EXTENDED REPORT

# The population prevalence of symptomatic radiographic foot osteoarthritis in community-dwelling older adults: cross-sectional findings from the Clinical Assessment Study of the Foot

Edward Roddy,[1] Martin J Thomas,[1] Michelle Marshall,[1] Trishna Rathod,[1] Helen Myers,[1] Hylton B Menz,[1,2] Elaine Thomas,[1] George Peat[1]

## ABSTRACT

**Objectives** To estimate the population prevalence of symptomatic radiographic osteoarthritis (OA) affecting the 1st metatarsophalangeal joint (MTPJ), 1st and 2nd cuneometatarsal joints (CMJs), navicular first cuneiform joint (NCJ) and talonavicular joint (TNJ) in community-dwelling older adults.

**Methods** 9334 adults aged ≥50 years registered with four general practices were mailed a health survey. Responders reporting foot pain within the last 12 months were invited to undergo weight-bearing dorso-plantar and lateral radiographs of both feet. OA at the 1st MTPJ, 1st and 2nd CMJs, NCJ and TNJ was graded using a validated atlas. Population prevalence estimates for symptomatic radiographic foot OA overall and for each joint were calculated using multiple imputation and weighted logistic regression modelling to account for missing data and non-response.

**Results** 5109 health surveys were received (adjusted response 56%). Radiographs were obtained on 557 participants. Overall population prevalence of symptomatic radiographic OA was 16.7% (95% CI 15.3% to 18.0%), 1st MTPJ 7.8% (6.7% to 8.9%), 1st CMJ 3.9% (2.9% to 4.9%), 2nd CMJ 6.8% (5.7% to 7.8%), NCJ 5.2% (4.0% to 6.4%) and TNJ 5.8% (4.8% to 6.9%). With the exception of the 1st CMJ, prevalence was greater in females than males, increased with age and was higher in lower socioeconomic classes. Three-quarters of those with symptomatic radiographic OA reported disabling foot symptoms.

**Conclusions** While cautious interpretation due to non-response is warranted, our study suggests that symptomatic radiographic foot OA affects one in six older adults and the majority report associated disability. Clinicians should consider OA as a possible cause of chronic foot pain in older people.

## INTRODUCTION

Symptomatic osteoarthritis (OA) is common in the general population and affects the lives of 10% of people aged over 60 years.[1] OA accounts for 15% of all musculoskeletal consultations in those aged 45 years and over in primary care.[2] It has a major impact on quality of life,[3] locomotor function,[4] social participation[5] and economic productivity.[6]

The foot is recognised as a target region for OA and was included in early descriptions of generalised OA,[7] yet it is the least-studied joint complex commonly affected by OA.[8] Although foot pain is prevalent among community-dwelling older adults[9–13] and frequently leads to consultation in primary care,[14] how OA contributes to this is unclear. Previous studies focused mainly on the 1st metatarsophalangeal joint (MTPJ), examined radiographic OA irrespective of pain or were undertaken in highly selected populations.[8 15 16] The few studies that have compared the prevalence of radiographic OA at multiple sites within the foot suggest that the 1st MTPJ is more frequently affected than the midfoot joints and lesser MTPJs.[8] Following the recent development of a radiographic atlas for foot OA,[17] two studies undertaken in populations of retirement village residents found that the prevalence of radiographic OA was highest at the 2nd cuneometatarsal joint (CMJ).[15 16] However, these studies do not relate the presence of radiographic OA to foot pain. Furthermore, the relative prevalence of symptomatic radiographic OA at different joints within the foot in the general population is not known. Such information is needed to provide a basis for understanding the aetiology of foot OA, to understand the community burden of symptomatic foot OA and inform healthcare provision and clinical need.

The objective of this study was to estimate the population prevalence of (1) symptomatic radiographic OA and (2) disabling symptomatic radiographic OA affecting the 1st MTPJ, 1st and 2nd CMJs, navicular first cuneiform joint (NCJ) and talonavicular joint (TNJ) in community-dwelling adults aged 50 years and over.

## METHODS

### Study design

This paper uses baseline data from a 3-year population-based prospective observational cohort, the Clinical Assessment Study of the Foot (CASF).[18] Adults aged 50 years and over registered with four general practices were invited to take part in the study, irrespective of consultation for foot pain or problems.

### Data collection

All eligible participants were mailed a health survey questionnaire that gathered information on aspects of general health, including Short Form-12 (SF-12),[19] Hospital Anxiety and Depression Scale

(HADS),[20] anthropometric characteristics (self-reported height and weight), foot pain and demographic and socioeconomic characteristics (age, gender, marital status, higher education, current employment status and occupation). Specific questions asked about foot pain included pain in and around the foot in the past 12 months; pain, aching or stiffness in the foot in the past month[21]; number of days with foot pain in the past 12 months; and the Manchester Foot Pain and Disability Index (MFPDI).[22] Participants were asked to indicate the location of foot pain experienced in the right and left feet in the past month by shading on a foot manikin (© The University of Manchester 2000. All rights reserved).[23] Non-responders to the health survey questionnaire were sent a reminder postcard after 2 weeks. Those who did not respond to the reminder postcard were sent a repeat health survey questionnaire 4 weeks after the initial mailing. Participants who reported pain in and around the foot in the past 12 months and provided written consent to further contact were invited to attend a research assessment clinic where weight-bearing dorso-plantar and lateral radiographs of each foot were obtained according to a defined standardised protocol.[17] Participants were asked to consent to review of their medical records by the research team.

## Scoring of radiographs

Plain radiographs were scored by a single reader (MM) blind to all other participant information. Osteophytes and joint space narrowing at the 1st MTPJ, 1st and 2nd CMJs, NCJ and TNJ were scored (0–3) according to a validated atlas.[17] Radiographic OA at each individual joint was defined as a score of 2 or more for osteophytes or joint space narrowing on either dorso-plantar or lateral views.

