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# Relationship between trade seniority and the development of radiographic knee osteoarthritis, and MRI-detected meniscal tears and bursitis in floor layers. A cross sectional study of a historical cohort.

Lilli Kirkeskov Jensen M.D. [1], Søren Rytter M.D. [2], Jacob Louis Marott M.Sc. [3], Jens Peter Bonde M.D. [1]

[1] Department of Occupational and Environmental Medicine, Bispebjerg Hospital, Denmark

[2] Department of Orthopaedic Surgery, Hospital Unit West, Holstebro, Denmark

[3] Copenhagen City Heart Study, Bispebjerg Hospital, Denmark



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Correspondence to: Dr. Lilli Kirkeskov, Department of Occupational and Environmental Medicine, Bispebjerg Hospital, Bispebjerg Bakke 23, 2400 Copenhagen NV, Denmark, Telephone +45 35 31 60 60. Telefax +45 35 31 60 70. E-mail lkir0013@bbh.regionh.dk

**ABSTRACT**

**Objectives:** An increased risk of developing knee disorders including radiographic knee osteoarthritis (OA) have been shown among workers with kneeling working demands. There may also be a dose-related association between duration of employment in occupations with kneeling work and development of radiographic knee-OA, and MRI detected meniscal tears, and bursitis.

**Design:** A cross-sectional study of a historical cohort.

**Setting:** Members of the trade unions for floor layers and graphic designers in Denmark.

**Participants:** 92 male floor layers and 49 graphic designers aged 36-70 years were randomly selected among participants from a clinical and radiographic study of 156 floor layers, and 152 graphic designers.

**Outcome measures:** Radiographic tibiofemoral (TF) and patellofemoral (PF) knee-OA, and MRI-detected meniscal tears and bursitis. Results were adjusted for age, earlier knee traumas, sports activities, and body mass index in logistic regression models. Association between TF OA and years in the floor laying trade was graphically examined by a restricted cubic spline with 4 knots.

**Results:** Increase in number of years with exposure to kneeling work is associated with radiographic TF-knee-OA with odds ratios of OR 0.7,95%CI 0.07-4.42; OR 1.89,95%CI 0.29-12.3; OR 4.82,95%CI 1.38-17 for < 20 years, 20-30 years, and >30 years of kneeling work, respectively. MRI- verified medial meniscal tears was increased among subjects with kneeling work with OR 1.96,95%CI 0.79-4.88 to OR 4.73,95%CI 1.16-19.4, but was not associated with duration of employment. Periarticular bursitis was increased in subjects with < 20 years of kneeling working activity. Lateral meniscal tears, and PF- kneeOA was not associated with duration of kneeling working activity or with kneeling work in general.

**Conclusions:** The findings suggest a dose-response relationship for radiographic TF-knee- OA in floor layers with a significant amount of kneeling work and an increase of MRI-verified medial meniscal tears among workers with kneeling work.

**ARTICLE SUMMARY**

**Article focus**

- An increased risk of developing knee disorders including radiographic knee osteoarthritis (OA) have been shown among workers with kneeling working demands. Workers with kneeling working positions have an increased risk of developing knee complaints in a much higher degree than can be explained by osteoarthritis.
- It is unknown if there is a dose-related association between duration of employment in occupations with kneeling work and development of radiographic knee-OA including both tibiofemoral and patellofemoral knee-OA
- It is unknown if MRI-detected meniscal tears, and bursitis around the knees can explain some of the knee complaints in subjects with kneeling work.

**Key messages**

- The study shows a dose-response-relationship between the duration of employment in work with kneeling working positions, and tibiofemoral knee-OA but not of patellofemoral knee-OA.
- There is an increased risk of developing MRI-detected medial meniscal tears and periarticular bursitis among floor layers compared to referents, but it is not associated to long duration of employment.
- The study suggests that other knee disorders than osteoarthritis may explain that floor layers have knee complaints.

**Strengths and limitations of the study**

- Study strength include investigation with both radiographic and MRI, the description of a variety of knee disorders, and the long duration of exposure among study group
- Limitation is the small number of participants due to economic reasons by conducting MRI

## INTRODUCTION

Demonstation of exposure-response and exposure-effect relations is considered important in causal inference and the risk of developing various knee disorders may depend on both the degree of daily exposure and years of exposure to kneeling and squatting work positions.

We have in previous studies described an increased risk of developing tibiofemoral (TF) osteoarthritis (OA) meniscal tears and bursitis among floor layers with high knee loads compared to referents without knee straining work.[1-4] Floor- layers install linoleum, carpet, and vinyl floorings. The work-tasks include removal of old flooring, grinding, filling, installation of underlay, measuring and cutting materials, gluing, welding, and installation of skirting board.The floor layers in this study did not usually use knee kickers, they altered their work-tasks, and none solely installed carpets. Graphic designers did layout of text and advertisements and made up pages before printing of newspapers, weekly papers, books, and other publications. They used visual display units, mostly while sitting. Their work did not include physically demanding or knee straining working positions. In an earlier study we measured the amount of kneeling work positions used by floor layers and graphic designers, using video recordings of short time periods without pauses and with continuous video recordings. The cumulative duration of time spent in kneeling work positions in one day have was 65% of the workday (SD 25%) for the discontinuous measurements[5,6] and 41% (SD 7.5%) for the continuous measurements for floor layers.[3] Graphic designers have no kneeling working demands. Only few occupations are exposed to the same high level of knee demands as floor layers. All Danish floor layers have the same job functions. They are skilled and continue in the profession for many years. Hence we can apply seniority in the profession as a proxy for the total amount of knee strain.

We have shown a trend towards an increased risk of TF OA increasing with the seniority as a floor layer,[3] but no association for meniscal tears.[4]

The purpose of this study was to analyze whether there is a dose-response relationship for the development of radiologically detected tibio-femoral (TF) and patellofemoral (PF) OA, and MRI demonstrated meniscal lesions and various forms of bursitis measured by seniority in the profession as floor layers compared to a group of referents without knee straining work demands.

## MATERIAL AND METHODS

### Study sample

A source population of 286 Danish floor layers and 370 graphic designers was established in 1994 based on membership list from trade unions. Male members aged 36-70 years in 2004, who were living in the geographical area of Copenhagen (capital city) or Aarhus (second largest city), Denmark were included in the study. Male workers, who were members of the trade union 10 years earlier, were also included. Graphic designers, all from Copenhagen, were included as a group of non-exposed. Their work tasks involved no knee demands. Danish floor layers and graphic designers are comparable regarding the level of education and socio-economic status. Questionnaires were mailed to the source population in year 2004-2005. The response rate was 89% and 78% among floor layers and graphic designers, respectively. The questionnaire included information on age, height, weight, and years in the profession, knee complaints, knee traumas, and sports activity. Questionnaire respondents were invited to participate in a clinical and radiographic investigation. Informed consent to participate was given by 156 floor layers and 152 graphic designers. Consent to perform a full radiographic examination (knees and pelvis) were given by 134 floor layers (Copenhagen=88; Aarhus=46) and 120 graphic designers (Copenhagen).[3] Among those a random sample of 92 (Copenhagen, n=45; Aarhus, n=47) floor layers and 49 graphic designers (Copenhagen) had a MRI of both knees (n=282). Examinations were conducted at two MR Centers over a 1-year period (2005-2006).[4] Only the participants who have been included in both the MRI-study and the radiological examination were included in the analysis of this paper. Permission was obtained from the Central Danish Region Committee on Biomedical Research Ethics.

### Magnetic resonance imaging

MR imaging at Center I was performed by a 1.5-Tesla scanner (SymphonyVision, Siemens Medical Systems, Erlangen, Germany) in 47 patients, and at Center II by a 1.5-Tesla scanner (Infinion, Philips, Best, The Netherlands) in 94 patients. The MRI sequences were identical for both the right and left knee. The following MRI sequences were obtained at Center I: sagittal proton density fat-saturated turbo spin echo (TR/TE, 3300/15 ms) and sagittal and coronal T2-weighted (4000/86 ms) fat-saturated turbo spin-echo; coronal T1-weighted (608/20 ms) spin-echo sequences and axial proton density fat-saturated turbo spin echo (3450/15 ms). The section thickness was 4 mm with an intersection gap of 0.4 mm; field of view was 200 x 200 mm and matrix 512 in all sequences. At Center II the MRI sequences included sagittal proton density fat-saturated turbo spin echo (TR/TE, 2500/18 ms) and sagittal and coronal T2-weighted (4000/85 ms) fat-saturated turbo spin-echo; coronal T1-weighted (400/13 ms) spin-echo and axial proton density fat-saturated turbo spin echo (2880/17 ms). The section thickness was 4 mm with an intersection gap of 0.4 mm; field of view was 150 x 150 mm and matrix 512 in all sequences.

A musculoskeletal radiologist with substantial MRI experience evaluated each of the 282 MR examinations. The observer was blinded to any medical history of knee disorders among participants. Due to differences in the appearance of MRI form the 2 centers, blinding of occupational affiliation was incomplete regarding participants from Center I, who were all floor layers. Blinding of occupational affiliation was complete concerning all participants from Center II. The medial and lateral meniscus of each knee was evaluated separately for abnormalities. Abnormalities in the MR signal intensities predicting degenerative tears were divided in grade 1-3.[4] The presence of bursitis was assessed in both knees of each participant. Bursitis was registered in the following bursae: subgastrocnemius, semimembranosus-gastrocnemius, , anserine, lateral (LCL) and medial (MCL) collateral ligament, iliotibial, prepatellar, superficial infrapatellar, deep infrapatellar bursae; and extracapsular synovial cysts (Rytter S, Kirkeskov L, Bonde JP, Egund N. MR imaging of intra- and periarticular cyst-like lesions of the knee joint in workers with occupational kneeling. Submitted 2011).

