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(Chief: Professor Sten Friberg, Stockholm)

The Munkfors Investigation

A study of the Frequency and Causes of the Stiff Neck-Brachialgia and Lumbago-Sciatica Syndromes, as well as observations on certain Signs and Symptoms from the Dorsal Spine and the Joints of the Extremities in Industrial and Forest Workers

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I. Introduction

The present investigation was initiated by Dr. Elof Edlund, physician-in-chief of the Province of Värmland, who considered it would be of interest to survey the form, degree and frequency of defects in the organs of the upright posture, and, if possible, to determine the factors that contribute to producing these defects. The funds to finance the investigation were collected by Dr. Edlund from the Värmland Chapter of the Red Cross, the Uddeholm Company, the Metal Workers Union, and the Federation of Employers. The following groups were studied:

100	boys	.....	in the	age	group	8	to 11	years
100	youths	.....	„	„	„	15	to 20	„
114	forest workers	...	„	„	„	35	to 49	„
163	industrial workers		„	„	„	35	to 49	„

The group of youths was selected at random from among industrial apprentices, errand boys, shop assistants and laboratory technicians in Munkfors.

The forest workers consisted of men between 35 and 49 years who worked in the neighborhood of Munkfors. Practically all of them had been working in the forests since the age of 12 to 14 years. Felling trees and transporting timber not only consume a tremendous amount of energy, but also are very hard on the back, both with regard to posture during work and because they involve much heavy lifting. Furthermore, the work is usually done under difficult climatic conditions (cold and dampness). Consequently, these forms of work must be regarded as among the most strenuous kinds of labor that exist.

The industrial workers were chosen by drawing lots among the 35 to 49-years-old men of the approximately 1200 workers employed by the Munkfors Company. The Company produces hot-drawn and cold-drawn sheet iron. The types of job included in the investigation represent medium-heavy and heavy industrial work. Most of the persons

studied had been employed by the Company since they began to work at the age of 15 years.

The investigation was conducted along three main lines:

1) A medical-physiological section covering the following points:
   a) social, hygienic and working conditions, medical history, clinical examination, various physiologic tolerance tests (to be published in a separate communication by N. Lundgren).
2) A dental investigation to determine the frequency of caries and certain orthopedic anomalies of the jaw (to be published in a separate communication by Kuttner).
3) An orthopedic clinical-roentgenologic investigation.

The orthopedic investigation was planned in consultation with Professor Sten Friberg, Chief of the Department of Orthopedics of the Caroline Institute. Dr. Edlund's thought had been to investigate the extent to which the postural faults of childhood and adolescence are of functional significance in the adult. Meantime, in view of the importance of the degenerative changes in the cartilage of the various jointsystems and of the lack of knowledge of their frequency, it was also considered desirable from the orthopedic point of view to study this question too. The persons examined were studied closely with reference to past diseases and to previous or current disorders of the upper and lower extremities and of the spine. The cervical, dorsal and lumbar sections of the spine, as well as the joints of the shoulders, elbows, wrists, hips and knees, and the feet were thoroughly examined with reference to mobility, postural faults and deformities, or other signs and symptoms. Finally, a roentgen examination was made of the wrists, the cervical, dorsal and lumbar spines, the pelvis and the hip joints.

The sources of error in recording subjective symptoms were threefold: 1) the faulty memory of the men examined; 2) a certain difficulty in some cases to evaluate the subjective reports; and 3) the possibility that subjective symptoms at an early stage might have caused a change of employment, which, in turn, would lessen the frequency of the symptoms in the higher age groups. Since considerable time was devoted to each case and great care was taken with the questioning, I do not believe that any important errors were made as a result of the subjects' forgetfulness. As far as the change to different employment is concerned, I consider that this source of error was a minor one, since Munkfors, the site of the investigation was chosen with this in mind. The population of Munkfors is very stable, and the chances of finding work except in heavy industry or the forests are small. Meantime, the

Table 1. Age Distribution of the Industrial and Forest Workers Examined

Age	Number 35 to 39 yrs.	Number 40 to 44 yrs.	Number 45 to 49 yrs.	Total
Industrial workers	54	53	56	163
Forest workers	33	50	31	114
Total	87	103	87	277

Company makes every effort to place men who cannot do heavy work in lighter jobs, which means that very few workmen leave the community.

The age distribution (Table 1) was taken into consideration in the comparisons between industrial and forest workers.

The following survey was based on the symptoms reported, including those present at the examination and those experienced in the past. The data thus assembled was collated with the objective findings and roentgen observations. Consequently, the chapters on the relatively unusual signs and symptoms in the upper and lower extremities are brief, while those on the two main syndromes, stiff neck-brachialgia and spinal insufficiency – lumbago-sciatica, are relatively long and detailed.

II. Upper Extremities

Wrists.

a) Industrial and forest workers in the age group 35 to 49 years ..... 277 cases.

1) 3 cases of unhealed fracture of the navicular (navicular pseudarthrosis) following an injury 15 to 20 years previously. All three patients had minor symptoms, but were able to work at normal capacity.

2) 2 cases of lunato-malacia. Both had been exposed to trauma 8 to 10 years previously. They had only minor symptoms and were able to work at normal capacity.

3) 6 cases with a tendency to tendovaginitis crepitans on unusual strain; working capacity scarcely affected.

4) 7 cases of periodical mild symptoms following overexertion, but not to the point of limiting working capacity. No objective findings.

5) 2 cases of mild symptoms and slight limitation of movement following a fracture of the radius.

6) 2 cases of ganglion of the wrist.

7) 3 cases showed roentgen signs of structural change in the lunatum, which might have been due to beginning malacia. No subjective signs and no limitation of movement.

8) 2 cases with some limitation of movement resulting from polyarthritis.

Altogether 27 cases (ten percent) had abnormalities in the wrists, but not severe enough to cause appreciable decrease in working capacity.

b) Apprentices ..... 91 cases.

1) 1 case of osteochondritis dissecans in the navicular of both hands. No definite symptoms (the patient was a weightlifter).

2) 2 cases of periodical mild symptoms in connection with exertion; in one of them volar flexion was somewhat impaired and in the other there were no definite signs. Roentgen was negative in both cases.
3) 88 remaining cases had no signs or symptoms originating in the wrists.

Elbows.

a) Industrial and forest workers ..... 277 cases.
1) 3 cases of slight restriction of movement after old injuries. No other findings.
2) 1 case of osteochondritis dissecans. Previously had locking of the joint, but no current trouble.
3) 1 case of very mild symptoms of epicondylitis following an injury to the elbow several years previously.

b) Apprentices ..... 91 cases.
None of this group had any signs or symptoms from the elbow joints.

Shoulders.

a) Industrial and Forest Workers 277 cases.
1) 2 cases of traumatic dislocation of the shoulder several years previously. No symptoms since then.

b) Apprentices ..... 277 cases
No signs or symptoms originating in the shoulder joints could be found in this group.

III. The Stiff Neck-Brachialgia Syndrome

The following description of the stiff neck – brachialgia syndrome is based almost exclusively on the material examined in the present study.

a) Symptoms.

With stiff neck or wry-neck, the patient has a sensation of stiffness in the neck. He keeps his head bent or twisted to one side, and any attempt to move it back into position is very painful. If the patient wants to look to one side he must twist his whole body. The symptoms may come on suddenly in connection with a sharp turn of the head or with some trauma of the same nature, just as lumbago sometimes results from stumbling. Cold draught is often stated to be the cause, but usually the patient awakens with a stiff neck and blames the attack on an uncomfortable sleeping position. Stiff neck seldom prevents the victim from working, and the symptoms sometimes disappear in a few hours, although they usually persist for two or three days and occasionally for a week or so. All variations are seen, from a sudden acute pain to a scarcely perceptible stiffness in the neck. The patient may have had only occasional attacks, although more frequent attacks, sometimes at intervals of several years, are commoner. In addition to the pain in the neck, there is not seldom radiating pain to one or the other shoulder, while full-fledged brachialgia with or without nerve root pain sometimes develops in connection with stiff neck.

Brachialgia, which actually means ache or pain in the arm, has gradually come to mean a certain type of ache or pain which often affects more than just the arm. Brachialgia is made up of two different components; the so-called deep pain and a typical dorsal nerve root pain. The deep pain feels like a stubborn ache or radiating pain in the shoulder and upper arm down toward the elbow. It seldom extends past the elbow, but often reaches back under the shoulder blade. There frequently develops at the same time a stiffness and limitation of move-

ment in the shoulder of the type usually called humeroscapular periarthritits. The deep pain is not seldom combined with radiation to the pectoral region and, if it is situated on the left side, to the heart area. The result is a picture greatly reminiscent of angina pectoris with pain in the heart area and the left arm. The present material contained a few typical cases, in which the patients sought medical attention, were given heart medicine, and did not dare work for long periods because of their "heart" trouble. Unlike angina pectoris, however, in which the attacks are brought on by exertion or excitement, the symptoms in question practically always appear when the patient is at rest. In general, a characteristic of the deep pain is that it often disappears when the patient is at work and returns when he has gone to bed at night or when he awakens in the morning. Work appears to have a deleterious effect in the sense that the symptoms at rest are more severe after a hard working day. Finally, certain forms of stubborn headache undoubtedly are a part of this syndrome. Several of the persons examined stated definitely that they had had typical neck symptoms or deep pain of the kind described above in connection with headache. In these cases the headache often radiated to the forehead down toward the bridge of the nose.

