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Demographic and clinical factors associated with radiographic severity of first metatarsophalangeal joint osteoarthritis: cross-sectional findings from the Clinical Assessment Study of the Foot

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SUMMARY

Objective: To explore demographic and clinical factors associated with radiographic severity of first metatarsophalangeal joint osteoarthritis (OA) (First MTPJ OA).
Design: 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 a clinical assessment and weight-bearing dorso-plantar and lateral radiographs of both feet. Radiographic first MTPJ OA in the most severely affected foot was graded into four categories using a validated atlas. Differences in selected demographic and clinical factors were explored across the four radiographic severity subgroups using analysis of variance (ANOVA) and ordinal regression.
Results: Clinical and radiographic data were available from 517 participants, categorised as having no ($n = 105$), mild ($n = 228$), moderate ($n = 122$) or severe ($n = 62$) first MTPJ OA. Increased radiographic severity was associated with older age and lower educational attainment. After adjusting for age, increased radiographic first MTPJ OA severity was significantly associated with an increased prevalence of dorsal hallux and first MTPJ pain, hallux valgus, first interphalangeal joint (IPJ) hyperextension, keratotic lesions on the dorsal aspect of the hallux and first MTPJ, decreased first MTPJ dorsiflexion, ankle/subtalar joint eversion and ankle joint dorsiflexion range of motion, and a trend towards a more pronated foot posture.
Conclusions: This cross-sectional study has identified several dose–response associations between radiographic severity of first MTPJ OA and a range of demographic and clinical factors. These findings highlight the progressive nature of first MTPJ OA and provide insights into the spectrum of presentation of the condition in clinical practice.

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Introduction

Symptomatic osteoarthritis (OA) causes significant disability in 10% of people aged over 60 years[1]. Although it is the least-studied joint complex commonly affected by OA, foot involvement is also common[2]. The most frequently affected region of the foot is the first metatarsophalangeal joint (first MTPJ), with radiographic changes observed in 20–48% of people aged 40 years and over[3,4]. Recently, the population prevalence of symptomatic radiographic first MTPJ OA was estimated to be approximately 8% in community-dwelling adults aged 50 years and over, with 72% of those affected reporting disabling foot symptoms[5]. Symptomatic first MTPJ OA has been shown to be associated with lower scores on the physical and social function subscales of the Short Form 36 questionnaire, indicating that the condition has a significant impact on general health-related quality of life[6].

First MTPJ OA is frequently observed in conjunction with hallux valgus[7] and hallux rigidus[8], and is widely considered to be a progressive condition resulting in osseous and soft tissue changes, crepitus and reduced range of motion[9–12]. Although no longitudinal studies have been undertaken to confirm this, there have been

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several attempts to classify the severity of first MTPJ OA for the purpose of treatment planning, using clinical and/or radiographic criteria. A recent systematic review identified 18 such grading scales, however none were derived from representative population samples that are free from referral bias that can occur in studies based in secondary care[13]. Understanding the relationship between radiographic severity of first MTPJ OA and demographic and clinical characteristics would provide useful insights into both the patterns of presentation of the condition in clinical practice, and the underlying physiological and biomechanical mechanisms that may be responsible for disease progression.

Therefore, the objective of this study was to examine the demographic and clinical factors associated with radiographic severity of first MTPJ OA in people aged 50 years and over who participated in a population-based prospective observational cohort study[14].

Methods

Study design

This paper utilises baseline data from the Clinical Assessment Study of the Foot (CASF)[14]. 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. Ethical approval was obtained from Coventry Research Ethics Committee (reference number: 10/H1210/5).

Health survey questionnaire

All eligible participants were mailed a Health Survey questionnaire that gathered information on aspects of general health including the Short Form-12 (SF-12)[15], foot pain, and demographic and socio-economic characteristics (age, gender, education 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[16]; number of days with foot pain in the past 12 months; and the Manchester Foot Pain and Disability Index (MFPDI)[17]. 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)[18]. Four areas of interest were documented: the dorsal or plantar aspects of the hallux (i.e., including and distal to the interphalangeal joint [IPJ]) and the dorsal or plantar aspects of the first MTPJ[19]. The presence and severity of hallux valgus was also documented using a validated line-drawing instrument. The instrument consists of five drawings for each foot, with each drawing illustrating a sequential increase in the hallux valgus angle of 15°[20]. Participants were asked to select for each foot the drawing which best depicted the severity of hallux valgus in that foot. The score was dichotomised for each foot by classifying the three most severe grades as present and the two least severe grades as absent[21]. 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 clinic where radiographs and clinical assessments were undertaken.

