CERVICAL SPINE DEGENERATIVE CHANGES (NARROWED INTERVERTEBRAL DISC SPACES AND OSTEOPHYTES) IN COAL MINERS

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Abstract. A series of 685 x-ray films of the cervical spine obtained in coal miners was analyzed to explore the occurrence of narrowed disc spaces and osteophytes in this occupational group, and to examine the association of x-ray changes with age, duration of employment, and duration of occupational exposure to hand-arm vibration. All data were extracted from individual medical files of coal miners examined for suspected hand-arm vibration-related disorders in 1989-1999 at the Occupational Medicine Center in Katowice. The narrowed intervertebral disc spaces were found in 188 coal miners (26.9%) and osteophytes in 332 coal miners (47.5%). The occurrence of degenerative changes in coal miners was similar to that observed in a small group of 68 blue-collar workers (no exposure to hand-arm vibration) employed in the coal industry. Univariate comparisons showed that narrowed intervertebral disc spaces and osteophytes were more frequent among older subjects and among subjects with longer duration of employment. The prevalence of changes also showed some relationship with the number of years of exposure to hand-arm vibration. The results of logistic regression analysis confirmed statistically significant effect of age, but not of other factors included in the model. When both x-ray changes were grouped together (a combined dependent variable) age remained the only statistically significant explanatory variable. The findings do not support the view that the examined degenerative changes in the cervical spine are more prevalent in coal miners and depend on duration of physical work or local exposure to hand-arm vibration in this occupational group.

Key words:
Cervical spine, X-ray, Coal-miners

INTRODUCTION

The effect of occupational factors on the spine is subject to a number of studies that usually focus on work-related complaints. The occurrence of low back pain syndrome and its relation to job-related factors is well documented in various occupational populations [1–5]. Much less is known about complaints related to other parts of the spine, although published evidence reveal the association of the neck pain syndrome with physical demands of the job. Body position at work, dynamic and static loads of the arms as well as the exposure to long-term whole-body (and sporadically local) vibration have been considered among risk factors for pain in the neck [6–12].

Work environment in underground coal mines in Poland is characterized by high physical load and exposure to hand-arm vibration. The complaints of pain in the low back and the neck are common in coal miners, and – at least in Poland – constitute an important public health issue [13]. A recent survey performed in this country
showed that 23–28% of coal miners suffered from the neck pain, whereas its prevalence among control subjects was 4% [14]. Ethical considerations exclude x-ray examination from research tools in occupational epidemiology studies on spine disorders. Although symptoms do not have to mirror x-ray changes, it might be of interest to explore the occurrence of x-ray changes in the spine in "high risk" workers. Having an access to a large number of x-ray films of the neck obtained in coal miners referred to the Occupational Medicine Center in Katowice because of suspected vibration-related disorders, we decided to analyze the occurrence of the x-ray changes and their job-related correlates.

The objectives of our study were: (a) to examine the occurrence of x-ray changes (narrowed intervertebral disc spaces and osteophytes) in the cervical spine in coal miners, and (b) to analyze the association of these changes with age, duration of employment, and duration of occupational exposure to hand-arm vibration.

MATERIALS AND METHODS

All x-ray films of the cervical spine (standard lateral projections) were obtained in 697 professionally active coal miners, employed underground in coal mines of Upper Silesia (Poland) and referred to the Occupational Medicine Center in Katowice for suspected hand-arm vibration syndrome. The medical examinations were performed in 1989–1999, thus the analysis involved already existing medical records. Approximately 100 files included anteroposterior projections of the cervical spine, however due to the small number and – in many cases – poor quality, they were excluded from interpretation. Also, the lack of systematic information on subjects' complaints and physical status restricted the final analysis of x-ray changes found on lateral projection of the cervical spine. The following occupational history data were extracted from the subjects' personal records: age (years), duration of employment in a mine (years), duration of exposure to local vibration (years) and average daily duration of exposure to local vibration (h). Cervical spine x-rays were read by a certified radiologist (one of the authors – B.S.). Two types of degenerative changes were identified: narrowed intervertebral disc space and osteophytes. The frequency of x-ray changes was compared between the subgroups of miners, and defined according to age and exposure to local vibration by means of a chi-square test. Criterion “p < 0.05” was used in examining the statistical significance of differences. The results of univariate analyses were verified by multivariate analyses. The models were tested using logistic regression method with backward elimination of statistically non-significant independent variables. The dependent variable was an x-ray change (either narrowed disc space – model I or osteophytes – model II; both x-ray changes – model III). The set of independent variables included “age”, “coal mine”, “number of years of employment”, “number of years of exposure to hand-arm vibration”, and “average number of hours of daily exposure to hand-arm vibration”. Statistical significance of the regression coefficients of independent variables was evaluated against the criterion “p < 0.05”.