This type of brachialgia was a relatively innocuous complaint, at least in the sense that it seldom prevented the patients from working. On the other hand, it was often said to prevent sleep. The symptoms were periodical, often appearing in the spring and autumn, and of varying intensity. Sometimes they lasted only a week or so, while at other times they persisted in more or less pronounced form for six months or more. All agreed that cold and damp were contributory factors, but few gave work as the cause.

Typical dorsal nerve root symptoms were relatively unusual in this material, although not so rare that a distinct connection with the deep pain could not be discerned. The dorsal root symptoms consist of numbness and radiating pain in the fingers, sensory impairment in many cases and disturbed reflexes and paresis in a few. Their nature is such that it is believed possible to distinguish clinically between root pressure from the sixth, seventh and eighth cervical nerve roots. Numbness of the fingers, particularly during the night, as the only symptom was not unusual, while the other signs of root pressure were rare. If pronounced root pressure symptoms were present, the attacks were usually very stubborn and often caused long absence from work.

b) Frequency.

Stiff neck was stated to have occurred in 64 percent of the industrial workers and in 71 percent of the forest workers. Despite the magnitude of these figures, they undoubtedly represent minimum levels, since it was often difficult for the patient to remember having had stiff neck, presumably because the symptoms were of short duration and caused little trouble. The rate of stiff neck was slightly higher in the forest workers than the industrial workers, but the difference was not statistically significant (Table 2).

It is noteworthy that there is no significant difference between the frequency in the various age groups. When the industrial and forest workers are lumped together, it is found that stiff neck was present in 64, 68 and 68 percent, respectively, in the three age groups (35 to 39 years, 40 to 44 years and 45 to 49 years). This indicates that stiff neck usually makes its appearance before the age of 40. About 10 percent of the industrial workers stated that they had stiff neck before the age of 20. This figure is undoubtedly underestimated, since the questioning on this point was not done consistently. In the apprentice group (15 to 20 years) stiff neck definitely occurred in not less than 35 percent (32 cases). All this adds up to evidence that the etiologic factor or factors that cause stiff neck begin to make themselves felt at an early stage, not seldom before the age of 20.

The brachialgia group includes all cases in which there had at some period been radiating pain or ache in the shoulder and arm, as well as a few in which there had only been radiating pain in the upper part of the chest or the shoulder blade. Mild but definite brachialgia was reported in the great majority of cases, although the symptoms had been so mild in some of them that the diagnosis was doubtful. It is possible, therefore, that the following figures for frequency are somewhat overestimated. However, this is of no great importance in comparing the various groups or in attempting to disclose the etiologic factors:

Table 2. Frequency of Stiff Neck – Brachialgia in Different Occupational Categories.

	No symptoms	Stiff Neck	Brachialgia	Both Stiff Neck-Brachialgia
Industrial workers, 163 cases	20 %	64 %	52 %	35 %
Forest workers 114 „	20 %	71 %	47 %	38 %
Total 277 „	20 %	67 %	49 %	36 %

Table 3. Frequency of Stiff Neck – Brachialgia in Different Age Groups.

Age group	No symptoms	Stiff Neck	Brachialgia	Stiff Neck-Brachialgia
15 to 20 years, 91 cases	65 %	35 %	1 %	1 %
35 to 39 „ 87 „	24 %	64 %	34 %	23 %
40 to 44 „ 103 „	20 %	68 %	52 %	41 %
45 to 49 „ 87 „	16 %	68 %	61 %	45 %
Total 368 „	31 %	59 %	37 %	28 %

Brachialgia was reported by 52 % (84/163) of the industrial workers and by 47 % (53/114) of the forest workers. The frequency was found to rise with age, particularly in the forest workers. If the industrial and forest workers are treated as one group, brachialgia was reported in 35, 52 and 61 percent, respectively, of the three age groups. Rare cases reported brachialgia before the age of 20, and the apprentice group shows one definite and three doubtful cases of brachialgia, i. e. a frequency of at most 4.4 percent.

The etiologic factor or factors that cause brachialgia thus appeared at an early stage in occasional cases, but became increasingly pronounced with age, with a distinct increase in frequency between the age groups 35 to 39 years and 45 to 49 years. Stiff neck, on the other hand, showed a relatively high frequency at an early age and made its first appearance after the age of 40 in only occasional cases. The similarity with the lumbago-sciatica syndrome is striking in this connection.

Of the 137 cases with brachialgia, 28 percent had symptoms originating in the left side, 32 percent in the right side and 40 percent had symptoms of bilateral origin. In the last-mentioned group the pain was seldom felt in both shoulders and arms at the same time, but as a rule it moved from one side to the other at varying intervals.

The following observations were made in the 137 cases which at one time or another had symptoms of brachialgia. (Table 4).

Table 4. Frequency of Various Symptoms in 137 Cases of Brachialgia.

a) Comparison Between Work Groups.

	53 Forest Workers	84 Industrial Workers	137 Total
Persistent symptoms	19 %	12 %	15 %
Repeated attacks	34 %	24 %	28 %
Radiating pain or numbness in the fingers	34 %	31 %	32 %
Headache	10 %	11 %	10 %
Radiating pain to chest	26 %	19 %	22 %
Stiffness in shoulder	6 %	7 %	7 %
Disabled for work	21 %	12 %	15 %
Trauma	0 %	6 %	4 %

b) Comparison Between Age Groups.

	30 35-39 yrs.	54 40-44 yrs.	53 55-49 yrs.
Persistent symptoms	17 %	15 %	13 %
Repeated attacks	30 %	22 %	32 %
Radiating pain or numbness in the fingers	20 %	30 %	42 %
Headache	10 %	13 %	8 %
Radiating pain to chest	23 %	19 %	25 %
Stiffness in shoulder	10 %	0 %	11 %
Disabled for work	23 %	10 %	17 %
Trauma	3 %	6 %	2 %

a) 15 percent (20/137) representing 19 percent (10/53) of the forest workers and 12 percent (10/84) of the industrial workers, had symptoms at the time of the investigation.

b) Repeated attacks were reported in 28 percent (38/137), representing 34 percent (18/53) of the forest workers and 24 percent (20/84) of the industrial workers. This suggests that repeated attacks of brachialgia more often occurred in forest workers than in industrial workers (cf. lumbago in Table 14). Statistical computation of the figures does not, however, reveal any significant difference.

c) 32 percent (44/137) reported that, in addition to the deep pain, they had at some time had radiating pain or numbness in one or more fingers, analogous to that in the leg in sciatica. These sensory nerve root disturbance were relatively late symptoms in the brachialgia syndrome and showed their highest frequency in the age group 45 to 49 years.

d) 10 percent (14/137) stated definitely that they often had headache in connection with their neck and shoulder symptoms. The headache usually radiated from the nape to the forehead and down over one eye to the bridge of the nose. The headache was not always accompanied by radiating pain to the shoulder, which is of interest when investigating the genesis of headache cases. If headache is the only symptom of brachialgia, it should be possible during an attack to find distinct tenderness over one of the cervical spinous processes or else to evoke pain by compression or movement of the cervical spine (see Table 6 and page 24).

e) In 22 percent (30/137) the usual deep pain was accompanied by radiating pain in the chest (pectoralis region) and, if the left side was involved, in the area of the heart. Two of these patients had been diagnosed as heart disease by a physician and had been on sick leave for a long period. Both patients, however, eventually returned to work on their own initiative. Evidence that the heart trouble in these cases actually was a symptom of brachialgia and not of angina pectoris, which, with the possible exception of the neck pain, presents the same type of radiating pain, is provided by the course of the disorder (return to manual labor without recurrence of symptoms) and by the fact that both patients stated definitely that the "heart trouble" was worst at rest. This last feature is typical of brachialgia, the pain of angina pectoris generally appearing following exertion or excitement.

f) 7 percent (9/137) volunteered the information that the attacks were sometimes accompanied by stiffness in the shoulder on the ipsilateral side. It may be difficult to differentiate between this kind of shoulder stiffness and the type seen in genuine humeroscapular periarthritis, but in these cases the patients reported concurrent neck symptoms and radiating pain or numbness in the fingers. They also stated that the shoulder stiffness disappeared without treatment at the same time as the other symptoms regressed. Humeroscapular periarhritis as a symptom of brachialgia should, therefore, also be borne in mind.

g) 15 percent (21/137) were disabled for work by the complaint, most of them for less than one month. The patients with stiff neck only were very seldom prevented from working and never for more than one or two days. Among the brachialgia cases, inability to work seemed to be commoner in the forest workers than the industrial workers, and this observation is borne out by the figures (21 percent of forest and 12 percent of industrial workers). No significant statistical difference could be found, however.

