Association between Dairy Product Consumption and Incidence of Total Hip Arthroplasty for Osteoarthritis

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ABSTRACT. Objective. The aim of this prospective cohort study was to determine whether dairy product consumption was associated with the incidence of total hip arthroplasty for osteoarthritis (OA).

Methods. There were 38,924 participants from the Melbourne Collaborative Cohort Study who had dairy product consumption recorded in 1990–1994. The incidence of total hip arthroplasty for OA during 2001–2013 was determined by linking cohort records to the Australian Orthopaedic Association National Joint Replacement Registry.

Results. Over an average of 11.8 years of followup, 1505 total hip arthroplasties for OA were identified (524 in men, 981 in women). In men, a 1 SD increase in dairy product consumption was associated with a 21% increased incidence of total hip arthroplasty for OA (HR 1.21, 95% CI 1.10–1.33), with a dose-response relationship observed for quartiles of dairy product consumption (p for trend = 0.001). These results were independent of age, body mass index, country of birth, education, smoking status, vigorous physical activity, calcium supplementation, energy consumption, circulating 25-hydroxy vitamin D, hypertension, and diabetes. No significant association was observed for women (HR 1.02, 95% CI 0.95–1.09).

Conclusion. Increasing dairy product consumption was associated with an increased risk of total hip arthroplasty for men with OA, with no significant association observed for women. Understanding the mechanisms may help identify strategies to prevent hip OA, particularly for men. (J Rheumatol First Release May 15 2017; doi:10.3899/jrheum.161395)

Key Indexing Terms:
DAIRY PRODUCT CONSUMPTION OSTEOARTHRITIS TOTAL HIP ARTHROPLASTY

Hip osteoarthritis (OA) is associated with significant healthcare costs and individual suffering. One in 4 people develops symptomatic hip OA in their lifetime[1]. Over the last 2 decades, the number of years lived with disability for hip OA has increased. Targeting modifiable risk factors for hip OA is important for reducing the disease burden. There is increasing evidence suggesting that a subtle change in hip bone geometry is involved in the pathogenesis of hip OA[2]. Because bone is a dynamic tissue undergoing constant remodeling and bone shape is modifiable, targeting factors affecting hip bone shape would be important for the prevention of hip OA.

Dairy products are the major source of dietary calcium, which is important for maintaining bone health. There may be other components of dairy products that affect bone health. Higher intakes of dairy products improve bone health with a positive association observed between dairy food consumption and bone mineral density (BMD)[3]. There is

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evidence for an increased risk of hip OA associated with higher BMD[4]. Higher milk consumption may alter hip bone geometry by reducing bone turnover[3] and bone resorption[5]. However, no study has investigated the relationship between dairy product consumption and the risk of hip OA. Arthroplasty for OA is one of the methods to define OA that identifies severe hip OA relevant to symptomatic disease burden and economic effect[6]. Because there are sex differences in hip bone shape and BMD[7], and incidence and severity of OA[8], we examined whether dairy product consumption was associated with the incidence of total hip arthroplasty for OA for men and women separately.

MATERIALS AND METHODS

Study population. The Melbourne Collaborative Cohort Study (MCCS) is a prospective cohort study of 41,514 participants aged 27–75 years, recruited through the electoral roll, advertisements, and community announcements in local media in 1990–1994[9]. The study protocol was approved by the Cancer Council Victoria Human Research Ethics Committee. Participants gave written consent to participate and for the investigators to obtain access to their medical records. Of these participants, 2590 (6.2%) were excluded because they (1) died or left Australia prior to January 1, 2001, (2) reported at second followup (2003–2007) having had any joint replacement prior to January 1, 2001, (3) left Australia before the recorded date of having a joint replacement, or (4) had a revision joint replacement as their first recorded procedure[10].

Dietary data. At baseline (1990–1994), a 121-item food frequency questionnaire (FFQ) developed from a study of weighed food records[11] was used to collect dietary data over the previous 12 months. Nutrient intakes were calculated from the FFQ using Australian food composition data[12]. The FFQ included 12 items related to consumptions of dairy products, including cottage cheese, ricotta cheese, feta cheese, low fat cheese, low cholesterol cheese, hard grating cheese, cream cheese, cheddar or similar cheese, ice cream, custard, cream or sour cream, yogurt, and milk drink. Energy from alcoholic beverages was added to that calculated from the FFQ. Calcium supplementation data were collected by asking whether participants took a calcium supplement at least once per week in last the 12 months.

