Osteoarthritis and meniscus disorders of the knee as occupational diseases of miners

G McMillan, L Nichols

Aim: To determine whether kneeling or squatting for prolonged periods is sufficiently causally associated with an increased risk of injury or degenerative disease of the knee joint as to meet the classic criteria to be considered an occupational disease of coal miners for whom these are or have been routine working postures.

Method: Systematic literature searches were made for studies relating to kneeling and squatting as part of the working environment of coal mines and the role of these postures in causation of knee disorders in coal miners, analogous occupations, populations, and communities. The working environment and potentially damaging forces on the knee when kneeling or squatting were described. Papers on the incidence or prevalence of knee disorders in occupational and other groups were scored against five criteria independently by each author, and from this a single consensus score representing the overall strength of evidence given by the research was awarded. The evidence was then weighed against the criteria for an occupational disease.

Results: Nineteen published papers were scored, the majority of which focussed on osteoarthritis as the outcome of interest. Few of the studies found focussed specifically on miners, and those that did tended to involve small numbers of subjects and were carried out before 1960, when the mining population was at its largest but epidemiological evidence of the risk factors for knee disorders was not well established. The non-mining studies in the review represent groups of workers with a similar or lesser kneeling content in their work.

Conclusion: The papers reviewed provide sufficient evidence to conclude that work involving kneeling and/or squatting is causally associated with an increased risk of osteoarthritis of the knee. In some of the more recent epidemiologically sound studies, frequent or prolonged kneeling or squatting doubles the general risk of osteoarthritis of the knees found in the general population. This may be of particular importance in welfare and medico-legal situations. There was also evidence to suggest that lifting, in combination with kneeling/squatting, an activity also performed by miners in the course of their work, is associated with an excess risk of osteoarthritis above that attributed to kneeling/squatting alone.

The miner who is the victim of immediate or long term effects of an injury of the knee resulting from an accident at work commonly qualifies for compensation under the accident provisions of state or company social security provisions or private insurance. In some countries those who have developed “beat knee”, defined as bursitis or subcutaneous cellulitis at or about the knee due to severe or prolonged external friction or pressure during employment in a specified occupation, also qualify for social security provisions or private insurance. In some countries those who have developed “beat knee”, defined as bursitis or subcutaneous cellulitis at or about the knee due to severe or prolonged external friction or pressure during employment in a specified occupation, also qualify for social security provisions or private insurance.
squatting; mining in general and coalmining in particular; nature and causation of knee injuries in general; and damage or disease of menisci, bursae, ligaments, and osteoarthritis of articular surfaces. The databases interrogated electronically were Dataster (for Medline, Toxfile, CancerLit, Embase, Biosis Previews, SciSearch, Pascal, NTIS, HSLI), Dialog (for NIOSHTic), STN (for SIGLE—System for Grey Literature in Europe), and the Internet (for COPAC and BLPC).

Two hundred and fifty five papers and reports were identified from the electronic databases within an abstract of each was provided. Each of the authors separately read these and selected those documents which they considered related to the working environment in coal mines and/or to knee problems related to any work, sport, or leisure or in communities or populations. Both selected the same 51 papers and, additionally, one or the other selected a total of 28 further papers. These 79 papers were obtained in full text. To these were added 31 papers, reports, or other documents which met these criteria having been noted in the bibliographies of papers already obtained, offered by colleagues from archives, or, from completion of the initial electronic search to start of analysis, found through weekly online reviews of additions to PubMed, new Health and Safety Executive publications, and finally scanning the contents pages of appropriate occupational health journals as these became available.

Within these 110 papers, two systematic and seven traditional reviews were identified. To avoid bias, these papers were not read, other than to scan the bibliographies, until after the authors had drawn consensus conclusions from their own systematic review.

The remaining 101 papers were studied in full text by the two authors to determine their potential contribution, again working independently of each other to form a written view but then debating to reach a consensus when opinions differed. It was agreed that 16 of these papers had nothing relevant to contribute.

Sixteen of the remaining papers contributed to an appreciation of coalminers’ working environment. Some of these and many of the others assisted in identifying and examining the risk factors for knee disorders. Finally, there were 19 published reports of studies which both authors agreed had sought causal links between knee disorders and the work of miners or analogous trades or work postures.

