

Workplace policies and prevalence of knee osteoarthritis: the Johnston County Osteoarthritis Project

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Objective: Previous studies on work and knee osteoarthritis (KOA) have been primarily focused on physical demands; very little is known about work-related organisational policies and KOA risks and outcomes. We examined the associations between workplace policies and KOA in a community-based population in the USA.

Methods: The associations between employment offering accommodations (switch to physically less demanding jobs; part-time work for people needing reduced time) and benefits policies (paid sick leave; disability payment) with KOA outcomes (knee symptoms; symptomatic KOA [sKOA]; asymptomatic radiographic KOA [rKOA]) were analysed in participants (n=1639) aged <65 years old and with completed employment histories and knee radiographs at baseline examination of the Johnston County Osteoarthritis Project. Multiple logistic regression models were used to estimate the prevalence odds ratios (ORs) of KOA associated with each workplace policy, adjusting for sociodemographic features, lifestyle factors, knee injuries, body mass index and other workplace characteristics. We used propensity score models to evaluate the differential selection in employment offering favourable policies and adjust for this potential bias accordingly.

Results: Individuals employed in workplaces offering better policies had significantly less knee symptoms. Lower sKOA prevalence was noted in workplaces offering job-switch accommodation (8% vs. 13%), paid sick leave (9% vs. 16%) and disability payment (8% vs. 16%) than their counterparts. In multivariable models, the difference in sKOA prevalence was statistically significant for paid sick leave (adjusted OR 0.58, 95% CI 0.37 to 0.91) and disability payment policies (adjusted OR 0.54, 95% CI 0.35 to 0.85). Even among those without overt knee-related symptoms, a similar pattern of negative association between workplace policies and rKOA was present and remained robust after propensity score adjustment.

Conclusion: The negative associations between KOA and workplace policies raise concerns about possible employment discrimination or beneficial effects of workplace policies. Longitudinal studies are needed to clarify the dynamic complexities of KOA risks and outcomes in relation to workplace policies.

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Studies on the interrelations of work and osteoarthritis (OA) remain an active area of research because of their profound implications for clinical practice and public policy. As indicated in recent reviews of epidemiological literature on the relationship between occupational factors and risks of knee OA (KOA),^{1,2} both case-control and prospective cohort studies have shown the positive associations between KOA and physical exposures in the workplace, and the strength of scientific evidence is moderate. Specifically, previous studies have shown that certain occupational activities (e.g., kneeling, squatting or climbing) increase the risk of KOA,^{3–6} presumably due to increased biomechanical loads on knee joints. However, most of the previous studies were primarily focused on individual-level attributes; very little data are available to examine the potential link between KOA and organisation-level workplace characteristics (e.g., workplace policies, employers' commitment), many of which play an important role in occupational health and safety.^{7,8}

The adverse health outcomes and substantial cost of arthritis demand a better understanding of the interrelationships between work and KOA because of the functional, psychological and social disabilities associated with KOA to affected individuals, families and society as a whole. Among employees with musculoskeletal conditions, approximately 25% lose their jobs within 2 years.⁹ The annual cost of arthritis-associated lost productivity was estimated to be US\$82 billion.¹⁰ Work environmental factors, such as the physical job demand, are known to be critical predictors for work disability in rheumatoid arthritis.¹¹

Several recent studies have examined the effectiveness of workplace interventions on occupational outcomes among patients with arthritis.^{9,12,13} Research on the interrelation of employment in workplaces with such policies and KOA outcomes will also have significant implications for regulation policy in the USA, since the provision of job accommodation to qualified employees is mandated by the Americans with Disabilities Act. However, except for studies concerning job-related accommodation, we uncovered no studies that examined KOA and a wide range of workplace policies (e.g., paid sick leave, disability payment, health plans).

Using the baseline data from an ongoing longitudinal study on OA, we aimed in the current study to: (1) describe the correlates of workplace policies; and (2) explore the cross-sectional associations of knee symptoms and KOA with workplace policies.

