Foot and Ankle Surgery 20 (2014) 52–56

Contents lists available at ScienceDirect

Foot and Ankle Surgery

journal homepage: www.elsevier.com/locate/fas

Bone mass and anthropometry in patients with osteoarthritis of the foot and ankle

M.C. Cöster [a,b,*], B.E. Rosengren [a], C. Karlsson [a], T. von Schevelow [a], H. Magnusson [a], L. Brudin [b], M.K. Karlsson [a]

[a] Department of Orthopedics and Clinical Sciences, Lund University, Skåne University Hospital, Malmö
[b] Department of Orthopedics, Kalmar Hospital, Kalmar, Sweden

ARTICLE INFO

Article history:
Received 25 July 2013
Received in revised form 10 September 2013
Accepted 14 October 2013

Keywords:
Anthropometry
BMD
Bone mineral density
BMI
Bone size
Osteoarthritis
Foot
Ankle

ABSTRACT

Background: Patients with hip and knee osteoarthritis (OA) have high bone mineral density (BMD) and high BMI. If the same accounts for patients with foot or ankle OA is unknown.
Methods: We measured BMD and femoral neck (FN) width by dual-energy X-ray absorptiometry in 42 women and 19 men with idiopathic OA in the foot or ankle, and in 99 women and 82 men as controls.
Results: Women with OA had significant higher BMI than controls. Women with OA had higher BMI-adjusted BMD ($p < 0.01$) and smaller BMI-adjusted FN width ($p < 0.01$) than controls. Men with OA had higher BMI adjusted-BMD ($p < 0.05$) and smaller BMI-adjusted FN width ($p < 0.01$) than controls.
Conclusion: Patients with OA in the foot or ankle have higher BMD and smaller bone size than being expected by their BMI. This phenotype may provide unfavourable forces across the joint and is hypothetically important for development of OA.

1. Introduction

Idiopathic osteoarthritis (OA) can be found virtually in all joints, including the hip, knee, spine, ankle, and foot [1,2]. Heredity, age, gender, level of sex hormones, ethnicity, and obesity are risk factors identified for OA [3], but local unfavorable biomechanical factors, such as monotonous repeated loads, instability, repeated minor injuries, and joint deformity, may also be included in the development of OA [4]. The foot and ankle, like the hip and knee, carry most of total body weight of the individual. Even though the cartilage is thinner in the ankle than the hip and knee, OA is more rarely found in the ankle [4–6], actually even less than in the hand, a region not exposed to the body weight [1,7]. These inconsistent findings have raised the hypothesis that idiopathic OA may be a non-homogeneous disease triggered by different pathophysiological mechanisms in different joints [3].

OA does not only affect the cartilage but also the skeleton, and both skeletal cysts, subchondral sclerosis, and osteophytes are commonly found with OA [8]. OA has also been associated with a phenotype with overall high bone mineral density (BMD) [9,10], a finding that has raised the hypothesis that high BMD may lead to a stiff skeleton with low load-absorptive ability, directing any mechanical load to the cartilage [3,11]. Overweight is a risk factor for OA, at least in the hip and knee [3,12] and a higher weight transfers a higher load to the joint cartilage [13]. Hypothetically, the risk would then be even greater if a high body weight was associated with a small skeleton, as pressure equals force/area (N/m^2). No study has however evaluated whether OA in the foot or ankle is associated with high body mass index (BMI), high BMD and relative to weight a small bone size. Our primary aim with this cross-sectional hypothesis generating study was to evaluate whether patients with idiopathic OA in the ankle or foot have higher BMD, smaller bone size, and higher BMI than the general population and, if so, this would depend on differences in lifestyle or anthropometry.

2. Material and methods

We included 61 patients who were collected when being referred to our clinic for decision making regarding surgery due to radiographic and clinical idiopathic OA of the foot or ankle and without clinical symptoms of OA in other joints. However, no radiographic evaluation was done in other joints. All participants were volunteers, Caucasians from the city of Malmö in southern

* Corresponding author at: Department of Clinical Sciences and Orthopedics, Skåne University Hospital in Malmö, S- 20522 Malmö, Sweden.
Tel.: +46 70 5851478; fax: +46 40336200.
E-mail address: maria.coster@med.lu.se (M.C. Cöster).

1268-7731/$ – see front matter
http://dx.doi.org/10.1016/j.fas.2013.10.008

Sweden and all had disabling pain from the affected joints as well as typical clinical and radiographic features of foot or ankle OA. No exclusion criteria were used. There were 42 women and 19 men with a median age of 64 years (range 42–87), all classified with OA grade 3 or 4 according to Kellgren and Lawrence [14]. Thirteen of the patients had ankle osteoarthritis, 8 arthritis in the hindfoot, 3 in the midfoot and 37 in the forefoot. As controls we included 181 individuals within the same age range and living in the same region without foot or ankle OA [15]. All participants answered a non-validated questionnaire regarding lifestyle factors. None of the participants had diseases or used steroids or other medication that could affect the bone metabolism.

Body weight and body height were measured by standard equipment and BMI calculated as weight/height squared (kg/m^2). BMD (g/cm^2) was measured by dual X-ray absorptiometry (DXA) (Lunar DPX-L® 1.3z, Lunar Corporation, Madison, Wisconsin, USA) in total body (TB), leg, and arm by a total body scan, first to fourth lumbar vertebra (L1–4) by a lumbar spine scan, and femoral neck (FN) by a hip scan. The FN width, a measurement often used as an estimate of bone size, was estimated from the anterior-posterior hip scan [16–19]. Total body lean mass and total body fat mass were evaluated from the TB scan. Daily calibration of the apparatus was done with a Lunar® phantom. The anthropometry measurements, the DXA measurements and the DXA analyses were conducted by two research technicians in our laboratory. The coefficient of variation (CV) after repositioning in 14 individuals was 0.4–3.0% for BMD depending on the measured region, for FN width 1.5%; total body lean mass 1.5% and total body fat mass 3.7%. Informed written consent was obtained before study start. The study was approved by the Ethics Committee of Lund University.