**Radiographs**

Radiological examinations of both knees were obtained in the standing weight-bearing position with the knee in 20-30 degree flexion in three views: posterior-anterior (PA), lateral and axial of the PF joint space. Radiographs were read and scored on workstations with 2K screens by one experienced musculoskeletal radiologist unaware of any medical history of knee disorders among all participants and blinded to occupational affiliation concerning the participants from Copenhagen. The radiographic scoring comprised assessment of the medial and lateral joint spaces of both the TF and PF compartments using a modified Ahlbäck scale (grade 0-6) of joint space narrowing (JSN) and subchondral bone attrition. The following grades of JSN were defined: grade 0 = normal; grade 1 = minimal but definite narrowing (25% JSN); grade 2 = moderate narrowing (50% JSN); grade 3 = severe narrowing (75% JSN); grade 4 = obliteration of the joint space, “bone on bone but no attrition”; grade 5 = < 5 mm attrition of subchondral bone and grade 6 = ≥ 5 mm bone attrition.[3] Knee OA was defined as JSN ≥ 25% in at least one knee and patterns of involvement categorized into medial or lateral TF OA and PF OA.

**Data analysis and statistics**

We have in earlier studies shown that there were only small variations in the degree of knee straining work activities among the different work tasks in floor layers.[5,6] Trade seniority for floor layers has therefore been used as a proxy for the exposure to knee straining work positions in the analyses of the this study, and categorized into three groups (≤20, 21-30, >30 years). Results for each of the three groups were compared to the group of graphic designers in total with no exposure to kneeling work activities. The association between the duration of employment in the trade (seniority) and the development of TF and PF OA (≥25% JSN), meniscal tears (grade 3), and bursitis was analysed among floor layers relative to graphic designers. The adjusted odds ratio (OR) with 95% confidence interval (CI) was computed and independent variables incorporated in the model of adjusted results were age, body mass index (BMI), knee straining sports, and earlier knee traumas.Sports activity (yes/no) was considered as potential knee straining if it was one of the following: football, handball, badminton, tennis, volleyball, ice hockey, weight lifting, and skiing. Earlier knee traumas (rupture of ligaments, meniscal tears operations, fractures including the knee joint) were categorized into two groups (yes/no). The dose-response relationship between years in the trade and risk of TF OA was graphically examined by a restricted cubic spline with 4 knots.

Correlation between TF and PF OA, bursitis and meniscal tears was evaluated by using Kappa statistics. The software package EpiData was used to code data and statistical analysis were conducted with SPSS statistics, version 17.0.

## RESULTS

Characteristics of the study sample are given in Table 1. Participants were all males; aged 42-70 at the time of the examination (mean age 55.6, SD 6.8 years). There was a marked difference in the age distribution and the trade seniority between the two study groups. Graphic designers were generally older and had a higher seniority than floor layers. Regarding height, weight and BMI the two groups were comparable.

**Table 1. Characteristics of the study sample**

| | **Floor layers** (n=92) | | **Graphic designers** (n=49) | |
|---|---|---|---|---|
| **Age**, years *(mean, SD)* | 54.5 | 7.2 | 57.7 | 5.6 |
| - *≤ 49 (n, %)* | *24* | *26.1* | *4* | *8.2* |
| - *>50 (n, %)* | *68* | *73.9* | *45* | *91.8* |
| **Seniority** †, years *(mean, SD)* | 29.6 | 9.8 | 35.9 | 6.5 |
| - *≤ 20 (n, %)* | *20* | *21.8* | *1* | *2.1* |
| - *21-30 (n, %)* | *27* | *29.3* | *10* | *20.4* |
| - *>30 (n, %)* | *45* | *48.9* | *38* | *77.5* |
| **BMI** ‡, $kg/m^2$ *(mean, SD)* | 26.2 | 3.4 | 26.6 | 4.8 |
| - *≤ 27 (n, %)* | *64* | *69.6* | *33* | *67.4* |
| - *≥ 28 (n, %)* | *28* | *30.4* | *16* | *32.6* |
| **Weight**, kg *(mean, SD)* | 84.1 | 12.7 | 84.5 | 17.7 |
| **Height**, cm *(mean, SD)* | 179.1 | 6.5 | 177.9 | 7.2 |

† Duration of employment in the trade ; ‡ BMI, body mass index

**Knee osteoarthritis**

The prevalence of TF OA was increased (but not significant) in floor layers compared to graphic designers; OR 2.46, 95% CI 0.83-7.28 adjusted for BMI, sports activities, age, and earlier knee traumas as shown in Table 2. On the contrary PF OA was more frequent in graphic designers compared to floor layers, OR 0.44, 95% CI 0.14-1.37.

**Table 2. Risk of radiographic tibio- and patellofemoral knee osteoarthritis (OA), and MRI detected meniscal tears, and bursitis. Floor layers (n=92) compared to graphic designers (n=49). Odds ratio (OR) with 95% confidence interval (CI).**

| | Floor layers | | Graphic designers | | | Adjusted |
|---|---|---|---|---|---|---|
| **Disorder** | n | % | n | % | OR* | 95% CI |
| Tibiofemoral OA § | 17 | 18.9 | 8 | 16.7 | 2.46 | 0.83-7.28 |
| Patellofemoral OA | 7 | 7.8 | 9 | 18.8 | 0.44 | 0.14-1.37 |
| Tears of medial meniscus# | 62 | 67.4 | 26 | 53.1 | 2.82 | 1.25-6.36 |
| Tears of lateral meniscus# | 12 | 13.0 | 11 | 22.4 | 0.78 | 0.29-2.10 |
| *Peripatellar bursitis:* | | | | | | |
| Prepatellar | 1 | 1.1 | 5 | 10.2 | 0.14 | 0.02-1.55 |
| Superficial infrapatellar | 4 | 4.3 | 2 | 4.1 | 0.90 | 0.14-5.75 |
| Deep infrapatellar | 10 | 10.9 | 2 | 4.1 | 3.53 | 0.64-19.6 |
| *Periarticular bursitis:* | 71 | 77.2 | 31 | 63.3 | 2.04 | 0.89-4.69 |
| Subgastrocnemius | 57 | 62.0 | 24 | 49.0 | 1.76 | 0.82-3.75 |
| Semimembranosus-gastrocnemius | 43 | 46.7 | 17 | 34.7 | 1.49 | 0.67-3.29 |
| Others** | 14 | 15.2 | 0 | 0 | - | - |

*OR is calculated relative to the reference group of graphic designers, and adjusted for body mass index, previous knee traumas, knee straining sports activities and age

** Others: anserine, lateral (LCL) and medial (MCL) collateral ligament, iliotibial bursae, and extra capsular synovial cysts.

# Uni or bilateral meniscal tears

§Missing radiographs in two floor layers and one graphic designer

A dose-response relationship measured by years in the trade (seniority) was shown for TF OA in floor layers with odds ratios increasing from OR 0.70 (ns) (≤20 years of exposure); OR 1.89 (ns) (21-30 years of exposure); to OR 4.82, 95% CI 1.38-17.0 (>30 years of exposure) when compared to graphic designers without exposure to kneeling work demands (Table 3). There was no dose-response relationship for PF OA.

**Table 3. Risk of radiographic tibio- and patellofemoral knee osteoarthritis (OA), and MRI detected meniscal tears, and bursitis; by trade seniority. Floor layers (n=92) compared to graphic designers (n=49). Odds ratio (OR) with 95% confidence interval (CI).**

| | **<=20 years** | | **21-30 years** | | **>30 years** | |
|---|---|---|---|---|---|---|
| **Disorder** | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Tibiofemoral OA§ | 0.70 | 0.07-7.42 | 1.89 | 0.29-12.3 | 4.82 | 1.38-17.0 |
| Patellofemoral OA | 1.30 | 0.27-6.33 | - | - | 0.48 | 0.12-1.88 |
| Tears of medial meniscus# | 4.73 | 1.16-19.4 | 4.59 | 1.28-16.5 | 1.96 | 0.79-4.88 |
| Tears of lateral meniscus# | 1.14 | 0.24-5.33 | 0.68 | 0.11-4.28 | 0.86 | 0.27-2.76 |
| *Peripatellar bursitis:* | | | | | | |
| Prepatellar | - | - | - | - | 0.27 | 0.03-2.72 |
| Superficial infrapatellar | - | - | - | - | 1.43 | 0.22-9.09 |
| Deep infrapatellar | 3.20 | 0.31-32.9 | 7.30 | 0.62-85.7 | 2.33 | 0.31-17.7 |
| *Periarticular bursitis:* | 12.20 | 1.31- 113 | 1.22 | 0.38-3.90 | 1.80 | 0.67-4.78 |
| Subgastrocnemius | 2.50 | 0.71-8.86 | 1.19 | 0.38-3.77 | 1.98 | 0.81-4.82 |
| Semimembranosus-gastrocnemius | 3.14 | 0.89-11.0 | 1.31 | 0.39-4.33 | 1.23 | 0.49-3.13 |

*OR is calculated relative to the reference group of graphic designers, and adjusted for body mass index, previous knee traumas, knee straining sports activities, and age

# Uni or bilateral meniscal tears

§Missing radiographs in two floor layers and one graphic designer

To further examine the dose-response relationship between years in the trade and TF OA we included years as floor layer as a continuous variable. The results showed a positive association between years in the floor layer and TF OA (Table 4).

**Table 4. Association between years as a floor layer and development of TF OA, PF OA, meniscal tears, and bursitis. Odds ratios (OR)* and 95% Confidence Intervals, CI.**

| Disorder | OR* | 96% CI |
|---|---|---|
| Tibiofemoral OA § | 1.04 | 1.01-1.07 |
| Patellofemoral OA | 0.96 | 0.93-1.00 |
| Tears of medial meniscus# | 1.02 | 1.00-1.05 |
| Tears of lateral meniscus# | 0.99 | 0.97-1.02 |
| Deep infrapatellar bursitis | 1.03 | 0.99-1.07 |
| Periarticular bursitis | 1.06 | 1.00-1.13 |

* OR is calculated relative to the reference group of graphic designers, and adjusted for body mass index, previous knee traumas, knee straining sports activities, and age
# Uni or bilateral meniscal tears
§Missing radiographs in two floor layers and one graphic designer

The same pattern was seen when including years of trade as a restricted cubic spline in a age-adjusted logistic regression model (Figure 1).