To establish intra-rater and inter-rater reliability for the presence of OA in each joint, radiographs from 60 randomly selected participants were rescored 8 weeks later by MM and scored by a second blind assessor (HBM). Intra-rater reliability was excellent (mean unweighted k=0.94, mean % agreement=99%), whereas inter-rater reliability was moderate (mean unweighted k=0.46, mean % agreement=79%).[24]

## Inflammatory arthritis exclusions

Participants were excluded from the current analyses if medical records (primary care and local hospital) or a clinical X-ray report by a consultant musculoskeletal radiologist identified them as having inflammatory arthritis (non-specific inflammatory arthritis, rheumatoid arthritis or psoriatic arthritis).

## Case definitions

Symptomatic radiographic OA at each individual joint was defined as radiographic OA (as defined above) together with pain in the past 4 weeks occurring in the corresponding region of the same foot on the foot manikin, as described by Garrow et al.[23] Individuals were defined as having symptomatic radiographic OA at each joint if either or both feet were affected. Overall symptomatic radiographic OA was defined as symptomatic radiographic OA in at least one of the five joints assessed.

Disabling symptomatic radiographic OA at each individual joint was defined as symptomatic radiographic OA at that joint (as defined above) together with at least 1 of the 10 items within the MFPDI function construct scored at the level of 'on most/every day(s)'.[25] Where all 10 items were scored as occurring 'none of the time' or 'on some days', foot pain was considered non-disabling. Individuals were defined as having disabling symptomatic radiographic OA at each joint if either or both feet were affected. Overall disabling symptomatic radiographic OA

was defined as disabling symptomatic radiographic OA in at least one of the five joints assessed.

## Statistical analysis

### Describing the sample

The sample size calculation for CASF was undertaken to ensure that sufficient numbers of participants were recruited to the research clinic to sufficiently power longitudinal analyses.[18] As such, a specific sample size calculation for this cross-sectional analysis was not performed. To determine the extent of selective non-participation, we compared the characteristics (age, gender and practice distribution) of health survey questionnaire responders with the mailed population. Selective non-response and non-consent were evaluated at each subsequent selection point (health survey questionnaire response, reported pain in and around the foot in the past 12 months, reported pain in and around the foot in the past 12 months and provided consent to further contact, attended research assessment clinic) by comparing marital status, higher education, employment status, occupational class, SF-12, HADS anxiety and depression subscales, body mass index, disabling foot pain,[25] number of days in the past 12 months with foot pain and Rasch MFPDI scores between participants at each point.

### Estimating population prevalence

Using baseline health survey questionnaire and radiographic data, the population prevalence of (1) symptomatic radiographic foot OA and (2) disabling symptomatic radiographic foot OA, in the individual overall and at each joint, were estimated using multiple imputation and weighted logistic regression modelling. Missing data arose from non-completion of individual items within the health survey questionnaire or questionnaire non-response. Missing item-level data were imputed using multiple imputation. Estimates were then weighted to take into account non-response. The assumption that data were missing at random was verified.

The imputation process was applied to all baseline responders to impute baseline variables using appropriate distributions. We have previously shown that the MFPDI fits the Rasch model.[26] Prior to inclusion in the imputation model, the MFPDI variable was Rasch-modelled to generate interval-level scores for both its pain and function constructs. The imputation model included age, gender, general practice, social class, marital status, number of days in the past 12 months with foot pain, Rasch MFPDI pain and function scores, individual MFPDI function items (to determine disabling foot pain[25]), report of pain, aching or stiffness in the foot in the last month, SF-12 score, HADS score and foot OA and pain regions. The number of imputations was set at 15, and imputed data sets were combined using Rubin's combination rules.[27] The mim: proportion command was used to determine the prevalence estimates (and 95% CIs ) for the total baseline responder population. The estimates were weighted to account for any initial selective non-response from the eligible baseline population to the health survey. Information on age, gender and general practice location was available for all individuals and was used to determine a weight to reflect the likelihood that a person, with a particular combination of age, gender and practice location, would return the health survey questionnaire. Weighted logistic regression, within the imputed data sets, was performed to determine prevalence estimates (and 95% CI) in the total baseline eligible mailed population. Population prevalence estimates for symptomatic radiographic foot OA were then stratified by gender, age group and socioeconomic class. All analyses were conducted using STATA V.12.0 (Stata Corporation, Texas, USA).

