Relative prevalence and distribution of knee, hand and foot symptomatic osteoarthritis subtypes in an English population

# Abstract

In this brief report, we use data from a series of three related cohorts on pain and OA at the knee, hand, and foot, which were conducted in North Staffordshire, England, and used a common approach for sampling, data collection, and coding, to estimate the relative prevalence of 10 different symptomatic radiographic OA subtypes at the knee, hand, and foot and to compare their association with age, sex, socioeconomic position and body mass index. Overall, symptomatic hand OA was more common than knee or foot OA (22.4% vs 17.4% vs 16.5%), due mainly to the high prevalence of nodal interphalangeal joint OA among women. First carpometacarpal joint OA was the most frequent subtype, with patellofemoral, tibiofemoral, (nodal) interphalangeal, and midfoot OA also common. Of the risk factors examined, the greatest differences between subtypes appeared to be their associations with sex and obesity: sex differences were noticeably greater for all forms of hand osteoarthritis except non-nodal interphalangeal joint OA, while obesity appeared most strongly associated with forms of knee OA. The prevalence of all subtypes was higher among older ages, and among those with lower educational attainment.

**Keywords:** osteoarthritis, prevalence, population, epidemiology, subtypes, obesity, socioeconomic status

# 1. Introduction

Whether it is risk alleles and gene expression (Reynard & Loughlin, 2013; Warner & Valdes, 2017), biomechanical or constitutional risk profiles (e.g. Cooper et al., 1994), osteoarthritis researchers have often sought to compare and contrast findings across different joints to gain new insights into the relative susceptibility to, and differential causes of, OA at different joints. Descriptive studies have a role in this endeavour. There are a great many published estimates of the population prevalence of peripheral joint osteoarthritis (Pereira et al., 2011; Kobayashi et al., 2016; Trivedi et al., 2010) and models incorporating multiple estimates, such as underpins the Global Burden of Disease project (Cross et al., 2014), represent an important advance. However, studies that are capable of directly comparing the frequency and distribution of different forms of joint-specific OA in the same underlying population can still be useful since they remove several sources of methodological heterogeneity that bedevil comparisons between studies. In this brief report, we draw on data from a series of three related cohorts on pain and OA at the knee (Peat et al., 2004), hand (Myers et al., 2007), and foot (Roddy et al., 2011), which were conducted in North Staffordshire in England, and used a common approach for sampling, data collection, and coding. We have previously published prevalence estimates from two of these studies but not using a harmonised approach to case definition (Marshall et al., 2013; Roddy et al., 2015). The current report adopted a harmonised approach to case definition and analysis, applying this to all three cohorts for the first time to consolidate evidence in relation to two main questions: (i) What is the relative prevalence of different symptomatic radiographic OA subtypes at the knee, hand, and foot? (ii) To what extent do these symptomatic radiographic OA subtypes exhibit similar relationships with age, sex, socioeconomic status and body mass index?

# 2. Methods

**Data sources**

We conducted a secondary analysis of cross-sectional survey data collected between 2002 and 2011 in three related population-based studies of adults aged 50 years and over in North Staffordshire, England: the Clinical Assessment Study of the Knee (CASK), the Clinical Assessment Study of the Hand (CASHA), and the Clinical Assessment Study of the Foot (CASF). The studies were each approved by Research Ethics Committee (LREC Project Nos. 1430, 10/H1210/5), and their protocols have been published (Peat et al., 2004; Myers et al., 2007; Roddy et al., 2011). Briefly, in each study, general practice registers were used as a population sample frame to mail a self-complete general health survey to all adults aged 50 years and over. Respondents who indicated that they had pain in the joint region of interest (knee, hand, foot) and consented to further contact were invited to attend a research assessment clinic that included standardised interview, physical examination, measurement of height and weight, and plain radiography. In CASK and CASHA, there was a two-stage mailing with all respondents reporting pain in or around the knee or hand in the past 12 months in the general health survey being invited to complete a more detailed regional pains questionnaire prior to being issued a clinic invite, whereas for CASF, the corresponding foot-specific questions were included in the single-stage health survey. The content of all the surveys and data collection instruments used at baseline is listed in the three publicly available protocol papers (Peat et al., 2004; Myers et al., 2007; Roddy et al., 2011).