Working independently, following the approach used by Maetzel et al., each of these 19 papers was scored in the range 0 to +++ for each of five attributes of the design and conduct of the study. These marks were then reflected in a summary score to indicate the weight that should be given to the evidence presented. The attributes were representativeness, exposure ascertainment, outcome ascertainment, control of confounders, and follow up or response rate. Consensus on the summary score was then achieved between the reviewers through discussion of areas of difference in scoring.

<table>
<thead>
<tr>
<th>Seam thickness (inches)</th>
<th>Working position</th>
<th>Degree of mechanisation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30 Lying (7.0)</td>
<td>55.7</td>
<td>18.9</td>
</tr>
<tr>
<td>30– Kneeling (47.9)</td>
<td>24.2</td>
<td>31.1</td>
</tr>
<tr>
<td>50– Stooping (39.1)</td>
<td>15.3</td>
<td>24.7</td>
</tr>
<tr>
<td>&gt;70 Standing (5.9)</td>
<td>34.4</td>
<td>25.5</td>
</tr>
</tbody>
</table>

*Derived from Liddell (1973)*

| Figure given in brackets is the percentage of face workers in the UK working in such a position.

Pressures in the knee joint

In the study by Watkins et al, the coalminer varied his kneeling posture according to the task in which he was engaged and according to his personal preference. It was observed that the stability of the knee joint could be compromised by damage or stretching of the ligaments, predisposing the joint to internal damage, a consequence which would be challenged today by those with experience of the management of patients with damaged or absent collateral ligaments.

Sharrard conducted experiments at the coalface to define the forces and pressures exerted upon miners’ knees in the course of kneeling. On average a miner moved his shovel every two to five seconds, setting up a repeated cycle of immense shearing strains and loads in alternate knees. Different portions of the knee were subjected to pressures at different times. Pressure could rise suddenly over a localised area from zero to as much as 200 lb/square inch.

Slips, trips and evasive actions

In 1957, Dr J B Atkins described the role of activities other than kneeling and crawling in the causation of internal derangements of the knee joint (a term encompassing ligament and/or meniscus damage) in miners in the South Wales coalfield. This evidence demonstrated the importance, as the dominant causal factor, of sudden twisting of the knee as evasive action was taken to avoid injury. Atkins recommended addressing the causes of injury by keeping roadways in good repair, not using smooth steel plates on the floor, providing boots which would give a better grip, improving lighting, and clearing obstructions at the coalface.

Kneepads

Kneepads have been in use in British mines since 1928–29 to protect against bent knee rather than other knee disorders. A wider view is taken in the United States where the Mines Safety and Health Administration appears to accept that kneepads may usefully contribute to prevention.
of not only bursitis, but also damage to other structures of the unprotected knee, and it encourages use of knee pads to prevent against damage to the menisci and the ligaments.16

**Risk factors for common knee disorders**

The prevalence of knee pain in the general population ranges from 10% to 60% depending on age, occupation, and the definition used.17 Osteoarthritis is the most commonly attributed cause18 but no formal diagnosis is given in many cases.19 There is a high degree of discordance between the presence of persistent knee pain and radiographic evidence of degenerative disease20 and psychological variables can greatly influence the effects of knee disorders.21

Meniscus tears are most likely to be caused by sudden rotatory or abductory strain on the semi-flexed knee joint.22 Adamson23 remarked 'The miner works below ground in a cramped position with the knees flexed; the cartilages, therefore, are particularly liable to injury when a sudden rotatory and abductory strain is thrown on the joint with the knee in a flexed or semi-flexed position. The miner is thus particularly liable to suffer cartilage injuries.' In the early 1960s, Sharrard and Liddell's study reinforced that view by showing that more coalminers than would be expected from the experience of the general population underwent meniscectomy.11 At the time it was suggested that this might have been due to miners being more likely to have meniscus damage than others or, at least in part, that miners cannot work with a torn meniscus whereas this might be possible for men in other trades29 and that miners are under more pressure to have surgery to enable their return to work (however, this may not always be achieved).25

Meniscectomy or meniscus injury predisposes the injured knee to the development of degenerative changes characteristic of OA. This is a common, chronic, slowly progressive, often disabling degenerative joint disorder affecting joint cartilage and subchondral bone, leading to loss of cartilage and, when extensive, to visible radiographic changes including the development of osteophytes. Such degenerative changes are irreversible. Many risk factors for OA have been identified. Those that do not or are unlikely to feature for coalminers include female gender, advanced age,30 and obesity.31-35 Those factors likely to affect them are injury (including meniscus damage and post traumatic deformity),37-40 with up to a threefold excess over those who have not had a knee injury, and surgery.41-45 These two risk factors have been shown to be powerful influences on the development of OA. Increased physical activity and loading other than obesity are also risk factors experienced by miners. These occur during repetitive movements of the joint through kneeling, squatting, and crawling, and both sudden and persistent external loading while kneeling.