On the whole, it can be said that even if the frequency of stiff neck - brachialgia was very high, the course of the disease was usually favorable, and the syndrome relatively seldom incapacitated the patients. A contributory factor is undoubtedly the circumstance that the symptoms in the mild cases were always stated to be less pronounced or to disappear while the patient was at work and to be most troublesome in the evening, night and morning.

h) In only five cases, or 3 to 4 percent, was a trauma reported in connection with the onset of the symptoms. Even if the questioning on this point was not entirely consistent, there is little doubt that trauma played an insignificant part in evoking the relatively mild forms of brachialgia that comprise the present material.

IV. The Connection Between the Stiff Neck-Brachialgia and the Cervical Spine

a) Brief Survey of the literature.

The usual medical textbooks make no mention of stiff neck, while brachialgia as a syndrome is described in unclear and diffuse terms. It was therefore surprising when studying this series of normally able-bodied men to find that one after another described in almost monotonous fashion the mild but typical symptoms of brachialgia which they had suffered on one or more occasions. The complaint was generally called "rheumatism".

Brachialgia as a syndrome was first described in the middle of the 19th century by Valleix (1841). It soon came to be attributed to neuritis, funiculitis or radiculitis with origin in the brachial plexus or the nerve roots. A drastic example was described in which the pains were so severe that the arm was amputated. Since this did not lead to any improvement, the root was severed, resulting in immediate cessation of the pain (Abbe, 1896). In brachialgia increasing attention has come to be paid to the frequent combination of cervical spondylosis resulting in narrowing of the intervertebral foramina due to osteoarthritic spurs and narrowing of the cervical interspaces, which many authors believed to be the commonest cause of the syndrome. Other workers stressed the importance of cervical rib on the theory that mechanical pressure on the inferior plexus branches in the angle between this rib and the insertion of the scalenus anterior was a common cause. This theory found some substantiation in the fact that scalenotomy led to a definite improvement in certain cases. Still other authors pointed out that the syndrome was also found in tumors in the upper thoracic aperture, in heart diseases, and in traumatic or indurative processes around the humeroscapular joint. They deduced from this that brachialgia was a form of referred pain, secondary to the diseases in question.

The whole problem took on an entirely new aspect with Schmorl's pioneer works on the pathologic anatomy of the intervertebral disks and the resultant theory, first evolved in the United States and France,

concerning the importance of disk prolapse in sciatica. A definite and common cause of root pressure had now been found for the first time. This was later verified by a great number of operations for lumbar disk prolapse and, during the last ten years, for cervical disk prolapse also.

Regarding the causes of the brachialgia syndrome, Nachlas wrote in 1944 that the symptoms might develop from irritation of the sensory neuron at any point between the cerebral cortex and the peripheral end-organ, and listed, in addition to the aforementioned causes, tumors of the thalamus, and tumors of the medulla. He added, however, that the clinical-neurologic picture of radiating pain, failure of reflexes, and the sensory and motor disturbances often indicate involvement of the nerve root. In addition, he asserted that the pathologic-anatomic observations showed that compression of the intervertebral foramen very often provides an organic background for the complaint. He therefore was of the opinion that the most common cause of brachialgia is to be found in changes around the nerve roots in the intervertebral foramina (disk prolapses, spondylosis, arthritis or synovitis in the intervertebral joints). Schmorl and his school produced convincing evidence that disk prolapse is secondary to disk degeneration, while Keyes and Compere (1932) and Lob (1933) proved by their studies of osteophyte formation in animals following experimental injuries to the disks, that the same is true of spondylosis.

Numerous interesting observations concerning the different components of the brachialgia syndrome have been published and will be summarized briefly in the following. Frykholm (1951) showed by experiments in connection with operations for cervical disk prolapse that the deep pain can be reproduced by moderate mechanical irritation of the ventral root, on the condition that the latter has already been injured or compressed. Stronger irritation produces muscular contractions, while cautious irritation of an intact root evokes no symptoms. It is also of interest that, if the dorsal root only is anesthetized with procaine, irritation of the ventral root causes no deep pain but only muscular contractions. It would thus appear that the deep pain is produced by moderate irritation of a compressed ventral root, on the condition that tha dorsal root is still functioning. This may also explain the circumstance that the deep pain is on the whole the same with involvement of different segments. The muscles are, as we know, innervated by several segments.

The sensory root symptoms, comprising radiating pain, paresthesias and numbness in the fingers, can be evoked by irritation of the dorsal root, which was also proved by Frykholm in connection with operative experiments. Irritation of the sixth cervical will evoke symptoms in the

first and second fingers, irritation of the seventh cervical in the second to fourth fingers, and irritation of the eight cervical in the fourth and fifth fingers. However, deviations are not unusual, and this system of segmental diagnosis is therefore not wholly reliable. According to Frykholm, both the deep pain and the radiating pain to the fingers originate in the nerve roots; the deep pain, in his opinion, is caused by irritation of the ventral motor root and the radiating pain in the fingers by irritation of the dorsal sensory root.

Headache as a component of the brachialgia syndrome has been described by several authors. Barré (1925) and Lieou (1926) drew up a syndrome, which they considered to be due to compression of the vertebral artery and its accompanying nerves as the result of lateral osteophytes and which, in addition to headache, included vertigo, tinnitus, certain visual disturbances, trigeminal pain, palatal paresthesias and paroxysmic attacks of hoarseness. Other authors who noted the connection between headache and cervical root involvement and spondylosis include Holbrook (1927), Gunther and Kerr (1929), Bisgard (1932), Kelly (1942) and Raney (1948). Some workers state that they have observed that headache is associated with disease processes in the upper cervical disks, but no definite proofs have been advanced.

Several authors have stated that radiating pain in the thorax or pseudo-angina pectoris may appear as symptoms of cervical spondylosis. Differentiation between true and pseudo-angina pectoris is an important diagnostic problem. Gunther and Sampson, who emphasized this difficulty as long as 1929, stated that the diagnosis should probably be pseudo-angina if the pain is exacerbated or evoked by movements of the neck, if the patient tolerates exertion, and if the symptoms are not improved by vasodilatory medication (nitrites, etc.).

Josey and Murphey (1946) described four cases in which the pseudo-angina disturbances disappeared in direct conjunction with operation for cervical disk prolapse (in three cases the sixth cervical disk on the left side and in one case the seventh cervical disk on the left side). The pain pathways that give rise to the symptoms are not definitely known. Reischauer (1949) went one step further and stated that true angina pectoris attacks could be provoked by irritation of the sympathetic trunk in cervical disk prolapse. He described two cases in support of this view.

It has long been observed that a painful contraction in the shoulder is associated with symptoms of brachialgia, (Duplay, 1872, and others). Brachialgia has been regarded as a form of referred pain from humeroscapular periarthritis. Reischauer (1949) on the other hand, believed the opposite to be true, and reported several case histories in

support of his theory. In his opinion, the stiffness of the shoulder joint in some cases is evoked by irritation of the sympathetic paravertebral trunk in cervical disk prolapse. Frykholm supplied strong evidence of this theory in 1951, when he reported that he had noted, in several cases of cervical disk prolapse in which there was concurrent painful contraction of the shoulder, that the contraction disappeared without special treatment very soon after operation for disk prolapse. It is also of interest that several authors (Ask-Upmark 1944, Hilker 1949, etc.) mentioned the existence of the painful shoulder contraction in heart disease (angina pectoris and heart thrombosis). It is possible that the irritation of the sympathetic nerve, which is assumed to evoke a painful contraction of the shoulder joint, may also at the same time cause a vasosclerotic heart to react with an attack of angina pectoris or a thrombosis and that this irritation of the sympathetic nerve may sometimes be caused by a cervical disk prolapse.

b) Clinical Signs Originating in the Cervical Spines.

The clinical study of the region in which the stiff neck-brachialgia syndrome originates was made according to the following plan:

a) The configuration and mobility of the cervical spine and the presence of tenderness over the spinous processes and of evocable pain were recorded. No real deviations from the normal configuration were found. The degree of cervical lordosis usually has a certain relationship to dorsal kyphosis. However, since we have no objective method of evaluating this condition and since it does not appear to have any connection with the stiff-neck-brachialgia syndrome, it was not analyzed in detail. The motion of the cervical spine was recorded as normal, sligthly restricted, and greatly restricted. It was sometimes difficult to draw the line between sligthly restricted and normal movement, which detracts from the value of this sign as an objective observation. Tenderness over the spinous processes was tested in the same way as in the lumbar spine, by exerting pressure with the thumb over the spinous processes. The upper and central spinous processes are difficult to distinguish from another, and therefore we frequently could only state the tenderness was located in approximately the fourth cervical to the sixth cervical process, etc. Evokable pain was tested by pressure on the head from above, both with the head held erect and with it bent to the right or to the left. If this caused the patient pain in the cervical spine or radiation to one shoulder or arm, evokable pain was stated to be present.

b) Neurologic signs from the upper extremities. The biceps and triceps reflexes, the sensibility, and the strength of the handgrip were studied.

c) The range of movement, as well as any tenderness in the joints of the shoulder, elbow, hand and fingers, was recorded. No definitely pathologic findings were made in the stiff neck-brachialgia cases. The few cases with pathologic findings in these joints were explained by other causes and will be described in another section. Meantime, a few patients reported that they felt stiffness in the shoulder joint in connection with brachialgia attacks, but no objective findings were made since none of these patients were examined during an attack.