Radiographic assessment

Weight bearing dorso-plantar and lateral radiographs were obtained from both feet according to a defined standardised protocol[22] and were scored by a single reader (MM), blind to all other participant information. Osteophytes and joint space narrowing at the first MTPJ from the dorso-plantar and lateral radiographs were each scored (zero to three) according to a validated atlas and classification system[22]. The foot with the most severe radiographic first MTPJ OA was selected as the index foot. In the case of both feet having the same radiographic severity rating, data from a randomly selected left or right foot were used. Participants were divided into four mutually exclusive radiographic severity groups using the following case definitions: (1) none = no radiographic evidence of OA in either first MTPJ; (2) mild = at least one score of one for either osteophytes or joint space narrowing in either the dorso-plantar or lateral views in either first MTPJ (but no scores above one); (3) moderate = at least one score of two for either osteophytes or joint space narrowing in either the dorso-plantar or lateral views in either first MTPJ (but no scores above two), and (iv) severe = at least one score of three for either osteophytes or joint space narrowing in either the dorso-plantar or lateral views in either first MTPJ. To establish intra-rater and inter-rater reliability for the severity of first MTPJ OA, 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 quadratic weighted $\kappa = 0.78$; mean % exact agreement = 82.1%; mean % close agreement = 99.2%), whereas inter-rater reliability was moderate (mean quadratic weighted $\kappa = 0.54$; mean % exact agreement = 60.6%; mean % close agreement = 96.1%).

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).

Clinical assessment

Participants underwent a standardised clinical interview and physical examination conducted by therapists blinded to the findings from radiography, postal questionnaires and medical records. In addition to anthropometric measurements (height, weight and body mass index (BMI)), a detailed clinical assessment of the foot and ankle was undertaken to document foot posture, range of motion, deformity and keratotic lesions. Foot posture was assessed with the participant standing in a relaxed bipedal position using Foot Posture Index (FPI), Arch Index (AI) and navicular height (NH) measurements. The FPI is a multidimensional visual observation tool consisting of six criteria scored on a 5-point scale (range, −2 to +2), and the summed score provides an index of the degree of the pronated/supinated posture of the foot, with higher scores representing a more pronated (flatter) foot[23]. Scores of the six criteria were converted to Rasch-transformed logit values[24]. The AI was calculated from static carbon paper footprints as the ratio of area of the middle third of the footprint to the entire footprint area ignoring the toes. The flatter the foot, the higher the AI[25]. To determine NH, the most medial prominence of the navicular tuberosity was palpated and marked with a marking pen. A ruler was then used to measure the height of the navicular tuberosity from the ground, and this value divided by the total length of the foot. The lower the NH, the flatter the foot[26]. Each of these measures of foot posture have been shown to have good reliability and to reflect the underlying skeletal alignment of the medial longitudinal arch[26].

Range of motion was assessed at the first MTPJ, subtalar joint and ankle joint. First MTPJ dorsiflexion range of motion was measured using a goniometer as the maximum angle at which the hallux could not be passively moved into further extension in a non-weight bearing position. The minimum amount of first MTPJ dorsiflexion required for normal gait is considered to be 65°[27]. Passive ankle/subtalar joint inversion and eversion were measured with the participant supine, using a flexible goniometer as described by Menadue *et al.*[28] Ankle joint dorsiflexion was measured using the weight bearing lunge test, with the knee

flexed[29] and extended[30]. The reliability of each of these tests has been reported previously[27–31]. Hyperextension of the first IPJ and keratotic lesions on the dorsal and plantar aspects of the first IPJ and first MTPJ were also documented as present or absent from clinical observations, and in combination with the hallux valgus assessment were categorised as 'deformity and keratotic lesions'.