METHODS

Study population

The Johnston County Osteoarthritis Project is an ongoing population-based cohort study of OA among African-Americans and whites in a rural North Carolina (USA) county. This study

Abbreviations: BMI, body mass index; CI, confidence interval; HAQ, Health Assessment Questionnaire; KL, Kellgren-Lawrence; KOA, knee osteoarthritis; NHIS-DS, National Health Interview Survey Disability Supplement; OR, odds ratio; rKOA, radiographic knee osteoarthritis; sKOA, symptomatic knee osteoarthritis

was approved by the institutional review boards of the University of North Carolina School of Medicine and the Centers for Disease Control and Prevention. Details of the sampling design and study protocol have been described elsewhere.¹⁴ In brief, participants in the Johnston County Osteoarthritis Project were recruited through a probability sampling scheme of residential streets, with African-Americans oversampled. All civilian, non-institutionalised, African-American or white adults aged ≥ 45 years who were physically and mentally capable of completing two home interviews and a clinic visit were eligible. Each participant had two interviewer-administered home questionnaires and a limited clinical, functional and radiographical examination at a clinic. Written informed consent was obtained from all participants. The current analyses were based on data from the baseline examination completed between 1991 and 1997. Among 3187 participants at baseline, there were 2684 subjects with completed employment histories and radiographic KOA data, 66 with no knee X-ray data (34 not completing knee X-ray examinations and 32 with non-classifiable X-ray reports) and 437 subjects who were either self-employed, did not answer the occupational questionnaire or reported that they had "never been employed". Since we were concerned that some participants might have either left their workplaces for many years or differentially recalled their workplace characteristics with more errors, we further excluded those aged 65 years ($n = 1039$, 14 with total knee replacement), two with missing age information and four with total knee replacement prior to the study inception, leaving a total of 1639 study participants for the current analyses.

Outcome measures

We defined the presence of knee symptoms according to a participant's response to the question, "On most days, do you have symptoms, aching, or stiffness in your [right, left] knee?" Radiographic KOA (rKOA) was defined from weight-bearing bilateral anterior-posterior radiographs of the knees, according to the Kellgren-Lawrence (KL) grading system.¹⁵ This system grades OA presence and severity in five levels from 0 to 4. Knee radiographs were read for KL grading by the same bone and joint radiologist (JBR) without knowledge of participant's clinical status or occupational characteristics. Both the inter-rater reliability and intra-rater reliability were high (weighted statistics 0.86 and 0.89, respectively).¹⁴ Participants with a KL grade of 2 in at least one knee were classified as having rKOA.

Three KOA outcome variables were examined for their associations with workplace policies: (1) the presence of reported knee symptoms; (2) symptomatic KOA (sKOA), defined as rKOA plus the presence of knee symptoms in that same joint; and (3) asymptomatic rKOA, defined as the presence of rKOA without knee symptoms. The associations with asymptomatic rKOA were examined in only those without knee symptoms. Since subjective awareness of knee joint problems may determine either the employability or the selection of workplaces, the above operational definitions cover a spectrum of all ascertainable KOA outcomes with two extremes either the most (knee symptoms) or the least (asymptomatic rKOA) likely to be subject to the influence of selection bias by the presence of knee symptoms.

Workplace policies

Study participants, if employed at the time of interview, were asked the question, "Does your present employer offer any of the following privileges for people with medical problems or conditions?" These included policies for: (1) work accommodation: opportunities to switch to physically less demanding jobs; availability of part-time work for people needing reduced time;

and (2) benefits: paid sick leave; short-term or long-term disability payment. All study participants, regardless of their employment status at the time of interview, were asked the same question pertaining to their last employment. Considering the amount of time needed for the putative association between workplace characteristics and knee joint disorders to occur, we assumed the relevant exposures of interest as the availability of each indicated workplace policy either from the current employment or from the last job, whichever had lasted for more than 3 years by the time of X-ray examination.

Measures of covariates

Demographics and lifestyle factors

Personal and sociodemographic information relevant to the current study, including age, gender, race, marital status, parenthood ("Have you ever had any children?"), educational attainment, employment status ("Are you now employed?"), household income, home-ownership, lifestyle factors (e.g., smoking, alcohol consumption) and frequencies of physical activities (squatting, standing, lifting, and walking) at home (never = 0, seldom = 1, sometimes = 2, often = 3, always = 4), was collected by interviewer-administered questionnaires.

Work-related covariates

According to the codes listed in the 1990 Census of Population and Housing Alphabetical Index of Industries and Occupations,¹⁶ we classified the self-reported job titles into six broad industrial groups: "Managerial and Professional Specialty Occupations", "Technical, Sales and Administrative Support", "Service Occupations", "Farming, Forestry and Fishing", "Precision Production, Craft and Repair Occupations" and "Operators, Fabricators and Labourers". Participants were also asked to rate the frequencies of physical activities (squatting, standing, lifting heavy objects, and walking) at work, each assessed on a five-point scale (never = 0, seldom = 1, sometimes = 2, often = 3, always = 4). Occupational groups and self-reported frequencies of physical activities, assessed for both current and previous employment separately, were considered as surrogate measures of work-related physical demands that might confound the associations, if any, between workplace policies and KOA.