**Knee disorders in coalminers and analogous knee stressing trades and activities**

Nineteen reports published in the scientific literature were reviewed formally to explore the relation between knee disorders and occupation as a miner or in an analogous trade. The principal characteristics and selected results from each paper are summarised in tables 2 and 3. Table 2 summarises studies which estimate the risks of knee injury associated with kneeling and squatting. Table 3 summarises studies that estimate the prevalence of knee injury in working populations. In both of these tables the papers are listed in order of the strength of evidence they were judged to contribute. There was very little disagreement in the scoring between the two reviewers. Only five papers were given differing scores.

The earliest paper included in this review describes a case control study in the Manchester coal fields.36 The incidence of rheumatic complaints was found to be no greater in miners than in the population as a whole. The degree of incapacity (unfitness for work) was greater in miners and there was evidence of an earlier onset of symptoms as shown by a steeper rise in incidence at the fourth decade, principally due to back-hip-sciatic pain.

Kellgren and Lawrence followed this field study with a clinical and radiographic investigation of a random sample of male coal miners in their fifth decade, matched for sex and age with two control groups.41 They were careful to avoid bias in history taking, clinical examination, and reading the radiographs. Their definitions for the classification of survey radiographs are still used as the standard practice for such surveys. A positive diagnosis was made on the presence of osteophytes alone rather than coupling that finding with loss of joint space. Although this more rigorous application may have restricted cases to moderately severe and severe arthritis, it would have ignored cases of early disease and is not a serious flaw in the study design. There was a general trend in favour of an excess of OA among the miners but the differences in prevalence were not statistically significant. From this observation Kellgren and Lawrence justifiably, and cautiously, concluded that miners aged 41–50 years of age possibly suffer more OA of the knees than either manual or office workers of the same age. This was the first real evidence to support that contention.

Lawrence expanded the series of studies by comparing the knees of men employed as coalface workers and as roadway workers in the same colliery, face workers in a nearby wet mine of similar seam height, and dock workers.42 Comparing face and other underground workers was a serious flaw because, as noted in the paper, it is likely that knee pain would be a frequent cause of transfer from the face to roadways. This study’s principal contribution is its demonstration of a more than twofold excess risk of definite radiographic OA of the knee in underground coal workers compared with manual workers and almost fourfold excess risk when compared with office workers, the latter difference being statistically significant.

The importance of the next paper is enhanced in terms of official appreciation, as the author was employed in the Medical Inspectorate of Mines, Ministry of Power.43 The aim of this study was to investigate the prevalence of internal derangements of the knee and the factors which might be responsible for such injuries. Although precise figures were not available for the incidence of internal derangements of the knee among miners, this disadvantage was overcome by working from admissions to rehabilitation centres to derive an estimate of minimum incidence. The rates for internal derangement of the knee in miners may be adjusted to give 180 per 100 000 men—more than twice the rate in men doing heavy work in a Welsh steel works. Kneeling in narrow seams was shown to be not the only, or even the main, cause of injury—these being slipping and tripping. It seems that, rather than wear and tear causing degeneration, repeated trauma incidents account for the incidence observed in miners.

The 1962 paper by Sharrard and Liddell44 demonstrated that miners, notably face workers and especially those aged 25–54 years, appear to have an excess incidence of meniscus damage of up to 9:1 over the general population. Although cartilage tears were most common in those who knelt at work, the evidence of knelted that the injury might actually occur when a man is more active or undertakes sudden movements on the knee. Laxity of the knee joint was linked to kneeling at work, thus increasing the susceptibility of the knee to rotary injuries and consequent damage of the menisci. This study is flawed only by the possible bias of miners, driven by the fitness requirements of their work, seeking hospital treatment at an earlier stage than other men.
This paper appears to have been the last one focussed solely on miners to be published in the literature in English. The next paper relevant to occupational strains on the knees was a study by Lindberg and Montgomery who used an archive paper relevant to occupational strains on the knees to be published in the literature in English. This paper appears to have been the last one focussed solely associated with OA of the knee in the First National Health and Nutrition Examination Survey (HANES I) population. Although these provide much valuable information about that disease and some about attributes of occupations linked to prevalence and severity, relatively little can be attributed to specific occupations. The first of these papers was published in 1988 by Anderson and Felson who studied factors associated with OA of the knee in the First National Health and Nutrition Examination Survey (HANES I) population. The physical demands of respondents’ jobs were assessed using a published national standard. Using this method rather than individual questioning is a weakness. The authors remarked that they might have underestimated attributable risk by failing to include those who had retired or switched jobs because of OA (the healthy worker effect). After controlling for confounders, there was a strong association between knee OA and physically demanding occupations in those aged 55–64 years.