The frequency of x-ray changes found in coal miners was compared with the summary figure obtained in 68 blue-collar workers (maintenance, transportation – no exposure to hand-arm vibration) employed in “surface services” at coal mines and examined in the same Occupational Medicine Center for non-specific musculatory complaints.

RESULTS

The subjects were men aged between 21 and 69 years (mean age and the standard deviation: 46.3 ± 6.5 years). All were employed underground for 22.2 ± 4.8 years (range: 5–35 years) on average. Duration of occupational exposure to hand-arm vibration ranged between 1 and 31 years (mean: 15.1 ± 16.0 years), and of daily average exposure to hand-arm vibration between 30 min and 6 h (mean: 1.9 ± 0.9 h). On 685 technically acceptable x-ray films, the narrowed intervertebral disc space was found in 188 coal miners (26.9%) and osteophytes in 332 coal miners (47.5%). Combined degenerative changes (both narrowed intervertebral disc space and osteophytes) were seen in 163 coal miners (23.3%). Narrowed intervertebral disc space was
found mostly in the lower part of the cervical spine: C2-
C3 in 4 (2.1%), C3-C4 in 12 (6.3%), C4-C5 in 15 (7.9%)
C5-C6 in 109 (57.9%), and C6-C7 in 100 (53.1%) sub-
jects. Osteophytes were distributed in a similar mode:
C1 – 0 (0.0%), C2 – 2 (0.6%), C3 – 30 (9.0%), C4 – 74
(22.2%), C5 – 235 (70.7%), C6 – 294 (88.5%) and C7
– 139 (41.7%) subjects. No defined x-ray changes were
found on 342 x-ray films (48.9%).

In a “convenience set” of 68 x-rays of blue-collar
workers employed in coal mines on the surface and not
exposed to vibration, osteophytes were found in 38.5%
and narrowed intervertebral disc space in 21.4% of
subjects. Both groups (miners and non-miners) were
similar in terms of age and duration of employment.

The occurrence of the changes according to age, dura-
tion of employment and duration of exposure to hand-arm
vibration is shown in Tables 1–3. Univariate comparis-
sions showed that narrowed intervertebral disc space and
osteophytes were more frequent among older subjects (Table 1)
and among subjects with longer duration of employment
(Table 2). The changes also showed some relationship
with the number of years of exposure to hand-arm vibra-
tion (Table 3). There were no differences between the
occurrence of the x-ray changes in subgroups of miners,
defined according to the average daily duration of expo-
sure to hand-arm vibration.

The results of univariate analyses were verified by means
of logistic regression analysis, with either narrowed
intervertebral distance (model I) or osteophytes (model II)
changes as the dependent variable. A set of independent
variables was tested in various configurations. For both
dependent variables, the analyses confirmed statistically
significant effects of age only. Age and the duration of
employment correlated at the level $r = 0.63$, and age
remained the only statistically significant variable when
both variables were included in a model tested by a back-

### Table 1. Occurrence of degenerative changes in the cervical spine by the age groups in 685 coal
miners

<table>
<thead>
<tr>
<th>X-ray change</th>
<th>Age group (years)</th>
<th>21–35</th>
<th>36–40</th>
<th>41–45</th>
<th>46–50</th>
<th>51–55</th>
<th>56–69</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narrowed intervertebral disc space (%)*</td>
<td></td>
<td>6.2</td>
<td>9.2</td>
<td>20.5</td>
<td>28.7</td>
<td>48.8</td>
<td>45.0</td>
</tr>
<tr>
<td>Osteophytes (%)</td>
<td></td>
<td>18.7</td>
<td>26.8</td>
<td>43.8</td>
<td>50.4</td>
<td>63.3</td>
<td>71.6</td>
</tr>
</tbody>
</table>

* Statistically significant difference between the defined age groups ($p = 0.001$).

### Table 2. Occurrence of degenerative changes in the cervical spine by duration of employment in
685 coal miners

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Narrowed intervertebral disc space (%)*</td>
<td></td>
<td>30.7</td>
<td>14.5</td>
<td>17.2</td>
<td>28.8</td>
<td>36.4</td>
<td>47.6</td>
</tr>
<tr>
<td>Osteophytes (%)</td>
<td></td>
<td>15.3</td>
<td>32.2</td>
<td>41.6</td>
<td>48.4</td>
<td>58.5</td>
<td>71.4</td>
</tr>
</tbody>
</table>

* Statistically significant difference between the defined groups ($p = 0.001$).

