Relation between locomotion impairment, functional independence in retirement, and occupational strain resulting from work carried out during working life. Study of a sample population of 350 miners in the Loire valley in France

P Calmels, R Ecochard, MA Blanchon, C Charbonnier, B Cassou, RGonthier

Abstract

Study objectives—To analyse long term effects of working conditions experienced at an advanced age, and after retirement by quantifying occupational strain, impairment, and disability to establish their interrelation.

Design—Retrospective study.

Participants—Retired miners from The French Coal Board who had worked in the coal fields of the Loire valley. From a potential population of 507 retired miners, 350 were completely evaluated.

Measurement—The study examines the occupational strain experienced by each subject, measured using both autoevaluation and evaluation by experts and the locomotion impairment and the functional independence.

Main results—A significant relation between the evaluation of occupational strain and functional independence and locomotion impairment of the low back was found and also a significant relation between locomotion impairment of the low back and the length of time spent working at the coal face.

Conclusions—This study confirms other studies as regards the effects of occupation on health status and on the aging process, but it goes further to show the consequences of this relation on functional independence.

(J Epidemiol Community Health 1998;52:283–288)

The impact of work on health status remains latent for an ever increasing length of time, largely because of preventive measures put into effect by healthcare officials in the workplace. It seems that it is possible to detect the long term effects of working conditions health status at a more advanced age, and after retirement.1 2

Wisner3 had a concept of wear and tear of work (“usure par le travail”), which has been developed by Bled.4 It is also widely recognised that occupation related strain contributes to the development of joint diseases, especially among manual workers and labourers.5

Some researchers have confirmed, not only the links between working conditions and occupation related diseases, but more specifically those between long and arduous working conditions and an accelerated aging process.6 7 However, direct links between the aging process and working conditions remain difficult to evaluate.7

Colvez8 has attempted to develop the concept of a delayed expression of occupation related disease, by linking various situations of employment held throughout working life using the concepts of impairment, disability, and handicap as defined by the WHO and proposed by P. Wood.9 10

To avoid any confusion between the symptoms of an illness and actual signs of aging, an analysis of functional independence seemed more appropriate than a study of diagnoses alone.9 Furthermore, according to Colvez and Robine,11 12 as a study of functional independence would take a comprehensive view of the health status, it is the best predictor of early death rates amongst the elderly.13

Confirmation of results is important because follow up medical examinations of the populations studied is difficult, and also because an evaluation of working conditions must take into account the diversity of positions of employment held, the variability of risk factors (such as injuries, environmental factors, etc), and any other changes occurring throughout working life.13

It seemed logical to select a sample group of people who are at risk, and thus, to develop a specific social security programme that interacts with both economic and public health needs. By so doing, an expensive and unnecessary supervision of other groups can be avoided.

We conducted a retrospective study of a population of retired miners to: (a) retrospectively quantify occupational strain, (b) evaluate health status by measuring impairment and disability, (c) establish the relation between occupational strain and health status.

Epidemiologically speaking, the coal mining population is an interesting one to study as it is easily identifiable. French coal miners enjoy the benefit of highly specified social and medical back up networks. Miners are monitored throughout their working lives at professional, medical, and personal levels, while a good social system facilitates monitoring of retired miners. Details of the professional environment...
from the Loire valley: generations 1927–1932 examined in 1994

<table>
<thead>
<tr>
<th>Level</th>
<th>Number of subjects</th>
<th>Percentage</th>
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<tr>
<td>&lt;0-20&lt;</td>
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<td>Total</td>
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<table>
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<th>Impairment</th>
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<td>Shoulder and elbow</td>
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<tr>
<td>Hand</td>
<td>9.5</td>
</tr>
<tr>
<td>Fingers</td>
<td>11.7</td>
</tr>
<tr>
<td>Thigh</td>
<td>18.1</td>
</tr>
<tr>
<td>Knee</td>
<td>37.2</td>
</tr>
<tr>
<td>Ankle and foot</td>
<td>9.7</td>
</tr>
<tr>
<td>Neck</td>
<td>26.9</td>
</tr>
<tr>
<td>Thoracic back</td>
<td>16.6</td>
</tr>
<tr>
<td>Low back</td>
<td>54.7</td>
</tr>
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</table>

**EVALUATION OF OCCUPATIONAL STRAIN**

The occupational strain experienced by each subject during their working life was measured using two independent rating systems: auto-evaluation and evaluation by experts. This procedure can be justified by the diversity of factors influencing occupational strain, particularly among those working at the coal face (atmospheric influences, the distance travelled to reach the coal face, work schedules, the depth of the coal face, the specification of tools, etc). This diversity was not so pronounced among those working on the surface.