Statistical analysis

All analyses were conducted using SPSS Version 21 (IBM Corporation, Armonk, NY). Differences in the frequencies of categorical variables across the four mutually exclusive radiographic severity groups (none, mild, moderate or severe) were analysed using ordinal regression, adjusting for age. The assumption of proportional odds was met for all variables. Ordinal regression parameter estimates were exponentiated to produce odds ratios (ORs) which are presented with 95% confidence intervals (CIs) for each of the age-adjusted ordinal regression models. Differences in the continuously-scored variables across the four groups were analysed using one-way analysis of variance (ANOVA), adjusting for age. ANOVA assumptions were met for all variables. *F*-values and associated *P*-values together with group means and 95% CIs are presented for each of the age-adjusted models, and categorical data are presented as *n* (%).

Results

Study population

As previously reported, a total of 5109 completed Health Survey questionnaires were received (adjusted response 56%)[5].Of these, 1635 individuals who reported pain in and around the foot in the past 12 months and provided written consent to further contact were invited to the research assessment clinic and 560 attended. 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. Complete clinical and radiographic data were available from 517 participants (287 women and 230 men, mean [SD] age 64.8 [8.4] years), who were categorised as having no first MTPJ OA (*n* = 105) or mild (*n* = 228), moderate (*n* = 122) or severe (*n* = 62) first MTPJ OA.

Factors associated with radiographic severity of first MTPJ OA

Table I reports the participant characteristics for each of the first MTPJ OA radiographic severity subgroups. Radiographic severity was significantly associated with increased age and lower educational attainment. Table II reports foot pain, posture, range of motion, deformity and keratotic lesion data for each of the first MTPJ OA radiographic severity subgroups. After adjusting for age, increased radiographic first MTPJ OA severity was significantly associated with an increased prevalence of dorsal hallux pain, dorsal first MTPJ pain, hallux valgus, first IPJ hyperextension,

keratotic lesions on the dorsal aspect of the hallux, keratotic lesions on the dorsal aspect of the first MTPJ, decreased first MTPJ dorsiflexion, ankle/subtalar joint eversion and ankle dorsiflexion with the knee flexed, and a trend towards more pronated foot posture according to FPI, AI and NH measurements.

Discussion

The objective of this study was to examine the demographic and clinical factors associated with increasing radiographic severity of first metatarsophalangeal joint OA (first MTPJ OA). Demographic factors were not significantly associated with radiographic severity, with the exception of increased age and lower educational attainment. The observed association with age is consistent with the well documented relationship between age and OA in general[32], and OA specifically affecting the first MTPJ[3,5]. Similarly, lower educational attainment has previously been shown to be a risk factor for knee OA[33] and foot pain severity associated with first MTPJ OA[34], as individuals with limited education are more likely have chronic diseases, to smoke, to have higher BMI, and to work in more physically demanding occupations[35].

We also found that as radiographic severity increased, there was a corresponding increase in the occurrence of dorsal hallux and first MTPJ pain, presence of hallux valgus and IPJ hyperextension deformities, and presence of keratotic lesions affecting the dorsal aspect of the first IPJ and MTPJ. A more pronated foot posture, decreased ankle/subtalar joint eversion and ankle joint dorsiflexion range of motion and a clear dose–response relationship between decreased first MTPJ dorsiflexion range of motion and increasing radiographic severity of first MTPJ OA were also observed. These cross-sectional observations of first MTPJ OA of increasing severity are consistent with a longitudinal pattern of progression and suggest that the degenerative changes that take place within the joint have implications for surrounding structures and the overall biomechanical function of the foot.