Self-reported pain in the previous 4 weeks at the knee, and specific locations in the hands and feet was collected in CASK, CASHA, and CASF by participants shading a whole-body manikin, hand drawings (Ferry et al., 1998), and foot manikin (Garrow et al., 2004) respectively. In CASK, CASHA, and CASF, plain radiographs of the knee (weight-bearing posteroanterior semiflexed/metatarsophalangeal, skyline, and lateral views), hands (posterior–anterior (PA) view, and feet (weight-bearing dorso-plantar and lateral views) respectively were taken according to standardised protocols and reported by trained readers using standardised grading systems and atlases and demonstrating acceptable reliability (Peat et al., 2004; Duncan et al., 2007; Myers et al., 2007; Marshall et al., 2013; Roddy et al., 2011; Roddy et al., 2015).

**Statistical analysis**

We defined a total of ten different symptomatic radiographic osteoarthritis subtypes using a common approach based on the combination of definite radiographic features and self-reported pain in the relevant joint site in the previous four weeks. The subtypes were: medial tibiofemoral joint OA, lateral tibiofemoral joint OA, patellofemoral joint OA, 1st carpometacarpal joint OA, nodal interphalangeal joint OA, non-nodal interphalangeal joint OA, generalised hand OA, erosive hand OA, 1st metatarsophalangeal joint OA, and midfoot OA. Participants could have more than one subtype. In addition, we provide estimates for aggregate case definitions: tibiofemoral joint OA, interphalangeal joint OA, knee OA, hand OA, and foot OA (see **Supporting Information Table S1** for operational definitions).

Using data from the general health and regional pains surveys and radiographic data from the clinical assessments, the population prevalences of each subtype were estimated using multiple imputation (MI; Rubin, 1987) and weighted logistic regression modelling applied to each cohort in turn (CASK for knee OA subtypes, CASHA for hand OA subtypes, CASF for foot OA subtypes). In each case, the MI models were applied to all responders to the general health survey. The variables entered into the MI models are listed in **Supporting Information Table S2**. The MI models were conditional such that we only imputed radiographs in participants reporting pain in the last year indicated in the general health survey. The number of imputations was set at 70-80 corresponding to the percentage of missing radiographs in those reporting pain in the last year, and the imputed data sets were combined using Rubin’s combination rules. Prevalence estimates (and 95% CIs) were then weighted to account for any selective non-response from the eligible baseline population to the general health survey. Information on age, sex and general practice 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, sex and general practice, would return the general health survey. The population prevalence estimates (and 95% CIs) in the total baseline eligible mailed population were reported and were then stratified by sex, age group, educational attainment, occupational class (based on standard occupational coding of current/last job title), and body mass index (categorised). Using Poisson regression models with robust standard errors and weighted for non-response to the general health survey, the prevalence rate ratios with 95% CI were provided adjusted for sex and age. Finally, any non-linear relationships between the prevalence of each subtype with age or body mass index were identified using fractional polynomials and were plotted with 95% CI. Analysis was conducted in Stata v14 (Stata Corporation, Texas, USA).

# 3. Results

Between July 2002 and May 2003, 8984 adults aged over 50 years were mailed the general health survey for CASK. 6108 responded (adjusted response 70%), 3106 of these reported knee pain in the past year, and of these 819 attended the research assessment clinic. For CASHA the corresponding numbers were 6412 mailed the general health survey between February 2004 and April 2005, 4511 responded (adjusted response 71%), 2114 reported hand pain in the past year, and 623 attended clinic. For CASF the corresponding numbers were 9334 mailed the general health survey between May 2010 and June 2011, 5109 responded (adjusted response 56%), 1635 reported foot pain in the past year, and 560 attended clinic. Detailed descriptions of the response rates and the characteristics of respondents and non-respondents have been previously published (Peat et al., 2006; Nicholls, 2016; Roddy et al., 2015).