Clinical covariates

Anthropometric measures (height in cm and weight in kg) were obtained during the clinical examinations, and body mass index (BMI in kg/m^2) was calculated. The presence of 14 physician-diagnosed co-morbid conditions (asthma, chronic bronchitis, emphysema, hypertension, stroke, high blood cholesterol, heart attack, other heart trouble, circulatory problems, cancer, chronic gall bladder/liver trouble, other kidney, prostate, bladder trouble, diabetes or high blood glucose levels, gout and rheumatoid arthritis) was assessed by interviewer-administered questionnaires. We also used data on self-rated health (on a four-point scale [excellent, good, fair, poor] ascertained with the following question: "Compared to other people of your age, how would you say your health is?"), prior history of knee injury, self-reported hip symptoms, and physical function measures based on the Health Assessment Questionnaire (HAQ).¹⁷

Statistical analyses

In crude analyses, we examined the frequency of having knee symptoms, sKOA (in all eligible participants) or asymptomatic rKOA (in those without knee symptoms), according to employment in workplaces offering each index policy. Each of the four policies was considered separately. To assess whether the availabilities of these workplace policies tend to be clustered,

we constructed logistic models by regressing the availability of one workplace policy and using the others as predictors. We employed separate multiple logistic regression models to estimate the prevalence odds ratios (ORs) of knee symptoms, sKOA and asymptomatic rKOA respectively associated with each workplace policy, adjusting for potential confounders. The list of confounders, as determined a priori, included age (<55, 55–64 years old), sex, race (African-Americans or white), educational attainment (≤ 11 vs. 12 vs. >12 years), BMI (in quartiles), smoking (current vs. ex-smoker vs. never) and previous knee injury.

We further constructed propensity score models¹⁸ to evaluate the remaining bias, if any, of selecting participants into workplaces with better policies. In brief, we first created a binary variable indicating *not* being employed in workplaces offering the indicated policy, and then constructed the logistic regression model to estimate the probability (the propensity score) of *not* being in workplaces with indicated policy for each subject. In addition to the covariates described in the main analyses, the propensity score models also incorporated information on medical co-morbidities, self-rated health, presence of hip symptoms, physical activities at home, HAQ measures and other sociodemographic factors (e.g., marital status, parenthood). The estimated propensity score was then entered as a continuous covariate in the logistic regression model to evaluate its association with sKOA and asymptomatic rKOA. Additional sensitivity analyses were conducted to examine whether any observed associations were sensitive to the different choices of cut-off duration to define relevant workplace policies (3 years vs. 1, 2, 5, 10 or 15 years of completed employment prior to baseline examination) or any residual confounding by other socioeconomic conditions (e.g., household income, home ownership). The Hosmer–Lemeshow test was used to assess the goodness-of-fit.¹⁹ All of these statistical analyses were carried out by STATA 8.0 statistical package (STATA Corporation, College Station, TX, USA).

RESULTS

Table 1 shows the distributions of personal, clinical, and occupational characteristics of the full sample (N = 1639), and also of those with and without self-reported knee symptoms. As expected, subjects with knee symptoms were older and more likely to be female; they also had higher BMI, reported more prior knee injuries, had a higher prevalence of rKOA (all with $p < 0.001$) and had higher prevalence of either current or past smoking ($p = 0.05$). Those with knee symptoms also had fewer years of formal education; they were more likely to be either currently or previously employed in workplaces with more physical demands (frequent squatting, standing and lifting), but more likely to be unemployed at the time of baseline examination ($p < 0.001$) and less likely to be employed in workplaces with reduced-time accommodation ($p = 0.02$) and better benefits policies (both with $p < 0.001$). The duration of index employment was 13 (SD 11) years (13 (SD 10) for current jobs and for 13 (SD 11) last jobs).

Table 2 shows the availability of workplace policies in relation to sociodemographic features, individual lifestyle factors, other workplace characteristics and KOA-related prevalence. Statistically significant associations were found with age (for four policies; all with $p < 0.001$), education (for reduced-time policy, $p = 0.002$; for work benefits, both with $p < 0.001$), race/ethnicity (for work benefits, both with $p < 0.05$), frequencies of squatting (for disability payment, $p = 0.01$), standing (for four policies; all $p < 0.001$), lifting and walking (for reduced-time, $p = 0.03$), at work (for work benefits, both with $p < 0.01$), sex (for disability payment, $p = 0.02$) and occupational group (with working in farming, forestry and

fishing industries the least likely to offer better policies with $p < 0.001$ except job-switch). There were no discernible differences or consistent patterns in the distributions of available workplace policies with regard to race, BMI or smoking behaviours.