Definition of hip OA. The Australian Orthopaedic Association National Joint Replacement Registry (AOA NJRR) collects information on prostheses, patient demographics, and type and reason for arthroplasty, with almost complete arthroplasty data[13]. Matching of MCCS participants using first name, surname, date of birth, and sex to the AOA NJRR to identify those who had an arthroplasty performed between January 1, 2001, and December 31, 2013 was performed using the Freely Extensible Biomedical Record Linkage system. The linkage study was approved by the Human Research Ethics Committee of Cancer Council Victoria (HREC 0601) and Monash University (2006000608). Hip OA was defined as the first recorded primary total joint arthroplasty being a total hip arthroplasty for OA.

Demographic, lifestyle, and anthropometric factors and circulating 25-hydroxy vitamin D [25(OH)D]. At baseline, a structured interview was used to obtain demographic and lifestyle information including date of birth, country of birth, smoking, physical activity during leisure time, and education. Weight was measured to the nearest 0.1 kg using digital electronic scales, and height was measured to the nearest 1 mm using a stadiometer. Body mass index (BMI) was calculated. Circulating 25(OH)D was measured for 2831 participants using dried blood spots collected in 1990–1994[14].

Statistical analysis. Cox proportional hazard regression models were used to estimate the HR and 95% CI for the incidence of total hip arthroplasty because of OA associated with dairy product consumption, with age as the time scale accounting for the actual age of the participant. Followup for total hip arthroplasty (calculation of person-time) began January 1, 2001, and ended at the date of first total hip arthroplasty for OA or date of censoring. Participants were censored at either the date of first hip arthroplasty for indications other than OA, the date of death, or end of followup (December 31, 2013), whichever came first. Dairy product consumption was standardized so that HR represents the effect of a 1 SD difference in dairy product consumption. Dairy product consumption was also categorized into quartiles based on the analysis sample with lowest consumption as the referent category. To test whether associations of dairy product consumption with hip arthroplasty risk were modified by sex, interactions were fitted and tested using the likelihood ratio test. Because an interaction was identified, sex-specific analyses were performed. Linear association was examined using the likelihood ratio test. Each analysis was adjusted for BMI, country of birth, education, smoking status, vigorous physical activity, and energy intake in model 1, with additional adjustment for calcium supplementation and comorbidities [hypertension (HTN) and diabetes] in model 2. Adjustment for 25(OH)D was performed for participants with 25(OH)D data available. All analyses were repeated stratifying by education level and country of birth, and excluding those with diabetes. The association between dietary calcium intake and risk of total hip arthroplasty for OA was also examined. All statistical analyses were performed using Stata 13.0 SE (StataCorp LP.).

RESULTS

Over 11.8 years (SD 2.9) of followup, 1505 total hip arthroplasties for OA were identified (524 men and 981 women). The characteristics of the participants are presented in Table 1. Both men and women who received a total hip arthroplasty were older, had greater BMI, more likely to be Australia/United Kingdom–born, non-smoker, and less physically active. Men who underwent hip arthroplasty had higher consumptions of dairy products and calcium. There was an interaction between dairy product consumption and risk of total hip arthroplasty ($p = 0.07$ for interaction); thus we examined men and women separately.

For men, a 1 SD increase in dairy product consumption was associated with a 21% increased risk of total hip arthroplasty for OA (HR 1.21, 95% CI 1.10–1.33; Table 2). There was a dose-response relationship between increasing quartiles of dairy product consumption and the risk of hip arthroplasty for OA (p for trend = 0.001), adjusted for age, BMI, country of birth, education, smoking status, vigorous physical activity, calcium supplementation, energy intake, HTN, and diabetes. The associations persisted when analyses were stratified by education level or country of birth, and when those with diabetes were excluded (Supplementary Table 1, available from the authors on request). Additional adjustment for 25(OH)D did not change the results (HR 1.28, 95% CI 0.97–1.69, $p = 0.08$ for a 1-SD increase in dairy product consumption). There was a trend for a positive association between dietary calcium intake and the risk of hip arthroplasty for OA (HR 1.12, 95% CI 0.97–1.31, $p = 0.12$). There was no significant association between dairy product consumption and risk of hip arthroplasty for OA in women.

DISCUSSION

In our prospective cohort study, higher dairy produce consumption was associated with an increased risk of total hip arthroplasty for OA for men but not women, independent

Table 1. Baseline characteristics of participants. Values are mean (SD) unless otherwise specified.