**Meniscal tears**

A significant higher prevalence of medial meniscal tears occurred among floor layers compared to graphic designers, as shown in Table 2. The risk of meniscal tears did not increase with trade seniority in floor layers compared to the graphic designers (Table 3). The adjusted OR for meniscal tears were 4.73; 4.59, and 1.96 for trade seniority ≤20 years, 21-30 years, and >30 years, respectively. There was no significant difference in the prevalence of lateral meniscal tears between the two study groups, and no dose-response relationship between seniority as a floor layers. Additionally, no correlation was found between medial meniscal tears and TF OA in floor layers (Kappa 0.04). Table 4 shows a significant association between years as a floor layer and the medial meniscal tears but not for laterale meniscal tears.

**Bursitis**

Nine graphic designers 9/49 (18%) were classified as having prepatellar, superficial or deep infrapatellar bursitis compared to 15/92 (16%) floor layers. The prevalence of prepatellar bursitis was higher in graphic designers (10.2%) compared to floor layers (1.1%). The prevalence of deep infrapatellar bursitis was on the contrary higher in floor layers (10.9%) compared to graphic designers (4.1%), OR 3.53, 95% CI 0.64-19.6. A higher prevalence of bursitis in the subgastrocnemius, semimembranosus-gastrocnemius, and other bursae (extracapsular synovial cysts, anserine, biceps, LCL and MCL, iliotibial) was observed in floor layers with OR 2.04, 95% CI 0.89-4.69.

The odds ratios for deep infrapatellar bursitis were OR 3.20, 95 % CI 0.31-32.9 for seniority ≤20 years, OR 7.30, 95% CI 0.62-85.7 for seniority 21-30 years, and OR 2.30, 95% CI 0.31-17.7, for seniority >30 years when compared to the whole group of graphic designers without knee straining work activities.

Fluid collections in other bursae (e.g. subgastrocnemius, semimembranosus – gastrocnemius) were increased significantly only for floor layers with ≤20 years of seniority (OR 12.2, 95% CI 1.31-113) (Table 3).

Table 4 shows a significant association between years as a floor layer and periarticulat bursitis.

No correlation between TF OA, deep infrapatellar bursitis and other bursitis was shown (Kappa 0.08 and 0.12, respectively).

## DISCUSSION

The results showed a significant association between years as a floor layer and development of TF OA, medial meniscal tears, and periarticular bursitis comparet to referants.

The OR for TF OA increased with the duration of employment in the trade. There were only significant differences between the non-exposed reference group and floor layers with more than 30 years of exposure, but there was a tendency towards a dose-response relationship shown by odds ratios >1 for the medium and high exposure groups, when compared to the reference group. These results indicate a dose-response relationship. The small number of workers who were investigated (n=141), and especially few referents among those with low seniority may influence results and explain the missing significance between all the exposure groups. Only few previous studies have investigated the dose-response relationship between knee OA and the quantity of kneeling work activities. Enderlein and Kasch found a higher frequency of knee OA in participants with a higher extent of hyperkeratosis in front of the patella (used as a measure for the extent of kneeling working position).[7] Sandmark et al. showed OR 2.1 and 1.4, respectively among workers with high and medium exposure to kneeling work demands compared to low or no exposure.[8] In a study, which included some of the floor layers from the same cohort as in this paper, but 10 years earlier, the OR for the association between knee OA and exposure to kneeling work activities were 2.9 (low/moderate exposure), 4.2 (high exposure), and 4.9 (very high exposure).[1] In summary, indication of a dose-response relationship for osteoarthritis in this study is supported by findings in previous studies.

The risk of medial meniscal tears was increased in floor layers compared to graphic designers, but there were no difference depending on trade seniority. If meniscal tears are caused by many years of kneeling work a dose-response effect due to accumulated exposures to kneeling work tasks may be expected. However, if meniscal tears are caused by trauma because of inappropriate posture when getting from kneeling work positions to the standing position many times a day meniscal tears may not necessarily depend on the duration of the kneeling work.

In this study, the average period of employment was 29.6 years for floor layers. Twenty two percent have been employed less than 20 years, but few of them have been employed less than 15 years. It is possible that damage to the meniscus occurs before. In conclusion, we did not found a dose-response effect between years of kneeling work and development of meniscal tears. However, the prevalence of medial meniscal tears were significantly increased in floor layers compared to the graphic designers. In general only few studies have examined the relationship between meniscal tears and occupational kneeling. In a nested case-control investigation by Baker et al.[9] the occupational activities of 67 men (4.8%) reporting meniscectomy were compared to 335 controls. After adjustment for sports participation, meniscectomy was associated with kneeling (OR 2.5, 95% CI 1.3-4.8) and squatting (OR 2.5, 95% CI 1.2-4.9) more than 1 hour in an average working day. In a case-control study Baker et al.[10] investigated 243 men aged 20-59 years who had a meniscal tear confirmed by arthroscopy and compared them to community controls matched by age and sex. Results showed a significant association between kneeling (OR 2.2, 95% CI 1.3-3.6) and squatting (OR 1.8, 95% CI 1.1-3.0) > 1 h/day and meniscal tears. Greinemann et al.[11] conducted a case-control study in 500 miners compared to 500 controls without knee demanding work postures, all men in the age of 50 years. In total 57 miners (11.4%) had a knee surgery for meniscal tears compared to 14 (2.8%) among controls (OR 4.5, 95% CI 2.5-7.8). Sharrard and Liddell[12] investigated the frequency of meniscectomies among miners and other patients and compared it to the frequency of appendectomies in the same period. Meniscectomy had been performed in 605 miners and 352 men from other occupations. Comparing the frequency of meniscectomy to appendectomy they found and increased incidence of meniscectomy among miners (OR 3.3, 95% CI 2.7-4.0). These results may indicate a possible association between occupational kneeling and development of meniscal tears.

Results in this study showed a higher prevalence of bursitis, in total, among floor layers compared to the reference group. A low prevalence of prepatellar and superficial infrapatellar bursitis in floor layers compared to the reference group was found and there was even a tendency of a higher prevalence among graphic designers. This finding do not correspond to earlier results of Myllimäki et al.[13] who in an ultrasound study found fluid accumulation in the superficial infrapatellar bursa among 5.3% floor layers compared to none in a reference group of painters. Results also showed a low prevalence of prepatellar bursitis among floor layers compared to the reference group. Only one floor layer and five from the reference group had fluid accumulation in the prepatellar bursae. Hill et al.[14] have showed that pre- and superficial infrapatellar bursitis is common among individuals with radiographic knee OA and described fluid in bursae as a physiologically phenomenon, which is consistent with findings in other studies.[15]

We found a higher prevalence of bursitis in the deep infrapatellar, subgastrocnemius, semimembranosus-gastrocnemius bursae, and other bursae (as anserine) in floor layers compared to graphic designers. Hill et al., 2003 found a 4% prevalence of bursitis in other bursae as semimembranosus, anserine, and iliotibial in subjects with knee OA compared to none in subjects without knee OA. It suggests that bursitis can occur among subjects with radiographic knee OA, but the association between knee OA and bursitis was not shown in this study where Kappa testing showed no correlations. A difference between the study group and the reference group in the prevalence of bursitis also does not support the assumption. Identification of bursitis in many bursae, including the posterior part of the knee joint indicates that bursitis may not only be caused by direct pressure on the knee when kneeling.

We do not know if there is a causal association between external knee pressure and development of knee disorders. However, it seems plausible that a combination of extreme flexion in the knee joint, micro traumas caused by frequent kneeling and a high external knee pressure may cause knee disorders such as knee OA and medial meniscal tears while some of the knee disorders including bursitis may be explained by external pressure or other intraarticular factors.

In conclusion, the results of this study indicate a positive dose-response relationship between seniority as a floor layer and the development of TF OA and possibly deep infrapatellar bursitis. The risk of developing bursitis in other locations around the knee joint was especially increased for floor layers with seniority ≤20 years. A dose-response relationship for meniscal tears and PT OA was not found, and there were no correlations between meniscal tears, bursitis, and TF OA.

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**Author contribution**

Lilli Kirkeskov made data analysis and was the principal author

Søren Rytter collected data and contributed to writing the article

Jacob Marrot participated in data analysis and contributed to the writing of the article

Jens Peter Bonde has assisted in the writing of the article

REFERENCES

[1] Jensen LK. Knee-straining work activities, self-reported knee disorders and radiographically determined knee osteoarthritis. Scand J Work Environ Health 2005;31:68-74.

[2] Jensen L, Mikkelsen S, Loft I, et al. Radiographic knee osteoarthritis in floorlayers and carpenters. Scand J Work Environ Health 2000;26:257-62.

[3] Rytter S, Egund N, Jensen LK, et al. Occupational kneeling and radiographic tibiofemoral and patellofemoral osteoarthritis. J Occup Med Toxicol 2009;13:19.

[4] Rytter S, Jensen LK, Bonde JP, et al. Occupational kneeling and meniscal tears: A magnetic resonance iamging study in floor layers. J Rheumatol 2009;36:1362-4.

[5] Jensen LK, Rytter S, Bonde JP. Exposure assessment of kneeling work activities among floor layers. Applied Ergonimics 2010;41:319-25.

[6] Jensen L, Eenberg W, Mikkelsen S. Validity of self-reporting and video-recording for measuring knee-straining work postures. Ergonomics 2000;43:310-6.