Felson and co-workers later used the Framingham Heart Study in a longitudinal assessment of occupational joint use and OA in a large cohort. They found that occupations which combined knee bending and physical demands were significantly related to and may be an important cause of radiographic OA.

In 1991 Vingård and colleagues published a report of a register based cohort study of the relation between occupation and OA of the hip and knee. Exposure was not ascertained from the individual but from an occupational assessment of physical

### Table 2: Characteristics and selected results of studies examining occupational kneeling and risk of knee injury (males only)

<table>
<thead>
<tr>
<th>Study period</th>
<th>Population</th>
<th>Exposure</th>
<th>Outcome*</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983–85</td>
<td>Cohort (US). Sample of population already taking part in heart study (n = 569)</td>
<td>Assessment of physical demand and knee bending requirement of occupations</td>
<td>K&amp;L&gt;2</td>
<td>1.07 (0.53 to 2.17)</td>
</tr>
<tr>
<td>Not specified</td>
<td>Case control (Finland). Cases: carpet and floor layers (n = 168). Controls: painters (n = 146)</td>
<td>Carpet/floor layers v painters</td>
<td>K&amp;L&gt;3</td>
<td>2.22 (1.38 to 3.58)</td>
</tr>
<tr>
<td>Not specified</td>
<td>Case control (UK). Cases: knee pain and radiographic OA (n = 109). Controls: no knee pain or OA (n = 218)</td>
<td>Time spent squatting or kneeling in longest held job before symptom onset</td>
<td>K&amp;L pain</td>
<td>2.90 (1.70 to 4.90)</td>
</tr>
<tr>
<td>1991–93</td>
<td>Case control (Sweden). Cases: knee replacement (n = 325). Controls: population register (n = 264)</td>
<td>Frequency of squatting/knee bends during working day: Time spent kneeling</td>
<td>Kneeling</td>
<td>2.10 (1.40 to 3.30)</td>
</tr>
<tr>
<td>Not specified</td>
<td>Case control (UK). Cases: waiting list for knee surgery (n = 203). GP controls (n = 203)</td>
<td>Time spent kneeling or squatting in all jobs held for one year or more</td>
<td>Kneeling</td>
<td>2.20 (1.00 to 4.90)</td>
</tr>
<tr>
<td>1958–60</td>
<td>Case control (UK). Cases: meniscectomy patients (n = 927). Controls: appendectomy patients (n = 1075)</td>
<td>Knee bending demand</td>
<td>Meniscectomy</td>
<td>2.00</td>
</tr>
<tr>
<td>1971–75</td>
<td>Cohort (US). Sample aged 35 to 64 years (n = 1853)</td>
<td>Degree of knee moment</td>
<td>Knee pain</td>
<td>4.00</td>
</tr>
<tr>
<td>1982–86</td>
<td>Case control (Sweden). Cases: knee pain and radiographic OA (n = 340). Controls: random selection from population registers (n = 680)</td>
<td>Time spent working in a kneeling or squatting position</td>
<td>Knee pain</td>
<td>2.00</td>
</tr>
<tr>
<td>Not specified</td>
<td>UK postal survey to patients of two GP practices (n = 1961)</td>
<td>Job title (longest held job)</td>
<td>Minisers v non-minisers</td>
<td>2.00</td>
</tr>
<tr>
<td>1992–93</td>
<td>Case control (Finland). Cases: knee arthroplasty (n = 53). Controls: random sample from population registry (n = 140)</td>
<td>Time spent squatting or kneeling in job at age 49 years</td>
<td>Kneele arthroplasty</td>
<td>2.90 (1.70 to 4.90)</td>
</tr>
<tr>
<td>1994–95</td>
<td>Cohort (Finland). Employed by forestry company (n = 3312).</td>
<td>Time spent working in a kneeling or squatting position.</td>
<td>Kneeling</td>
<td>1.30 (0.70 to 2.30)</td>
</tr>
<tr>
<td>1980</td>
<td>Cohort (Sweden). Hospital care for OA of the knee born 1905 and 1945 reporting same occupation in two consecutive censuses (n = 221)</td>
<td>Occupational exposure to forces on the lower extremities (high v low)</td>
<td>Hospital care</td>
<td>1.40 (1.10 to 1.90)</td>
</tr>
</tbody>
</table>

