed the estimates by > 10%. Analyses were done separately for the middle-aged and older women. The estimated mean scores within each group and at each time point were plotted on graphs. Interpretation of the results was mainly based on visual inspection of these graphs. To determine whether the course of the outcomes differed between those with good MH and those with poor MH, the p-value for interaction was estimated by repeating the models with year-relative-to-time-of-surgery included as a continuous variable and with separate models for strata of TKA or THA. In addition, the predicted mean values at year of surgery and 2 years later were estimated and used to calculate the percentage recovery in the TKA and THA groups relative to their respective no-TKA and no-THA matches.

Ethics

Ethical clearance for the ALSWH study was obtained from the Universities of Newcastle (H0760795) and Queensland (2004000224). Additional ethical clearance was obtained for linkage with the AOANJRR data from the Universities of Newcastle (H-2012-0281), Queensland (2012001153) and Adelaide (H-2012-125). All participants signed informed consent.

Results

Of the 12,338 eligible middle-aged participants, 11,306 (92%) and 10,571 (86%) could be included in the matched analyses for TKA and THA, respectively (Figure 1). After excluding participants with missing data on MH, data were available for 373 participants with TKA (including 103 (28%) with poor MH), and for 9,364 participants with no TKA (including 1886 (20%) with poor MH). For THA, data were available for 176 participants with THA and for 8,846 participants with no THA, of whom 43 (24%) and 1,716 (19%), respectively, had poor MH. The average age was 50 (SD 1.5) in 1998, 60 (SD 2.7) at the time of TKA, and 59 (SD 2.7) at the time of THA. Participants whose data were included in the analyses were slightly older (p < 0.001), had a higher level of education, had lower BMI, were more likely to be physically active, were less likely to have poor MH, were less likely to have TKA or THA, and scored better on well-being than participants whose data were excluded from the analyses (p < 0.01) (Table 2, see Supplementary data). Women with poor MH were more likely to have no formal education

women, time was truncated at −13 and +10 years for middle-aged women and at −10 and +8 years for older women.

Based on TKA and MH status, 4 groups were created: no TKA/good MH, TKA/good MH, no TKA/poor MH, and TKA/poor MH. Similar groups were created for THA. The group allocation was based on MH status at the last survey before surgery for those with TKA and their matched participants without TKA. Table 1 (see Supplementary data) illustrates the definition of the group and time variables. Sample characteristics were summarized and compared between the groups.

To estimate mean scores for each of the outcomes over time, linear mixed modeling was used with random intercept. The group and time variables were included as categorical variables and the outcomes were included as continuous variables. In the main analyses, an interaction term of group×year-
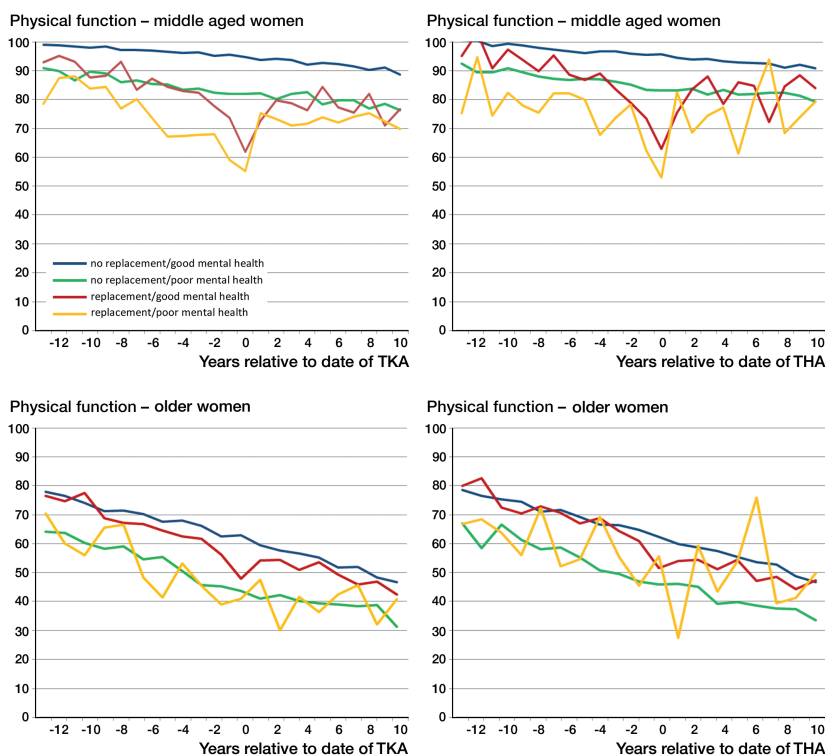
Figure 2. Associations between total knee arthroplasty (TKA) or total hip arthroplasty (THA), depression, and physical function over time in middle-aged and elderly women. The predicted mean values were derived from the regression models after adjustment for level of education, BMI, physical activity, and age at surgery.

than those with good MH (Tables 3 and 4, see Supplementary data). Women with TKA were more likely to have surgical menopause and had higher BMI than those with no TKA (Table 3, see Supplementary data). Women with THA were more likely to use hormone replacement therapy or oral contraceptives and to have a higher BMI than those with no THA (Table 4, see Supplementary data).