The relationship between radiographic OA and symptoms has been extensively investigated at the knee[36] and hand[37], however very little is known about this association in foot joints. We found that as radiographic severity of first MTPJ OA increased, there was a corresponding increased prevalence of pain in both the hallux and first MTPJ, suggesting some degree of concordance between radiographic changes and symptoms. Although significant associations between radiographic severity and foot pain at specific sites was observed, no differences in scores on the MFPDI subscales or foot pain severity were found. This finding, however, needs to be considered in the context of the study design. Participants who attended the clinical assessment were all required to have reported foot pain in the baseline health questionnaire, so it is likely that many participants' responses to the MFPDI and foot pain severity question related to any pain in their feet, not specifically pain affecting the great toe. Similarly, the lack of association between radiographic severity and SF-12 component scores is likely to reflect the influence of pain and impaired function elsewhere in the

Table I
Participant characteristics for each of the first MTPJ OA radiographic severity subgroups. Values are mean (95% CI) unless otherwise noted

	None (*n* = 105)	Mild (*n* = 228)	Moderate (*n* = 122)	Severe (*n* = 62)	Significance*
Age, years	62.2 (60.5, 63.9)	64.9 (63.9, 66.0)	65.4 (64.0, 66.9)	68.0 (66.1, 70.0)	F_3 = 6.8, *P* < 0.001
Female, *n* (%)	59 (56)	133 (58)	66 (54)	29 (47)	1.2 (0.9, 1.7)
Height, m	1.63 (1.61, 1.65)	1.65 (1.63, 1.66)	1.64 (1.63, 1.66)	1.65 (1.63, 1.68)	F_3 = 0.8, *P* = 0.477
Weight, kg	78.8 (75.6, 82.0)	83.3 (81.1, 85.4)	82.8 (79.5, 86.1)	83.0 (78.5, 87.6)	F_3 = 1.7, *P* = 0.158
BMI, kg/m²	29.5 (28.4, 30.6)	30.7 (30.0, 31.5)	30.6 (29.6, 31.7)	30.3 (28.9, 31.7)	F_3 = 1.1, *P* = 0.347
Completed higher education, *n* (%)	36 (35)	65 (29)	20 (17)	12 (20)	0.5 (0.4, 0.8)
Managerial/administrative/professional occupation, *n* (%)	34 (32)	61 (27)	26 (21)	14 (23)	0.7 (0.5, 1.0)

* F statistic and P values shown for ANOVAs (continuous variables), and ORs (95% CIs) shown for ordinal regression (categorical variables). BMI, body mass index.

Table II
Foot and ankle characteristics according to radiographic severity of first^t MTPJ OA. Values are mean (95% CI) unless otherwise noted