*K&L and Ahlbäck refer to classifications of radiographic appearance of arthrosis of the knee.

†Results given are for male and female subjects combined.
physician’s interpretation of records. Outcome definition was from discharge records rather than radiographs or other more clearly defined source operating to an auditable standard. Although there was a classification for miners and quarrymen, the numbers of workers in this group were insufficient to carry out a specific analysis.

Next to be published was a study of knee disorders in carpet and floor layers compared with age matched pain-
al retoters. 47 The study provided more evidence to suggest that work in which a considerable amount of time is spent weight bearing on the knees may be a risk factor for the development of OA above the age of 50 years.

To concentrate on grade 3 OA and over, the method used is thought to be satisfactory, although the radiographs were not weight bearing. There was a sound, well disciplined reading regime for the radiographs and good agreement between readers. The differences in prevalence of OA in the three groups were not statistically significant. For those aged 50 years and above, the differences in prevalence of OA and knee complaints over the previous 12 months was statistically significant between trade groups. Assuming they have the same annual dose of wear and tear from floor laying, the differences in prevalence between young and older subjects appear to demonstrate a time dose response. Overall, the study provides more evidence to suggest that work in which a considerable amount of time is spent weight bearing on the knees may be a risk factor for the development of OA above the age of 50 years.

Returning to the order of publication, the next two papers are by Cooper and colleagues and were published in 1994. They describe a well designed, population based case control study to determine the profile of several putative risk factors for OA of the knee. Occupational activity is discussed in the second paper. Adjusting for obesity and Heberden’s nodes, the odds ratio (OR) for kneeling and for squatting, calculated separately, were statistically significant. When the OR are calculated for kneeling adjusting for squatting, and vice versa, then the OR for each is reduced, remaining increased but not significantly. Subjects who regularly lifted over 25 kg at work in addition to kneeling or squatting were found to be more than five times as likely to have knee OA than subjects who did neither activity; however, this analysis is based on small numbers of subjects. Unfortunately the number of male cases is small (n = 30). It is unfortunate for studies of miners, who form an all male group in the UK, that the rates for men and women are combined. In summary, these studies add

<table>
<thead>
<tr>
<th>Study period</th>
<th>Population</th>
<th>Exposure</th>
<th>Outcome*</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lawrence &amp; Aitken-Swan</td>
<td>1945–49</td>
<td>Case control (UK). Cases: miners (n = 1742). Controls: non-miners from engineering yard, offices, mining families and the local population (n = 1931)</td>
<td>Miners v non-miners</td>
<td>Rheumatic pain in the knee</td>
</tr>
<tr>
<td>Atkins</td>
<td>1953</td>
<td>Cohort (UK). Mine employees with damage to a knee cartilage</td>
<td>Employment in mine</td>
<td>Meniscus damage</td>
</tr>
<tr>
<td>Kellgren &amp; Lawrence</td>
<td>Not specified</td>
<td>Case control (UK). Cases: miners (n = 84). Controls: manual (n = 45) and office workers (n = 42)</td>
<td>Miners v manual v office workers</td>
<td>Radiograph assessed on five point scale of severity</td>
</tr>
<tr>
<td>Jensen et al</td>
<td>Not specified</td>
<td>Case control (Denmark). Cases: floorlayers (n = 50). Controls: carpenters (n = 51) and compositors (n = 49)</td>
<td>Floorlayers v carpenters v compositors</td>
<td>Radiograph assessed on five point scale of severity</td>
</tr>
<tr>
<td>Lawrence</td>
<td>Not specified</td>
<td>Case control (UK). Cases: miners (n = 221). Controls: dockers (n = 54) and light manual/office staff (n = 87)</td>
<td>Miners v dockers v light manual/office workers with definite radiographic changes</td>
<td>Radiograph assessed on five point scale of severity</td>
</tr>
<tr>
<td>Lindberg &amp; Montgomery</td>
<td>Not specified</td>
<td>Case control (Sweden). Cases: shipyard workers (n = 332). Controls: teachers/office staff v population controls (occupation unknown)</td>
<td>Shipyard workers v teachers/office staff v population controls (occupation unknown)</td>
<td>Ablation (where available)</td>
</tr>
</tbody>
</table>

* K&L refers to Kellgren and Lawrence criteria.

