Clinica/ and functional examination of the spine in working communities: occurrence of alterations in the male control group

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Summary
The paper reports the results obtained by applying a clinical method for the study of spinal disease as described elsewhere in a control group of 200 male subjects, stratified for age, who had not been exposed to classically accepted occupational risk indicator for spinal disorders. For each age class the following data are supplied: frequency of cervic thoracic and lumbar disease; frequency of scoliosis and dissymmetry of lower limbs; mean values and range of mobility parameters for the various spinal region. The possible applications are discussed.

Relevance
The values presented here, obtained from a structured examination, provide a set of age-related reference values for males in light industry. They form a basis for comparison with other male occupational groups, to assess the effects on these variables from work-related demands on the spine.

Key Words: Spine, Mobility, Occupational medicine, Back pain, Clinical examination

Introduction
It is common practice in occupational medicine that possible work-induced impairment be studied alongside assessment of the risk factor. In the case of manual handling and of incorrect work postures, such study is of necessity aimed at morphological and functional alterations of the locomotor system.

To this aim, we have described and validated a method for the clinical and functional examination of the locomotor system and of the spine in particular. The signs and symptoms observed by this method are organized, according to standardized criteria, for classification into different pictures of clinical-functional spondyloarthropathy. In general, this means the presence of a regional spinal disorder, probably degenerative, shown by anamnesis, clinical procedures and functional impairment, independent from the radiologic picture.

The application of the method in working communities does, however, require appropriate reference data, on the basis of which a more exhaustive analysis of the group results can be made.

The aim of this research was to establish such reference data and parameters for males by studying a group of subjects not exposed to occupational postural hazards, such as prolonged fixed postures (both sitting and standing), manual material handling and whole body vibrations during their lifetime. In this context, brief notes will be provided regarding the clinical method used.
It should be noted that preliminary studies of the reproducibility of the method regarding qualitative variables (i.e., the classification of positive anamnestic) and quantitative variables showed good intra- and inter-observer reproducibility of the variables observed.

Methods

Clinical examination.

The examination used consisted of six basic parts, outlined below:

Physiological and occupational anamnesis:
It is fundamental important to assess the present of past and present exposures to the mechanical factors which, at work or at home, overload the spine.

Disease history:
Diseases which have occurred in the last 12 months are particular interest. The area, radiation, characteristics and temporal patterns of the disease are recorded. Evenabilities induced by the disease are also investigated.

Measurement of some anthropometric parameters:
The anthropometric parameters chosen are those that have a functional role in the general aims of the clinical examination, especially for spinal mobility assessment. Among them, length of lower limbs is routinely measured in order to check leg length inequality.

Figure 1. Frontal plane behind the scoliosometer: observation of the patient facing the instrument.

Figure 2. Measurement of thoracic kyphosis and lumbar lordosis with flexicurve.
Assessment of mobility:

The following movements are examined separately: extension, flexion, lateral inclination (side-bending) and rotation, respectively, for the cervical and thoraco-lumbar spine.

For the cervical spine, passive movements are examined (subject prone or supine with fixed shoulder) using an inclinometer (Figure 4) with the exception of the lateral inclination when a goniometer is used. For the thoraco-lumbar spine active movements are evaluated with the pelvis fixed, estimating the linear measurements and their transformation into angular values, except for rotation when a goniometer is used (Figure 5).

The flexion angle is measured using the following parameters: a) Height from suprasternal notch to bed surface (with the subject seated and perfectly upright); b) Height from suprasternal notch to bed surface (with patient flexed holding the pelvis still).

The right and left inclination angles are calculated using the following two parameters: a) Height from C, to bed surface (with patient perfectly upright) (Figure 6); b)
Figure 7. Measurement of distance between C, and seating surface with patient bending sideways.

**Figure 8:** Procedure to calculate the flexion and inclination angle of the spine (cervical spine excluded).

Height to bed surface (with patient bending right and left) (Figure 7).

The above parameters are used in the trigonometrical formula shown in Figure 8 to calculate the flexion and inclination angles. The extension angle is measured using the following parameters: a) Distance between the suprasternal notch and the centre of the line that joins the ASIS (with patient supine on the bed); b) Distance (with patient prone and forehead resting on the bed) between suprasternal notch and surface of the bed; c) Distance between suprasternal notch and bed surface (with spine bend backwards).

The above parameters are used in the trigonometrical formula shown in Figure 9 to calculate the extension angle. It should be noted that in the different trigonometrical formulas presented there exists a slight discrepancy between A and A1. Nevertheless, as a preliminary test of reproducibility, the method was demonstrated to be statistically satisfactory, whilst that was not the case when the measurements were taken with the goniometer.

It is obvious that the angles measured in this way are not equivalent to those taken from X-rays. They are, therefore, considered indices of the flexibility of the thoraco-lumbar spine along the sagittal and frontal sagittal.

In the study of spine mobility it should be noted whether the patient feels any pain during movement.

**Classification:**

To facilitate standardized analysis of the results, an original classification procedure was developed, based on clinical and functional features (Table 1).