[7] Enderlein G, Kasch J. Modellierung von Dosis-Wirkungsbeziehungen für expositionsabhängige Veränderungen am Bewegungsapparat. Z gesamte Hyg 1989;35:215-8.

[8] Sandmark H, Hogsted C, Vingård E. Primary osteoarthrosis of the knee in men and women as a result of lifelong physical load from work. Scand J Work Environ Health 2000;26:20-5.

[9] Baker P, Reading I, Cooper C, et al. Knee disorders in the general population and their relation to occupation. Occup Environ Med 2003;60:794-7.

[10] Baker P, Coggon D, Reading I, et al. Sports injury, occupational physical activity, joint laxity, and meniscal damage. J Rheumatol 2002;29:557-63.

[11] Greinemann H. Die Kniegelenkartrose des Bergmannes - eine Berufskrankheit. Unfallchirurgie 1997;23:10-7.

[12] Sharrard W, Liddell FD. Injuries to the semilunar cartilages of the knee in miners. British Journal of Industrial Medicin 1962;19:195-202.

[13] Myllymäki T, Tikkakoske.T, Typpö T, et al. Carpet-layer's knee. An ultrasonographic study. Acta Radiologica 1993;34:496-9.

[14] Hill CL, Gale DR, Chaisson CE, et al. Periarticular lesions detected on magnetic resonance imaging. Arthritis & Rheumatism 2003;48:2836-44.

[15] Janzen DL, Peterfy CG, Forbes JR, et al. Cystic lesions around the knee joint: MR imaging findings. Am J Roentgenol 1994;163:155-61.

Legend

Figure 1. The dose-response relationship between years in the trade and risk of tibio-femoral osteoarthritis, TF OA, graphically examined by a restricted cubic spline with 4 knots.

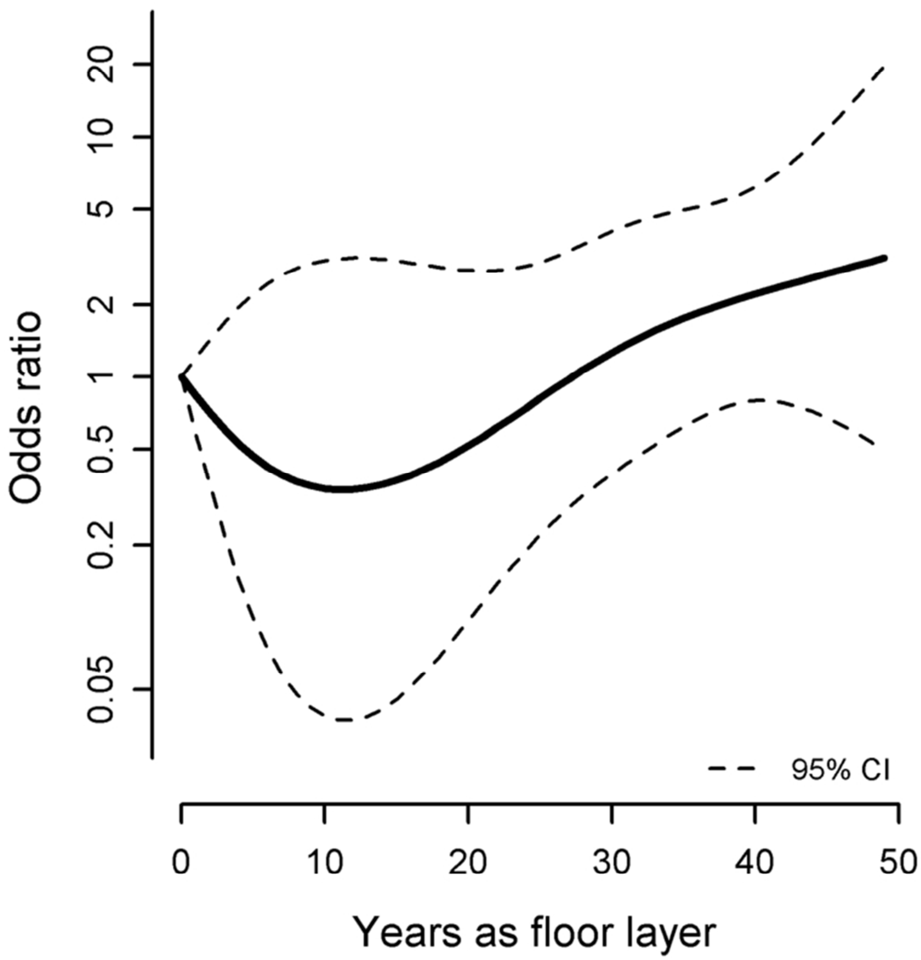


Figure 1. The dose-response relationship between years in the trade and risk of tibio-femoral osteoarthritis, TF OA, graphically examined by a restricted cubic spline with 4 knots.
69x69mm (300 x 300 DPI)

**STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology***
**Checklist for cohort, case-control, and cross-sectional studies (combined)**

| Section/Topic | Item # | Recommendation | Reported on page # |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 2 |
| Objectives | 3 | State specific objectives, including any pre-specified hypotheses | 2 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 5-6 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 5-6 |
| Participants | 6 | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants | 5-6 |
| | | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case | |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 5-6 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | *5-6* |
| Bias | 9 | Describe any efforts to address potential sources of bias | |
| Study size | 10 | Explain how the study size was arrived at | 5 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 7 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 7 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | 7 |
| | | (*c*) Explain how missing data were addressed | 7 |
| | | (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed | |

| | | | |
|---|---|---|---|
| | | *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy | |
| | | (*e*) Describe any sensitivity analyses | |
| **Results** | | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 5 |
| | | (b) Give reasons for non-participation at each stage | 5 |
| | | (c) Consider use of a flow diagram | |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 5 |
| | | (b) Indicate number of participants with missing data for each variable of interest | |
| | | (c) *Cohort study*—Summarise follow-up time (eg, average and total amount) | |
| Outcome data | 15* | *Cohort study*—Report numbers of outcome events or summary measures over time | |
| | | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure | |
| | | *Cross-sectional study*—Report numbers of outcome events or summary measures | 8 |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | 9 |
| | | (*b*) Report category boundaries when continuous variables were categorized | 9-11 |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | 12 |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 13 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 13-15 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 15 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 16 |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

# Relationship between years in the trade and the development of radiographic knee osteoarthritis, and MRI-detected meniscal tears and bursitis in floor layers. A cross sectional study of a historical cohort.

| | |
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~~Trade seniority~~Years of employment and knee disorders

# Relationship between years in the trade~~trade seniority~~ and the development of radiographic knee osteoarthritis, and MRI-detected meniscal tears and bursitis in floor layers. A cross sectional study of a historical cohort.

Lilli Kirkeskov Jensen M.D. [1], Søren Rytter M.D. [2], Jacob Louis Marott M.Sc. [3], Jens Peter Bonde M.D. [1]

[1] Department of Occupational and Environmental Medicine, Bispebjerg Hospital, Denmark

[2] Department of Orthopaedic Surgery, Hospital Unit West, Holstebro, Denmark

[3] Copenhagen City Heart Study, Bispebjerg Hospital, Denmark



Key Indexing Terms:

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Correspondence to: Dr. Lilli Kirkeskov, Department of Occupational and Environmental Medicine, Bispebjerg Hospital, Bispebjerg Bakke 23, 2400 Copenhagen NV, Denmark, Telephone +45 35 31 60 60. Telefax +45 35 31 60 70. E-mail lkir0013@bbh.regionh.dk

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**ABSTRACT**

**Objectives:** An increased risk of developing knee disorders including radiographic knee osteoarthritis (OA) have been shown among workers with kneeling working demands. There may also be a dose-related association between duration of employment in occupations with kneeling work and development of radiographic knee-OA, and MRI detected meniscal tears, and bursitis.

**Design:** A cross-sectional study of a historical cohort.

**Setting:** Members of the trade unions for floor layers and graphic designers in Denmark.

**Participants:** 92 male floor layers and 49 graphic designers aged 36-70 years were randomly selected among participants from a clinical and radiographic study of 156 floor layers, and 152 graphic designers.

**Outcome measures:** Radiographic tibiofemoral (TF) and patellofemoral (PF) knee-OA, and MRI-detected meniscal tears and bursitis. Results were adjusted for age, earlier knee traumas, sports activities, and body mass index in logistic regression models. Association between TF OA and years in the floor laying trade was graphically examined by a restricted cubic spline with 4 knots.

**Results:** Increase in number of years with exposure to kneeling work is associated with radiographic TF-knee-OA with odds ratios of OR 0.7,95%CI 0.07-4.42; OR 1.89,95%CI 0.29-12.3; OR 4.82,95%CI 1.38-17 for < 20 years, 20-30 years, and >30 years of kneeling work, respectively. MRI- verified medial meniscal tears was increased among subjects with kneeling work with OR 1.96,95%CI 0.79-4.88 to OR 4.73,95%CI 1.16-19.4, but was not associated with duration of employment. Periarticular bursitis was increased in subjects with < 20 years of kneeling working activity. Lateral meniscal tears, and PF- kneeOA was not associated with duration of kneeling working activity or with kneeling work in general.

**Conclusions:** The findings suggest a dose-response relationship for radiographic TF-knee- OA in floor layers with a significant amount of kneeling work and an increase of MRI-verified medial meniscal tears among workers with kneeling work.

## ARTICLE SUMMARY

### Article focus

- An increased risk of developing knee disorders including radiographic knee osteoarthritis (OA) have been shown among workers with kneeling working demands. Workers with kneeling working positions have an increased risk of developing knee complaints in a much higher degree than can be explained by osteoarthritis.
- It is unknown if there is a dose-related association between duration of employment in occupations with kneeling work and development of radiographic knee-OA including both tibiofemoral and patellofemoral knee-OA
- It is unknown if MRI-detected meniscal tears, and bursitis around the knees can explain some of the knee complaints in subjects with kneeling work.