	None (n = 105)	Mild (n = 228)	Moderate (n = 122)	Severe (n = 62)	Significance*
Foot pain and health status					
Hallux pain – dorsal, n (%)	22 (21)	58 (25)	30 (25)	35 (44)	2.1 (1.4, 2.9)
Hallux pain – plantar, n (%)	10 (10)	32 (14)	11 (9)	6 (10)	1.2 (0.7, 1.9)
First MTPJ pain – dorsal, n (%)	21 (20)	50 (22)	38 (31)	28 (45)	2.2 (1.5, 3.1)
First MTPJ pain – plantar, n (%)	23 (22)	57 (25)	24 (20)	9 (15)	1.2 (0.8, 1.8)
MFPDI pain subscale	−0.1 (−0.4, 0.2)	−0.2 (−0.4, 0.0)	−0.3 (−0.6, 0.0)	−0.4 (−0.8, 0.0)	$F_3 = 0.7, P = 0.562$
MFPDI function subscale	−0.7 (−1.1, −0.3)	−0.6 (−0.9, −0.3)	−0.6 (−1.0, −0.3)	−1.0 (−1.5, −0.5)	$F_3 = 0.7, P = 0.570$
Foot pain severity (0–10 scale)	5.4 (4.9, 5.9)	5.3 (4.9, 5.6)	5.2 (4.7, 5.6)	5.3 (4.6, 5.9)	$F_3 = 0.2, P = 0.884$
SF-12 physical component	38.1 (35.7, 40.5)	37.9 (36.2, 39.5)	38.4 (36.2, 40.6)	39.8 (36.7, 42.9)	$F_3 = 0.4, P = 0.764$
SF-12 mental component	48.4 (46.2, 50.5)	48.6 (47.1, 50.1)	50.6 (48.6, 52.7)	48.7 (45.9, 51.5)	$F_3 = 1.0, P = 0.376$
Foot posture					
FPI	2.1 (1.7, 2.4)	2.5 (2.3, 2.8)	2.9 (2.6, 3.2)	2.3 (1.9, 2.8)	$F_3 = 3.9, P = 0.009$
AI	0.237 (0.227, 0.247)	0.241 (0.234, 0.248)	0.258 (0.248, 0.267)	0.238 (0.225, 0.251)	$F_3 = 4.0, P = 0.008$
NH adjusted for foot length	0.173 (0.167, 0.179)	0.174 (0.170, 0.178)	0.165 (0.159, 0.170)	0.177 (0.170, 0.185)	$F_3 = 3.4, P = 0.018$
Range of motion					
First MTPJ dorsiflexion, degrees	74.0 (70.9, 77.2)	64.3 (62.2, 66.5)	59.0 (56.1, 61.8)	42.0 (37.9, 46.2)	$F_3 = 50.7, P < 0.001$
Ankle/subtalar joint inversion, degrees	26.7 (25.2, 28.2)	26.4 (25.4, 27.5)	26.7 (25.4, 28.1)	27.2 (25.5, 29.1)	$F_3 = 0.2, P = 0.928$
Ankle/subtalar joint eversion, degrees	12.8 (11.7, 13.8)	12.2 (11.5, 12.9)	11.1 (10.1, 12.0)	11.0 (9.6, 12.3)	$F_3 = 2.6, P = 0.049$
Ankle joint dorsiflexion – knee extended, degrees	64.0 (62.3, 65.7)	62.9 (61.7, 64.0)	62.4 (60.8, 63.9)	61.0 (58.8, 63.2)	$F_3 = 1.6, P = 0.201$
Ankle joint dorsiflexion – knee flexed, degrees	53.3 (51.6, 54.9)	53.5 (52.4, 54.6)	51.7 (50.2, 53.2)	50.5 (48.3, 52.6)	$F_3 = 2.8, P = 0.041$
Deformity and keratotic lesions					
Hallux valgus, n (%)	21 (20)	68 (30)	47 (39)	27 (44)	1.8 (1.3, 2.5)
First IPJ hyperextension, n (%)	10 (10)	24 (11)	24 (20)	12 (19)	1.9 (1.2, 3.0)
Keratotic lesion on dorsal aspect hallux, n (%)	11 (11)	43 (19)	30 (25)	12 (19)	1.5 (1.0, 2.3)
Keratotic lesion on dorsal aspect first MTPJ, n (%)	8 (8)	44 (19)	34 (28)	22 (36)	2.4 (1.6, 3.6)

* F statistic and P values shown for ANOVAs (continuous variables), and ORs (95% CIs) shown for ordinal regression (categorical variables), adjusted for age. MTPJ, metatarsophalangeal joint; MFPDI, Manchester Foot Pain Disability Index; SF, Short Form; FPI, Foot Posture Index; AI, Arch Index; NH, navicular height; IPJ, interphalangeal joint.

body. A similar phenomenon has been reported at the hand, where radiographic OA is weakly associated with general measures of hand function, but strongly associated with tenderness in the same joint[38]. This suggests that structure-pain associations in the hand and foot are most appropriately investigated at individual joint level.

All three measures of foot posture showed a significant overall trend towards a flatter/more pronated foot with increasing radiographic severity of first MTPJ. However, the relationship was not linear, with the highest values observed in the moderate radiographic severity group. This is likely due to the smaller sample size in the severe group. The contribution of foot posture to the development of first MTPJ OA is unclear. Although several authors have proposed that pronated foot posture may predispose to first MTPJ OA due to increased plantar fascial tension limiting the ability of the hallux to dorsiflex, two cross-sectional studies have reported no difference in radiographic arch height measurements between individuals with and without first MTPJ OA[39]. The only prospective study so far undertaken found that individuals with rearfoot valgus of at least 5° were 23% more likely to subsequently develop first MTPJ OA[40]. The planned follow-up of our cohort will help clarify whether pronated foot posture is indeed a risk factor for the onset and/or progression of first MTPJ OA.