## RESULTS

### Study population

In 2010/2011, the baseline health survey questionnaire was mailed to 9334 adults aged 50 years and over (figure 1). During the mailing process, 140 exclusions due to deaths, departures from the general practitioner practices, incorrect addresses and ill-health (dementia, severe or terminal illness) were identified, leaving an eligible baseline population of 9194. In total, 5109 completed health survey questionnaires were received (adjusted response 56%). Of these, 1635 individuals who reported pain in and around the foot in the past 12 months and provided consent to further contact were invited to the research assessment clinic and 560 attended. The median time between receiving the completed health survey questionnaire and clinic attendance was 37 days (IQR 27–47). Participants with incomplete radiographs (n=3), incomplete foot pain data (n=8) and inflammatory arthritis (n=24) were excluded, leaving a total of 525 eligible clinic attenders with complete data.
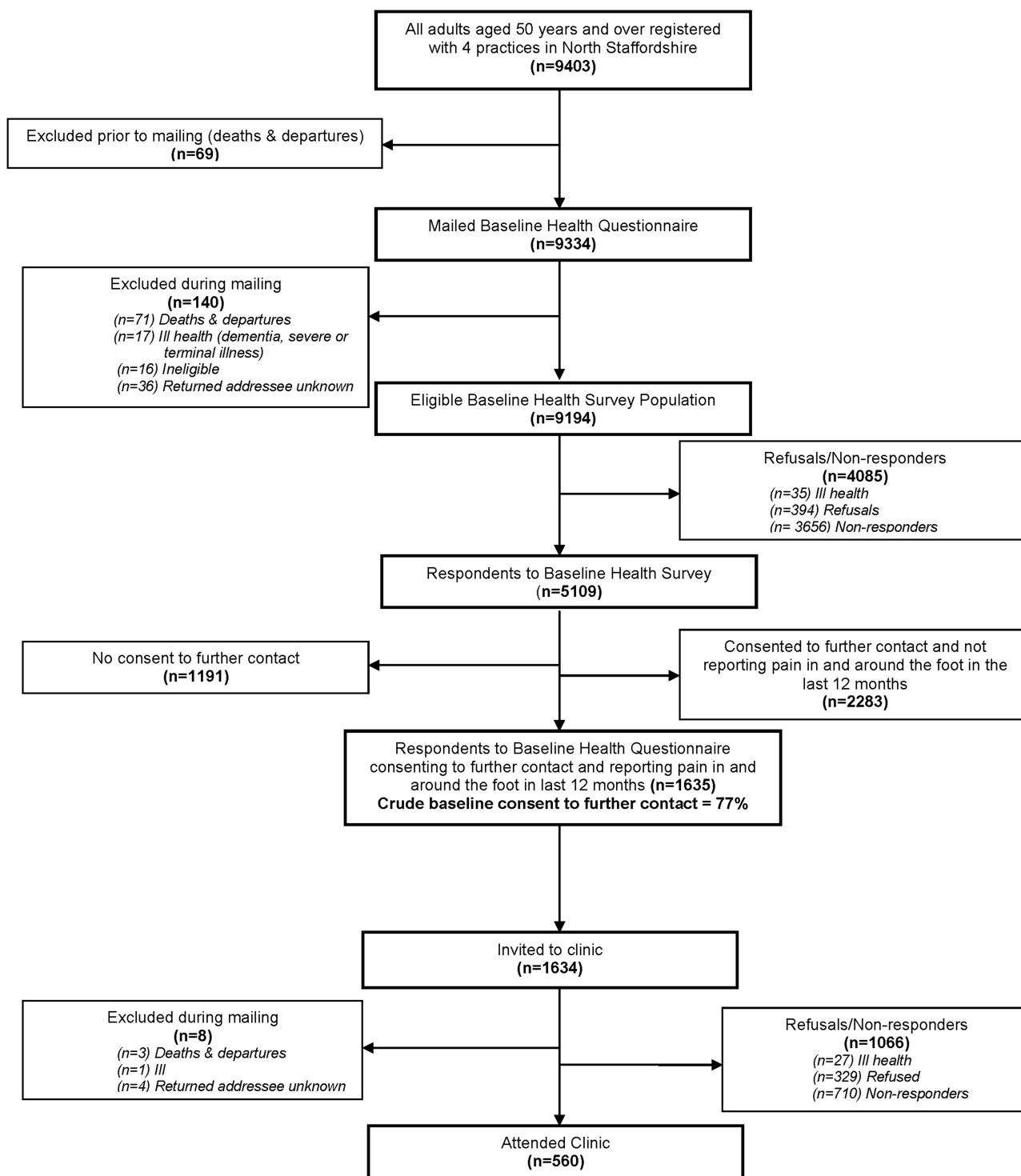


**Figure 1** Flowchart showing recruitment of participants into study.

## Selective non-participation

The age, gender and practice distribution of the samples at the various selection points were broadly representative of the baseline eligible population, although women aged 75 years and over were under-represented among clinic attenders (table 1).

Demographic, general health, psychological and lifestyle characteristics were available on the 5109 respondents to the health survey (table 2). Clinic attenders were more likely to have attended higher education and have managerial, administrative or professional occupations, had a higher number of days of foot pain and greater impairment in function on the MFPDI.

## Frequency of symptomatic radiographic foot OA in clinic attenders

Of 525 eligible clinic attenders, 188 (35.8%) had symptomatic radiographic foot OA affecting at least one of the five joints. The 1st MTPJ was most commonly affected (n=93), followed by the 2nd CMJ (n=67), TNJ (n=53), NCJ (n=36) and 1st CMJ (n=22).

## Population prevalence of symptomatic radiographic foot OA

Population prevalence estimates were almost identical in the baseline responder population and the total baseline eligible mailed population, hence the latter data are presented. The population prevalence of symptomatic radiographic foot OA in adults aged 50 years and over was 16.7% (95% CI 15.3% to 18.0%). The most commonly affected joint was the 1st MTPJ (7.8%; 95% CI 6.7% to 8.9%), followed by the 2nd CMJ (6.8%; 95% CI 5.7% to 7.8%), TNJ (5.8%; 95% CI 4.8% to 6.9%), NCJ (5.2%; 95% CI 4.0% to 6.4%) and 1st CMJ (3.9%; 95% CI 2.9% to 4.9%) (table 3).

Symptomatic radiographic foot OA overall was more prevalent in females than males, at older ages and in lower socioeconomic classes. The prevalence remained lower in the managerial/professional class after stratification by age and gender. Similar patterns were seen at the 1st MTPJ, 2nd CMJ, NCJ and TNJ. However, the population prevalence of symptomatic radiographic OA at the 1st CMJ did not differ by age and gender.

## Frequency of disabling symptomatic radiographic foot OA in clinic attenders

Of the 188 participants with symptomatic radiographic foot OA, 130 (69%) reported disabling foot symptoms. Again, the 1st MTPJ was most commonly affected (n=58), followed by the 2nd CMJ (n=52), TNJ (n=41), NCJ (n=24) and 1st CMJ (n=15). In addition, after excluding inflammatory arthritis, 129 clinic attenders had disabling foot pain but did not meet criteria for radiographic foot OA. Seventy-eight (60%) of these had grade 1 osteophyte or joint space narrowing in one or more joints in either foot.

## Population prevalence of disabling symptomatic radiographic foot OA

The population prevalence of disabling symptomatic radiographic foot OA in adults aged 50 years and over was 12.6% (95% CI 11.5% to 13.7%). Pain was most commonly disabling at the 1st MTPJ (5.6%; 95% CI 4.7% to 6.6%) and the 2nd CMJ (5.6%; 95% CI 4.7% to 6.6%), followed by the TNJ (4.7%; 95% CI 3.9% to 5.6%), the NCJ (4.1%; 95% CI 3.1% to 5.0%) and the 1st CMJ (3.1%; 95% CI 2.2% to 3.9%) (table 4).