Table 5 shows the frequency of clinical signs originating in the cervical spine in all the industrial and forest workers. It will be noted that the frequency rises with age and that this increase is entirely accounted for by the fact that a certain limitation of motion in the cervical spine becomes more and more prevalent. No difference between the two vocational categories could be found.

Of greater interest is Table 6, which correlates the signs with the symptoms reported. Of the 56 patients who had never had symptoms of stiff neck-brachialgia, 25 percent (14/56) showed pathologic signs originating in the cervical spine, consisting in all but one case of a slight limitation of motion. Eighty-six percent of these 14 cases, but only 36 percent of the remaining 42 cases, showed roentgen signs of cervical disk degeneration. There was thus a distinct correlation be-

Table 5. Clinical Signs Originating in the Cervical Spine in Industrial and Forest Workers.

Age group	Limitation of movement	Pressure tenderness over spinous processes	Evokable pain	Neurological signs	Total No. of cases with clinical signs
35-39 yrs ..... 87 cases	18 %	20 %	10 %	2 %	32 %
40-44 yrs. ..... 103 cases	50 %	27 %	11 %	2 %	60 %
45-49 yrs. ..... 87 cases	56 %	17 %	10 %	9 %	67 %
Total ..... 277 cases	42 %	22 %	10 %	4 %	53 %

Table 6. Clinical Signs Originating in the Cervical Spine in Cases With and Without Stiff Neck and Brachialgia.

	Number of cases	Limitation of movement	Pressure tenderness over spinous processes	Evokable pain	Neurological signs	Total no. of cases with clinical signs
No symptoms	56	23 %	2 %	0 %	0 %	25 %
Stiff neck	84	38 %	10 %	2 %	2 %	44 %
Brachialgia	137	53 %	38 %	20 %	7 %	72 %
Brachialgia during examinitation	20	65 %	80 %	65 %	10 %	100 %

tween limitation of movement and roentgen signs of disk degeneration in the cervical spine. Of the 84 cases with stiff neck only, 44 percent had clinical signs, generally consisting of a certain limitation of motion. Tenderness of the spinous processes was present in eight of these cases (10 percent), the majority of which were undergoing or had recently undergone an attack of neck trouble. Of the 137 who had at some time had brachialgia, 72 percent had clinical signs emanating from the cervical spine. Twenty of these 137 cases had brachialgia at the time of the examination. This entire group of 20 had clinical signs emanating from the cervical spine, and 18 of them (90 percent) had either tenderness of the spinous processes or evokable pain, or both. This indicates that brachialgia generally has some connection with the cervical spine. Tenderness of the spinous processes and evokable pain were present in not a few of the 137 cases with brachialgia. The former sign, in particular, appeared to persist long after the subjective signs had disappeared, which probably means that the symptoms are ever-latent and ready to erupt either without apparent reason or as a consequence of a minor trauma, an extra strain, a chill, an infection, or something of the kind.

The 12 cases with neurologic signs were divided as follows: mild paresis (impaired strength of the handgrip) plus sensory impairment, 1; failure of the biceps and triceps reflex in one arm, 1; impairment or failure of the triceps reflex, 10. The last-mentioned sign was bilateral in three cases, and it is therefore possible that in these cases it was due to faulty technique in testing these reflexes.

To sum up the clinical signs, it can be stated that tenderness of the spinous processes and evokable pain were present in 90 percent of the cases with current brachialgia, but scarcely ever in the group "entirely free from symptoms". This would indicate that the symptoms of bra-

chialgia usually are associated with changes in the cervical spine. There is also a definite relationship between limitation of movement and roentgen signs of disk degeneration in the cervical spine.

The relationship between pressure tenderness of the spinous processes in the upper dorsal spine and brachialgia is discussed on Page 59.

c) Roentgen Signs of Disk Degeneration in the Cervical Spine.

The roentgen examination of the cervical spine consisted of one frontal picture, three lateral pictures (bending forward and backward and normal posture) and two oblique pictures to visualize the intervertebral foramina on both sides. Focusing was done under fluoroscopy. Signs of disk degeneration were considered to be: thinning of the disk and osteophytic deposits on the margins of the vertebral bodies. Positive evidence of disk degeneration was classified as moderate or pronounced. It was sometimes difficult to differentiate between positive and negative, and a number of cases were therefore labeled "uncertain".

The frequency of roentgen signs of disk degeneration in the various vocational and age groups in shown in Tables 7 and 8. It is immediately obvious that disk degeneration increases with age. While 61 percent of the youngest industrial workers and 70 percent of the youngest forest workers showed signs of disk degeneration, the corresponding figures for the oldest industrial workers and the oldest forest workers were 80 percent and 100 percent, respectively. Eight percent of the apprentices (15 to 20 years) showed mild signs of disk degeneration. A comparison between the two vocational groups reveals that the frequency of disk degeneration was somewhat higher among the forest workers than among the industrial workers. Statistical analysis of the figures, excluding the roentgenologically uncertain cases, shows a probable difference ($p = 0.02 - 0.05$). If the total number of degenerated cervical disks (Table 9) in industrial and forest workers is compared, the difference is statistically significant ($p < 0{,}001$). The investigation therefore indicates that disk degeneration in the cervical spine is somewhat more common in forest workers than industrial workers.

Frequency of roentgen signs of disk degeneration in the cervical spine:

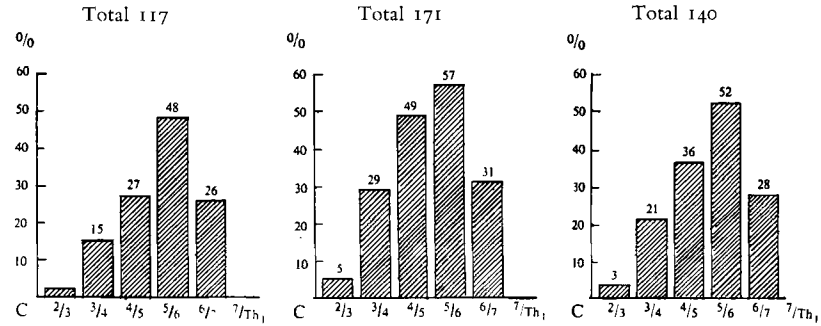
Table 7. Industrial workers 163 cases (2 cases not X-rayed).

Age group	Roentgen neg.	Roentgen positive Mild	pronounced	total	Roentgen Uncertain
35 to 39 yrs. (54)	28 %	32 %	29 %	61 %	11 %
40 to 44 yrs. (53)	25 %	26 %	42 %	68 %	7 %
45 to 49 yrs. (54)	13 %	22 %	58 %	80 %	7 %
Total ..... (161)	22 %	27 %	43 %	70 %	8 %

Table 8. Forest workers 114 cases.

Age group	Roentgen neg.	Roentgen positive Mild	pronounced	total	Roentgen uncertain
35 to 39 yrs. (33)	21 %	52 %	18 %	70 %	9 %
40 to 44 yrs. (50)	16 %	40 %	42 %	82 %	2 %
45 to 49 yrs. (31)	0 %	26 %	74 %	100 %	0 %
Total ..... (114)	13 %	39 %	44 %	83 %	4 %

Table 9. Frequency in percent of roentgen signs of disk degeneration in the various cervical disks.



161 industrial workers 114 forest workers 275 industrial and forest workers

The diagram in Table 9 shows the frequency in percent of roentgen signs of disk degeneration in the various cervical disks. It reveals that the fifth cervical disk most often shows degeneration, after which come the fourth and then the sixth cervical disk. In no case could definite degeneration be demonstrated in the seventh cervical disk, which is probably partly due to the difficulty of satisfactory X-ray visualization of this disk and to the fact that it often appears as a dorsal disk, thus further complicating evaluation.