Because this was a retrospective study, objectivity depended on precise descriptions of positions of employment within the industry; the career profile of the subject with reference to any changes in positions of employment held; the exact location of the work site and any peculiarities associated with individual coal fields; the length of time worked using modern mining methods; and the length of time spent working at the coal face. Following these guidelines, we established two independent methods of evaluating occupational strain.

**Auto-evaluation of occupational strain**

This rating system, derived from a retrospective analysis with the aid of a questionnaire, is constructed along the lines of information gathered from the retired miners, by two surveyors who have received some training as to the nature of the mining industry. The

**KEY POINTS**

- From an epidemiological point of view, this paper offers a retrospective analysis of a large population of miners. The work is interesting because it has been carried out with an original and specific tool to assess occupational strain in this population. This tool has been validated, and takes into account, an auto-evaluation by the subject and an evaluation by an expert.
- From a public health point of view, this study is of interest because it considers functional disability as a consequence of the position of employment held, and their current state of functional independence.

The age of first employment was noted for each subject and the length of time spent working in the mine and time spent working directly at the coal face.

- The principal disorder observed among this population of miners is pulmonary disease, and in particular, pneumoconiosis. However, because of the difficulty of the work, and the frequency of accidents and injuries, it seemed important to examine the effects experienced throughout working life on the joint and muscular system and thus to evaluate the locomotion impairment and the functional disability. The effects of repeated minor injuries will manifest themselves at this level.

**Methods**

**POPULATION**

The subjects of this study were retired miners from The French Coal Board (“Les Charbonnages de France”), who were over 60 years of age in 1985, and who had been in retirement for at least 10 years. They had worked in the coal fields of the Loire valley for a period of at least 15 years, and belonged to the generations of 1927 to 1932. In this region, all retired miners are systematically registered in the social service. Nevertheless, the records are destroyed after death and it is impossible to establish accurately the total number of miners who had worked in this area. A total of 507 retired miners were randomly selected (sampling fraction two thirds) among the subjects being alive at the start of this study. Each of these subjects was contacted and invited to attend for assessment, within the context of a study evaluating their occupational strain experienced because of the position of employment held, and their current state of functional independence.

The age of first employment was noted for each subject and the length of time spent working in the mine and time spent working directly at the coal face.
peculiar to the coal fields of the Loire valley, and how these factors may affect the career of the subject.

Each position of employment is located on a scale of coefficients ranging from 0.5 to 5, and increasing with occupational strain. Each year accounts for 1 point on this scale. Each position of employment was located on the scale as follows: (a) at coal face: hewer = 4 to 5; explosives handler = 3 to 4; electromechanic = 2 to 3; packer = 1 to 3. (b) On surface: welder = 3; carpenter = 2; packer = 1 to 3; office worker = 0.5.

This method of measuring occupational strain was developed and evaluated during a preliminary study. The evaluation by experts was initially determined by two independent experts, with blinding procedure. The analysis of reproducibility of evaluation of the occupational strain has been performed on 25 subjects. These results show a difference less than 1% and Pearson's coefficient is 0.93. The expert evaluation of occupational strain ranges from 15 to 150.

**EVALUATION OF LOCOMOTION IMPAIRMENT**
Guided by a questionnaire asking the subject to answer simple yes/no type questions, concerning easily recognisable signs of physical impairment, an expert, different from experts evaluating occupational strain, assessed locomotion impairment according to WHO recommendations. The evaluation took into account any impairment of the shoulder/arm, elbow, hand, fingers, thigh, knee, foot and ankle, lower back, and neck. This method to measure locomotion impairment was also developed and evaluated during a preliminary study.

**EVALUATION OF FUNCTIONAL INDEPENDENCE**
Functional independence was assessed using the French version of the Functional Independence Measure (FIM). Consists of a scale of functional independence used in physical rehabilitation and developed by Granger. The 18 items cover the daily living activities, cognitive function, and socialisation. The 18 items can be divided into several groups including self care (eating, grooming, bathing, dressing upper body, dressing lower body, toileting), sphincter control (bladder management, bowel management), mobility (bed, chair, wheelchair, toilet, tub, shower), locomotion (walk or wheelchair, stairs), communication (comprehension, expression), social cognition (social interactions, problem solving, memory). Dependability is evaluated according to seven levels of severity: 7 = total independence; 6 = modified independence (use of technical aids); 5 = slight dependence (supervision needed); 4 = minimal level of dependence (autonomy > 75%); 3 = medium level of dependence (autonomy 50% to 75%); 2 = high level of dependence (autonomy 25% to 50%); 1 = total dependence (autonomy < 25%). The scale ranges from a minimum value of 18 points if the subject is totally independent, to a possible 126 points if the subject is totally dependent.