The proportion of individuals with symptomatic radiographic foot OA who reported disabling symptoms was as follows: overall 75.4%, 1st MTPJ 71.7%, 2nd CMJ 82.4%, TNJ 81.0%, NCJ 78.8% and 1st CMJ 79.5%.

**Table 1**  Age, gender and practice differences between exclusions, non-responders and responders at each baseline selection point

| N | All mailed participants | Exclusions | Non-responders and refusals | Responders | Reported foot pain in the last 12 months | Eligible for invite to clinic | Attended research clinic |
|---|---|---|---|---|---|---|---|
| | 9334 | 140 | 4085 | 5109 | 2086 | 1635 | 560 |
| **Practice** | | | | | | | |
| A | 2515 (27) | 38 (27) | 906 (22) | 1571 (31) | 592 (28) | 488 (30) | 191 (34) |
| B | 3218 (34) | 52 (37) | 1585 (39) | 1581 (31) | 666 (32) | 526 (32) | 176 (31) |
| C | 1785 (19) | 27 (19) | 857 (21) | 901 (18) | 361 (17) | 269 (16) | 86 (15) |
| D | 1816 (19) | 23 (16) | 737 (18) | 1056 (21) | 467 (22) | 352 (22) | 107 (19) |
| **Gender** | | | | | | | |
| Males | 4611 (49) | 90 (64) | 2082 (51) | 2439 (48) | 887 (43) | 710 (43) | 247 (44) |
| Females | 4723 (51) | 50 (36) | 2003 (49) | 2670 (52) | 1199 (57) | 925 (57) | 313 (56) |
| **Age** | | | | | | | |
| 50–64 | 5126 (55) | 60 (43) | 2503 (61) | 2563 (50) | 1073 (51) | 896 (55) | 300 (54) |
| 65–74 | 2443 (26) | 28 (20) | 885 (22) | 1530 (30) | 608 (29) | 471 (29) | 179 (32) |
| 75+ | 1765 (19) | 52 (37) | 697 (17) | 1016 (20) | 405 (19) | 268 (16) | 81 (14) |
| **Age, males** | | | | | | | |
| 50–64 | 2687 (58) | 41 (46) | 1383 (66) | 1263 (52) | 499 (56) | 418 (59) | 139 (56) |
| 65–74 | 1212 (26) | 15 (17) | 441 (21) | 756 (31) | 250 (28) | 195 (27) | 74 (30) |
| 75+ | 712 (15) | 34 (38) | 258 (12) | 420 (17) | 138 (16) | 97 (14) | 34 (14) |
| **Age, females** | | | | | | | |
| 50–64 | 2439 (52) | 19 (38) | 1120 (56) | 1300 (49) | 574 (48) | 478 (52) | 161 (51) |
| 65–74 | 1231 (26) | 13 (26) | 444 (22) | 774 (29) | 358 (30) | 276 (30) | 105 (34) |
| 75+ | 1053 (22) | 18 (36) | 439 (22) | 596 (22) | 267 (22) | 171 (18) | 47 (15) |

Figures represent numbers and percentages.

## DISCUSSION

While cautious interpretation is warranted due to non-response, our study suggests that one in six adults aged 50 years and over have symptomatic radiographic OA affecting at least one of the five foot joints studied in either or both feet. The most commonly affected joint was the 1st MTPJ, followed by the 2nd CMJ, TNJ, NCJ and 1st CMJ. The prevalence of symptomatic radiographic foot OA generally increased with age, particularly