Of the 10,434 eligible older participants, 10,003 (96%) and 9,676 (93%) could be included in the matched analyses for TKA and THA, respectively (Figure 1). After excluding data on participants with missing data on MH, data were available for 520 participants with TKA (including 43 (8%) with poor MH), and for 8,772 participants with no TKA (including 812 (9%) with poor MH). For THA, data were available for 398 participants with THA (including 29 (7%) with poor MH) and 8,552 participants with no THA (including 783 (9%) with poor MH). The average age was 75 (SD 1.5) in 1998, 82 (SD 3.1) at the time of TKA, and 82 (SD 3.3) at the time of THA. Participants whose data were included in the analyses had a higher level of education, were more likely to be physically active, were less likely to have poor MH, and were less likely to have TKA or THA than participants whose data were excluded from the analyses (p < 0.01) (Table 2, see Supplementary data). Women with poor MH were more likely to have no formal education and to be inactive than those with

good MH (Tables 5 and 6, see Supplementary data). Women with TKA generally had higher BMI than those without TKA (Table 5, see Supplementary data). Women with THA were less likely to be smokers than women with no THA (Table 6, see Supplementary data).

In middle-aged participants with good MH, a clear decline in physical function was observed in those with TKA during the last few years leading up to surgery (year = 0) (Figure 2). After surgery, physical function returned to the levels at 3 years before surgery, but remained lower than in women who did not have a TKA. Similar patterns were observed for participants with good MH, although with generally lower levels of physical function. Also, the osteoarthritis-related onset of decline in physical function commenced earlier for those with poor MH than for those with good MH. Similar patterns were observed for THA, but with more fluctuation in physical function in the THA/poor MH group due to the small group size. In general, similar patterns were also observed in the older participants, though with a steeper decline in physical functioning over time across all groups and a smaller decline in physical function before TKA or THA (Figure 2). The p-values for interaction between MH and time were 0.07 in the middle-aged women with TKA, 0.4 in the middle-aged women with THA, 0.8 in the older women with TKA, and 0.4 in older women with THA, suggesting that the trajectories for physical functioning were similar for those with good and poor MH.

In both the middle-aged and the older TKA groups, a decline in bodily pain scores (i.e. reflecting an increase in pain) was observed prior to surgery, while scores were stable in the no-TKA groups (Figure 3). A similar decline in bodily pain scores occurred in those with TKA and poor MH compared with those with poor MH only, particularly in middle-aged participants. Similar patterns were observed for THA in both age groups. The p-values for interaction between MH and time ranged from 0.2 to 0.6 within the TKA and THA groups in middle-aged and older women, suggesting that the trajectories for bodily pain were similar for those with good and poor MH.