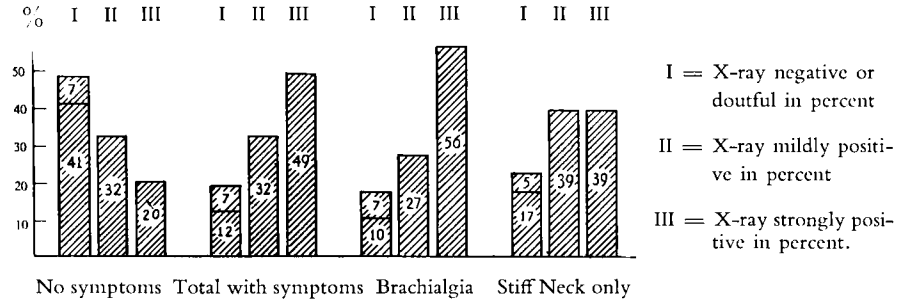
Table 10 and the diagram in Table 11 show the correlation between roentgen evidence of disk degeneration in the cervical spine and the stiff neck-brachialgia syndrome. Both disk degeneration and stiff neck-brachialgia increase with age. However, this does not necessarily mean that the two conditions are interrelated, and each age group was therefore recorded separately. Disk degeneration in all groups is clearly more frequent among those with symptoms than those without. The diagram in Table 11 illustrates this graphically.

On the basis of the foregoing, there was a disinct correlation in this material between disk degeneration in the cervical spine and the occurrence of stiff neck-brachialgia trouble, as the latter is described at the beginning of the chapter. Analysis of the figures yields interesting information.

Table 10. Roentgen Evidence of Disk Degeneration in the Cervical Spine in Cases with and without the Stiff Neck-Brachialgia Syndrome.

Age group	Total No. of cases		No. of X-ray positive		No. of strongly X-ray positive	
35-39 yrs.	No symptoms	21 cases	38 %	8/21	10 %	2/21
87 cases	With symptoms	66 cases	73 %	48/66	30 %	20/66
40-44 yrs.	No symptoms	21 cases	52 %	11/21	24 %	5/21
103 cases	With symptoms	82 cases	80 %	66/82	46 %	38/82
45-49 yrs.	No symptoms	14 cases	71 %	10/14	29 %	4/14
85 cases	With symptoms	71 cases	90 %	64/71	70 %	50/71
Total:	No symptoms	56 cases	52 %	29/56	20 %	11/56
275 cases	With symptoms	219 cases	81 %	178/219	49 %	108/219

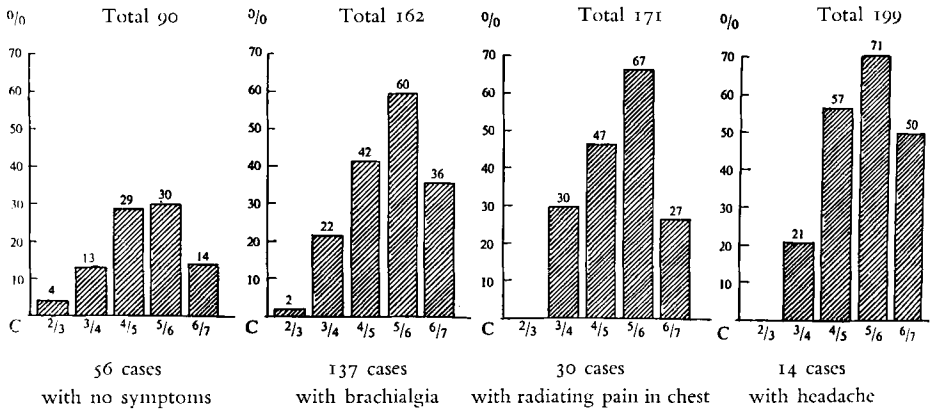
Table 11. Correlation Between Roentgen Evidence of Disk Degeneration and the Stiff Neck-Brachialgia Syndrome.



Several cases with symptoms had no roentgen signs of disk degeneration. This is not surprising, since we know that disk degeneration must be relatively pronounced before it can be visualized on ordinary roentgenograms. Of greater interest is the fact that several cases with pronounced X-ray signs of disk degeneration had never had any trouble and that many cases with strongly pronounced roentgen changes had only had very slight and highly transitory troubles. Since there is nevertheless a distinct connection between disk degeneration and the stiff-neck-brachialgia syndrome, the troubles are probably caused by changes secondary to the disk degeneration.

The diagram in Table 12 illustrate the relative frequency of X-ray evidence of disk degeneration in the various cervical disks in 30 cases of brachialgia with radiating pain in the chest and 14 cases of brachialgia with concurrent headache. For the purpose of comparison, all 137 cases of brachialgia were included, as well as 56 cases with no symptoms. It appears from the diagrams that the distribution of disk degeneration between the different disks in the headache or "chest pain" cases is the same as in the total brachialgia group and the group without symptoms. This does not support the view held by some workers that the headache originates in the upper cervical disks and the chest pain in the lower cervical disks. Since roentgen signs of disk degeneration are not synonymous with symptoms and since disk degeneration with secondary changes may be present without being visible on ordinary X-rays, the foregoing argument is not entirely convincing. It is clear, however, that the roentgen changes are more pronounced in the headache and "chest pain" cases. The figures in the diagrams represent the number of

Table 12. Distribution of X-ray Signs of Disk Degeneration Between the Various Cervical Disks in a Few Special Cases.



degenerated disks in 100 cases of each kind. This figure is 90 among those completely free of trouble, 162 among those with brachialgia, 171 among those with pain radiating in the chest and 199 among those with headache.

Finally, it should be noted that more or less well-developed so-called cervical ribs were found in ten of the 275 industrical and forest workers. Only four (40 %) of these had some brachialgia. Consequently, no connection between cervical rib and brachialgia can be established on the basis of this material.

d) Summary,

The stiff neck-brachialgia syndrome showed a very high frequency (80 %). Definite similarities with the lumbago-sciatica syndrome can be noted, and both clinical signs and roentgen findings indicate that the genesis is generally associated with degenerative changes in the intervertebral disks of the cervical spine. The course is generally benign, and the symptoms relatively seldom necessitate medical care or incapacitate the patient for work. The syndrome includes pseudo-angina pectoris, as well as certain forms of headache and humeroscapular periarthritis. The sympathetic nervous system seems to play a not inconsiderable part in the apparance of the symptoms (page 55).

V. Static Postural Deformities of the Spine

a) Types and Frequencies,

Static postural deformities included pelvic tilt, lordosis, kyphosis and scoliosis. Pelvic tilt, an oblique position of the pelvis leading to static scoliosis due to unequal length of the legs, was surprisingly common and was found in about one third of the persons examined. The difference in leg length varied between 1 and 2.5 cm and in most cases was 1 to 1.5 cm. The right leg was the shorter twice as often as the left. The frequency was about the same in all the groups. It only differed appreciably among the boys of 8 to 11 years, in whom it was lower probably partly because they had not yet finished growing and partly because a pelvic tilt of less than 0.5 to 1 cm cannot be recorded precisely. Scoliosis of non-static origin as well as lordosis and kyphosis, cannot be measured objectively in the same way, but must instead be evaluated subjectively, which makes it difficult to differentiate between normal and abnormal. The frequency figures cited must therefore be accepted with certain reservations. There were no deformities severe enough to be called a handicap in this material. The reason for this is probably that grave deformities are rare and also that persons with them usually choose other occupations then heavy industrial and forest work. In the group of boys between 8 to 11 years, the individual variation in the configuration of the spine were astonishing. What at first glance appeared to be pronounced lordosis or kyphosis might at

Table 13. Frequency af static postural deformities of the spine in 277 industrial and forest workers and its correlation with lumbar spine trouble.

	No. of cases	No. with lumbar spine trouble	Total frequency of lumbar spine trouble
Pelvic tilt	30 % (82/277)	78 % (64/82)	80 % (220/277)
Kyphosis	14 % (40/277)	78 % (31/40)	80 % (220/277)
Lordosis	17 % (48/277)	77 % (37/48)	80 % (220/277)

second glance look like a completely straight back. Consequently no fixed static postural deformity could be found in the group of children, except for the five cases of pelvic tilt, in which there was mild static scoliosis.

Kyphosis was considered to be present among the adults (35 to 49 years) in 40 cases, or 14 percent, and among the 15 to 20-year-olds in 12 cases, or 13 percent. Kyphosis was usually associated with roentgen signs of Scheuermann's disease in the dorsal vertebrae, and was more common in forest workers than industrial workers (cf. chapter on the dorsal spine).

Lordosis, which was found either alone or compensatorily with kyphosis, was considered to be present in 17 percent of the adults and in 9 percent of the youths. Scoliosis of non-static origin was considered to be present in 6 cases (2 percent) of the adults and in none of the youths or children. In all these 6 cases there was slight but clearly visible scoliosis. Very mild forms of scoliosis, that were not immediately apparent, were not included.

b) Correlation with Lumbar Spine Trouble.

The frequency of symptoms from the lumbar spine among the cases with static postural deformities (Table 13), whether pelvic tilt, lordosis or kyphosis, did not differ from the normal. All the six scoliosis cases had had some lumbar spine troubles, but they were so few in number that no conclusion could be drawn as to a possible connection between scoliosis and lumbar spine trouble. The investigation therefore indicates that pelvic tilt, kyhosis and lordosis have no particular importance in spinal trouble and that persons with moderate forms of these deformities are not less suited to heavy work than others. From this in can be deduced, therefore, that moderate static postural deformities are only of cosmetic significance.