**Table 2** Demographics, general health, psychological and lifestyle characteristics at each baseline selection point

| | Responded to health survey | Reported foot pain in the last 12 months | Eligible for invite to clinic | Attended research clinic |
|---|---|---|---|---|
| N | 5109 | 2086 | 1635 | 560 |
| **Marital status** | | | | |
| Married/co-habiting | 3466 (68) | 1368 (66) | 1096 (67) | 388 (69) |
| Divorced/separated | 473 (9) | 207 (10) | 173 (11) | 57 (10) |
| Widowed | 806 (16) | 367 (18) | 264 (16) | 85 (15) |
| Single | 296 (6) | 110 (5) | 79 (5) | 28 (5) |
| Missing | 68 (1) | 34 (2) | 23 (1) | 2 (1) |
| **Higher education** | | | | |
| Yes | 843 (17) | 368 (18) | 323 (20) | 145 (26) |
| No | 3996 (78) | 1615 (77) | 1253 (77) | 398 (71) |
| Missing | 270 (5) | 103 (5) | 59 (4) | 17 (3) |
| **Employment status** | | | | |
| Employed | 1442 (28) | 510 (24) | 432 (26) | 121 (22) |
| Retired | 2831 (55) | 1140 (55) | 859 (53) | 338 (60) |
| Unable due to illness | 305 (6) | 187 (9) | 150 (9) | 44 (8) |
| Unemployed | 71 (1) | 31 (1) | 25 (2) | 8 (1) |
| Housewife | 179 (4) | 94 (5) | 76 (5) | 27 (5) |
| Other | 143 (3) | 59 (3) | 51 (3) | 17 (3) |
| Missing | 138 (3) | 65 (3) | 42 (3) | 5 (1) |
| **Occupational class** | | | | |
| Managerial/administrative/professional | 1011 (20) | 352 (17) | 307 (19) | 145 (26) |
| Intermediate | 887 (17) | 356 (17) | 293 (18) | 98 (18) |
| Routine/manual | 2668 (52) | 1149 (55) | 891 (55) | 282 (50) |
| Other* | 543 (11) | 229 (11) | 144 (9) | 35 (6) |
| **Baseline SF-12: mean (SD)** | | | | |
| Physical (0–100) | 41.54 (12.43) | 37.07 (12.15) | 37.50 (12.24) | 38.00 (12.28) |
| Missing | 628 (12) | 280 (13) | 179 (11) | 41 (7) |
| Mental (0–100) | 49.24 (11.37) | 46.68 (12.02) | 47.18 (11.88) | 48.88 (11.11) |
| Missing | 628 (12) | 280 (13) | 179 (11) | 41 (7) |
| **Baseline HADS anxiety** | | | | |
| None (0–7) | 3037 (59) | 984 (47) | 809 (49) | 307 (55) |
| Possible (8–11) | 1194 (23) | 608 (29) | 465 (28) | 154 (28) |
| Probable (12–21) | 776 (15) | 461 (22) | 336 (21) | 91 (16) |
| Missing | 102 (2) | 33 (2) | 25 (2) | 8 (1) |
| **Baseline HADS depression** | | | | |
| None (0–7) | 3637 (71) | 1277 (61) | 1049 (64) | 389 (69) |
| Possible (8–11) | 922 (18) | 501 (24) | 368 (23) | 119 (21) |
| Probable (12–21) | 451 (9) | 275 (13) | 193 (12) | 44 (8) |
| Missing | 99 (2) | 33 (2) | 25 (2) | 8 (1) |
| **BMI (kg/m$^2$)** | | | | |
| <20 | 174 (3) | 58 (3) | 37 (2) | 11 (2) |
| 20.0–24.9 | 1510 (3) | 522 (25) | 396 (24) | 132 (24) |
| 25.0–29.9 | 1948 (38) | 768 (37) | 605 (37) | 221 (39) |
| ≥30 | 1229 (24) | 651 (31) | 538 (33) | 191 (34) |
| Missing | 248 (5) | 87 (4) | 59 (4) | 5 (1) |
| **Disabling foot pain†** | | | | |
| Yes | – | 862 (63) | 683 (62) | 283 (63) |
| No | – | 404 (30) | 354 (32) | 68 (34) |
| Missing | – | 100 (7) | 68 (6) | 16 (4) |
| **Number of days with foot pain‡** | | | | |
| Less than 7 days | – | 343 (16) | 276 (17) | 74 (13) |
| 1–4 weeks | – | 291 (14) | 226 (14) | 68 (12) |
| 1–3 months | – | 256 (12) | 196 (12) | 66 (12) |

*Continued*

**Table 2** Continued

| N | Responded to health survey 5109 | Reported foot pain in the last 12 months 2086 | Eligible for invite to clinic 1635 | Attended research clinic 560 |
|---|---|---|---|---|
| 3+ months | – | 1158 (56) | 918 (56) | 348 (62) |
| Missing | – | 38 (2) | 19 (1) | 4 (1) |
| Rasch MFPDI: mean (SD)‡ | | | | |
| Function | – | −0.36 (2.16) | −0.49 (2.17) | −0.58 (2.14) |
| Missing | – | 28 (1) | 18 (1) | 3 (1) |
| Pain | – | −0.31 (1.57) | −0.35 (1.57) | −0.20 (1.55) |
| Missing | – | 51 (2) | 31 (2) | 3 (1) |

Figures represent numbers and percentages unless otherwise stated.
*Includes housewives, non-workers, retired people and those inadequately described.
†For those who reported foot pain in the last month.
‡For those who reported foot pain in the last year.
BMI, body mass index; HADS, Hospital Anxiety and Depression Scale; MFPDI, Manchester Foot Pain and Disability Index; SF12, Short-Form 12.

among women, and was higher in lower socioeconomic classes. The exception to this observation was the 1st CMJ, where age and gender patterns were not evident, although this joint had the lowest prevalence of OA (3.9%). Levels of disability were high at all sites, with three-quarters of those with symptomatic radiographic foot OA reporting disabling foot symptoms. The proportion of those with symptomatic radiographic OA who reported disabling symptoms was lower at the 1st MTPJ compared with the midfoot joints.

To our knowledge, this is the first study to report the population prevalence of symptomatic radiographic foot OA. Numerous previous studies have reported the prevalence of radiographic foot OA [8] or the association between radiographic foot OA and foot pain,[15] [16] but none report the proportion with painful radiographic foot OA. Not surprisingly, the prevalence estimates for symptomatic radiographic foot OA obtained in our study are lower than those in the published literature for radiographic foot OA irrespective of symptoms. Surveys

undertaken in populations comparable to ours estimate the prevalence of radiographic OA at the 1st MTPJ (Kellgren and Lawrence grade $\geq 2$ [28]) to range from 20% to 35% in middle-aged and older adults.[8] [29–33] Using the same validated atlas in an older population, Menz et al[15] also found that the 2nd CMJ is the most commonly affected of the four midfoot joints studied. The base of the second metatarsal, forming the 2nd CMJ, is the keystone of the transverse arch and occupies a recessed position relative to the first and third metatarsals, potentially making the 2nd CMJ more susceptible to excess loading and development of OA.[34] When compared with estimates of symptomatic OA at the knee, hip and hand from similar populations of older adults,[35] the overall prevalence of symptomatic radiographic foot OA in our study is higher than the hip (5.0–7.4%), similar to the knee (7.6–16.4%) and lower than the hand (21.6%).