**Relative prevalence of symptomatic radiographic OA subtypes**

Overall, symptomatic hand OA was more common than knee or foot OA (22.4% vs 17.4% vs 16.5%), due mainly to the high prevalence of nodal interphalangeal joint OA among women (**Table 1**). First carpometacarpal joint OA was the most frequent subtype, with patellofemoral, tibiofemoral, (nodal) interphalangeal, and midfoot OA also common. As expected, within the tibiofemoral joint, medial involvement was more common than lateral.

**Relative associations with age, sex, individual socioeconomic position, and body mass index**

The prevalence of all subtypes was higher among older ages, although the association appeared strongest for knee OA subtypes and generalised hand OA (**Figure 1; Supporting Information Tables S3 & 4**). Females had a higher prevalence of all subtypes except non-nodal interphalangeal joint OA and medial tibiofemoral joint OA. Sex-specific differences were greatest for nodal interphalangeal joint OA, generalised hand OA, and erosive hand OA. After adjusting for age and sex, higher educational attainment was associated with 10-30% lower prevalence of most subtypes. While higher prevalences of foot OA subtypes were observed among those whose current or last job was classed as a routine or manual occupation, there was no consistent or strong association with knee and hand OA. Higher prevalences of all knee and foot subtypes, particularly midfoot OA, were observed in obese adults. Prevalence of most subtypes increased linearly with older age and higher BMI (**Supporting Information Figure S1**).

# 4. Discussion

This brief report consolidates prevalence estimates for ten different subtypes of symptomatic OA at the knee, hand, and foot using a common approach to case definition and analysis, based on a harmonised approach to sampling and data collection conducted over a nine year period within a defined local population in England. The purpose was to facilitate comparisons between these different subtypes in their frequency and distribution.

Of the risk factors examined, the greatest differences between subtypes appeared to be by sex and obesity: sex differences were noticeably greater for all forms of hand OA except non-nodal interphalangeal joint OA, while obesity appeared most strongly associated with forms of knee OA. A higher prevalence of knee OA among women has been previously reported across multiple studies, albeit with some between-study heterogeneity (Srikanth et al., 2005). In the present study, such differences were relatively modest and indeed absent for medial tibiofemoral joint OA across each age group. The sample frame for our knee study included a former mining community and this may have caused a higher than expected prevalence of medial tibiofemoral knee OA among men in our study. The lack of higher prevalence of knee and hand OA subtypes among adults from routine/manual occupations was unexpected but was based on current or last job title and so will reflect any selective shifting to less physically demanding occupations later in working life.

The current prevalence estimates were relatively high when considered against previous comparable studies from other countries, against modelled estimates for Staffordshire from the Global Burden of Disease project, and against local population estimates of ‘disabling OA’ based on self-report (**Supplementary Information Table S5**). The effect of differences in definitions must be suspected. One factor may be the lower symptom threshold used in the current study, requiring pain in the past four weeks rather than the more stringent standard of ‘symptoms on most days’ which was not available across all three cohorts for all the joint locations needed to construct comparable subtype case definitions. Based on our data, 45-65% of those reporting pain in the past 4 weeks report symptoms on most days in the previous month. This proportion was not substantially different by joint (knee 56%, hand 50%, foot 59%). Another factor in case definitions is how precisely the location of symptoms and radiographic changes are matched. For example, the present analysis produced lower estimates for most symptomatic radiographic hand OA subtypes than a previous analysis of the same cohort but which did not match symptoms and radiographic changes to the same degree but instead required cases to have hand symptoms on a few days or more in the past month (Marshall et al., 2013).