3. Statistics

Statistical calculations were done with Statistica®, 7.1 (StatSoft, Tulsa, OK, USA). Data are presented as numbers with proportions (%), means ± standard deviations (SD) or as means with 95% confidence intervals (95% CI). Group differences are evaluated by Student's *t*-test and chi-square test. No Bonferoni correction was applied. ANCOVA was used in two different models adjusting for in model 1 significant group differences found in lifestyle factors and in model 2 for body size estimated through BMI. Odds ratios (OR) were calculated by logistic regression to estimate differences in the risk of having OA with each higher standard deviation (SD) total body BMD. Area under curve (AUC) was calculated from the receiver operating characteristic (ROC) curve for total body BMD.

4. Results

Age and lifestyle stratified by gender in the OA and the control groups are presented in Table 1. Women with foot or ankle OA had significantly higher BMI (mean difference 3.8 kg/m^2, 95% CI 2.4, 5.3; $p < 0.001$) and higher BMD (mean difference TB-BMD 0.10 g/cm^2, 95% CI 0.06, 0.13; $p < 0.001$) compared to women in the control cohort, while there was no difference in FN width (mean difference 0.7 mm, 95% CI–0.4, 1.8; $p = 0.08$) (Table 2).

Men with foot or ankle OA had higher BMD (mean difference TB-BMD 0.07 g/cm^2, 95% CI 0.02, 0.12; $p = 0.01$) and smaller FN width (mean difference 2.2 mm, 95% CI 0.5, 3.9; $p = 0.005$) but not significantly higher BMI (mean difference 1.6 kg/m^2, 95% CI 0.0, 3.2; $p = 0.10$) than men in the control cohort (Table 2).

After in model 1 adjustment for group differences in lifestyle factors, women with foot or ankle OA still had higher BMD (TB-BMD; $p < 0.001$) and men had smaller bone width ($p = 0.02$) than controls while the BMD difference in men disappeared (TB-BMD; $p = 0.07$)

After in model 2 adjustment for group differences in body size (BMI), both women and men with foot or ankle OA had higher BMD than controls (women TB-BMD; $p = 0.003$ and men TB-BMD; $p < 0.05$), as well as a smaller FN width (women $p = 0.007$; men $p = 0.007$) (Table 2).

Each SD higher total body BMD was in women associated with an OR of 2.9 (95% CI 1.9, 4.5) for having OA, while the corresponding OR in men was 2.1 (95% CI 1.2, 3.6). The ROC curves revealed that BMD discriminated individuals with foot or ankle OA from controls with an AUC of mean 0.75 (95% CI 0.68, 0.82) (Fig. 1).

5. Discussion

This is the first report that infers women and men with OA in the foot or ankle have larger body size adjusted BMD and smaller body size adjusted bone size than the general population. A phenotype with a body size adjusted high BMD usually result in high bone stiffness with less mechanical force absorptive ability causing a greater impact on the cartilage. In addition a body size adjusted small skeletal and size would result in a high load per area and then possibly also a high load across the joint cartilage. If also, as in the women, there is a high BMI the load would be even greater than in individuals with normal BMI. We can in this study not state that the cartilage load actually is higher than normal, since no such measurements were done, but since a phenotype with high BMD, high BMI and small bone size provide a hypothetical base for high

Table 1
Age and lifestyle in 42 women and 19 men with osteoarthritis of the ankle or foot joints, and in 99 women and 82 men in a control cohort. Data are presented as mean values (SD) for continuous parameters and number with proportion (%) for categorical parameters unless otherwise stated. Significant group differences are highlighted in bold. Evaluations of group differences are done by chi-2 test (smoking), Fisher's exact test (all other categorical parameters) and Mann-Whitney's *U*-test (coffee consumption).

Parameter	Women			Men		
	Subjects with osteoarthritis	Controls	*p*-value for difference	Subjects with osteoarthritis	Controls	*p*-value for difference
Number	42	99	–	19	82	–
Age (median; range)	62 (42–83)	63 (41–82)	–	65 (49-–87)	66 (49-87)	–
Ongoing physical activity	30 (71%)	33 (35%)	<0.001	15 (79%)	29 (41%)	0.004
Blue collar worker	22 (52%)	54 (57%)	0.71	8 (42%)	46 (66%)	0.07
Smokers (never/ex/smokers; %)	39%/24%/37%	5%/77%/18%	<0.001	26%/58%/16%	3%/72%/25%	0.01
Alcohol intake	38 (93%)	71 (85%)	0.26	17 (89.5%)	63 (92.6%)	0.64
Coffee (cups/day)	3 (2)	4 (3)	<0.001	3.6 (3.3)	3.9 (2.8)	0.003
Any food restriction	5 (12%)	0 (0%)	0.002	0 (0.0%)	1 (1.4%)	1.00
Diabetes	5 (12%)	1 (1%)	0.009	2 (10.5%)	4 (4.9%)	0.31
History of fracture	20 (48%)	25 (25%)	0.01	6 (32%)	15 (18%)	0.22
Diseases other than diabetes	34 (81%)	49 (49%)	<0.001	11 (58%)	48 (59%)	1.00
Ongoing medication	29 (71%)	49 (52%)	0.06	9 (56%)	39 (56%)	1.00