Strengths of our study include the population size, the primary care setting and the combination of multiple imputation

**Table 3** Population prevalence of symptomatic foot OA by anatomical location and age, gender and socioeconomic classification

| | 1st MTPJ | 1st CMJ | 2nd CMJ | NCJ | TNJ | Overall |
|---|---|---|---|---|---|---|
| Symptomatic radiographic OA | 7.8 (6.7 to 8.9) | 3.9 (2.9 to 4.9) | 6.8 (5.7 to 7.8) | 5.2 (4.0 to 6.4) | 5.8 (4.8 to 6.9) | 16.7 (15.3 to 18.0) |
| Males | 6.7 (5.3 to 8.0) | 3.6 (2.4 to 4.9) | 5.0 (3.8 to 6.2) | 3.8 (2.4 to 5.2) | 5.0 (3.4 to 6.7) | 14.3 (12.6 to 16.0) |
| Females | 8.8 (7.4 to 10.3) | 4.2 (2.9 to 5.4) | 8.5 (6.9 to 10.2) | 6.7 (5.0 to 8.3) | 6.6 (5.3 to 8.0) | 18.9 (16.9 to 20.9) |
| Age | | | | | | |
| 50–64 | 6.9 (5.5 to 8.2) | 4.1 (2.8 to 5.4) | 6.0 (4.6 to 7.4) | 4.8 (3.4 to 6.2) | 5.6 (4.1 to 7.1) | 15.9 (13.9 to 17.9) |
| 65–74 | 8.7 (6.6 to 10.8) | 3.5 (2.2 to 4.7) | 6.4 (4.8 to 7.9) | 4.9 (3.1 to 6.8) | 5.7 (4.1 to 7.2) | 17.0 (14.8 to 19.2) |
| 75+ | 9.0 (6.7 to 11.2) | 3.9 (1.6 to 6.2) | 9.8 (7.2 to 12.5) | 7.0 (4.7 to 9.3) | 7.0 (4.8 to 9.1) | 18.5 (15.8 to 21.1) |
| Age, males | | | | | | |
| 50–64 | 5.8 (4.1 to 7.5) | 4.0 (2.3 to 5.7) | 4.6 (3.1 to 6.0) | 3.5 (1.9 to 5.2) | 5.0 (2.8 to 7.2) | 13.9 (11.5 to 16.3) |
| 65–74 | 8.0 (5.5 to 10.6) | 3.2 (1.3 to 5.2) | 4.6 (2.6 to 6.7) | 3.6 (1.7 to 5.6) | 4.6 (2.5 to 6.8) | 15.0 (12.0 to 18.0) |
| 75+ | 7.1 (4.3 to 9.9) | 2.9 (0.3 to 5.4) | 7.2 (4.3 to 10.2) | 4.9 (2.1 to 7.6) | 5.9 (3.0 to 8.8) | 14.4 (10.8 to 18.1) |
| Age, females | | | | | | |
| 50–64 | 7.9 (6.1 to 9.8) | 4.3 (2.4 to 6.2) | 7.5 (5.0 to 10.0) | 6.1 (4.1 to 8.1) | 6.1 (4.3 to 7.9) | 17.9 (15.1 to 20.6) |
| 65–74 | 9.4 (6.5 to 12.3) | 3.7 (1.7 to 5.6) | 8.2 (6.0 to 10.4) | 6.3 (3.6 to 8.9) | 6.7 (4.1 to 9.4) | 19.0 (15.6 to 22.4) |
| 75+ | 10.3 (7.3 to 13.4) | 4.7 (1.7 to 7.7) | 11.7 (8.0 to 15.5) | 8.6 (5.1 to 12.2) | 7.7 (4.8 to 10.6) | 21.4 (17.7 to 25.2) |
| Socioeconomic classification | | | | | | |
| Managerial and professional | 4.8 (3.3 to 6.3) | 2.5 (0.8 to 4.1) | 3.7 (2.1 to 5.3) | 2.5 (0.9 to 4.2) | 3.8 (2.1 to 5.5) | 10.2 (8.0 to 12.5) |
| Intermediate occupations | 8.7 (5.9 to 11.5) | 4.0 (1.0 to 7.0) | 6.9 (4.6 to 9.2) | 6.1 (3.7 to 8.6) | 6.1 (3.0 to 9.3) | 17.9 (14.7 to 21.1) |
| Routine and manual | 8.3 (6.6 to 10.0) | 4.1 (2.9 to 5.4) | 7.3 (5.7 to 8.9) | 6.1 (4.6 to 7.6) | 6.4 (4.9 to 7.8) | 18.2 (16.2 to 20.1) |

CMJ, cuneometatarsal joint; OA, osteoarthritis; MTPJ, metatarsophalangeal joint; NCJ, navicular first cuneiform joint; TNJ, talonavicular joint.

**Table 4** Population prevalence of disabling symptomatic foot OA by anatomical location, age and gender

| | 1st MTPJ | 1st CMJ | 2nd CMJ | NCJ | TNJ | Overall |
|---|---|---|---|---|---|---|
| Disabling symptomatic radiographic OA | 5.6 (4.7 to 6.6) | 3.1 (2.2 to 3.9) | 5.6 (4.7 to 6.6) | 4.1 (3.1 to 5.0) | 4.7 (3.9 to 5.6) | 12.6 (11.5 to 13.7) |
| Males | 4.9 (3.7 to 6.0) | 2.7 (1.7 to 3.8) | 4.0 (2.9 to 5.1) | 2.8 (1.7 to 3.8) | 3.9 (2.6 to 5.3) | 10.6 (9.2 to 12.0) |
| Females | 6.4 (5.1 to 7.6) | 3.4 (2.3 to 4.5) | 7.2 (5.7 to 8.7) | 5.3 (3.9 to 6.7) | 5.5 (4.3 to 6.7) | 14.5 (12.8 to 16.2) |
| **Age** | | | | | | |
| 50–64 | 4.6 (3.4 to 5.8) | 3.1 (2.0 to 4.3) | 4.8 (3.5 to 6.0) | 3.5 (2.4 to 4.6) | 4.4 (3.1 to 5.6) | 11.5 (9.9 to 13.0) |
| 65–74 | 5.9 (4.2 to 7.7) | 2.7 (1.6 to 3.9) | 5.2 (3.7 to 6.7) | 3.8 (2.3 to 5.3) | 4.5 (3.1 to 5.9) | 12.4 (10.4 to 14.3) |
| 75+ | 8.3 (6.1 to 10.4) | 3.5 (1.3 to 5.8) | 9.0 (6.6 to 11.5) | 6.2 (4.1 to 8.4) | 6.2 (4.3 to 8.2) | 16.6 (14.2 to 19.0) |
| **Age, males** | | | | | | |
| 50–64 | 4.0 (2.5 to 5.4) | 2.9 (1.5 to 4.2) | 3.2 (2.0 to 4.3) | 2.3 (1.1 to 3.5) | 3.8 (2.0 to 5.5) | 9.7 (7.8 to 11.5) |
| 65–74 | 5.5 (3.4 to 7.6) | 2.7 (1.0 to 4.4) | 4.2 (2.2 to 6.2) | 3.0 (1.4 to 4.7) | 3.8 (1.8 to 5.8) | 11.2 (8.6 to 13.7) |
| 75+ | 7.0 (4.2 to 9.8) | 2.5 (0.1 to 5.0) | 6.7 (3.9 to 9.5) | 4.1 (1.6 to 6.5) | 4.9 (2.1 to 7.6) | 12.9 (9.4 to 16.4) |
| **Age, females** | | | | | | |
| 50–64 | 5.3 (3.7 to 6.9) | 3.4 (1.7 to 5.2) | 6.4 (4.3 to 8.5) | 4.8 (3.0 to 6.5) | 5.0 (3.3 to 6.7) | 13.3 (11.0 to 15.6) |
| 65–74 | 6.4 (3.9 to 8.8) | 2.8 (1.1 to 4.5) | 6.2 (4.1 to 8.3) | 4.5 (2.5 to 6.6) | 5.3 (3.1 to 7.5) | 13.6 (10.7 to 16.5) |
| 75+ | 9.2 (6.3 to 12.1) | 4.3 (1.3 to 7.2) | 10.8 (7.4 to 14.2) | 7.9 (4.6 to 11.1) | 7.3 (4.6 to 9.9) | 19.3 (15.8 to 22.7) |