Prevalence estimates are particular to time and place. It is important to note that the population for these studies was overwhelmingly Caucasian (>90%). Care is needed when trying to infer our findings beyond this population given evidence of important differences in OA occurrence between different countries, ethnic groups, and cultures. Similarly, data collection and estimates occurred over a 9-year period between 2002-2011. While an ageing population would be expected to result in increasing prevalence of OA over time (and hence our overall rates may under-estimate prevalence in 2020), our age-specific prevalence estimates should be less prone to becoming ‘outdated’. Sampling for each of our three cohorts was from different general practices within North Staffordshire which could be a source residual confounding of observed differences between knee, hand, and foot OA. Our approach to modelling used a large amount of available covariate data but ultimately assumes that the combination of multiple imputation and inverse probability weighting is sufficient to adjust for selective non-participation. Risk factor information available and comparable across all cohorts was relatively limited: we were unable to investigate injury, nutritional, hormonal or other factors where differential relationships with subtypes are hypothesised. Unfortunately, we did not have a hip OA cohort. Finally, in looking at each subtype in turn we must recognise that many individuals with prevalent symptomatic OA over the age of 50 years have multiple co-existing OA subtypes, and this reduces our ability to distinguish subtype-specific associations.

Despite these limitations, the current study provides one of the few insights into the relative prevalence and distribution of a range of symptomatic osteoarthritis subtypes within a defined UK population. While some differences are noted, a general pattern of consistently higher prevalence across most subtypes is seen in older, female, lower socioeconomic status, and obese individuals, suggesting the potential value of common action across all subtypes to their prevention and management in populations.

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**Table 1. Comparative prevalence of symptomatic radiographic OA (sROA) subtypes at the knee, hand, and foot in adults aged over 50 years: North Staffordshire, 2002-2011**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Both sexes | Male |  Female |
|  | % | 95%CI | % | 95%CI | % | 95%CI |
|  Medial tibiofemoral joint sROA | 9.8  | (8.6, 11.1) | 9.7  | (8.0, 11.4) | 9.9  | (8.3, 11.56) |
|  Lateral tibiofemoral joint sROA | 6.7  | (5.6, 7.7) | 5.9  | (4.5, 7.3) | 7.3  | (5.8, 8.8) |
| Tibiofemoral joint sROA | 12.8  | (11.4, 14.1) | 12.1  | (10.4, 13.9) | 13.3  | (11.4, 15.1) |
| Patellofemoral joint sROA | 13.2  | (11.9, 14.6) | 11.3  | (9.5, 13.1) | 14.8  | (12.9, 16.7) |
| **Knee sROA (any)** | **17.7**  | **(16.3, 19.1)** | **16.0**  | **(14.0, 17.9)** | **19.2**  | **(17.3, 21.1)** |
| 1st carpometacarpal joint sROA | 15.8  | (14.2, 17.5) | 11.0  | (9.0, 13.1) | 20.1  | (17.8, 22.5) |
|  Nodal interphalangeal joint sROA | 10.7  | (9.2, 12.1) | 6.0  | (4.3, 7.6) | 14.8  | (12.8, 16.9) |
|  Non-nodal interphalangeal joint sROA | 3.0  | (2.0, 4.0) | 2.9  | (1.7, 4.2) | 3.1  | (1.7, 4.4) |
| Interphalangeal joint sROA | 13.2  | (11.9, 14.6) | 8.6  | (6.9, 10.4) | 17.3  | (15.4, 19.2) |
| Generalised hand sROA | 5.2  | (4.2, 6.3) | 2.6  | (1.5, 3.7) | 7.6  | (6.0, 9.1) |
| Erosive hand sROA | 2.0  | (1.2, 2.8) | 0.6  | (0.0, 1.2) | 3.3  | (2.0, 4.5) |
| **Hand sROA (any)** | **22.4**  | **(20.8, 24.0)** | **16.1**  | **(14.0, 18.3)** | **28.0**  | **(25.6, 30.3)** |
| 1st metatarsophalangeal joint sROA | 8.0  | (6.7, 9.2) | 6.8  | (5.4, 8.2) | 9.1  | (7.3, 10.9) |
| Midfoot sROA | 10.6  | (9.1, 12.1) | 8.7  | (6.9, 10.4) | 12.5  | (10.6, 14.5) |
| **Foot sROA (any)** | **15.9**  | **(14.3, 17.5)** | **13.4**  | **(11.5, 15.2)** | **18.3**  | **(16.1, 20.6)** |

**FIGURE LEGENDS**

**Figure 1. Pattern of cross-sectional associations between symptomatic radiographic OA subtypes at the knee, hand, and foot, and selected risk factors**