In both the middle-aged and the older participants, a decline in social function was observed prior to surgery in the TKA and THA groups that did not have poor MH, with levels returning to pre-surgery levels and in the same range as for those with no TKA or THA (Figure 4). Poor MH was more strongly associated with social functioning than TKA and THA were. In women with poor MH, social function scores were in the same range for those with TKA or THA and for those without. In the middle-aged women, the p-values for
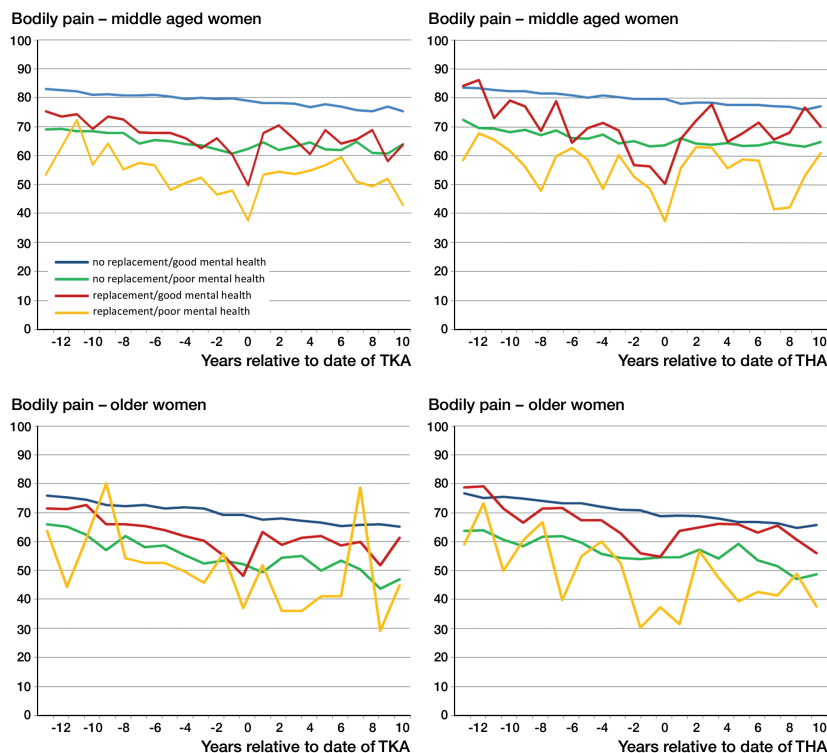
Figure 3. Associations between total knee arthroplasty (TKA) or total hip arthroplasty (THA), depression, and bodily pain over time in middle-aged and elderly women. The predicted mean values were derived from the regression models after adjustment for level of education, BMI, physical activity, and age at surgery.

interaction between MH and time were 0.3 and 1.0 in those with TKA and THA, respectively, suggesting that the trajectories for social functioning were similar for those with good MH and for those with poor MH. In older women, the p-values for interaction between MH and time were 0.007 and 0.02 in those with TKA and THA, respectively, suggesting that the trajectories for social functioning differed between those with good MH and those with poor MH.

In the middle-aged and older participants with good MH, mental health scores were stable for those with TKA or THA and for those without (Figure 5). A decline in MH was observed prior to surgery, but only in the 2 groups with poor MH. For the older cohort, this was affected by the definition of MH. TKA or THA did not affect the long-term course of mental health before or after surgery. In the middle-aged women, the p-values for interaction between MH and time were 0.1 and 0.4 in women with TKA and THA, respectively, suggesting that the trajectories for mental health were similar for those with good MH and those with poor MH. In older women, the p-values for interaction between MH and time were 0.02 and 0.3 in women with TKA and THA, respectively, suggesting that the trajectories for MH differed between those with good MH and those with poor MH in the TKA group only.

2 years after TKA or THA, physical function and bodily pain recovered to levels equivalent to those before the onset

of accelerated decline, and to over 80% of the level of physical function in those with no TKA or THA (Table 7, see Supplementary data). This rate of recovery was in the same range for women with good MH and for women with poor MH.

Discussion

This large cohort study with up to 10 years of follow-up after surgery confirmed that osteoarthritis-related TKA and THA improve physical function and reduce pain (Vissers et al. 2011). In addition, the results suggest that women with poor mental health also benefit from surgery. TKA and THA were also found to be associated with restoration of social function in women with good MH, but this was less clear in women with poor MH. Long-term trajectories of mental health were unaffected by TKA or THA.

For the participants with good MH, our results suggest a gradual decline in physical function over time, which accelerates during the last 3 years before TKA or THA. This is consistent with findings from the MOST and OAI studies (Øiestad et al. 2016). Recovery rates for physical function were over 80% in those with TKA or THA, which is in the same range as previously reported recovery rates (i.e. 50–80% for physical function and 70–80% for functional capacity (Vissers et al. 2011)). Based on visual interpretation of the graphs, at the group level, the rate of decline after recovery appeared similar to that in those without TKA or THA (Figure 1). These patterns were observed in both middle-aged and older women, though less markedly in the older women, which may be due to comorbidities and age-related decline. Similar patterns were observed for bodily pain.