The classification procedure is derived from a combination of the various anamnestic, tic, clinical—morphological z:

**Figure 9.** Procedure to obtain the extension angle of the spine (cervical spine excluded) from lengths A—B—C.
Table 2. Criteria for assessment of cervical, thoracic and lumbar mobility

<table>
<thead>
<tr>
<th>Movements</th>
<th>Reduced mobility</th>
<th>Painful mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical region</td>
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<td>Flexion</td>
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<tr>
<td>Left inclination</td>
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<td></td>
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<tr>
<td>Right rotation</td>
<td>4 out of 6 reduced</td>
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<tr>
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<tr>
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<tr>
<td>Left rotation</td>
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<td>Extension</td>
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<td>Right inclination</td>
<td>3 out of 4 reduced</td>
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<tr>
<td>Left inclination</td>
<td>2 main movements</td>
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<td>Extension</td>
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<td>Right inclination</td>
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<tr>
<td>Left inclination</td>
<td>2 main movements</td>
<td></td>
</tr>
</tbody>
</table>

Main movements of regions

Table 3. Head and trunk movements: reference values per age class, in males *

<table>
<thead>
<tr>
<th>Parameter</th>
<th>16-25 min—max</th>
<th>26-35 min—max</th>
<th>36-45 min—max</th>
<th>46-55 min—max</th>
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<td>54-94</td>
<td>49-88</td>
<td>47-85</td>
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<td>31-72</td>
<td>29-66</td>
<td>26-68</td>
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<tr>
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<td>36-63</td>
<td>34-62</td>
<td>32-57</td>
</tr>
<tr>
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<td>40-65</td>
<td>38-62</td>
<td>35-60</td>
<td>33-58</td>
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<tr>
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<td>69-97</td>
<td>65-97</td>
<td>60-99</td>
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<td>69-98</td>
<td>66-95</td>
<td>61-93</td>
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<tr>
<td>Flexion</td>
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<td>30-54</td>
<td>30-53</td>
<td>31-54</td>
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<tr>
<td>Extension</td>
<td>19-37</td>
<td>15-33</td>
<td>14-31</td>
<td>13-30</td>
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<tr>
<td>Right inclination</td>
<td>27-46</td>
<td>25-44</td>
<td>23-43</td>
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<td>24-44</td>
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<tr>
<td>Right rotation</td>
<td>34-68</td>
<td>29-69</td>
<td>28-61</td>
<td>25-58</td>
</tr>
<tr>
<td>Left rotation</td>
<td>32-67</td>
<td>27-69</td>
<td>29-61</td>
<td>24259</td>
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</table>

* Movement values < or > minimum and maximum reference values are considered 'reduced' and 'increased'

Table 4. Thoracic kyphosis and lordosis angle: reference values for 16-55 years age group, in males *

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
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<tr>
<td>Thoracic kyphosis</td>
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<td></td>
</tr>
<tr>
<td>Lumbar lordosis</td>
<td>12</td>
<td>30</td>
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</tbody>
</table>

* Angle values < or > minimum and maximum reference values are considered 'reduced' and 'increased'

and clinical—functional variables in three separate pictures that are not necessarily connected by a single linear process. These three pictures are clinical—functional spondyloarthropathy of first, second and third degree. The thoracic spine is treated separately in the procedure since, from the point of view of clinical—functional alterations, it behaves differently from the other vertebral regions.

For flexion, extension, inclination and rotation of head and trunk, and for the parameters 'thoracic kyphosis angle' and 'lumbar lordosis angle', the values correspond to the 5th and to the 95th percentiles of the distributions were calculated.

Values for mobility parameters were treated separately in four age classes, since a-e is an influencing factor; data

---To identify reference values for some of the parameters studied, the data collected in several studies on adult male subjects were suitably selected and statistically analysed.
on the angles of the sagittal curves of the spine were, however, treated independently of age. In fact, age, in our data, had no effect on these parameters, at least for the age group considered here.

Table 3 gives the reference values for the head and trunk movements in males. Table 4 shows the reference values for the thoracic kyphosis and lumbar lordosis angles in males. According to these values, for an individual diagnosis, the angles may be classified as 'reduced' or 'increased'.

The group examined

In the present study, the clinical method previously illustrated was applied to a control group of male subjects in order to achieve the following:

a) Estimate the frequency of clinical–functional cervical, thoracic and lumbosacral spondyloarthropathy in four age classes (15-25, 26-35, 36-45, 46-55 years) of male subjects not exposed to occupational postural hazards;

b) Identify mean values and confidence interval of the mean of the various articular-mobility parameters studied within these age classes.

Such data are necessary in order to make comparisons with similar data obtained in investigations on workers exposed to occupational postural hazards, even though a verification of the aetiological basis of the risk factors under study will require longitudinal epidemiological studies. Other aspects considered here were the occurrence of scoliosis and dissymmetry of lower limbs in the adult population.

Two preliminary conditions were established for the choice of characteristic for the control group: a) stratification into four age classes (16-25, 26-35, 36-45, 46-55 years); b) inclusion of subjects who had not, either presently or in the past, been employed in jobs involving exposure to risk factors such as prolonged fixed (both sitting, and erect) postures, manual lifting, moving or transport of load or whole-body vibrations.