With increasing radiographic severity, there was a reduction in eversion range of motion at the ankle/subtalar joint, dorsiflexion of the ankle joint with the knee flexed, and dorsiflexion of the first MTPJ. Although the differences between radiographic severity groups for ankle and ankle/subtalar range of motion were small, the linear, dose–response relationship we observed between radiographic severity and first MTPJ dorsiflexion range of motion is an important finding which suggests that degenerative changes within the first MTPJ have a direct impact on the biomechanical function of the foot. First MTPJ dorsiflexion plays an important role in gait, allowing the centre of mass to progress forwards over the foot during propulsion[41]. In the absence of sufficient first MTPJ dorsiflexion, people with first MTPJ OA will often adopt an apropulsive walking pattern with a shortened step length[42]. The

necessary amount of dorsiflexion required for normal gait is not well established, however a minimum cut-off of 65° is commonly reported[27]. In the current study, mean first MTPJ dorsiflexion range of motion was less than 65° in the mild radiographic severity group, which is consistent with a cut-off score (64°) used previously as a diagnostic predictor of radiographic first MTPJ OA, and then decreased substantially further in the moderate and severe groups[12].

In addition to decreased first MTPJ range of motion, increased radiographic severity was also associated with hallux valgus, first IPJ hyperextension deformity and keratotic lesions on the dorsal aspect of the hallux and first MTPJ. The association with hallux valgus is consistent with D'Arcangelo et al.,[7] who reported a strong linear association between radiographic first MTPJ OA and increasing severity of hallux valgus in older people. These findings suggest that OA affecting the first MTPJ may develop in conjunction with two different, but related clinical conditions: hallux valgus, in which the hallux is laterally deviated, and hallux rigidus, in which the hallux remains neutrally aligned in the transverse plane[43]. The association between radiographic severity and first IPJ hyperextension is consistent with the biomechanical model of hallux rigidus, in which the first IPJ hyperextends in order to compensate for the lack of first MTPJ dorsiflexion during propulsion[11]. Due to the dorsal prominence of both the first MTPJ (resulting from the dorsal exostosis) and hallux (resulting from first IPJ hyperextension), the formation of keratotic lesions at these sites in response to pressure from footwear is a common clinical finding[9]. This was confirmed in our results, with a significant association observed between radiographic first MTPJ OA severity and presence of keratotic lesions on the dorsal aspect of the hallux and first MTPJ, accompanied by an increased prevalence of pain at these sites.

Strengths of our study include the use of a population-based sample, a validated atlas and scoring system to grade radiographic features of OA, and a rich source of self-reported and clinical assessment data. Previously published grading scales for this condition have not been widely adopted and none have been formally evaluated for validity or reliability[13]. However, several

limitations of our study are worthy of acknowledgement. Firstly, the overall response to the postal Health Survey questionnaire from which the clinical sample was derived was lower than expected compared to our previous population surveys. However, responders to the health survey questionnaire did not appear to differ greatly from the mailed population[5]. Secondly, there was some potential for misclassification of participants into the radiographic severity categories due to the moderate reliability of the foot atlas. Finally, our data are cross-sectional, so we cannot confirm that the patterns observed across the radiographic severity subgroups are indicative of the trajectory of disease progression over time. However, the planned follow-up of this cohort will allow us to address this question in further detail.

In summary, the findings of this study demonstrate that there is a continuum of clinical presentations of first MTPJ OA related to radiographic severity. Specifically, as radiographic severity increased, there was an increased prevalence of dorsal toe pain, hallux valgus and IPJ hyperextension deformity, keratotic lesions affecting the dorsum of the toe, pronated foot posture and a decrease in first MTPJ dorsiflexion, ankle/subtalar joint eversion and ankle joint dorsiflexion range of motion. The dose–response nature of several of these associations suggests that first MTPJ OA may be a progressive disorder which has an accumulative impact on surrounding structures and the load-bearing function of the foot.

Contributions

ER and GP conceived the study. ER, MJT, MM, HLM, HBM and GP designed the study. MJT, MM and HLM undertook acquisition of data. Analysis was undertaken by HBM, TR and ET. HBM drafted the manuscript. All authors interpreted data, revised the article critically for important intellectual content, and approved the final version of the manuscript. HBM (h.menz@latrobe.edu.au) and GP (g.m.peat@keele.ac.uk) take responsibility for the integrity of the work as a whole, from inception to finished article.

Competing interest statement

The authors have no completing interests to declare.

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