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### Table 3: Contingency table between functional independence measure and coefficient of strain for 350 retired miners from the Loire valley: generations 1927–1932 examined in 1994 (percentage of subjects are in parentheses)

<table>
<thead>
<tr>
<th>Coefficient of strain</th>
<th>Functional independence measure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>120</td>
</tr>
<tr>
<td>Auto-evaluated &lt;0–20&lt;</td>
<td>11 (32.3)</td>
</tr>
<tr>
<td>&lt;20–35</td>
<td>12 (35.3)</td>
</tr>
<tr>
<td>&gt;35</td>
<td>34 (100)</td>
</tr>
<tr>
<td>Evaluated by expert  &lt;0–50&lt;</td>
<td>7 (20.6)</td>
</tr>
<tr>
<td>&lt;50–90&lt;</td>
<td>13 (38.2)</td>
</tr>
<tr>
<td>&gt;90</td>
<td>14 (41.2)</td>
</tr>
<tr>
<td>Total 159 (100)</td>
<td>88 (100)</td>
</tr>
</tbody>
</table>

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### Table 4: Contingency table between low back impairment, coefficient of strain, and time spent working at the coal face for 350 retired miners from the Loire valley: generations 1927–1932 examined in 1994 (percentage of subjects are in parentheses)

<table>
<thead>
<tr>
<th>Time at coal face</th>
<th>Low back impairment</th>
</tr>
</thead>
</table>
|                   | Without limitation | With limitation | Total | Odds ratio of limitation (95% confidence intervals)
|                |                   |                  |       |                      |
| Auto-evaluated 0 | 59 (37.1)         | 17 (16.5)        | 105 (100) | 1 |
| <0–10 years     | 51 (32.1)         | 26 (29.5)        | 47 (100)  | 1.7 (1.2, 2.9) |
| <11–20 years    | 49 (30.8)         | 33 (17.5)        | 42 (100)  | 1.2 (1.0, 2.1) |
| <20–35 years    | 55 (36.9)         | 34 (38.6)        | 48 (100)  | 1.6 (0.9, 2.7) |
| >20–35 years    | 159 (100)         | 88 (100)         | 103 (100) | 1 |
| Time evaluated 0 | 46 (28.9)         | 24 (27.3)        | 19 (18.5) | 1 |
| <50–90 years    | 58 (36.5)         | 30 (34.1)        | 36 (34.9) | 124 | 1.2 (0.7, 2.1) |
| <90 years       | 55 (36.8)         | 34 (38.6)        | 48 (100)  | 1.6 (0.9, 2.7) |
| Total 159       | 88 (100)          | 103 (100)        | 103 (100) | 1 |

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This evaluation was perform by the same expert who evaluated locomotion impairment, and who is a physical medicine and rehabilitation doctor, trained to the use of the FIM as a functional assessment scale.

**STATISTICAL ANALYSIS**

Statistical analysis takes into account the type of variable: it is a correlation between a variable probably conforms with the mode of distribution proposed by Gauss, the index of occupational strain, and another variable without conformity with this mode of distribution, the value of the FIM. The distribution of values of the FIM in this cohort appears to be asymmetrical. We have used an exact test preferentially, the Jonckheere-Terpstra test, to establish the correlation between occupational strain and both locomotion impairment and functional independence. This non-parametric test offers the possibility to keep the hypothesis of independence between the values of the index of occupational strain and the values of the FIM.

The significance level was set at a value of $p<0.05$.

**Results**

**POPULATION**

From a potential population of 507 retired miners, we initially had to exclude 22 from this study: eight were deceased, three could not be contacted, six had been institutionalised, three declined to take part, and two did not submit accurate or reliable information.

From the remaining 485 subjects who took part, only 350 (or 72.16%) of the initial sample population had been completely evaluated in the period between November 1992 and November 1993.

The study showed that: (a) the age of first employment was below 15 years for 249 subjects (71.1%); (b) the length of time spent working in the mine was between 30 and 40 years for 185 subjects (52.7%), and over 20 years for 340 subjects (97.1%). The overall average length of time spent working in the mine was 32.7 years; (c) the length of time spent working at the coal face was between 20 and 30 years for 165 subjects (47.1%), and over 20 years for 216 subjects (61.7%).

**EVALUATION OF OCCUPATIONAL STRAIN**

The auto-evaluated coefficient of occupational strain is greater than 35 for 127 subjects (36.3%). The coefficient of occupational strain as evaluated by the experts, is greater than 90 for 137 subjects (39.1%). (Table 1).

**EVALUATION OF LOCOMOTION IMPAIRMENT**

The evaluation of locomotion impairment shows that the low back (54.7% of subjects) and the arm (41% of subjects) are worst affected. (Table 2).

**EVALUATION OF FUNCTIONAL INDEPENDENCE**

The evaluation of functional independence shows that: (a) 34 subjects (9.7%) have a FIM of less than 120; (b) 247 subjects (70.6%) have a FIM of 124 or more. (Table 1).