CMJ, cuneometatarsal joint; OA, osteoarthritis; MTPJ, metatarsophalangeal joint; NCJ, navicular first cuneiform joint; TNJ, talonavicular joint.

and weighted logistic regression modelling to account for missing data and non-response. A further strength is the use of a standardised protocol to obtain radiographs of both feet and a validated atlas and scoring system to grade features of OA at multiple foot joints.[17] Previous studies of radiographic foot OA are limited by focusing on the 1st MTPJ, using unspecified or uniplanar radiographic views or taking non-weight-bearing views.[8] The limitations of our study are worthy of acknowledgement. The overall response to the postal health survey questionnaire was lower than we had expected when compared with response in our previous population surveys[36 37] despite the use of several strategies to increase response to postal questionnaire surveys.[18 38 39] Responders to the health survey questionnaire did not appear to differ greatly from the mailed population by age, gender or practice distribution. Inverse probability weighting based on these variables still leaves potential non-response bias related to other determinants of response associated with foot pain and radiographic OA. Similarly, only one-third of health survey questionnaire responders who were eligible to attend the research assessment clinic did so. Those in managerial, administrative or professional occupations and those who received higher education were over-represented in clinic attenders. In terms of the external validity of our findings, the UK population census 2011 suggests that the source population has a low representation of ethnic minority groups but does not differ from the national picture in terms of age and gender.[40] Intra-rater reliability for the presence of OA in a joint was excellent, whereas inter-rater reliability was only moderate, concurring with the original validation of the atlas.[17] However, it became apparent that the main assessor systematically took a more conservative approach to scoring radiographic features than the second assessor. Therefore, the population prevalence of symptomatic radiographic foot OA is possibly underestimated. This is particularly true of our overall prevalence estimate, which is based only on the five joints assessed in the atlas and does not include other joints within the foot. Observations regarding inter-rater reliability provide further support for the previous recommendation that single examiners or consensus approaches should be employed when scoring radiographs for research purposes.[16 41]

The main clinical implication of our findings arises from the prevalence of symptomatic radiographic foot OA and associated disability suggesting that this poses a significant public health problem that increases with age. Approximately 20% of people with musculoskeletal foot problems consult their general practitioner over a 3-year period[14]; therefore, our findings suggest that clinicians should be aware of OA as a possible cause of chronic foot pain in older people. In addition, a significant number had disabling foot pain and milder radiographic features and may be at risk of future progression and are therefore of potential importance for early recognition and intervention. Recognition of foot OA in primary care would be enhanced by a better understanding of which clinical foot OA phenotypes present to primary care and how they are diagnosed in this setting. It would be worthwhile exploring the contribution of radiographic foot OA to clinical phenotypes and how these present to and are diagnosed in primary care.