### Key messages

- The study shows a dose-response-relationship between the duration of employment in work with kneeling working positions, and tibiofemoral knee-OA but not of patellofemoral knee-OA.
- There is an increased risk of developing MRI-detected medial meniscal tears and periarticular bursitis among floor layers compared to referents, but it is not associated to long duration of employment.
- The study suggests that other knee disorders than osteoarthritis may explain that floor layers have knee complaints.

### Strengths and limitations of the study

- Study strength include investigation with both radiographic and MRI, the description of a variety of knee disorders, and the long duration of exposure among study group
- Limitation is the small number of participants due to economic reasons by conducting MRI

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**INTRODUCTION**

~~Demonstation~~Demonstration of exposure-response and exposure-effect relations is considered important in causal inference and the risk of developing various knee disorders may depend on both the degree of daily exposure and years of exposure to kneeling and squatting work positions.

We have in previous studies described an increased risk of developing tibiofemoral (TF) osteoarthritis (OA) meniscal tears and bursitis among floor layers with high knee loads compared to referents without knee straining work.[1-4] Floor layers install linoleum, carpet, and vinyl floorings. The work-tasks include removal of old flooring, grinding, filling, installation of underlay, measuring and cutting materials, gluing, welding, and installation of skirting ~~board.The~~board. The floor layers in this study did not usually use knee kickers, they ~~altered their~~perform all kinds of work-tasks, and none solely installed carpets. Graphic designers did layout of text and advertisements and made up pages before printing of newspapers, weekly papers, books, and other publications. They used visual display units, mostly while sitting. Their work did not include physically demanding or knee straining working positions. In an earlier study we measured the amount of kneeling work positions used by floor layers and graphic designers, using video recordings of short time periods without pauses and with continuous video recordings. The cumulative duration of time spent in kneeling work positions in one day have was 65% of the workday (SD 25%) for the discontinuous measurements[5,6] and 41% (SD 7.5%) for the continuous measurements for floor layers.[3] Graphic designers have no kneeling working demands.

Only few occupations are exposed to the same high level of knee demands as floor layers. All Danish floor layers have the same job functions. They are skilled and continue in the profession for many years. Hence we can apply seniority in the profession as a proxy for the total amount of knee strain.

We have shown a trend towards an increased risk of TF OA increasing with ~~the seniority~~duration of employment as a floor layer,[3] but no association for meniscal tears.[4]

The purpose of this study was to analyze whether there is a dose-response relationship for the development of radiologically detected tibio~~-~~femoral (TF) and patellofemoral (PF) OA, and MRI demonstrated meniscal lesions and various forms of bursitis measured by seniority in the profession as floor layers compared to a group of referents without knee straining work demands.

## MATERIAL AND METHODS

### Study sample

A source population of 286 Danish floor layers and 370 graphic designers was established in 1994 based on membership list from trade unions. Male members aged 36-70 years in 2004, who were living in the geographical area of Copenhagen (capital city) or Aarhus (second largest city), Denmark were included in the study. Male workers, who were members of the trade union 10 years earlier, were also included. Graphic designers, all from Copenhagen, were included as a group of non-exposed. Their work tasks involved no knee demands. Danish floor layers and graphic designers are comparable regarding the level of education and socio-economic status. Questionnaires were mailed to the source population in year 2004-2005. The response rate was 89% and 78% among floor layers and graphic designers, respectively. The questionnaire included information on age, height, weight, and years in the profession, knee complaints, knee traumas, and sports activity. Questionnaire respondents were invited to participate in a clinical and radiographic investigation. Informed consent to participate was given by 156 floor layers and 152 graphic designers. Consent to perform a full radiographic examination (knees and pelvis) were given by 134 floor layers (Copenhagen=88; Aarhus=46) and 120 graphic designers (Copenhagen).[3] Among those a random sample of 92 (Copenhagen, n=45; Aarhus, n=47) floor layers and 49 graphic designers (Copenhagen) had a MRI of both knees (n=282). Examinations were conducted at two MR ~~Centers~~Centres over a 1-year period (2005-2006).[4] Only the participants who have been included in both the MRI-study and the radiological examination ~~were included~~were included in the analysis of this paper. Permission was obtained from the Central Danish Region Committee on Biomedical Research Ethics.

### Magnetic resonance imaging

MR imaging at ~~Center~~Centre I was performed by a 1.5-Tesla scanner (SymphonyVision, Siemens Medical Systems, Erlangen, Germany) in 47 patients, and at ~~Center~~Centre II by a 1.5-Tesla scanner (Infinion, Philips, Best, The Netherlands) in 94 patients. The MRI sequences were identical for both the right and left knee. The following MRI sequences were obtained at ~~Center~~Centre I: sagittal proton density fat-saturated turbo spin echo (TR/TE, 3300/15 ms) and sagittal and coronal T2-weighted (4000/86 ms) fat-saturated turbo spin-echo; coronal T1-weighted (608/20 ms) spin-echo sequences and axial proton density fat-saturated turbo spin echo (3450/15 ms). The section thickness was 4 mm with an intersection gap of 0.4 mm; field of view was 200 x 200 mm and matrix 512 in all sequences. At ~~Center~~Centre II the MRI sequences included sagittal proton density fat-saturated turbo spin echo (TR/TE, 2500/18 ms) and sagittal and coronal T2-weighted (4000/85 ms) fat-saturated turbo spin-echo; coronal T1-weighted (400/13 ms) spin-echo and axial proton density fat-saturated turbo spin echo (2880/17 ms). The section thickness was 4 mm with an intersection gap of 0.4 mm;

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field of view was 150 x 150 mm and matrix 512 in all sequences.

A musculoskeletal radiologist with substantial MRI experience evaluated each of the 282 MR examinations. The observer was blinded to any medical history of knee disorders among participants. Due to differences in the appearance of MRI form the 2 centerscentres, blinding of occupational affiliation was incomplete regarding participants from CenterCentre I, who were all floor layers. Blinding of occupational affiliation was complete concerning all participants from CenterCentre II. The medial and lateral meniscus of each knee was evaluated separately for abnormalities. Abnormalities in the MR signal intensities predicting degenerative tears were divided in grade 1-3.[4] The presence of bursitis was assessed in both knees of each participant. Bursitis was registered in the following bursae: subgastrocnemius, semimembranosus-gastrocnemius, , anserine, lateral (LCL) and medial (MCL) collateral ligament, iliotibial, prepatellar, superficial infrapatellar, deep infrapatellar bursae; and extracapsular synovial cysts (Rytter S, Kirkeskov L, Bonde JP, Egund N. MR imaging of intra- and periarticular cyst-like lesions of the knee joint in workers with occupational kneeling. Accepted for publication 2012).

**Radiographs**

Radiological examinations of both knees were obtained in the standing weight-bearing position with the knee in 20-30 degree flexion in three views: posterior-anterior (PA), lateral and axial of the PF joint space. Radiographs were read and scored on workstations with 2K screens by one experienced musculoskeletal radiologist unaware of any medical history of knee disorders among all participants and blinded to occupational affiliation concerning the participants from Copenhagen. The radiographic scoring comprised assessment of the medial and lateral joint spaces of both the TF and PF compartments using a modified Ahlbäck scale (grade 0-6) of joint space narrowing (JSN) and subchondral bone attrition. The following grades of JSN were defined: grade 0 = normal; grade 1 = minimal but definite narrowing (25% JSN); grade 2 = moderate narrowing (50% JSN); grade 3 = severe narrowing (75% JSN); grade 4 = obliteration of the joint space, “bone on bone but no attrition”; grade 5 = < 5 mm attrition of subchondral bone and grade 6 = ≥ 5 mm bone attrition.[3] Knee OA was defined as JSN ≥ 25% in at least one knee and patterns of involvement categorized into medial or lateral TF OA and PF OA.

Field Code Changed

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**Data analysis and statistics**

We have in earlier studies shown that there were only small variations in the degree of knee straining work activities among the different work tasks in floor layers.[5,6] Trade seniorityDuration of employment for floor layers has therefore been used as a proxy for the exposure to knee straining work positions in the analyses of the this study, and categorized into three groups (≤20, 21-30, >30 years). Results for each of the three groups were compared to the group of graphic designers in total with no exposure to kneeling work activities. The association between the duration of employment in the trade (seniority) and the development of TF and PF OA (≥25% JSN), meniscal tears (grade 3), and bursitis was analysed among floor layers relative to graphic designers. The adjusted odds ratio (OR) with 95% confidence interval (CI) was computed and independent variables incorporated in the model of adjusted results were age, body mass index (BMI), knee straining sports, and earlier knee traumas. Sports activity (yes/no) was considered as potential knee straining if it was one of the following: football, handball, badminton, tennis, volleyball, ice hockey, weight lifting, and skiing. Earlier knee traumas (rupture of ligaments, meniscal tears operations, fractures including the knee joint) were categorized into two groups (yes/no).

Graphics splines are curves with simplicity of construction and a capacity to approximate complex shapes through curve fitting and interactive curve design. The restricted cubic splines provide a general and robust approach for adapting linear methods to model non-linear relationships between a response variable and one or more continuous covariates.The dose-response relationship between years in the trade and risk of TF OA was graphically examined by using thea restricted cubic spline with 4 knots.[7,8].

Correlation between TF and PF OA, bursitis and meniscal tears was evaluated by using Kappa statistics. The software package EpiData was used to code data and statistical analysis were conducted with SPSS statistics, version 17.0.

## RESULTS

Characteristics of the study sample are given in Table 1. Participants were all males; aged 42-70 at the time of the examination (mean age 55.6, SD 6.8 years). There was a marked difference in the age distribution and the ~~trade seniority~~duration of employment between the two study groups. Graphic designers were generally older and had a higher seniority than floor layers. Regarding height, weight and BMI the two groups were comparable.