VI. The Lumbar Insufficiency-Lumbago-Sciatica Syndrome

a) Types.

The patients were questioned extremely carefully concerning their history of symptoms from the lumbar spine. In several cases, the patients denied that they had ever had trouble with their back. When asked if they had ever had lumbago, the same patients replied: "Why, yes, several times." Other said they had never had lumbago, but replied in the affirmative if they were asked if they had ever strained their back. Likewise, it was sometimes difficult to get information about mild forms of spinal insufficiency. An excellent test question in these cases concerned harvesting potatoes and picking berries, which practically all our subjects did in the autumn. Some of the men said this caused them no trouble, while others said they had suffered from stiff muscles, because they were unaccustomed to the work, but that they felt better if they kept on with the work for a few days. Others, in turn, said they had symptoms typical of spinal insufficiency, being only able to work for short periods or having to crawl on their knees, or even to give up. Mild forms of intermittent sciatica were also denied by some when asked if they had sciatica or radiating pains in the legs, but were admitted if the query concerned "rheumatism" in the legs. A preliminary tabulation of spinal symptoms revealed that the frequency was disproportionately low among the older industrial workers. This seemed improbable and illogical, and we decided to look more closely into the matter. We found that practically the entire group had been queried during the first four or five days, before we had evolved a suitable questioning technique and come to understand the local dialect. Follow-up examination of these persons "without symptoms", who were questioned during the first two weeks of the investigation, revealed that some of them had had both lumbago and troubles indicative of spinal insufficiency, not disclosed by the first questioning. This all adds up to the fact that one must be extremely thorough and spend a relatively long time with each patient, if reliable data is to be elicited from them.

The anamnestic study of lumbar spine trouble yielded three main types, which can be more or less clearly differentiated from one another:

1) *Attacks of acute lumbago or lumbago-like conditions* (strains from lifting heavy weights, sprains, etc.). I endeavored to find out both the age at which the first attack of lumbago occurred and whether there had been one or more attacks. I also was interested in determining whether the patient was incapacitated for work and *if so* the length of his absence from work was brief (at most two to three weeks) or if it was lengthy (at least three to four weeks). Furthermore, I tried to find out if the lumbago had made its appearence without apparent cause or in connection with lifting a heavy burden or with an accident, which is of interest from the insurance point of view. Finally, I noted if the patient had been completely free from trouble during the intervals between attacks or had had signs of spinal insufficiency, as described in the following.
2) *Symptoms of insufficiency emanating from the lumbar spine.* By lumbar insufficiency is meant tiredness or pain in the small of the back of more or less intermittent character. These symptoms are often only provoked by certain forms of exertion, particularly work in a bent-forward position (e. g. removing the bark from tree trunks, harvesting potatoes or berries, etc.). The individual with lumbar insufficiency then has pain resembling a tight band across the small of the back or sometimes feels that his back "is broken in two." He finds it difficult to straighten his back when he tries to stand up. Sometimes these symptoms are experienced when the patient has been sitting or standing for a long time in the same position, or the patient may report that the small of his back feels stiff when he gets up in the morning. These patients often state that they prefer to avoid lifting heavy weights, so as not to bring on their symptoms. Typical of these symptoms is the variation in intensity. Periods of rather pronounced trouble alternate with either insignificant symptoms or none at all. The attacks also vary in length from a couple of weeks or a month to a year or more. Some state that their trouble is accentuated regularly spring and autumn, and the forest workers were especially prone to associate these exacerbations with cold and dampness. I tried to divide these cases into two groups: a) those whose trouble periodically disrupted their work and normal existence and perhaps led to incapacity for work, and b) those whose symptoms were so mild that they did not inter-

fere with work. Obviously there were some cases which it was difficult to place in one group or the other, but one the whole I believe that the "tree-barking or potato-gathering" test was a reliable one.

3) *Sciatica.*
Sciatica was considered to be present if the patient had ever had definitely radiating pain in one or the other leg, as a rule down the posterior or lateral aspect of the thigh and lower leg, often combined with numbness or tingling in the foot and toes. In most cases the patients described a clear and unequivocal picture of sciatica, both with regard to symptoms and to course. I tried to divide the cases into two groups, one with mild or transitory symptoms and one with more pronounced or recurrent sciatica with truly incapacitating effect. Two cases with mild but definite pathologic conditions in the hip resembled a certain type of sciatica (the L_4 syndrome).

b) Clinical Examination,

The clinical study of the lumbar and the dorsal spine was conducted along the following lines:

1) *Pelvic tilt.*
2) *Deviations from the normal configuration of the spine*, i. e. kyphosis or lordosis or scoliosis.
The foregoing two groups are discussed in detail in the chapter on static spinal deformities and are not, like the rest, associated directly with more or less current trouble originating in the lumbar spine.
3) *Contraction in the long muscles of the spine*, detected by palpation with the patient standing in as relaxed a position as possible. Strong contractions are easily diagnosed, while evaluation of mild contraction is inevitably subjective, which of course detracts from the value of the sign. In an investigation of this size, however, one develops such a routine that evaluation becomes relatively uniform. The persons examined were divided into three groups: a) no contraction, b) mild to moderate contraction, and c) pronounced contraction.
4) *Percussion or pressure tenderness in the spinous processes of the vertebrae.*
This sign is elicited by blows with a percussion hammer or by firm pressure with the thumb on one spinous process at a time. In most

cases with current and in many with more or less latent spinal trouble, distinct tenderness can be evoked in a single spinous process; radiating pain in one side or the other and, in sciatica, all the way down the leg, may be experienced together with tenderness. There was tenderness in two processes in some cases, but rarely in more than two. Sometimes the tenderness was more pronounced if the spinous process was pressed to one side or the other or if pressure exerted between two spinous processes. Thus percussion tenderness, the presence of which is easily determined, is a valuable sign, which probably also indicates the level at which the spinal symptoms originate.

5) *Restriction of movement in the lumbar spine.* The motion of the spine is often reported in terms of the ability to bend the trunk forward. This is of course no real indication of the motion of the spine, since it takes place primarily in the hip joints. One not seldom finds persons who are completely stiff-backed but who nevertheless can bend forward and place their palms on the floor. Here the movement occurs entirely in the hip joints. The fact that this movement nevertheless is often restricted in cases of acute back trouble is due to the presense of the Lasègue sign. Lateral and backward bending give a better picture of the motion of the lumbar spine. To use forward bending as an indicator of lumbar spine movement, the thumb is placed on the spinous process of the first sacral and the forefinger on the spinous process of the first lumbar vertebra. The patient is then instructed to bend forward and rise up again, and the examiner notes the change in distance between his thumb and forefinger during the movement. The rising movement is more satisfactory, since it is sometimes difficult to keep the fingers in place when the patient bends forward. As in mild muscular contraction, slight restriction is a subjective finding, in which one is sometimes doubtful as to the category to which the patient should properly be referred. Those examined have been divided into three groups:

1) no restriction of movement, 2) mild restriction of movement, and 3) pronounced restriction of movement.

6) *Lasègue sign.* Generally speaking the sign is only present when the patient has relatively severe symptoms. This was unusual in the present series of working men, and the Lasègue sign was therefore of little interest here. There is one point that should be noted, however: It is usually possible, when in the supine position, to raise the leg to an angle of 90 degrees. Meantime, a great many of the youths and even more of the children were not able to raise the leg to more

than 70 to 75 degrees, although the Lasègue sign was not really present (no definite pain in the spine or leg). This was probably due to the fact that the growth in length of the muscles does not keep pace with the bones and that the hip extensor muscles therefore cannot cope with the considerable extension required by the test. This was also sometimes observed in adults.

7) *Neurologic signs.* The neurologic signs recorded are as follows: loss or diminution of knee or ankle jerk, paresis in the extensor of the great toe, the peroneus or the triceps and sensory disturbances in the leg.

c) The frequency in different age and vocational groups.

Lumbago was reported in 55 percent (100/162) of the industrial workers and 54 percent (61/114) of the forest workers, or the same frequency in both groups (Table 14). However, if the material is divided into those who had had only one or two attacks and those who had had three or more attacks, it will be found that more forest workers had numerous attacks than industrial workers (Table 14). The difference is statistically probable ($p < 0.02$). It therefore appears that forest work is more apt to provoke lumbago in persons with a tendency to the condition than is industrial work. Furthermore, forest work is undoubtedly a greater strain on the back, both with regard to working position and to heavy lifting. The forest worker does have one advantage in that he can adapt his working tempo to suit himself, whereas the industrial worker is dependent on his team, his machine, or the assembly line.

Table 14. Frequency of lumbago among industrial and forest workers.