As shown in Table 3, the availabilities of these workplace policies tended to be clustered. Workplaces offering one benefit were very likely to offer the other, and workplaces providing one accommodation were likely to make the other also available. Also, there were appreciable positive correlations between accommodation and benefit policies.

Results of multiple logistic regression analyses for the associations of knee symptoms and sKOA with workplace policies are presented in Tables 4 and 5. There were statistically significant differences in the frequency of knee symptoms and sKOA across six occupational groups, and self-reported physical demands were often significantly associated with more knee symptoms or higher sKOA prevalence (e.g., knee symptoms and lifting; sKOA and walking) in the adjusted models (numerical data not shown). We observed statistically significant negative association between knee symptoms and employment in workplaces offering better policies (Table 4). Lower prevalence of knee symptoms was found in workplaces offering better policies (job-switch: 31% vs. 42%; reduced-time: 34% vs. 40%; paid sick-leave: 33% vs. 48%; disability payment: 32% vs. 48%). Except for reduced-time policy, such differences remained statistically significant in the multi-variable analyses (adjusted Model I), although the magnitude of negation association was changed.

Statistically significant lower sKOA prevalence was found in workplaces offering job-switch accommodation (8% vs. 13%), paid sick leave (9% vs. 16%) and disability payment (8% vs. 16%). In adjusted models (Table 5), for those in workplaces offering workplace benefits, the odds of having sKOA was approximately 42–46% lower than for those in workplaces without such these policies (for paid sick leave: adjusted OR 0.58, 95% CI 0.37 to 0.91, $p = 0.017$; for disability payment: adjusted OR 0.54, 95% CI 0.35 to 0.84, $p = 0.007$). These statistically significant associations were estimated from logistic regression models with reasonable goodness-of-fit to our empirical data, as suggested by the results of the Hosmer–Lemeshow tests (with one $p = 0.21$ and all the others $p > 0.52$).

Three propensity score models (with their areas under the receiver operating characteristic [ROC] curve equal to 0.75, 0.85 and 0.92, respectively) were constructed for the association of availability of disability pay with sKOA. Estimated propensity scores were all associated with increased prevalence of sKOA (with ORs 4.16, 2.53 and 3.10 associated with a one-unit increase in each estimated propensity score). However, adding each propensity score to the multiple logistic models did not alter the statistically significant negative association between disability payment policy and sKOA (estimated ORs 0.49 [95% CI 0.31 to 0.79], 0.54 [95% CI 0.32 to 0.91] and 0.55 [95% CI 0.30 to 1.00]).

We found a lower prevalence of asymptomatic rKOA in workplaces offering job-switch accommodation (13% vs. 17%), paid sick leave (13% vs. 18%) and disability payment (12% vs. 27%). In adjusted models (Table 5), the odds of having asymptomatic rKOA among those in workplaces offering disability payments were estimated to be approximately 50% lower than those in workplaces without such a policy (adjusted OR 0.48, 95% CI 0.29 to 0.77). The estimated propensity scores were all associated with increased prevalence of asymptomatic rKOA (ORs 2.65, 2.25 and 2.24 associated with one-unit increase in each estimated propensity score), but further adjustment for each propensity score in the multiple logistic models did not alter the statistically significant negative

Table 1 Personal, clinical and workplace characteristics of Johnston County Osteoarthritis Project sample (n = 1639), stratified by the presence of knee symptoms