**Table 1. Characteristics of the study sample**

| | Floor layers (n=92) | | Graphic designers (n=49) | |
|---|---|---|---|---|
| **Weight**, kg *(mean, SD)* | 84.1 | 12.7 | 84.5 | 17.7 |
| **Height**, cm *(mean, SD)* | 179.1 | 6.5 | 177.9 | 7.2 |
| **Age**, years *(mean, SD)* | 54.5 | 7.2 | 57.7 | 5.6 |
| - *≤ 49 (n, %)* | *24* | *26.1* | *4* | *8.2* |
| - *>50 (n, %)* | *68* | *73.9* | *45* | *91.8* |
| **~~Seniority~~ Duration of employment** †, years *(mean, SD)* | 29.6 | 9.8 | 35.9 | 6.5 |
| - *≤ 20 (n, %)* | *20* | *21.8* | *1* | *2.1* |
| - *21-30 (n, %)* | *27* | *29.3* | *10* | *20.4* |
| - *>30 (n, %)* | *45* | *48.9* | *38* | *77.5* |
| **BMI** ‡, kg/m$^2$ *(mean, SD)* | 26.2 | 3.4 | 26.6 | 4.8 |
| - *≤ 27 (n, %)* | *64* | *69.6* | *33* | *67.4* |
| - *≥ 28 (n, %)* | *28* | *30.4* | *16* | *32.6* |
| **Proportion with knee complaints during past 12 months** | | | | |
| | **Floor layers** | | **Graphic designers** | |
| | *n* | *%* | *n* | *%* |
| ~~**Weight**, kg *(mean, SD)*~~ | ~~84.1~~ | ~~12.7~~ | ~~84.5~~ | ~~17.7~~ |
| ~~**Height**, cm *(mean, SD)*~~ | ~~179.1~~ | ~~6.5~~ | ~~177.9~~ | ~~7.2~~ |
| **Tibiofemoral osteoarthritis*** | | | | |
| - *No=113* | 35 | 47.9 | 16 | 40.0 |
| - *Yes=25* | 11 | 64.7 | 7 | 87.5 |

| | | |
|---|---|---|
| **Patellofemoral osteoarthritis*** | | |
| - *No=122* | 40 39.0 | 17 43.6 |
| - *Yes=16* | 6 85.7 | 6 66.7 |
| **Medial meniscal tears** | | |
| - *No=53* | 16 53.3 | 11 47.8 |
| - *Yes=88* | 30 48.4 | 13 50.0 |
| **Lateral menisval tears** | | |
| - *No=118* | 41 51.2 | 18 47.4 |
| - *Yes=23* | 5 41.7 | 6 54.5 |
| **Pre- and infrapatellar bursitis** | | |
| - *No=123* | 41 51.2 | 21 48.8 |
| - *Yes=18* | 5 41.7 | 3 50.0 |
| **Periarticular bursitis** | | |
| - *No=39* | 10 47.6 | 7 38.9 |
| - *Yes=102* | 36 50.7 | 17 54.8 |

* missing=3, ‡ Duration of employment in the trade ; ‡ BMI, body mass index

**Knee osteoarthritis**

The prevalence of TF OA was increased (but not significant) in floor layers compared to graphic designers; OR 2.46, 95% CI 0.83-7.28 adjusted for BMI, sports activities, age, and earlier knee traumas as shown in Table 2. On the contrary PF OA was more frequent in graphic designers compared to floor layers, OR 0.44, 95% CI 0.14-1.37.

**Table 2. Risk of radiographic tibio- and patellofemoral knee osteoarthritis (OA), and MRI detected meniscal tears, and bursitis. Floor layers (n=92) compared to graphic designers (n=49). Odds ratio (OR) with 95% confidence interval (CI).**

| | Floor layers | | Graphic designers | | Adjusted | |
|---|---|---|---|---|---|---|
| **Disorder** | n | % | n | % | OR* | 95% CI |
| Tibiofemoral OA § | 17 | 18.9 | 8 | 16.7 | 2.46 | 0.83-7.28 |
| Patellofemoral OA | 7 | 7.8 | 9 | 18.8 | 0.44 | 0.14-1.37 |
| Tears of medial meniscus# | 62 | 67.4 | 26 | 53.1 | 2.82 | 1.25-6.36 |
| Tears of lateral meniscus# | 12 | 13.0 | 11 | 22.4 | 0.78 | 0.29-2.10 |
| *Peripatellar bursitis:* | | | | | | |
| Prepatellar | 1 | 1.1 | 5 | 10.2 | 0.14 | 0.02-1.55 |
| Superficial infrapatellar | 4 | 4.3 | 2 | 4.1 | 0.90 | 0.14-5.75 |
| Deep infrapatellar | 10 | 10.9 | 2 | 4.1 | 3.53 | 0.64-19.6 |
| *Periarticular bursitis:* | 71 | 77.2 | 31 | 63.3 | 2.04 | 0.89-4.69 |
| Subgastrocnemius | 57 | 62.0 | 24 | 49.0 | 1.76 | 0.82-3.75 |
| Semimembranosus-gastrocnemius | 43 | 46.7 | 17 | 34.7 | 1.49 | 0.67-3.29 |
| Others** | 14 | 15.2 | 0 | 0 | - | - |

*OR is calculated relative to the reference group of graphic designers, and adjusted for body mass index, previous knee traumas, knee straining sports activities and age

** Others: anserine, lateral (LCL) and medial (MCL) collateral ligament, iliotibial bursae, and extra capsular synovial cysts.

# Uni or bilateral meniscal tears

§Missing radiographs in two floor layers and one graphic designer

A dose-response relationship measured by years in the trade (seniority) was shown for TF OA in floor layers with odds ratios increasing from OR 0.70 (ns) (≤20 years of exposure); OR 1.89 (ns) (21-30 years of exposure); to OR 4.82, 95% CI 1.38-17.0 (>30 years of exposure) when compared to graphic designers without exposure to kneeling work demands (Table 3). There was no dose-response relationship for PF OA.

**Table 3. Risk of radiographic tibio- and patellofemoral knee osteoarthritis (OA), and MRI detected meniscal tears, and bursitis; by ~~trade seniority~~years in the trade. Floor layers (n=92) compared to graphic designers (n=49). Odds ratio (OR) with 95% confidence interval (CI).**

| | **<=20 years** | | **21-30 years** | | **>30 years** | |
|---|---|---|---|---|---|---|
| **Disorder** | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Tibiofemoral OA§ | 0.70 | 0.07-7.42 | 1.89 | 0.29-12.3 | 4.82 | 1.38-17.0 |
| Patellofemoral OA | 1.30 | 0.27-6.33 | - | - | 0.48 | 0.12-1.88 |
| Tears of medial meniscus# | 4.73 | 1.16-19.4 | 4.59 | 1.28-16.5 | 1.96 | 0.79-4.88 |
| Tears of lateral meniscus# | 1.14 | 0.24-5.33 | 0.68 | 0.11-4.28 | 0.86 | 0.27-2.76 |
| *Peripatellar bursitis:* | | | | | | |
| Prepatellar | - | - | - | - | 0.27 | 0.03-2.72 |
| Superficial infrapatellar | - | - | - | - | 1.43 | 0.22-9.09 |
| Deep infrapatellar | 3.20 | 0.31-32.9 | 7.30 | 0.62-85.7 | 2.33 | 0.31-17.7 |
| *Periarticular bursitis:* | 12.20 | 1.31- 113 | 1.22 | 0.38-3.90 | 1.80 | 0.67-4.78 |
| Subgastrocnemius | 2.50 | 0.71-8.86 | 1.19 | 0.38-3.77 | 1.98 | 0.81-4.82 |
| Semimembranosus-gastrocnemius | 3.14 | 0.89-11.0 | 1.31 | 0.39-4.33 | 1.23 | 0.49-3.13 |

*OR is calculated relative to the reference group of graphic designers, and adjusted for body mass index, previous knee traumas, knee straining sports activities, and age

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To further examine the dose-response relationship between years in the trade and TF OA we included years as floor layer as a continuous variable. The results showed a positive association between years in the floor layer and TF OA (Table 4).

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**Table 4. Association between years as a floor layer and development of TF OA, PF OA, meniscal tears, and bursitis. Odds ratios (OR)* and 95% Confidence Intervals, CI.**

| **Disorder** | OR* | 96% CI |
|---|---|---|
| Tibiofemoral OA § | 1.04 | 1.01-1.07 |
| Patellofemoral OA | 0.96 | 0.93-1.00 |
| Tears of medial meniscus# | 1.02 | 1.00-1.05 |
| Tears of lateral meniscus# | 0.99 | 0.97-1.02 |
| Deep infrapatellar bursitis | 1.03 | 0.99-1.07 |
| Periarticular bursitis | 1.06 | 1.00-1.13 |

* OR is calculated relative to the reference group of graphic designers, and adjusted for body mass index, previous knee traumas, knee straining sports activities, and age

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The same pattern was seen when including years of trade as a restricted cubic spline in a age-adjusted logistic regression model (Figure 1).

**Meniscal tears**

A significant higher prevalence of medial meniscal tears occurred among floor layers compared to graphic designers, as shown in Table 2. The risk of meniscal tears did not increase with ~~trade seniority~~duration of employment in floor layers compared to the graphic designers (Table 3). The adjusted OR for meniscal tears were 4.73; 4.59, and 1.96 for ~~trade seniority~~duration of employment ≤20 years, 21-30 years, and >30 years, respectively. There was no significant difference in the prevalence of lateral meniscal tears between the two study groups, and no dose-response relationship between seniority as a floor layers. Additionally, no correlation was found between medial meniscal tears and TF OA in floor layers (Kappa 0.04). Table 4 shows a significant association between years as a floor layer and the medial meniscal tears but not for ~~laterale~~lateral meniscal tears.