		One or two attacks of lumbago	Repeated attacks of lumbago	Total lumbago
Industrial workers	162 cases	28 %	27 %	55 %
Forest workers	114 „	17 %	37 %	54 %
Total	276 „	24 %	31 %	55 %

With regard to the frequency in the various age groups (Table 15) lumbago was reported definitely in four of the 15 to 20-year-old cases and as doubtful in two (mild and transitory symptoms), or in altogether < 7 percent, and in 52, 50 and 63 percent respectively of the adult groups. The increase in frequency from the 35 to 39 years group

to the 45 to 49 years group was relatively insignificant. This would indicate that the factor or factors that cause lumbago generally make their appearance before the age of 40 years and in occasional cases at the age of 15 to 20 years.

Table 15. Frequency of lumbago in different age groups.

Age groups	15 to 20 yrs. 91 cases	35 to 39 yrs. 87 cases	40 to 44 yrs. 102 cases	45 to 49 yrs. 87 cases
Lumbago, one or two attacks	7 %	24 %	20 %	28 %
Lumbago repeated attacks ..	0 %	28 %	30 %	35 %
Total lumbago	7 %	52 %	50 %	63 %

Symptoms of insufficiency in the lumbar spine were reported by 60 percent of the industrial workers (mild in 37 percent and pronounced in 23 percent) and by 63 percent of the forest workers (mild in 39 percent and pronounced in 24 percent). There was thus no real difference between the two groups (Table 16).

Table 16. Frequency of symptoms of insufficiency in the lumbar spine.

		Mild Insufficiency	Pronounced Insufficiency	Total Insufficiency
Industrial workers	162 cases	37 %	23 %	60 %
Forest workers	114 „	39 %	24 %	63 %
Total	276 „	38 %	23 %	61 %

The frequency of lumbar insufficiency in the various age groups was 8 percent (mild but definite) in the youths (15 to 20 years) and 56, 58 and 69 percent in the youngest, middle and oldest of the adults, respectively (Table 17).

Table 17. Frequency of symptoms of insufficiency in the lumbar spine in the various age groups.

Age group	15 to 20 yrs. 91 cases	35 to 39 yrs. 87 cases	40 to 44 yrs. 102 cases	45 to 49 yrs. 87 cases
Mild insufficiency	8 %	34 %	40 %	38 %
Pronounced „	0 %	22 %	18 %	31 %
Total	8 %	56 %	58 %	69 %

Sciatica (Table 18) was reported in 28 percent (45/162) of the industrial workers, in 18 percent of which it was so mild that the patient was either not incapacitated for work at all or only for a day or so. In the remaining ten percent the sciatica was severe enough to cause the patient to seek medical attention and to incapacitate him for work for at least three weeks. Several cases had more or less latent sciatica with periodical acute attacks, and eight cases, or 5 percent of the industrial workers, had sciatica at the time of the examination (seven of them showed the Lasègue sign), although mild enough to permit them to work. One patient had undergone operation for disk prolapse in 1944 with good results, but he had nevertheless had a recurrence in the same leg one year after the operation. Sciatica was reported in 33 percent of the forest workers, in 19 percent in mild form and in 14 percent pronounced. Four patients (4 percent) had symptoms at the time of the examination, one of them being unable to work and the other three being partially incapacitated. No significant difference between the vocational groups could be found.

Table 18. Frequency of sciatica.

		Mild sciatica	Pronounced sciatica	Total
Industrial workers	162 cases	18 %	10 %	28 %
Forest workers	114 „	19 %	14 %	33 %
Total	276 „	18 %	12 %	30 %

Table 19. Frequency of sciatica in the different age groups.

Age group	15 to 20 yrs. 91 cases	35 to 39 yrs. 87 cases	40 to 44 yrs. 102 cases	45 to 49 yrs. 87 cases
Mild sciatica	1 %	18 %	15 %	22 %
Pronounced sciatica	0 %	8 %	12 %	15 %
Total	1 %	26 %	27 %	37 %

The frequency in the different age groups appears from Table 19. Among the apprentices, there was one 20-year-old with a typical case of intermittent but relatively mild lumbago-sciatica, which had first appeared four years previously in connection with an encephalitis, for which the patient was hospitalized for six weeks. The genesis of this case is therefore somewhat unclear, but clinical examination revealed

pronounced muscular contraction in the lumbar spine, failure of the left ankle jerk, paresis of the extensor of the great toe and triceps with considerable atrophy of the gastrocnemius muscles, as well as decreased sensibility in the anterolateral aspect of the calf, the dorsum of the foot and the great toe (L V). In the three adult age groups, sciatica was reported in 26, 27 and 37 percent, respectively.

Table 20. Total frequency of lumbar spine trouble (lumbago, lumbar insufficiency or sciatica) in different vocational groups.

		Mild trouble	Pronounced trouble	Total
Industrial workers	162 cases	33 %	45 %	78 %
Forest workers	114 „	31 %	51 %	82 %
Total	276 „	33 %	47 %	80 %

If all those who reported either lumbago, lumbar insufficiency or sciatica are lumped together (Table 20), we will find a total frequency among the adults of 80 percent (78 percent of the industrial and 82 percent of the forest workers). If only those with pronounced trouble are included, the figure will be 47 percent (45 percent of the industrial and 51 percent of the forest workers). This means that approximately half of the 35 to 49-year-olds had either had repeated attacks of lumbago or sciatica with at least three weeks of sick leave or such pronounced lumbar insufficiency that they had periodically been incapacitated for work. The frequency of "pronounced trouble" is higher among the forest workers, which corresponds well with the fact that "repeated attacks of lumbago" were also more common among them. Statistical analysis, however, reveals no significant difference.

The total frequency of lumbar spine trouble in the different age groups is shown in Table 21.

Table 21. Frequency of lumbar spine trouble in different age groups.

Age group	15 to 20 yrs. 91 cases	35 to 39 yrs. 87 cases	40 to 44 yrs. 102 cases	45 to 49 yrs. 87 cases
Mild trouble	15 %	35 %	33 %	30 %
Pronounced trouble ..	0	41 %	45 %	55 %
Total	15 %	76 %	78 %	85 %

Among the apprentices, 15 percent were considered to have mild and none to have pronounced trouble. The frequency is definitely higher among the adults, but the difference between the various adult age groups is relatively insignificant.

Clinically, there is little doubt that lumbago, lumbar insufficiency and sciatica are inter-related, i. e. that they belong together and often constitute different manifestations of the same disturbance. It is therefore interesting to examine the present material from that point of view. Table 22 shows the frequency of the different conditions both alone and combined with one another.

Table 22. Different Forms of Lumbar Spine Trouble Either Isolated or Combined.

No symptoms	(56/276)	20.3 %
Lumbago only	(37/276)	13.4 %
Symptoms of insufficiency only	(43/276)	15.6 %
Sciatica only	(6/276)	2.2 %
Lumbago plus insufficiency	(57/276)	20.6 %
Lumbago plus sciatica	(9/276)	3.3 %
Insufficiency plus sciatica	(20/276)	7.2 %
Lumbago plus insufficiency plus sciatica	(48/276)	17.4 %

Table 23. Correlation between Lumbago, Lumbar Insufficiency and Sciatica in 35 to 49-year-olds.

a)	Total No. of cases	No. with insufficiency	No. with sciatica	No. with insufficiency or sciatica
With lumbago	151	70 % (105/151)	38 % (57/151)	76 % (114/151)
Without lumbago	125	50 % (63/125)	21 % (26/125)	55 % (69/125)

b)	Total No. of cases	No. with lumbago	No. with sciatica	No. with lumbago or sciatica
With lumbar insufficiency	168	63 % (105/168)	40 % (68/168)	74 % (125/168)
Without lumbar insufficiency	108	43 % (46/108)	14 % (15/108)	48 % (52/108)

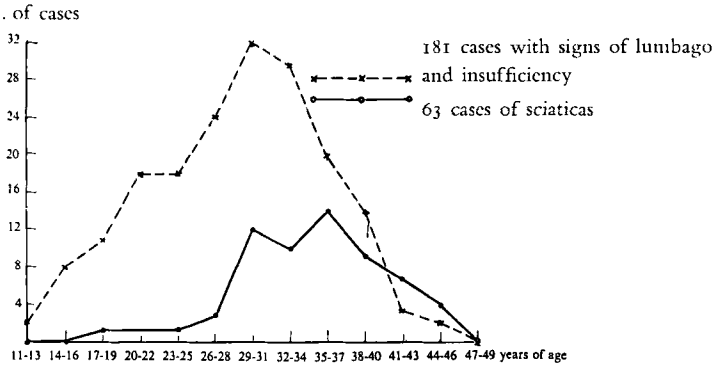
c)	Total No. of cases	No. with lumbago	No with insufficiency	No. with lumbago or insufficiency
With sciatica ..	83	69 % (57/83)	82 % (68/83)	93 % (77/83)
Without sciatica	193	49 % (94/193)	52 % (100/193)	71 % (137/193)

It appears from Table 23a) that both lumbar insufficiency and sciatica were more common in persons who had at some time had lumbago than among those who had never had lumbago. Table 23 b) shows that sciatica and lumbago were more common in persons who had had symptoms of insufficiency in the lumbar spine than among those who had not. Table 23 c) reveals a similar correlation between cases with and without sciatica. The differences are all established statistically. In other words, there was in this material a definite relationship between lumbago, symptoms of insufficiency in the lumbar spine and sciatica. This in turn suggests that all three have a common factor in their genesis.

d. *Age at Onset of Lumbar Spine Trouble.*

A large number of patients who reported spinal trouble were able to state fairly exactly the age at which their symptoms first appeared. This was the case in 105 of 124 industrial workers and 76 of 90 forest workers with lumbago or lumbar insufficiency. Thirty-seven of 45 industrial workers and 26 of 38 forest workers with sciatica, remembered the first signs of the complaint. The age reported by the patients is rather too high than too low, since there seemed to be a general ten-

Table 24. Age at Onset of Lumbago – Insufficiency and Sciatica.