	Current study population		Subjects with knee symptoms		Subjects without knee symptoms	
	n	Mean (SD) or %	n	Mean (SD) or %	n	Mean (SD) or %
Age (years)*	1639	55 (6)	650	55 (6)	986	54 (6)
Sex**						
Men	594	36%	204	31%	390	40%
Women	1045	64%	446	69%	596	60%
Race						
African-American	553	34%	233	36%	320	32%
White	1086	66%	417	64%	666	68%
Education***						
12 years	434	27%	231	36%	202	21%
>12 years	1203	73%	418	64%	783	79%
Smoking						
Current	414	25%	185	28%	228	23%
Ex-smoker	475	29%	178	28%	296	30%
Never	742	46%	284	44%	457	47%
BMI (kg/m ²)**	1636	29.5 (6.3)	650	31.3 (7.1)	983	28.3 (5.4)
History of knee injury**						
No	1353	84%	445	70%	907	93%
Yes	254	16%	186	30%	68	7%
Radiographic KOA grade**						
0	866	52%	276	42.5%	588	59.6%
1	420	25%	170	26.2%	249	25.2%
2	270	16%	136	20.9%	134	13.6%
3	66	4%	52	8.0%	14	1.4%
4	17	1%	16	2.5%	1	0.1%
Currently employed**						
No	685	42%	349	54%	334	34%
Yes	954	58%	301	46%	652	66%
Occupational factors†						
Physical demands***						
Squatting***	1364	1.8 (1.0)	518	1.9 (1.1)	844	1.8 (1.0)
Standing**	1364	2.3 (1.1)	518	2.5 (1.1)	844	2.2 (1.1)
Lifting**	1364	1.5 (1.1)	518	1.7 (1.1)	844	1.4 (1.1)
Walking	1357	2.8 (1.0)	517	2.8 (1.0)	838	2.7 (1.0)
Workplace policies†						
Job-switch**						
No	791	64%	330	70%	460	59%
Yes	454	36%	140	30%	314	41%
Reduced-time***						
No	761	61%	305	65%	455	59%
Yes	479	39%	161	35%	318	41%
Paid sick leave**						
No	391	29%	187	37%	203	24%
Yes	938	71%	312	63%	626	76%
Disability payment**						
No	484	37%	231	47%	252	31%
Yes	810	63%	261	53%	549	69%
Occupational categories**,†						
Technical, sales and administrative support	349	27%	112	23%	237	29%
Managerial and professional specialty	293	22%	89	18%	203	25%
Operators, fabricators and labourers	281	22%	120	24%	161	20%
Service occupation	204	16%	100	20%	104	13%
Precision production, craft and repair	147	11%	52	11%	94	12%
Farming, forestry and fishing occupation	30	2%	20	4%	10	1%
Prevalence of symptomatic KOA**,‡		12%		29%		–
Prevalence of rKOA**,††		22%		31%		15%

Values are n and mean and SD, or n and %. The total number of subjects summed up across each subcategory varies slightly because of missing data.

*p<0.05, **p<0.01, ***p<0.001 statistically significant different characteristics between participants with and without knee symptoms; †self-reported frequency measured on an ordinal scale (never = 0, seldom = 1, sometimes = 2, often = 3, always = 4) for current employment or last employment lasting for 3 years; ‡defined as having KL grade 2–4 plus symptoms in the same knee; ††rKOA defined as KL grade 2–4 vs. 0–1.

association between disability payment policy and asymptomatic rKOA (with estimated ORs 0.52 [95% CI 0.37 to 0.74], 0.55 [95% CI 0.37 to 0.82] and 0.53 [95% CI 0.34 to 0.83]).

Additional sensitivity analyses were carried out to evaluate if the above findings were sensitive to further adjustment for KL grade, employing different ways to temporally characterise workplace policies, or confounding by other socioeconomic conditions. We found that the negative association between workplace benefits and knee symptoms prevalence remained statistically significant even after additional adjustment for KL grade (Table 4, adjusted Model II). When occupational

variables were defined with different durations of employment, the estimated OR did not change substantially when using 1, 2 or 5 years as the cut-off (data not shown), and there was a tendency toward stronger negative associations as the employment duration increased (e.g., disability payment policy: adjusted OR 0.49 [95% CI 0.28 to 0.87] and OR 0.41 [95% CI 0.21 to 0.82] for choosing 10 and 15 years as the cut-off, respectively). Analyses restricted to the 1348 (82% of all eligible participants [1639]) who provided additional information on household income (four levels: <US\$10 000, US\$10 000–US\$20 000, US\$20 000–US\$35 000, >US\$35 000) and home-ownership showed the

Table 2 Availability of workplace policies in relation to personal, clinical and workplace characteristics†