## REFERENCES

1. World Health Organisation. *The burden of musculoskeletal conditions at the start of the new millennium*. Report of a WHO Scientific Group. WHO Technical Report Series No. 919; 2003.
2. Jordan K, Clarke AM, Symmons DPM, *et al*. Measuring disease prevalence: a comparison of musculoskeletal disease using four general practice consultation databases. *Br J Gen Pract* 2007;57:7–14.
3. Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. *PLoS Med* 2006;3:e442.
4. Guccione AA, Felson DT, Anderson JJ, *et al*. The effects of specific medical conditions on the functional limitations of elders in the Framingham Study. *Am J Public Health* 1994;84:351–8.
5. Wilkie R, Peat G, Thomas E, *et al*. Factors associated with restricted mobility outside the home in community-dwelling adults ages fifty years and older with knee pain: an example of use of the International Classification of Functioning to investigate participation restriction. *Arthritis Rheum* 2007;57:1381–9.
6. Woolf AD, Pfleger B. Burden of major musculoskeletal conditions. *Bull World Health Organ* 2003;81:646–56.
7. Kellgren JH, Moore RA. Generalized osteoarthritis and Heberden's nodes. *Br Med J* 1952;1:181–7.
8. Trivedi B, Marshall M, Belcher J, *et al*. A systematic review of radiographic definitions of foot osteoarthritis in population-based studies. *Osteoarthritis Cartilage* 2010;18:1027–35.
9. Thomas MJ, Roddy E, Zhang W, *et al*. The population prevalence of foot and ankle pain in middle and old age: a systematic review. *Pain* 2011;152:2870–80.
10. Nix S, Smith M, Vicenzino B. Prevalence of hallux valgus in the general population: a systematic review and meta-analysis. *J Foot Ankle Res* 2010;3:21.
11. Badlissi F, Dunn JE, Link CL, *et al*. Foot musculoskeletal disorders, pain, and foot-related functional limitation in older persons. *J Am Geriatr Soc* 2005;53:1029–33.
12. Benvenuti F, Ferrucci L, Guralnik JM, *et al*. Foot pain and disability in older persons: an epidemiologic survey. *J Am Geriatr Soc* 1995;43:479–84.
13. Menz HB, Lord SR. The contribution of foot problems to mobility impairment and falls in community-dwelling older people. *J Am Geriatr Soc* 2001;49:1651–6.
14. Menz HB, Jordan KP, Roddy E, *et al*. Musculoskeletal foot problems in primary care: what influences older people to consult? *Rheumatology (Oxford)* 2010;49:2109–16.
15. Menz HB, Munteanu SE, Landorf KB, *et al*. Radiographic evaluation of foot osteoarthritis: sensitivity of radiographic variables and relationship to symptoms. *Osteoarthritis Cartilage* 2009;17:298–303.
16. Menz HB, Munteanu SE, Zammit GV, *et al*. Foot structure and function in older people with radiographic osteoarthritis of the medial midfoot. *Osteoarthritis Cartilage* 2010;18:317–22.
17. Menz HB, Munteanu SE, Landorf KB, *et al*. Radiographic classification of osteoarthritis in commonly affected joints of the foot. *Osteoarthritis Cartilage* 2007;15:1333–8.
18. Roddy E, Myers H, Thomas MJ, *et al*. The clinical assessment study of the foot (CASF): study protocol for a prospective observational study of foot pain and foot osteoarthritis in the general population. *J Foot Ankle Res* 2011;4:22.
19. Ware J Jr, Kosinski M, Keller SD. A 12-Item Short-Form Health Survey: construction of scales and preliminary tests of reliability and validity. *Med Care* 1996;34:220–33.
20. Zigmond AS, Snaith RP. The hospital anxiety and depression scale. *Acta Psychiatr Scand* 1983;67:361–70.
21. Dufour AB, Broe KE, Nguyen US, *et al*. Foot pain: is current or past shoewear a factor? *Arthritis Rheum* 2009;61:1352–8.
22. Garrow AP, Papageorgiou AC, Silman AJ, *et al*. Development and validation of a questionnaire to assess disabling foot pain. *Pain* 2000;85:107–13.
23. Garrow AP, Silman AJ, Macfarlane GJ. The Cheshire Foot Pain and Disability Survey: a population survey assessing prevalence and associations. *Pain* 2004;110:378–84.
24. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics* 1977;33:159–74.
25. Roddy E, Muller S, Thomas E. Defining disabling foot pain in older adults: further examination of the Manchester Foot Pain and Disability Index. *Rheumatology (Oxford)* 2009;48:992–6.
26. Muller S, Roddy E. Rasch analysis of the Manchester Foot Pain and Disability Index. *J Foot Ankle Res* 2009;2:29.
27. Rubin DB. *Multiple imputation for non-response in surveys*. Wiley, 1987.
28. Kellgren JH, Lawrence JS. Radiological assessment of osteo-arthrosis. *Ann Rheum Dis* 1957;16:494–502.
29. Bremner JM, Lawrence JS, Miall WE. Degenerative joint disease in a Jamaican rural population. *Ann Rheum Dis* 1968;27:326–32.
30. van Saase JL, Vanderbroucke JP, van Romunde LKJ, *et al*. Osteoarthritis and obesity in the general population. A relationship calling for an explanation. *J Rheumatol* 1988;15:1152–8.
31. van Saase JL, van Romunde LK, Cats A, *et al*. Epidemiology of osteoarthritis: Zoetermeer Survey. Comparison of radiological osteoarthritis in a Dutch population with that in 10 other populations. *Ann Rheum Dis* 1989;48:271–80.
32. Wilder FV, Barrett JP, Farina EJ. The association of radiographic foot osteoarthritis and radiographic osteoarthritis at other sites. *Osteoarthritis Cartilage* 2005;13:211–15.
33. Wilder FV, Leaverton PE, Rogers MW. Height and radiographic osteoarthritis: an epidemiologic assessment-short communication. *J Musculoskelet Res* 2008;11:185–9.
34. Pearce CJ, Calder JD. Surgical anatomy of the midfoot. *Knee Surg Sports Traumatol Arthrosc* 2010;18:581–6.
35. Pereira D, Peleteiro B, Araújo J, *et al*. The effect of osteoarthritis definition on prevalence and incidence estimates: a systematic review. *Osteoarthritis Cartilage* 2011;19:1270–85.
36. Peat G, Thomas E, Handy J, *et al*. The Knee Clinical Assessment Study-CAS(K). A prospective study of knee pain and knee osteoarthritis in the general population: baseline recruitment and retention at 18 months. *BMC Musculoskelet Disord* 2006;7:30.
37. Thomas E, Peat G, Harris L, *et al*. The prevalence of pain and pain interference in a general population of older adults: cross-sectional findings from the North Staffordshire Osteoarthritis Project (NorStOP). *Pain* 2004;110:361–8.
38. Edwards P, Roberts I, Clarke M, *et al*. Increasing response rates to postal questionnaires: systematic review. *Br Med J* 2002;324:1183.
39. Mallen CD, Dunn KM, Thomas E, *et al*. Thicker paper and larger font increased response and completeness in a postal survey. *J Clin Epidemiol* 2008;61:1296–300.
40. Office for National Statistics. Annual population survey. http://www.nomisweb.co.uk/articles/692.aspx (accessed 11 Apr 2013)
41. Guermazi A, Hunter DJ, Li L, *et al*. Different thresholds for detecting osteophytes and joint space narrowing exist between the site investigators and the centralized reader in a multicenter knee osteoarthritis study—data from the Osteoarthritis Initiative. *Skeletal Radiol* 2012;41:179–86.