In terms of physical function and pain, our results suggest that middle-aged women with either good or poor MH benefit from TKA and THA in much the same way (Figures 2 and 3; Table 7, see Supplementary data). Although many studies have investigated whether poor pre-surgery MH predisposes to poorer post-surgery outcomes (Vissers et al. 2012), few studies have examined the influence of mental health before surgery on pre- to post-surgery change in function and pain. Like the present study, other, smaller, studies have shown that patients with poor MH do experience improvements in physical function and pain (even if the improvements are not as great as in people without any mood disorders) (Duivenvoorden et al. 2013, Perez-Prieto et al. 2014, Utrillas-Compaired et al. 2014). Our results also suggest that these gains are sustained up to 10 years after TKA. However, there were substantial fluctuations in the trajectories for the women with poor
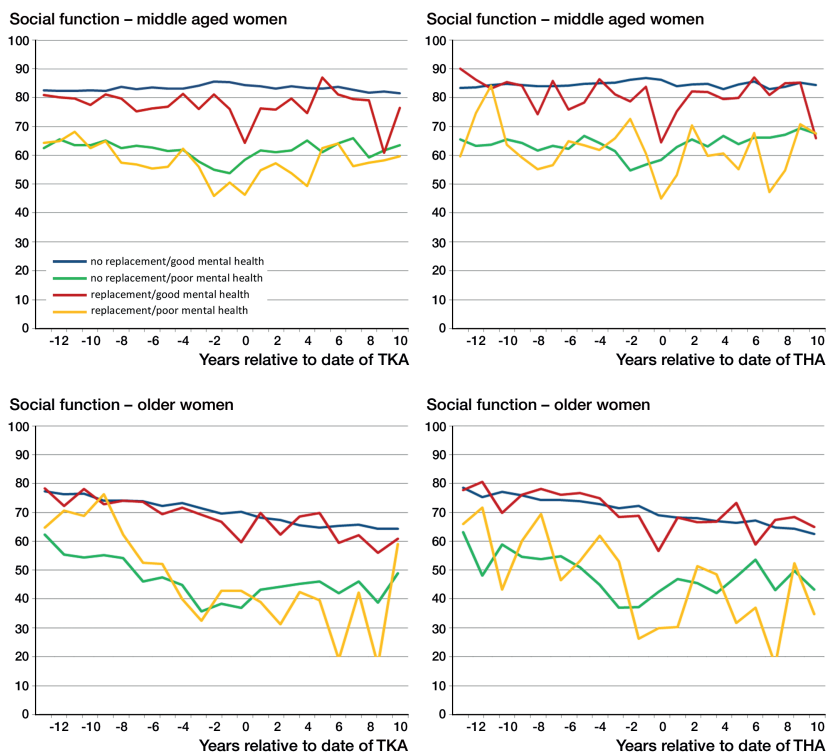
Figure 4. Associations between total knee arthroplasty (TKA) or total hip arthroplasty (THA), depression, and social function over time in middle-aged and elderly women. The predicted mean values were derived from the regression models after adjustment for level of education, BMI, physical activity, and age at surgery.

MH and hip or knee replacement, suggesting that there may be considerable individual variation in the post-surgery course of recovery. Participants with poor MH reported having poorer physical function and more pain at all time points than did those with good MH. In addition, the pre-surgery decline in physical function started years earlier in middle-aged women with poor MH than in middle-aged women with good MH. This suggests that women with poor MH have their symptoms for a longer period of time and/or wait longer to have surgery.

In our samples of middle-aged and older women with good MH, social functioning was affected by severe osteoarthritis, but it recovered after TKA or THA. A narrative review in 2004 concluded that there was inconclusive evidence for an effect of arthroplasty on social functioning (Ethgen et al. 2004). More recent studies that have measured social function with either the SF-36 (Santic et al. 2012, Alentorn-Geli et al. 2013) or measures of participation (Davis et al. 2012, Maxwell et al. 2013) have found statistically significant improvements after surgery. A study that used the SF-36 found no effect on social function; however, the dropout level from that study was substantial (63% at 2 years after surgery) (Xie et al. 2010). Overall, the evidence indicates a positive effect of TKA and THA on social function. Our results also show that depression affects social functioning more than severe osteoarthritis does. However, due to the small group size and strong fluctuations

in the group of women with poor MH and with TKA or THA, recovery in social functioning following surgery is less clear. The only other study that examined this relationship found that participants with distress—and also participants with no distress—showed improvements in social functioning after TKA and THA (Lavernia et al. 2012). Further research is needed to determine whether social functioning improves after surgery in patients with poor MH.

In middle-aged and older participants with good mental health, the MH scores were not influenced by severe osteoarthritis or TKA or THA. This is consistent with the literature (Santic et al. 2012, Alentorn-Geli et al. 2013, Pivec et al. 2015). A study by Papakostidou et al. (2012) suggested that CES-D10 scores improved from preoperatively to 12 months after TKA in women, but not in men (Papakostidou et al. 2012). However, in that study the mean CES-D10 score in women at baseline was high (10 (SD 6)), suggesting that many of the women had scores indicative of depression. Our findings show that in the participants with poor MH, both those with arthroplasty (TKA or THA) and those without recovered to the same extent. Hence, the improvement observed in CES-D10 scores in the study by Papakostidou may reflect natural fluctuations or regression to the mean rather than an effect of TKA or THA.