	Job-switch (n = 1245)		Reduced-time (n = 1240)		Paid sick leave (n = 1329)		Disability payment (n = 1294)	
	Yes (n = 454) (SD)	No (n = 791) (SD)	Yes (n = 479) (SD)	No (n = 761) (SD)	Yes (n = 938) (SD)	No (n = 391) (SD)	Yes (n = 810) (SD)	No (n = 484) (SD)
Age (years)	54 (6*)	55 (6)	54 (6*)	55 (6)	54 (6*)	56 (6)	54 (6*)	56 (6)
Education								
12 years	18%*	29%	18%*	30%	17%*	41%	16%*	38%
>12 years	82%*	71%	82%*	70%	83%*	59%	84%*	62%
Race								
African-American	36%	32%	34%	32%	31%*	37%	30%*	37%
White	64%	68%	66%	68%	68%*	63%	70%*	63%
Sex								
Men	42%	37%	39%	40%	40%	35%	41%*	35%
Women	58%	63%	61%	60%	60%	65%	59%*	65%
BMI (kg/m ²)	29 (6)	29 (6)	29 (6)	29 (6)	29 (6)	29 (6)	29 (6)	29 (6)
Smoking								
Current	24%	25%	22%	26%	23%	29%	23%	28%
Ex-smoker	32%	29%	33%	28%	30%	28%	31%	27%
Never	44%	46%	45%	46%	47%	43%	46%	45%
Occupational physical activities‡								
Squatting	1.8 (1.0)	1.8 (1.0)	1.9 (1.0)	1.8 (1.0)	1.8 (1.0)	1.9 (1.0)	1.8 (1.0*)	1.9 (1.0)
Standing	2.1 (1.1*)	2.5 (1.1)	2.2 (1.1*)	2.4 (1.0)	2.2 (1.0*)	2.6 (1.1)	2.2 (1.0*)	2.6 (1.0)
Lifting	1.4 (1.1)	1.5 (1.1)	1.5 (1.1)	1.5 (1.1)	1.4 (1.0*)	1.6 (1.2)	1.4 (1.0*)	1.7 (1.2)
Walking	2.8 (1.0)	2.7 (1.0)	2.8 (1.0*)	2.7 (1.0)	2.7 (1.0)	2.8 (1.0)	2.7 (0.9)	2.8 (1.1)
Occupational categories								
Technical, sales and administrative support	28%	24%	31%*	23%	29%*	22%	28%*	23%
Managerial and professional specialty	20%	23%	25%*	20%	28%*	10%	28%*	14%
Operators, fabricators and labourers	24%	22%	16%*	25%	19%*	28%	20%*	23%
Service occupation	13%	17%	16%*	16%	13%*	21%	11%*	22%
Precision production, craft and repair	13%	11%	10%*	12%	10%*	14%	11%*	13%
Farming, forestry and fishing occupation	2%	2%	2%*	3%	<1%*	5%	<1%*	5%
Knee symptoms prevalence	31%*	42%	34%*	40%	33%*	48%	32%*	48%
sKOA prevalence††	8%*	13%	9%	12%	9%*	16%	8%*	16%
Asymptomatic rKOA Prevalence‡‡	13%	17%	16%	14%	13%	18%	12%*	20%

Values are means and SD, or %

*p<0.05 for different characteristics between employment with and without indicated workplace policy; †those currently employed or holding prior employment for longer than 3 years by the time of X-ray examination, excluding those self-employed or with missing/non-classifiable X-ray reports; ‡self-reported frequency measured on an ordinal scale four-point scale (never=0, seldom=1, sometimes=2, often=3, always=4); ††defined as having KL grade 2–4 plus symptoms in the same knee; ‡‡radiographic KOA (KL grade 2–4 vs. 0–1); prevalence estimated for those without self-reported knee symptoms.

same robust negative association between workplaces offering disability payment and sKOA, even after also adjusting for either of these socioeconomic factors (data not shown).

DISCUSSION

In this cross-sectional analysis of baseline data from a large community-based biracial cohort of men and women aged 44–65 years at inception, we found that those with knee symptoms and symptomatic KOA were less likely to be employed in workplaces offering policies for accommodation and benefits. Even among those without overt knee symptoms, participants employed in workplaces offering disability payment had a

statistically significantly lower prevalence of asymptomatic rKOA than those in workplaces without such a benefit. Further, these discrepancies could not be completely explained by differences in age, race, sex, socioeconomic status, BMI, smoking habit, prior knee injury, frequencies of occupational physical activities or occupational group.

Several plausible scenarios may underlie the observed negative associations between workplace policies and prevalence of knee symptoms and sKOA. First, the negative associations between knee symptoms and employment in workplaces with better policies could be the result of knee symptom-based selection in employment, since people with

Table 3 The interrelation of available workplace policies

	Reduced time		Paid sick leave		Disability pay	
	OR	95% CI	OR	95% CI	OR	95% CI
Job-switch	12.7*	9.47 to 17.2	1.15	0.74 to 1.78	2.30*	1.52 to 3.48
Reduced time	–	–	1.29	0.85 to 1.95	1.08	0.74 to 1.60
Paid sick leave	–	–	–	–	26.8*	18.8 to 38.1

Values are ORs (95% CIs) estimated from logistic models regressing the log-odds of having been employed in workplaces offering the indicated policy on the other 3 policies among those currently employed or holding prior employment longer than 3 years by the time of X-ray examination.

*p<0.01.