Characteristics	Total Hip Arthroplasty for OA	No Total Hip Arthroplasty for OA	p*
Men			
Number	524	15,130	
Age at MCCS baseline, yrs	57.8 (7.8)	55.2 (8.8)	< 0.0001
BMI, kg/m^2	27.7 (3.7)	27.1 (3.6)	0.0002
Country of birth, n (%)			< 0.001
Australia/UK	448 (85.5)	11,096 (73.3)	
Italy/Greece	76 (14.5)	4034 (26.7)	
Education, n (%)			0.42
Primary and some secondary	247 (47.2)	7391 (49.0)	
Completed secondary and degree/diploma	276 (52.8)	7690 (51.0)	
Smoking, n (%)			< 0.001
Non-smoker	233 (44.5)	6330 (41.9)	
Ex-smoker	253 (48.3)	6615 (43.7)	
Current smoker	38 (7.2)	2179 (14.4)	
Vigorous physical activity, n (%)			< 0.001
None	361 (68.9)	11,551 (76.4)	
1–2×/week	73 (13.9)	1544 (10.2)	
≥ 3×/week	90 (17.2)	2030 (13.4)	
Diabetes, n (%)	18 (3.4)	638 (4.2)	0.38
Hypertension, n (%)	112 (21.4)	3018 (20.0)	0.42
Energy from diet, kJ/day	10,568.5 (3996.4)	10,362.0 (3842.8)	0.23
Calcium supplement, n (%)	19 (3.6)	405 (2.7)	0.19
Dairy product intake, times/week	36.9 (22.0)	32.4 (20.2)	< 0.0001
Dietary calcium, mg/day	914.1 (437.3)	871.5 (407.7)	0.02
Women			
Number	981	22,289	
Age at MCCS baseline, yrs	57.5 (7.6)	54.6 (8.6)	< 0.0001
BMI, kg/m^2	27.0 (4.8)	26.7 (4.9)	0.03
Country of birth, n (%)			< 0.001
Australia/UK	865 (88.2)	17,158 (77.0)	
Italy/Greece	116 (11.8)	5131 (23.0)	
Education, n (%)			0.03
Primary and some secondary	579 (59.2)	13,850 (62.7)	
Completed secondary and degree/diploma	399 (40.8)	8244 (37.3)	
Smoking, n (%)			0.09
Non-smoker	658 (67.1)	15,435 (69.3)	
Ex-smoker	242 (24.7)	4855 (21.8)	
Current smoker	80 (8.2)	1996 (8.9)	
Vigorous physical activity, n (%)			0.01
None at all	750 (76.5)	17,910 (80.4)	
1–2×/week	132 (13.5)	2666 (11.9)	
≥ 3×/week	98 (10.0)	1709 (7.7)	
Diabetes, n (%)	11 (1.1)	669 (3.0)	0.001
Hypertension, n (%)	244 (24.9)	4886 (21.9)	0.03
Energy from diet, kJ/day	8596.0 (3029.1)	8541.7 (3419.0)	0.63
Calcium supplement, n (%)	177 (18.1)	3547 (15.9)	0.07
Dairy product intake, times/week	36.7 (20.3)	35.4 (20.5)	0.05
Dietary calcium, mg/day	884.6 (412.3)	857.7 (422.5)	0.05

* For difference between those with and without total hip arthroplasty for OA, independent samples Student t test or chi-square test were used where appropriate.
OA: osteoarthritis; MCCS: Melbourne Collaborative Cohort Study; BMI: body mass index.

of age, BMI, country of birth, education, smoking status, physical activity, energy intake, calcium supplementation, circulating 25(OH)D, and comorbidities.

In our study, men in the highest 2 quartiles of dairy product consumption were more likely to be born in Australia/United Kingdom, more educated, and more physically active, and less likely to be diabetic and hypertensive than those in the lowest 2 quartiles (Supplementary Table 2, available from the authors on request), suggesting they would be of higher socioeconomic status, healthier, and more fit for undergoing hip arthroplasty. The rate of total hip arthroplasty for OA was similar regardless of education status (primary/some secondary vs completed secondary/degree/diploma, 3.3% vs 4.5%, p = 0.19), calcium supplementation

Table 2. Relationship between dairy product consumption and the incidence of total hip replacement for osteoarthritis. Model 1 adjusted for body mass index, country of birth, education, smoking status, vigorous physical activity, and energy intake. Model 2 adjusted for body mass index, country of birth, education, smoking status, vigorous physical activity, energy intake, calcium supplementation, hypertension, and diabetes. Values are HR (95% CI) unless otherwise specified.