### Table 3. Occurrence of degenerative changes in the cervical spine by duration of occupational
exposure to hand-arm vibration in 685 coal miners

<table>
<thead>
<tr>
<th>X-ray change</th>
<th>Duration of occupational exposure to hand-arm vibration (years)</th>
<th>1–5</th>
<th>6–10</th>
<th>11–15</th>
<th>16–20</th>
<th>21–25</th>
<th>26–31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narrowed intervertebral disc space (%)*</td>
<td></td>
<td>21.7</td>
<td>24.3</td>
<td>19.2</td>
<td>33.1</td>
<td>28.5</td>
<td>42.8</td>
</tr>
<tr>
<td>Osteophytes (%)**</td>
<td></td>
<td>41.3</td>
<td>44.4</td>
<td>40.9</td>
<td>48.5</td>
<td>57.1</td>
<td>66.6</td>
</tr>
</tbody>
</table>

* Statistically significant difference between the defined groups ($p = 0.02$).
** Statistically significant difference between the defined groups ($p = 0.04$).
ward elimination procedure. When both x-ray changes were grouped together (a combined dependent variable – model III), the results of logistic regression analysis did not change; age remained the only statistically significant explanatory variable.

**DISCUSSION**

The objective of the study was to assess the frequency of two x-ray changes (narrowed intervertebral disc spaces and osteophytes) in the cervical spine in coal miners, and to explore their associations with age, duration of employment and duration of occupational exposure to local, hand-arm vibration. In coal miners aged 21–69 years, approximately 50% of subjects showed degenerative changes in the cervical spine. This figure was similar to an estimated prevalence of degenerative changes in the general population of middle-aged men in Poland [15,16]. In the study group of miners, the frequencies of osteophytes (47.5%) and narrowed intervertebral disc space (26.9%) were slightly higher than the values found in a “convenience set” of 68 x-rays of surface blue-collar workers employed in coal mines (38.5% and 21.4%, respectively). Although both groups were similar in terms of employment duration, a more specific elaboration of the difference is not justified because of unrepresentativeness of the groups. The findings do not suggest job-related x-ray changes in the cervical spine and such an interpretation is supported by the consistent effect of age but not of occupational variables on the occurrence of changes, either examined as a combined variable or as its components. Reference data on the prevalence of x-ray changes in the spinal cord in coal miners are hardly available. The 1952 British study, involving x-ray examination in 84 coal miners aged 40–50 years, showed that the narrowed cervical discs and changed vertebral plates were more frequent in this group (54%) than in 45 reference manual workers (42%), or in 42 office workers (38%) [17].

Compared to the evidence concerning work-related low back pain, the neck disorders in occupational populations are less known. Physical workload, whole-body vibration exposure, psychosomatic and psychological factors are thought to play a role as predictive factors for symptoms or treatment of the problem, but specific occupational risk factors for radiological changes of the cervical spine remain unknown [9,18,19]. Available, although limited data may indicate the role of a mechanical strain at work. A record linkage project revealed a statistically significant risk of hospital admissions because of prolapsed cervical intervertebral disc among professional drivers, thus suggesting a role of whole-body vibration, sedentary position, heavy lifting or accelerations/decelerations [20]. In a group of professionally active dockers, the prevalence of degenerative x-ray changes in cervical spine was 34% and in the authors’ opinion it depended on the degree of physical load at work [21].

Our findings do not support the concept of work-related degenerative x-ray changes in the cervical spine of coal miners. However, it remains unknown to what extent our findings could be generalized in respect to the occupational setting under study. The data used in our analysis were obtained in a case series and not in a representative sample. However, the number of x-ray films of the cervical spine was large enough to examine internal correlations between x-ray changes and work-related variables, and to examine the differences between subgroups of miners defined according to the exposure characteristics. The range of employment duration and of exposure to local, hand-arm vibration was quite wide, thus permitting this kind of analyses. The composition of our case series could favor an overestimation of the occurrence of degenerative changes in the cervical spine, hence the obtained figures could reflect the upper limit of the estimate for this occupational group. Another potential limitation of causative inference could stem from the lack of data on antero-posterior projections of the cervical spine. We only analyzed two x-ray changes and it remains unknown whether other x-ray abnormalities correlate with exposure variables in question. However, it cannot be excluded that the exposure-effect relationship, if present, would appear already in relation to two x-ray changes included in the study. Another potential limitation (although of lesser relevance to the study objective) was lack of data on neck-related complaints. Available information, derived from the medical
files, did not allow to explore subjects’ complaints in a systematic way. However, there is no apparent correlation between x-ray signs of the cervical spine degenerative changes and patients’ complaints or functional limitations, and even magnetic resonance imaging and discography do not provide a reliable insight in this issue [22–24].

In conclusion, our findings do not support the claim that the occurrence of narrowed intervertebral disc space and osteophytes in the cervical spine is more prevalent in coal miners and depends on duration of physical work or local exposure to hand-arm vibration in this occupational group.

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REFERENCES