Table 4 The associations between workplace policies and prevalence OR of knee symptoms

Workplace policies	Crude analysis		Adjusted analyses			
	OR	95% CI	Model I†	95% CI	Model II‡	95% CI
Job-switch						
No	1.00		1.00		1.00	
Yes	0.62**	0.49 to 0.79	0.74*	0.55 to 1.00	0.75	0.56 to 1.01
Reduced-time						
No	1.00		1.00		1.00	
Yes	0.76*	0.59 to 0.96	0.88	0.66 to 1.18	0.86	0.64 to 1.16
Paid sick leave						
No	1.00		1.00		1.00	
Yes	0.54**	0.43 to 0.69	0.70*	0.52 to 0.95	0.71	0.53 to 0.97*
Disability payment						
No	1.00		1.00		1.00	
Yes	0.52**	0.41 to 0.65	0.69*	0.52 to 0.92	0.72	0.53 to 0.96*

Values are ORs (95% CIs) of having symptomatic KOA.

*p<0.05, **p<0.01; †adjusted for age (<55, 55–64 years), sex, race (black vs. white), years of educational attainment (≤11, 12, >12 years), BMI (in quartiles), smoking status (current vs. ex-smoker vs. never), history of prior knee injury, employment status, and the self-reported frequencies of squatting, standing, lifting and walking (level 0–4 for each activity), plus six occupational groups; ‡adjusted for KL grading plus all Model I covariates.

knee symptoms might be less likely to be employed or to retain employment in workplaces offering better policies. Even among those without overt knee symptoms, people might be self-aware of their extant or future risks for KOA (e.g., family histories, symptoms in other joints). If these “high-risk” participants preferred to remain in employment in workplaces offering accommodations and benefits, this would result in a *positive* confounding that would have led to a *less* negative association between better workplace policies and KOA. On the other hand, these “vulnerable subjects” might have certain characteristics that would have made them more likely to be denied employment or less likely to retain their employment in workplaces offering better policies. If these characteristics were also predictive of KOA, the observed consistent negative association between workplace benefits and KOA might simply reflect the consequence of this negative confounding by these unmeasured characteristics that were *both* associated with the *propensity* of *not* being in workplaces with better policies *and* predictive of sKOA (as suggested by the positive associations of sKOA and asymptomatic rKOA with increasing propensity scores). Nevertheless, the revealed robust associations between disability payment policy and lower prevalence of either sKOA or asymptomatic rKOA supply a strong rationale for further research.

Assuming the observed negative associations reflect some effects of favourable organisational factors, how could the availabilities of better workplace policies affect the development or progression of KOA in our study population? Given the long latency period of KOA, although the average duration of index employment was 13 years, we were uncertain about the underlying mechanisms (either biologically or socio-environmentally) by which the availabilities of better workplace policies could translate themselves into lower KOA risks. It is more likely that better employment policies may help diseased workers in coping with arthritis symptoms, thus contributing to the progression rather than the development of KOA. We did find the negative associations between knee symptoms and workplace benefits remained statistically significant (Table 4, adjusted Model II) even after adjustment for KL grades, supporting the hypothesis that better employment policies may provide the work environment or climate for better coping with clinical symptoms among patients with KOA.

Compared with the results of previous studies on the provision of work accommodation, both similarities and differences were noteworthy regarding the demographic and occupational correlates of available workplace policies. Those in workplaces not offering any of the four policies were systematically older and had

Table 5 Associations of symptomatic knee osteoarthritis and asymptomatic radiographic knee osteoarthritis with workplace policies

Workplace policies	sKOA		Asymptomatic KOA					
	Crude analysis		Adjusted analyses†		Crude analysis		Adjusted analyses†	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Job-switch								
No	1.00		1.00		1.00		1.00	
Yes	0.62*	0.42 to 0.91	0.73	0.45 to 1.18	0.74	0.49 to 1.11	0.67	0.42 to 1.07
Reduced time								
No	1.00		1.00		1.00		1.00	
Yes	0.75	0.51 to 1.09	0.96	0.61 to 1.53	1.16	0.78 to 1.74	1.39	0.88 to 2.20
Paid sick leave								
No	1.00		1.00		1.00		1.00	
Yes	0.51**	0.36 to 0.73	0.58*	0.37 to 0.91	0.71	0.46 to 1.09	0.77	0.46 to 1.27
Disability payment								
No	1.00		1.00		1.00		1.00	
Yes	0.45**	0.31 to 0.63	0.54**	0.35 to 0.84	0.54*	0.36 to 0.81	0.48*	0.29 to 0.77

Values are ORs (95% CIs) of having sKOA or asymptomatic radiographic KOA (assessed by KL grade 2–4 vs. 0–1).