**CORRELATED STATISTICAL ANALYSIS**

The statistical tests (Jonckheere-Terpstra and $\chi^2$) show: (a) a significant and negative relation between functional independence and the auto-evaluated coefficient of occupational strain ($p = 0.03$) and the coefficient of occupational strain as evaluated by the experts ($p = 0.04$) but no significant relation with the length of time spent working at the coal face (table 3).

(b) A significant and positive relation between locomotion impairment of the low back and the auto-evaluated coefficient of occupational strain ($p = 0.03$), the coefficient of occupational strain as evaluated by the experts ($p = 0.04$), the length of time spent working at the coal face ($p = 0.02$) (table 4).

(c) A significant and positive relation between impairment of the shoulder/arm and the auto-evaluated coefficient of occupational strain ($p = 0.001$).

(d) No significant relation between the FIM and impairment of the lumbar vertebrae or impairment of the shoulder/arm.

**Discussion**

The results of this study show that occupational strain has a significant effect on low back impairment, shoulder/arm impairment, and the functional independence among this population of retired miners.

Several points need further discussion. With regard to the population, a bias could have occurred because we did not analyse all the miners working in the Loire coal mine born between 1927 and 1932, but only the subjects who have worked during a sufficient period to have the benefit of a pension paid by the mine coal social service. Therefore, subjects who died before retirement, subjects who worked less than 15 years in the mine could not be analysed. The results of the preliminary study show a defect of 30% of the potential population of all the coal mine workers. Secondly it appears that the miners present an excess of mortality between 60 and 65 years with comparison with the French male population of the same age.

With regard to the age of the study population, we think that no bias occurred with the analysis with impairment, because all the subjects had only small differences in their age (from 60 to 65 years) and because, apart for major diseases, the relation between age and impairment appears significantly important and a factor of dependence after 70 years in frailty in the elderly.

The relations between occupational strain and health status are in line with the results obtained by Wisner,7 who observed signs of premature aging among some workers. They are also in accordance with the results of Desplanques6 and Fox,11 who observed social inequality of death. They are in line with Teiger's study, which shows uneven distribution of death rates among groups of workers according to their position of employment. They are also in line with the retrospective study of occupation and its associated illnesses.
by Collins.1 And finally, these results confirm those obtained by Derriennc and Cassou,2 which retrospectively evaluate working life with reference to exposure to various risks, and then link this to locomotion impairment and disability.

Even though this study was conducted retrospectively, the choice of the sample group of retired miners makes it important.1 Firstly, because the retired miners benefit from highly specified social and medical networks, they could be easily located and contacted. Epidermologically speaking, the variety of positions of employment held and the associated working conditions are well documented. All of the subjects shared the same work site and worked for the same company. The experts could call on a wide body of background information regarding the risks peculiar to this industry. All of these factors greatly facilitated our analysis.

Furthermore, in this study, functional independence analysis highlights some interesting areas for discussion, which may have been overlooked by a study of diagnoses alone: (1) Because the functional measure analyses the effects of clinical symptoms on daily living activities, it takes into account the overall state of health of the person1 and gives an appreciation of quality of life. (2) By using functional analysis to determine the importance of occupation as a risk factor of premature aging, this study immediately aligns itself with the two concepts: because of raised life expectancy levels, preventive measures must be adopted during working life to decrease the levels of occupational disease subsequently revealed in retirement.4, 24–26; the concept of life expectancy as a risk factor of premature aging, this could call on a wide body of background information which relates to locomotion impairment and functional independence of some subjects as it relates to their previous occupation. It would also go some way to answering the economic and social problems posed by increased life expectancy levels and associated incapacity.

Other studies could be conducted along these lines to evaluate the part played by occupational conditions in the aging process and to examine the influence of socioeconomic conditions associated with working conditions. It would be interesting to compare this study of retired miners with similar ones of other professional groups. This would, in all probability, lead to a better understanding of the dependence of some subjects as it relates to their previous occupation. It would also go some way to answering the economic and social problems posed by increased life expectancy levels and associated incapacity.

In conclusion, this study confirms that repercussions of occupational strain can be felt after retirement among this sample population of retired miners. It not only measures locomotion impairment, but also examines its effect on daily living activities. Using this method we were able to estimate the quality of life of the retired miners.

The authors thank Pr Y Matillon and Dr J Ecchoard: service d’informatique médicale, Hospices Civils de Lyon, Dr R Simand and J Mayer: service de médecine du travail, Charbonnages de France, Dr D Seydoux: Centre de Medecine Spécialisée de la Société de Secours Miniere de la Loire for their help in this study.

Funding: this study was developed with grants from INSERM (contrat de recherche externe No 921103).

21 Hollander M, Wolfe DA. *Non parametric statistical methods*. 

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