The size of the control group was established in relation to the variability of the spinal mobility parameters, so as to keep the 95% confidence interval of the mean of these parameters to 5 degrees5,6. The size of the sample that adequately guaranteed the aims of the study was calculated to be 50 subjects for each age class, i.e. a total of 200 subjects6.

In this sample size the confidence limits for the frequency (f) of pathological cases under study were f=0.14 according to the formula used to calculate these limits, and in the most unfavourable circumstances where f=0.509.

Data analysis

The statistical analyses have been carried out taking into account the following points:

a) Absolute frequency and percentage (f) of qualitative variables (in particular diagnosis) and estimation of relative confidence limits (1) for each age class, according to the formula:

\[ T = f + 1.96 \sqrt{\frac{f(1-f)}{n}} \]

b) Mean, standard deviation and 95% confidence interval of the mean of quantitative parameters (in particular amplitude of movements of cervical, thoracic and lumbar...

<table>
<thead>
<tr>
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<tr>
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<td>32</td>
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<td>40</td>
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<td>(19.1-44-9)</td>
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<td></td>
<td>(12.2-32-8)</td>
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<tr>
<td>Thoracic</td>
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<td>10</td>
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<td>18</td>
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<td>24</td>
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<td></td>
<td>(0.5-15-5)</td>
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<td>(17-18-3)</td>
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<td>(74-28-6)</td>
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<td>(12.2-35-8)</td>
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<tr>
<td>Lumbosacral</td>
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<td>12</td>
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<td>28</td>
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<td>(15.6-40-4)</td>
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<td>(32.2-63-8)</td>
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</table>
Table 6. Head movements: mean value (*), standard deviation (in brackets) and 95% confidence interval of the mean, by age class in the control group. *P test value and relative level of significance shown for each parameter.

| Head movements | 16-25 | 26-35 | 36-45 | 46-55 | F  
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<td>51.9(6-55)</td>
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<td>87.1(4-92)</td>
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</table>

***p < 0.0001

chisquare to test the existence of significative statistical differences.

c) One-way analysis of variance (ANOVA) for the quantative parameters in relation to the four age classes.

Results

Figure 10 shows, by means of histograms, the observed per cent frequency of subjects with 'clinical-functional cervical, thoracic and lumbosacral spondyloarthritis' for each of the age classes considered. The cases of spondyloarthropathy are reported by -rade (I, 11, III) according to our classification, and as a whole. These data and the relative 95% confidence limits for estimation of the occurrence of the disease studied in similar populations are shown in more detail in Table 5. Considering the per cent frequencies of pathological cases independently of the 'free' curve, it can be observed that they tend to increase with increase in age; the increase is minimal for the thoracic re-ion, but becomes more evident for the cervical re-ion and even more marked for the lumbosacral re-ion. For both the cervical and the lumbosacral... reions, the differente between age classes in frequency of norma) and pathological cases was statistically significant (x^2 = 18.3 for the cervical region, x^2 = 31.8 for the lumbar region; p < 0.001).

Figure 11 shows the per cent frequency of the cases of scoliosis observed in the four age classes, and within the entire control group. The frequency of cases of scoliosis,
which were all slight (between 10 and 15° of convexity), is somewhat high (on average 54%, with 95% confidence limits of 47 to 60%) and, as was to be expected, there were no substantial differences between the different age classes.

Figure 12 shows, for all classes and in the control group as a whole, the frequency of subjects with leg dis- symmetry greater than 1 cm. In this case, too, the frequencies observed are certainly not negligible and are independent of age.

Tables 6 and 7 report, for the four age classes and for the cervical and the thoraco-lumbar-sacral spine, respectively, the following data regarding joint mobility parameters (angles of flexion and extension, left and right inclination, left and right rotation): a) mean angle value; b) standard deviation; c) 95% confidence interval of the mean for estimation of the mean value of this feature in the general population; d) the value of F and the relative level of significance.

Discussion

A method for the clinical-functional examination of the spine was devised by us. It was applied to a group of male subjects, stratified by age, who were not exposed to occupational postural risks, in order to provide referential data in epidemiological studies.
are moved from their job following a diagnosis of spondyloarthropathy at a periodic health check. Both these phenomena would lead to an underestimation of the occurrence of the disease in the group under study.

c) It is advisable that the groups under study include subjects who have been employed on the job for at least 5 years, so as to guarantee that there has been adequate time for any disease to develop.

d) It is preferable to exclude subjects who have previously employed for more than 5 years altogether on jobs involving hazards for the spine.

The purpose of this selection is to ensure that any increased occurrence of a disease be attributed to one and not many jobs. On the other hand, it should be remembered that, besides the jobs which involve a sanale risk for the spine, there are some which involve more than one risk factor (e.g.: (1) vibrations and static postures for heavy vehicle drivers; (2) postures with the trunk flexed, lifting of load and, commonly, tractor vibrations in agricultural work, etc.). In these cases, the higher occurrence of disease which may be observed is generically attributed to the job and it is not possible to distinguish the proportion due to each hazard.

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