Table 3: Characteristics and selected results of studies examining occupational kneeling and prevalence of knee injury (males only)
needs for a rewarding life, which might include the need for...

...list for knee surgery, an assumption that may be unsound.

...bending and lifting. The finding in miners is based on 148

...qualify. Although symptoms rather than radiographic

...was a little ambiguous about the frequency of pain needed to

...kneeling, both with a dose response association.

...than lifting and physically strenuous work increased the risk of

...employees of a Finnish forestry company. Working with the

... IN 2000, O’Reilly et al conducted a study to examine the

...on miners as an occupational group. Those that do

...kneeling and squatting carried an excess risk that was statistically significant. The risk was

**CONCLUSIONS**

Few of the studies that have been reviewed focus specifically on miners as an occupational group. Those that do concentrate on miners tend to involve small numbers of study subjects and were carried out in 1950s and 60s when epidemiological evidence of the risk factors for OA was not well established. It is unfortunate that large scale epidemiological studies were not carried out by the industry at that time, prompted by the apparent excess risks reported in the literature and other reports. The quality of studies has increased steadily over the decades and is now at a high level. It is considered that enough have been reviewed to allow an informed evidence based conclusion to be drawn on lesions of the ligaments and menisci and on OA of the knee joint.

The score attached to each paper indicates the weight that may be given to the evidence it provides. As an aid to drawing conclusions in a disciplined way, the number of + marks for
and against the propositions that work as a miner or in analogous trades or activities increases the risk of knee disorders are shown in Table 4. This is not a quantitative exercise (so there are no totals), but it should be used as a visual aid to the strength and consistency of the accumulated evidence. From this it can be concluded that there is strong and generally consistent evidence from well-conducted epidemiological studies, based on established methodology, to conclude that work involving kneeling and/squatting is associated with an increased risk of OA of the knees. This evidence has been maintained and strengthened over the years. The pattern of evidence for damage to the menisci has changed through time. Clearly this was a serious problem up to the 1960s but the evidence suggests that it has been resolved. These injuries are of particular biological significance as they predispose to the development of OA.

There is also evidence in the medical literature that, before and perhaps in and beyond the 1970s, underground workers in mines spent a significant proportion of time in a kneeling or squatting posture. Post 1970, the proportion of time spent kneeling or squatting reduced with increasing mechanisation during their work. Underground work miners are also required to lift substantial weights (>25 kg) while in a kneeling or squatting position. There is evidence from several of the epidemiological studies reviewed to suggest that lifting, in combination with kneeling/squatting, is associated with an excess risk of OA above that attributed to kneeling/squatting alone. Thus there were hazards that relate to the disorder and the exposure preceded the appearance of that disorder. The temporality required for proof of a causal relation criterion is met.

Proof of specificity strengthens proof of a causal relation. This presents a problem as only the apparent earlier age of onset of the pathology seen in miners sets it apart from the knee disorders seen in other working men.

Demonstration of dose-response is another required criterion that poses a problem in both meniscus damage and OA. The former is usually an acute event; the latter becomes increasingly common with age in the general population. No evidence has been found which allows separation of age from time employed as a miner—it is possible that the two run so closely together that they are inseparable.

Plausibility and coherence of the relation present no problems. It would be much less plausible for no damage to be done given the stresses the lower limbs endure during work at a coalface. The development of the disorders described in the studies seems to be perfectly in line with what is known of their natural history.

Little animal experimental evidence is available. There have been no prospective trials following groups of men which include a substantial proportion of miners over years to determine what happens to their knees. What animal evidence has been studied during the review indicates that the articular cartilage of the knee joint is susceptible to damage if placed under sustained pressure. Studies of pressures on the knee during coalface work have demonstrated that these are substantial.