*p<0.05, **p<0.01; †adjusted for age (<55, 55–64 years), sex, race (black vs. white), years of educational attainment (≤11, 12, >12 years), BMI (in quartiles), smoking status (current vs. ex-smoker vs. never), history of prior knee injury, employment status, and the self-reported frequencies of squatting, standing, lifting and walking (level 0–4 for each activity), plus six occupational groups.

higher educational attainment than their counterparts. African-American participants were less likely to be employed in such workplaces. Women were less likely than men to be employed in workplaces offering disability payment. Similar patterns of distribution by age, sex and education levels remained when we further examined such differences among those with knee symptoms or only those who were employed at the time of interview (data not shown). Data collected from 4927 employees with disabilities in the National Health Interview Survey Disability Supplement (NHIS-DS) 1994 to 1995 suggested that older people (aged >50 years) were less likely to receive workplace accommodations.²⁰ The NHIS-DS survey also indicated that Americans with disabilities were more likely to receive work accommodation if employed in the occupational categories of technical, sales and administrative support or executive professionals than if they were in farming occupations. In our present study, we found those in the occupational categories of technical, sales and administrative support or in managerial and professional specialties were more likely to be in workplaces offering any of the four policies, which were least likely to occur in farming, forestry and fishing occupations. Both the NHIS-DS in 1994 to 1995 and the Health and Retirement Survey⁹ in 1992 reported that people with higher educational attainments were more likely to receive work accommodations for their disabilities or musculoskeletal conditions. However, men in the NHIS-DS were less likely to receive workplace accommodation than women, whereas the Health and Retirement Study indicated that men were more likely to receive special equipment and change tasks than women.

Our work highlights several methodological implications for future studies on the interrelations of work and KOA. Regardless of the likelihood of residual or unmeasured confounding by other work-related factors, the revealed negative associations of sKOA and asymptomatic rKOA with workplace policies, independent of occupational physical activities and occupational categories, suggest that future studies should look at both individual- and organisation-level factors in workplaces to provide a better understanding of the multi-dimensionality of occupational determinants of KOA risks and outcomes. Our analyses also illustrated the presence of confounding by indication²¹ (i.e., by the unmeasured characteristics both indicative of the propensity to be employed in workplaces with better workplace policies and also predictive of sKOA or asymptomatic rKOA). In the context of arthritis employment research, confounding by indication arises first from the fact that those who receive any workplace intervention in a non-experimental setting are likely to carry certain personal attributes (e.g., severity of arthritis, co-morbidities, perceived needs for help) and occupational characteristics (e.g., supportive work environment, organisational commitment), which jointly determine the indications for prescribing such interventions. Confounding by indication has been implicated by others as a plausible explanation for null findings or lack of consistent effectiveness of job accommodation provisions on employment outcome.²² The importance of better controlling for confounding by indication (e.g., by propensity score modelling) should not be overlooked in future observational studies on occupational outcomes of arthritis.

We recognise that there are several limitations for our study. First, the interpretation of our findings is limited by the cross-sectional design. Without additional information on the chronological profiles of workplace characteristics and longitudinal changes of knee radiographs, we are unable to make any causal inference on the interrelationships between employment with workplaces policies and KOA. Second, the availability of workplace policies was based on self-report. We did not have employment records or other external sources of data to verify this information. Because participants did not have the

Main messages

In this community-based study, the authors demonstrated the importance of looking beyond individual-level risk factors and examining organisation-level workplace characteristics in relation to KOA.

Individuals employed in workplaces offering better policies had less knee symptoms and lower prevalence of symptomatic or asymptomatic knee osteoarthritis, independent of socio-demographic features, lifestyle factors, knee injuries, BMI, physical demands in the workplace and job titles.

Policy implications

The revealed negative associations between KOA and better workplace policies raise concerns about potential employment discrimination in individuals with KOA or potential beneficial effects of favourable workplace policies.

Longitudinal studies are needed to clarify the dynamic complexities of KOA risks and outcomes in relation to workplace policies.

knowledge about their KL radiographic grades at the time of interview, the self-reporting errors were more likely to lead to non-differential misclassification (especially among those without overt knee symptoms), which often would have biased the associations towards the null. Third, given that the availabilities of workplace benefits tend to cluster with each other, we were unable to examine the independent association of knee symptoms or KOA with each workplace policy. Finally, although subjects in community-based studies are generally more representative than those recruited from clinical settings, our findings may not be completely generalisable to other communities. However, using data collected from residents in Johnston County, North Carolina, USA, we believe results of our current analyses add to knowledge about employment in workplaces offering accommodations and benefits in the southern USA, where a nationwide survey found that people with disabilities were less likely to receive workplace accommodations.²⁰

CONCLUSION

Our exploratory, cross-sectional analyses indicated the presence of negative associations of knee symptoms and KOA with employment in workplaces offering better policies. High-quality longitudinal data are needed to clarify whether the provision of workplace policies has protective effects on the development or progression of KOA, and whether individuals with propensities for KOA are denied or unable to retain employment with favourable workplace policies.

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