**Bursitis**

Nine graphic designers 9/49 (18%) were classified as having prepatellar, superficial or deep infrapatellar bursitis compared to 15/92 (16%) floor layers. The prevalence of prepatellar bursitis was higher in graphic designers (10.2%) compared to floor layers (1.1%). The prevalence of deep infrapatellar bursitis was on the contrary higher in floor layers (10.9%) compared to graphic designers (4.1%), OR 3.53, 95% CI 0.64-19.6. A higher prevalence of bursitis in the subgastrocnemius, semimembranosus-gastrocnemius, and other bursae (extracapsular synovial cysts, anserine, biceps, LCL and MCL, iliotibial) was observed in floor layers with OR 2.04, 95% CI 0.89-4.69.

The odds ratios for deep infrapatellar bursitis were OR 3.20, 95 % CI 0.31-32.9 for seniority ≤20 years, OR 7.30, 95% CI 0.62-85.7 for seniority 21-30 years, and OR 2.30, 95% CI 0.31-17.7, for seniority >30 years when compared to the whole group of graphic designers without knee straining work activities.

Fluid collections in other bursae (e.g. subgastrocnemius, semimembranosus – gastrocnemius) were increased significantly only for floor layers with ≤20 years of seniority (OR 12.2, 95% CI 1.31-113) (Table 3).

Table 4 shows a significant association between years as a floor layer and periarticulat bursitis.

No correlation between TF OA, deep infrapatellar bursitis and other bursitis was shown (Kappa 0.08 and 0.12, respectively).

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**DISCUSSION**

The results showed a significant association between years as a floor layer and development of TF OA, medial meniscal tears, and periarticular bursitis comparetcompared to referantsreferents.

The OR for TF OA increased with the duration of employment in the trade. There were only significant differences between the non-exposed reference group and floor layers with more than 30 years of exposure, but there was a tendency towards a dose-response relationship shown by odds ratios >1 for the medium and high exposure groups, when compared to the reference group. These results indicate a dose-response relationship. The small number of workers who were investigated (n=141), and especially few referents among those with low seniority may influence results and explain the missing significance between all the exposure groups. Only few previous studies have investigated the dose-response relationship between knee OA and the quantity of kneeling work activities. Enderlein and Kasch found a higher frequency of knee OA in participants with a higher extent of hyperkeratosis in front of the patella (used as a measure for the extent of kneeling working position).[9][7] Sandmark et al. showed OR 2.1 and 1.4, respectively among workers with high and medium exposure to kneeling work demands compared to low or no exposure.[10][8] In a study, which included some of the floor layers from the same cohort as in this paper, but 10 years earlier, the OR for the association between knee OA and exposure to kneeling work activities were 2.9 (low/moderate exposure), 4.2 (high exposure), and 4.9 (very high exposure).[1] In summary, indication of a dose-response relationship for osteoarthritis in this study is supported by findings in previous studies.

The risk of medial meniscal tears was increased in floor layers compared to graphic designers, but there were no difference depending on trade seniorityduration of employment. If meniscal tears are caused by many years of kneeling work a dose-response effect due to accumulated exposures to kneeling work tasks may be expected. However, if meniscal tears are caused by trauma because of inappropriate posture when getting from kneeling work positions to the standing position many times a day meniscal tears may not necessarily depend on the duration of the kneeling work.

In this study, the average period of employment was 29.6 years for floor layers. Twenty two percent have been employed less than 20 years, but few of them have been employed less than 15 years. It is possible that damage to the meniscus occurs before. In conclusion, we did not found a dose-response effect between years of kneeling work and development of meniscal tears. However, the prevalence of medial meniscal

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tears were significantly increased in floor layers compared to the graphic designers. In general only few studies have examined the relationship between meniscal tears and occupational kneeling. In a nested case-control investigation by Baker et al.[11][9] the occupational activities of 67 men (4.8%) reporting meniscectomy were compared to 335 controls. After adjustment for sports participation, meniscectomy was associated with kneeling (OR 2.5, 95% CI 1.3-4.8) and squatting (OR 2.5, 95% CI 1.2-4.9) more than 1 hour in an average working day. In a case-control study Baker et al.[12][10] investigated 243 men aged 20-59 years who had a meniscal tear confirmed by arthroscopy and compared them to community controls matched by age and sex. Results showed a significant association between kneeling (OR 2.2, 95% CI 1.3-3.6) and squatting (OR 1.8, 95% CI 1.1-3.0) > 1 h/day and meniscal tears. Greinemann et al.[13][11] conducted a case-control study in 500 miners compared to 500 controls without knee demanding work postures, all men in the age of 50 years. In total 57 miners (11.4%) had a knee surgery for meniscal tears compared to 14 (2.8%) among controls (OR 4.5, 95% CI 2.5-7.8). Sharrard and Liddell[14][12] investigated the frequency of meniscectomies among miners and other patients and compared it to the frequency of appendectomies in the same period. Meniscectomy had been performed in 605 miners and 352 men from other occupations. Comparing the frequency of meniscectomy to appendectomy they found and increased incidence of meniscectomy among miners (OR 3.3, 95% CI 2.7-4.0). These results may indicate a possible association between occupational kneeling and development of meniscal tears.

Results in this study showed a higher prevalence of bursitis, in total, among floor layers compared to the reference group. A low prevalence of prepatellar and superficial infrapatellar bursitis in floor layers compared to the reference group was found and there was even a tendency of a higher prevalence among graphic designers. This finding do not correspond to earlier results of Myllimäki et al.[15][13] who in an ultrasound study found fluid accumulation in the superficial infrapatellar bursa among 5.3% floor layers compared to none in a reference group of painters. Results also showed a low prevalence of prepatellar bursitis among floor layers compared to the reference group. Only one floor layer and five from the reference group had fluid accumulation in the prepatellar bursae. Hill et al.[16][14] have showed that pre- and superficial infrapatellar bursitis is common among individuals with radiographic knee OA and described fluid in bursae as a physiologically phenomenon, which is consistent with findings in other studies.[17][15]

We found a higher prevalence of bursitis in the deep infrapatellar, subgastrocnemius, semimembranosus-gastrocnemius bursae, and other bursae (as anserine) in floor layers compared to graphic designers. Hill et al., 2003 found a 4% prevalence of bursitis in other bursae as semimembranosus, anserine, and iliotibial in subjects with knee OA compared to none in subjects without knee OA. It suggests that bursitis can occur among subjects with radiographic knee OA, but the association between knee OA and bursitis was not shown in this study where Kappa testing showed no correlations. A difference between the study group and the reference group in the prevalence of bursitis also does not support the assumption. Identification of bursitis in many bursae, including the posterior part of the knee joint indicates that bursitis may not only be caused by direct pressure on the knee when kneeling.

We do not know if there is a causal association between external knee pressure and development of knee disorders. However, it seems plausible that a combination of extreme flexion in the knee joint, micro traumas caused by frequent kneeling and a high external knee pressure may cause knee disorders such as knee OA and medial meniscal tears while some of the knee disorders including bursitis may be explained by external pressure or other intraarticular factors.

The strength of this study is that the floor layers have worked many years in the occupation and have had a substantially amount of kneeling work, and that the study included both radiographic, MRI, and self-reported data.

One of the limitations of the study is the low participation rate which may lead to a risk of underestimation of a real risk. Participants in the radiological and MRI-study represented a smaller proportion of those who answered the questionnaire and there was a predominance of graphic designers with self-reported knee complaints and knee traumas in the study compared to the questionnaire participants of graphic designers (15% compared to 38%). However such a selection bias would typically also result in an underestimation of a real risk.

Graphic designers are in the study in general older than floor layers. This may have an impact on the number with knee OA, as particularly increases with age. We therefore adjusted for age in the analysis.

In the analysis concerning years of employment in the trade the graphic designers was defined as having been employed zero years within the floor laying trade. The distribution of the number of years in employment of graphic designers is therefore irrelevant in this context.

Results from the current study may also have been diluted by a healthy worker selection. In the study which consisted of a historical cohort of workers it was however possible to include workers who had expired. The impact of a secondary healthy worker selection may thereby be minimized, although not eliminated. Yet, the effect of a primary healthy worker selection cannot be ruled out, e.g. selection of people with good health status into the workforce at the time of hire. Overall it is considered that the limitations of the study mainly go against an underestimation of the real risk.

In conclusion, the results of this study indicate a positive dose-response relationship between ~~seniority~~ duration of employment as a floor layer and the development of TF OA and possibly deep infrapatellar bursitis. The risk of developing bursitis in other locations around the knee joint was especially increased for floor layers with seniority ≤20 years. A dose-response relationship for meniscal tears and PT OA was not found, and there were no correlations between meniscal tears, bursitis, and TF OA.

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**Acknowledgements**

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**Author contribution**

~~Lilli Kirkeskov made data analysis and was the principal author~~

~~Søren Rytter collected data and contributed to writing the article~~

~~Jacob Marrot participated in data analysis and contributed to the writing of the article~~

~~Jens Peter Bonde has assisted in the writing of the article~~

LK, corresponding author has the primary responsibility for design, analysis and preparation of the manuscript.

SR and JPB have been deeply involved in the study design. SR has collected data under the supervision of LK and JPB. All authors, LK, SR, JPB, JLM have received the original data and have been deeply involved in the analysis of data, discussion of the manuscript, drafting and revising it critically. Each author has read and approved the final manuscript writing.

Reference List


[1] Jensen LK. Knee-straining work activities, self-reported knee disorders and radiographically determined knee osteoarthritis. Scand J Work Environ Health 2005;31:68-74.

[2] Jensen L, Mikkelsen S, Loft I, et al. Radiographic knee osteoarthritis in floorlayers and carpenters. Scand J Work Environ Health 2000;26:257-62.

[3] Rytter S, Egund N, Jensen LK, et al. Occupational kneeling and radiographic tibiofemoral and patellofemoral osteoarthritis. J Occup Med Toxicol 2009;13:19.