Most of the evidence presented is based on analogous work activities rather than studies of miners. Analogy of exposure through domestic or commercial exposures to kneeling, squatting, or knee bending forms an important part of the evidence of a causal relation between knee disorders and the work done by coalminers.

Overall, the accumulated evidence meets the criteria sufficiently to conclude that there is a causal relation between aspects of work as a coalminer and the development of OA of the knee joint and, perhaps only in the past, damage to the menisci and ligaments. Prolonged kneeling and squatting may predispose the coalminer’s knees to suffer damage to the menisci when he slips, trips, or seeks to avoid falling objects and so forcibly rotates the knee joint. It is, however, these events rather than kneeling and squatting that appear to be most associated with the increased risk. Persistent prolonged kneeling, squatting, and repeated knee bending are associated with an increased risk of OA, and that risk is increased in combination with heavy lifting.

It is more difficult to draw conclusions as to whether repetitive physical occupational activity appeared to be a major risk factor for knee OA. By 1987 there was more evidence from the Framingham Osteoarthritis Study and it appeared that knee injury and occupational knee bending and physical labour were risk factors.

Writing in 1991, Peyron seemed convinced that overuse of normal joints was associated with an increase in the incidence of OA in the knees and advised modifying working conditions. In the same year Hochberg published a review looking at current concepts and new insights to the epidemiology of OA. The attention in this review focussed on prospective epidemiological studies including three USA community studies and concluded that subjects with knee OA are more likely to have held jobs with greater knee bending and strength demands. Revisiting the topic in a 1994 review, Felson states: “Multiple studies of individual occupations and of populations have suggested that occupation-related joint overuse is an important cause of knee, hip and other joint OA. Occupational physical activities over many years can induce OA in selected joints. Well-studied examples include evidence of OA in the knees and spine of miners.”

The following year, Cooper stated “There is now clear epidemiological evidence that occupational activity is a contributor to the risk of osteoarthritis at the hip and knee . . . For the knee, evidence suggests that repetitive knee use, perhaps coupled with heavy lifting, is the principal biomechanical factor.”

It is thought that Jensen and Eenberg were the first to apply systematic reviews techniques to knee OA. Summarising the results, they stated that all the studies reviewed demonstrated a significantly increased prevalence of knee OA for subjects with kneeling or squatting work and four showed this relationship with heavy physical work. Occupational exposure could not be sufficiently documented as the cause of meniscal lesions. Maetz and colleagues systematically
reviewed nine papers, all included in this review, and scored by the system used here. They concluded that, in men, a consistent positive relation exists between work involving knee bending and knee OA, with an OR of approximately two. In 2000, Palmer and Cooper, investigating the effect of repeated movements and trauma on the musculoskeletal system, found the most compelling evidence linking knee OA came from the HANES and the Framingham studies.43

In overall conclusion, the review papers have moved over time towards conclusions similar to those of this review. Little has been said recently about meniscus and ligament injuries in reviews but the 1950s and 60s papers remain convincing. There is evidence that coalminers have long had an excess risk of meniscus lesions and that those who have routinely had to kneel or squat and lift heavy weights in these positions have been placed at excess risk of developing OA of the knee joint.

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ECHO

Physical sports curtail sick leave

Companies would benefit by encouraging employees to take part in physical sports, reducing sick leave, according to a prospective study. Physically demanding sports lowered sickness absence among workers in industrial, administrative, and service sectors and especially those in sedentary jobs, the cohort study in the Netherlands has confirmed.

For workers with sedentary jobs risk of absence was less if they had engaged in sport, though not frequently, compared with never doing sport, after adjustment for age, sex, alcohol intake, and smoking. They also had a better chance of recovery—within five days—but clocked up a higher proportion of short absences.

Mean duration of sick leave was significantly lower and about 20 days less at baseline for workers who practised sport compared with those who did not or those who had never done so in their lifetime. The largest differences occurred in jobs with a large sedentary component, at 25 and 50 days less, respectively.

The data form part of the study on musculoskeletal disorders, absenteeism, stress, and health (SMASH) determining work risk factors for musculoskeletal injuries to the lower back, neck, and shoulder. This study compared sickness absences in over 1700 men and women aged 18–59 years working for 24 hours minimum a week for at least a year in 24 companies. Data on work and sporting activities were collected from questionnaires at baseline and yearly for three years and on sick leave from company records.

The study confirms other studies, most of which are cross sectional or interventional.