The strengths of the present study include the use of data from 2 large population-based samples of middle-aged and older women who completed 6 and 5 surveys, respectively, over 15-year and 12-year periods. The large and representative sample allowed comparison of participants with and without TKA or THA—those with good MH and those with poor MH. The linkage with AOANJRR data ensured high validity of the exposure; there is 100% compliance from hospitals that perform replacement surgery (Graves et al. 2004, Australian Orthopaedic Association National Joint Replacement Registry 2013). However, as probabilistic linkage was used, there may have been some mismatches, although the sensitivity and specificity of probabilistic linkage are generally high (74–98% and 99–100%, respectively) (Silveira and Artmann 2009). The long-term follow-up of outcomes measured independently from the TKA and THA procedures meant that the course of outcomes could be modeled over long periods of time, leading up to the replacement and following the replacement. The matching enabled comparison of trajectories between participants with and without arthroplasty, but not all participants could be matched. There were statistically significant differences in characteristics between participants whose data were included and those whose data were excluded from the analy-

Mental health – middle aged women

Mental health – middle aged women

Mental health – older women
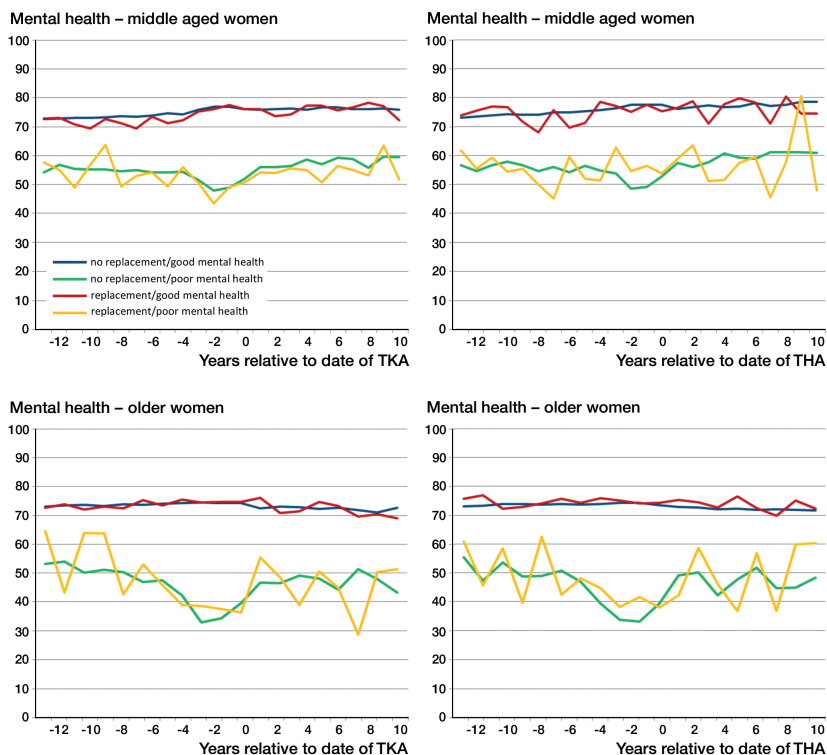
Mental health – older women

Figure 5. Associations between total knee arthroplasty (TKA) or total hip arthroplasty (THA), depression, and mental health over time in middle-aged and elderly women. The predicted mean values were derived from the regression models after adjustment for level of education, BMI, physical activity, and age at surgery.

ses (Table 2, see Supplementary data). However, absolute differences tended to be small. The SF-36 is one of the most used outcome instruments in studies on the effectiveness of TKA and THA (Ethgen et al. 2004, Vissers et al. 2011), and findings for physical function tend to be similar to those reported for the WOMAC and gait analysis (Vissers et al. 2011).

In conclusion, comparison of the long-term course of well-being between women with TKA or TKA and those without suggests that women benefit in terms of improvement in physical and social functioning and reduced pain. After recovery, age-related decline in physical and social function continues at the same rate as for those without TKA or THA. Patients with poorer mental health do benefit from surgery, though not necessarily to the same extent. Thus, it is our view that poor MH should not be a contraindication for TKA or THA.

Supplementary data

Tables 1–7 are available in the online version of this article.

GP was responsible for analysis, and for drafting the manuscript. ML, AD, and GM provided statistical advice. SG provided clinical input. All the authors were responsible for the study design and interpretation of the results, and provided critical feedback on the drafts.

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