[4] Rytter S, Jensen LK, Bonde JP, et al. Occupational kneeling and meniscal tears: A magnetic resonance iamging study in floor layers. J Rheumatol 2009;36:1362-4.

[5] Jensen LK, Rytter S, Bonde JP. Exposure assessment of kneeling work activities among floor layers. Applied Ergonimics 2010;41:319-25.

[6] Jensen L, Eenberg W, Mikkelsen S. Validity of self-reporting and video-recording for measuring knee-straining work postures. Ergonomics 2000;43:310-6.

[7] Harrell FE. Regression modeling strategies with applications to linear models, logistic regression and survival analysis. 1st ed ed. New York: Springer-Verlag, 2001.

[8] Marrie R, Dawson N, Garland A. Quantile regression and restricted cubic splines are useful for exploring relationships between continuos variables. Journal of Clinical Epidemiology 2009;62:511-7.

[9] Enderlein G, Kasch J. Modellierung von Dosis-Wirkungsbeziehungen für expositionsabhängige Veränderungen am Bewegungsapparat. Z gesamte Hyg 1989;35:215-8.

[10] Sandmark H, Hogsted C, Vingård E. Primary osteoarthrosis of the knee in men and women as a result of lifelong physical load from work. Scand J Work Environ Health 2000;26:20-5.

[11] Baker P, Reading I, Cooper C, et al. Knee disorders in the general population and their relation to occupation. Occup Environ Med 2003;60:794-7.

[12] Baker P, Coggon D, Reading I, et al. Sports injury, occupational physical activity, joint laxity, and meniscal damage. J Rheumatol 2002;29:557-63.

[13] Greinemann H. Die Kniegelenkartrose des Bergmannes - eine Berufskrankheit. Unfallchirurgie 1997;23:10-7.

[14] Sharrard W, Liddell FD. Injuries to the semilunar cartilages of the knee in miners. British Journal of Industrial Medicin 1962;19:195-202.

[15] Myllymäki T, Tikkakoske.T, Typpö T, et al. Carpet-layer's knee. An ultrasonographic study. Acta Radiologica 1993;34:496-9.

[16] Hill CL, Gale DR, Chaisson CE, et al. Periarticular lesions detected on magnetic resonance imaging. Arthritis & Rheumatism 2003;48:2836-44.

[17] Janzen DL, Peterfy CG, Forbes JR, et al. Cystic lesions around the knee joint: MR imaging findings. Am J Roentgenol 1994;163:155-61.

REFERENCES

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[1] Jensen LK. Knee-straining work activities, self-reported knee disorders and radiographically determined knee osteoarthritis. Scand J Work Environ Health 2005;31:68-74.

[2] Jensen L, Mikkelsen S, Loft I, et al. Radiographic knee osteoarthritis in floorlayers and carpenters. Scand J Work Environ Health 2000;26:257-62.

[3] Rytter S, Egund N, Jensen LK, et al. Occupational kneeling and radiographic tibiofemoral and patellofemoral osteoarthritis. J Occup Med Toxicol 2009;13:19.

[4] Rytter S, Jensen LK, Bonde JP, et al. Occupational kneeling and meniscal tears: A magnetic resonance iamging study in floor layers. J Rheumatol 2009;36:1362-4.

[5] Jensen LK, Rytter S, Bonde JP. Exposure assessment of kneeling work activities among floor layers. Applied Ergonimics 2010;41:319-25.

[6] Jensen L, Eenberg W, Mikkelsen S. Validity of self-reporting and video-recording for measuring knee-straining work postures. Ergonomics 2000;43:310-6.

[7] Enderlein G, Kasch J. Modellierung von Dosis-Wirkungsbeziehungen für expositionsabhängige Veränderungen am Bewegungsapparat. Z gesamte Hyg 1989;35:215-8.

[8] Sandmark H, Hogsted C, Vingård E. Primary osteoarthrosis of the knee in men and women as a result of lifelong physical load from work. Scand J Work Environ Health 2000;26:20-5.

[9] Baker P, Reading I, Cooper C, et al. Knee disorders in the general population and their relation to occupation. Occup Environ Med 2003;60:794-7.

[10] Baker P, Coggon D, Reading I, et al. Sports injury, occupational physical activity, joint laxity, and meniscal damage. J Rheumatol 2002;29:557-63.

[11] Greinemann H. Die Kniegelenkartrose des Bergmannes - eine Berufskrankheit. Unfallchirurgie 1997;23:10-7.

[12] Sharrard W, Liddell FD. Injuries to the semilunar cartilages of the knee in miners. British Journal of Industrial Medicin 1962;19:195-202.

[13] Myllymäki T, Tikkakoske.T, Typpö T, et al. Carpet-layer's knee. An ultrasonographic study. Acta Radiologica 1993;34:496-9.

[14] Hill CL, Gale DR, Chaisson CE, et al. Periarticular lesions detected on magnetic resonance imaging. Arthritis & Rheumatism 2003;48:2836-44.

[15] Janzen DL, Peterfy CG, Forbes JR, et al. Cystic lesions around the knee joint: MR imaging findings. Am J Roentgenol 1994;163:155-61.

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Legend

Figure 1. The dose-response relationship between years in the trade and risk of tibio-femoral osteoarthritis, TF, TF OA, graphically examined by a restricted cubic spline with 4 knots.[7]

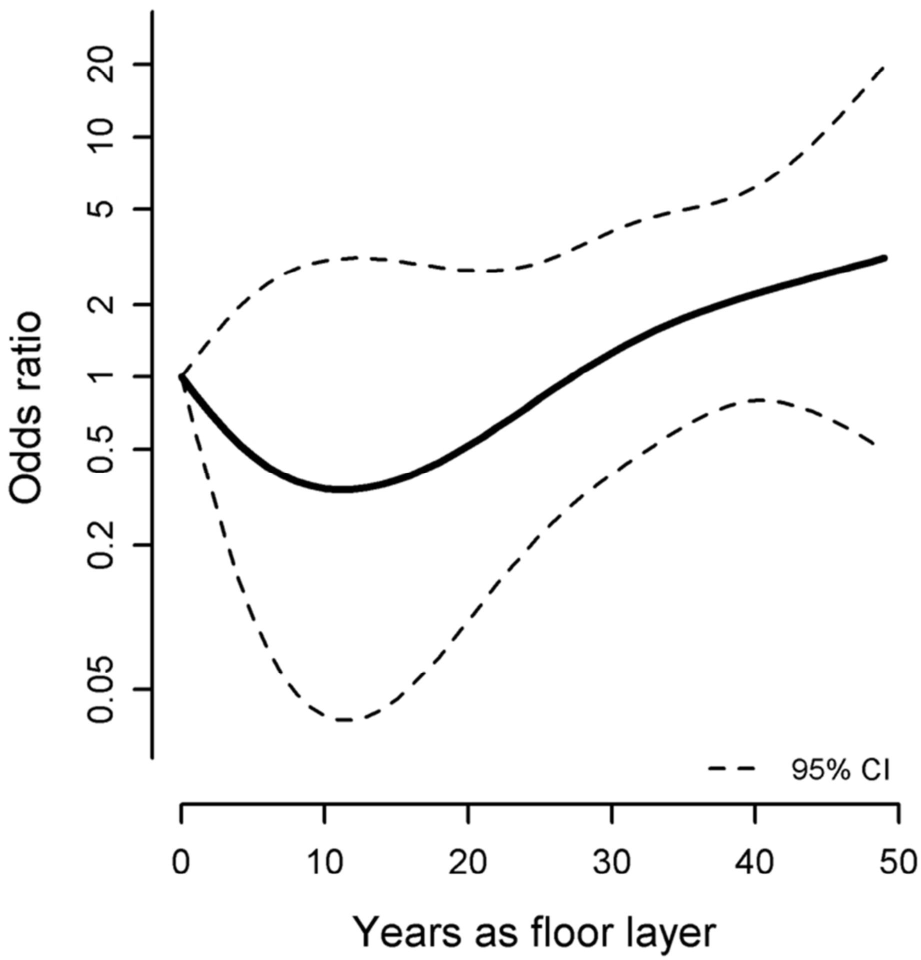


Figure 1. The dose-response relationship between years in the trade and risk of tibio-femoral osteoarthritis, TF OA, graphically examined by a restricted cubic spline with 4 knots.
69x69mm (300 x 300 DPI)

**STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology***
**Checklist for cohort, case-control, and cross-sectional studies (combined)**

| Section/Topic | Item # | Recommendation | Reported on page # |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 2 |
| Objectives | 3 | State specific objectives, including any pre-specified hypotheses | 2 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 5-6 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 5-6 |
| Participants | 6 | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants | 5-6 |
| | | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case | |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 5-6 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | *5-6* |
| Bias | 9 | Describe any efforts to address potential sources of bias | |
| Study size | 10 | Explain how the study size was arrived at | 5 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 7 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 7 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | 7 |
| | | (*c*) Explain how missing data were addressed | 7 |
| | | (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed | |

| | | | |
|---|---|---|---|
| | | *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy | |
| | | (*e*) Describe any sensitivity analyses | |
| **Results** | | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 5 |
| | | (b) Give reasons for non-participation at each stage | 5 |
| | | (c) Consider use of a flow diagram | |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 5 |
| | | (b) Indicate number of participants with missing data for each variable of interest | |
| | | (c) *Cohort study*—Summarise follow-up time (eg, average and total amount) | |
| Outcome data | 15* | *Cohort study*—Report numbers of outcome events or summary measures over time | |
| | | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure | |
| | | *Cross-sectional study*—Report numbers of outcome events or summary measures | 8 |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | 9 |
| | | (*b*) Report category boundaries when continuous variables were categorized | 9-13 |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | 13-14 |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 14 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 16 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 13-15 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 15 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 18 |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.