Variables	Model 1	Model 2
Men		
Dairy product consumption, per SD	1.21 (1.10–1.33)	1.21 (1.10–1.33)
p	< 0.001	< 0.001
Dairy product, quartiles		
1, ≥ 0 and < 18×/week	1.00	1.00
2, ≥ 18 and < 32.5×/week	1.13 (0.87–1.47)	1.13 (0.87–1.47)
3, ≥ 32.5 and < 48×/week	1.31 (1.01–1.70)	1.31 (1.01–1.70)
4, ≥ 48×/week	1.56 (1.19–2.04)	1.56 (1.19–2.04)
p for trend	0.001	0.001
Women		
Dairy product consumption, per SD	1.02 (0.95–1.09)	1.02 (0.95–1.09)
p	0.65	0.62
Dairy product, quartiles		
1, ≥ 0 and < 18×/week	1.00	1.00
2, ≥ 18 and < 32.5×/week	1.00 (0.82–1.21)	1.00 (0.82–1.22)
3, ≥ 32.5 and < 48×/week	1.08 (0.89–1.30)	1.08 (0.89–1.30)
4, ≥ 48×/week	1.07 (0.87–1.30)	1.07 (0.88–1.30)
p for trend	0.39	0.39

(no supplementation vs supplementation, 3.3% vs 3.6%, p = 0.64), diabetes (non-diabetic vs diabetic, 3.4% vs 2.7%, p = 0.77), or HTN (nonhypertensive vs hypertensive, 3.3% vs 3.6%, p = 0.64), but higher for Australia/United Kingdom–born men (Australia/United Kingdom vs Italy/Greece, 3.9% vs 1.9%, p < 0.001). We found significant association between dairy product consumption and risk of total hip arthroplasty for OA after adjusting for these potential confounders. Similar associations persisted when analyses were stratified by educational level or country of birth or repeated excluding those with diabetes. Taken together, these associations suggest that our results are not simply due to confounding.

Bone sclerosis is a key radiographic feature of hip OA[15]. Hip bone shape abnormalities and greater BMD are risk factors for hip OA[2,4]. There was an increase in BMD of up to 15% in patients with hip OA over those without[16]. In late-stage OA, there is a decrease in bone resorption without reduced formation[17]. Higher dairy product consumption and calcium intake are related to increased BMD[3]. Longitudinal data show that higher milk consumption reduces bone turnover[3] and bone resorption[5], resulting in an anabolic state of bones that would subsequently cause bone sclerosis or altered hip bone geometry. Dairy products may affect the risk of hip OA through their effects on hip bone properties, which are involved in the pathogenesis of hip OA. The FFQ has different degrees of error in the measurement of calcium intake from different sources[18], which might explain our finding of a positive but nonsignificant relationship between dietary calcium intake and the risk of hip OA. Alternatively, the observed association may be attributable to other components of dairy produce.

We found a sex difference in the association between dairy product consumption and the incidence of hip OA. It may be that other factors, such as hormones, have a greater effect on bone metabolism in women of this age group than in men. Women lose 50% of their trabecular bone and 30% of their cortical bone during the course of their lifetime, half of which is lost during the perimenopause and the first 10 years after menopause[19]. Sex steroids are associated with hip bone geometric changes[20]. Sex differences have also been noted in the prevalence, severity, and incidence of hip OA[8]. A positive relationship being observed in men is consistent with our previous finding of a positive association between serum 25(OH)D concentrations and risk of hip arthroplasty for OA for men, but not women[6].

Our study has several limitations. Dietary data collected at baseline may not be representative of diet consumption over the longer term. People with OA are likely to have modified their dietary habits by restricting high-calorie diets including dairy product consumption to lose weight. Thus, dietary change during followup would have attenuated the observed associations. Moreover, there is evidence that per-capita dairy product consumption is relatively stable in industrialized countries over the last 3 decades[21]. Different components of dairy products might have different effects on OA. However, our aim in this study was to examine dairy product consumption in general. Therefore, caution is required in translating our findings into public health messages. Arthroplasty is performed to manage endstage OA.

Therefore, it may be a marker of OA incidence, progression, or being selected for arthroplasty. The time from the onset of symptoms to hip arthroplasty is 8 years on average[22], whereas in our study dairy product consumption was measured 20 years prior to the outcome measure. Further, including participants with early- or middle-stage hip OA in the nonarthroplasty group would have mitigated the strength of observed association. Arthroplasty as a treatment for OA may be influenced by several factors such as access to healthcare, socioeconomic status, and patient preference, in addition to disease severity. In Australia, there is universal health insurance, so arthroplasty is available to all. We did not have accurate arthroplasty data prior to 2001. This may have resulted in nondifferential misclassification of hip arthroplasty, which is likely to bias the results to the null. Prolonged regular sporting activity may increase the risk of hip arthroplasty for OA, but our sample was community-based, and thus it is unlikely that many were engaged in regular sporting activity. The strengths of our study include its prospective design, large sample size, and the validation and completeness of arthroplasty data from the AOA NJRR[13].

Increasing dairy product consumption was associated with an increased risk of total hip arthroplasty for OA for men, with no significant association observed for women. Understanding the mechanisms may help identify strategies to prevent hip OA, particularly for men.

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