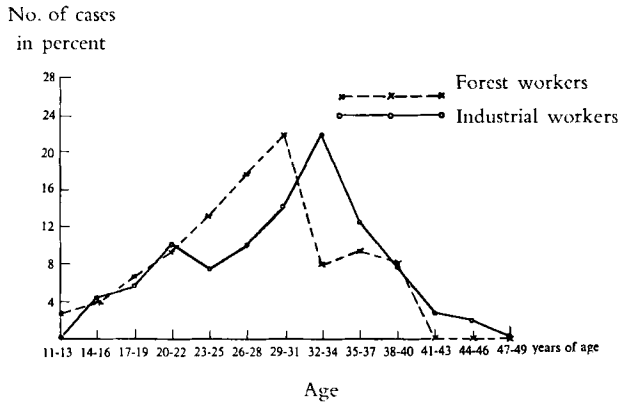


Age at the Onset of the Symptoms

dency to errors of memory in the former direction, at least in the cases which could be checked.

The average age of onset was 28 to 29 years for lumbago or lumbar insufficiency and 35 years for sciatica. The curves in Table 24 show the age at which the various symptoms appeared, with the material divided into three-year groups from 11 to 13 up to 47 to 49 years. We see that fairly many cases had lumbago or lumbar insufficiency even before the age of 25 years, that the peak was in the age group 29 to 31 years, and that the symptoms appeared after the age of 40 years in only a handful of cases. It would be interesting to examine the 50 to 60-year-olds to study the later course of events. Sciatica seldom appeared before the age of 25 years, the peak was at 35 to 37 years, and not a few cases first had the disease between 40 to 49 years.

Table 25. Age at Onset of Lumbago or Lumbar Insufficiency in Different Vocational Groups.



Comparison between the two vocational groups reveals that lumbago and lumbar insufficiency first appeared at an average age of 27.5 years in the forest workers and 29.5 years in the industrial workers. The curves in Table 25 illustrate the material divided into three-year groups with the forest and industrial workers treated separately. It will be noted that the curve for the forest workers shows a general trend toward somewhat lower ages. Statistical computation of the figures reveals no significant difference between the two groups, although it can perhaps be suspected that the forest workers developed lumbar spine trouble at a somewhat earlier age than the industrial workers.

Sciatica first appeared at an average age of 34 years in the forest workers and 35⅔ years in the industrial workers. The difference was not significant here either.

These figures correspond well with Friberg's and Hirsch's observations on the age distribution of patients, who visited the Orthopedic Clinic of the Caroline Institut for back trouble and who showed roentgen signs of disk degeneration in the lumbar spine. The majority of these patients were admitted between the age of 31 and 40 years.

On the basis of the foregoing, therefore, the factors that cause lumbar spine trouble appear at an early stage and often make themselves felt at or before the age of 30 years.

e) Effect on Working Capacity.

Fifty-five percent of the 276 industrial and forest workers had at some time been incapacitated by lumbago, lumbar insufficiency or sciatica. Of these, 38 percent had been unable to work for at most three weeks and 17 percent for more than three weeks. The rate for the forest workers was slightly higher than for the industrial workers, but the difference between the two groups was not statistically significant.

Table 26. Incapacity for Work Caused by Lumbar Spine Trouble.

	Industrial workers 162 cases	Forest workers 114 cases	Total 276 cases
Incapacitated for less than 3 weeks .	37 %	39 %	38 %
Incapacitated for more than 3 weeks	15 %	21 %	17 %
Total	52 %	60 %	55 %

Comparison between the different age groups shows a certain increase in incapacity with age. In general it seemed that an attack of lumbago before the age of 30 years seldom lasted more than a day or so, or at

Table 27. Incapacity for Work Caused by Lumbar Spine Trouble in Different Age Groups.

	15-20 yrs. 91 cases	35-39 yrs. 87 cases	40-44 yrs. 102 cases	45-49 yrs. 87 cases
Incapacitated for 3 weeks or less	4 %	40 %	34 %	39 %
Incapacitated for more than 3 weeks	0 %	10 %	20 %	22 %
Total	4 %	50 %	54 %	61 %

the most one week, while attacks in older patients were more protracted.

The patient's will to work is a factor to be borne in mind when evaluating incapacity. It was my impression that morale was exceptionally good in this respect. As an example I may mention two forest workers whose back trouble was so severe that they had to crawl on their knees when they were removing bark from tree trunks. But they nevertheless kept on working. Another forest worker had a two-week-old malleolar fracture at the time of examination. He had stayed at home for a week, but then had begun working again to the best af his ability. When one is evaluating capacity for work as a result of back trouble, one should therefore also consider those who are at work despite their symptoms. Naturally these people are not working at full capacity, but the degree of incapacity is difficult to measure and cannot be recorded in figures.

It would be most interesting to find out how many workers were compelled to change occupation as a result of back trouble. No figures could be determined in this respect with regard to the forest workers, but a study of those industrial workers who had been transferred yielded a certain amount of information. The Munkfors Company has long attempted to provide work for the invalided also. Furthermore, since the population is highly stable, very few former employees disappear from the local labor market. Of the approximately 1200 industrial workers at the Munkfors Company, 30 had been given other jobs due to orthopedic conditions. Fifteen of these or 1.25 % of the total complement had been given lighter work as a result of back trouble. The majority of the 15 were relatively well adjusted to their new jobs and were only moderately troubled by their spinal conditions. Five of the remaining 15 had been transferred because of brachialgia, four because of sequellae of accidents, 2 for trouble with the Achilles tendons, one because of sequellae of poliomyelitis, one for ankylosis of the hip following epiphyseolysis, one for claudication and one for arthritis.

To summarize, 55 percent of the 35 to 49-year-old examined had at some time been incapacitated by spinal trouble; the sick leave was so short in two-thirds of them, however, that it had slight sociological importance. The capacity of those who went on working despite their back trouble was undoubtedly diminished, but the degree to which it was affected is difficult to estimate. This point should not be ignored, however, when attempting to evaluate the sociological significance of spinal trouble. One and a quarter percent of 1200 industrial workers in Munkfors had to be transferred to other jobs because of back trouble. Most of them adjusted well to their new work, but in general they

earned less money. Meantime, it is important to note that workmen with very troublesome spinal conditions can make a useful contribution if they are given suitable employment.

f) Heavy Lifting and Accidents as Contributory Factors in Lumbago.

The figures cited below may represent an under-estimation, since the questioning on this point was not entirely consistent from the outset. On the other hand, information about lifting and accidents was usually volunteered by the persons examined, and for that reason it is unlikely that many cases were missed.

Lumbago was stated to have developed in immediate connection with heavy lifting in 36 (40 percent) of the 90 industrial workers who reported the condition. In 15, of these 36 cases, the lifting was complicated by an accident – the patient stumbled or fell. Heavy lifting was said to be the cause of lumbago in 21 (34 percent) of the 61 forest workers with the condition and heavy lifting combined with an accident in 11 of these 21. Both vocational groups thus show approximately the same figures.

The foregoing means that, in the legal sense, accidents as causes of lumbago only occurred in about one-fifth of the lumbago cases and that heavy lifting of the kind usual in work with or without concurrent accident was reported in at most 40 percent. Among the 40 percent, several had had repeated attacks of lumbago, only some of which could be referred to outside causes like lifting or accidents. The attacks came on without any apparent external cause in 60 percent of those who had lumbago. Whether the heavy work was a contributory factor in these cases in which it did not directly cause the attacks cannot be judged without comparison with a similar group with light manual labor. No such group is available in the present material, but an investigation of this kind is at present being conducted on another series. Meantime, the fact that the total frequency of spinal trouble is the same for the

Table 28. Heavy Lifting and Accidents as Causes of Lumbago.

	No. of cases with lumbago	No. of cases with heavy lifting as cause	No. of cases with concurrent accident
Industrial workers	90	40 % (36/90)	17 % (15/90)
Forest workers	61	34 % (21/61)	18 % (11/61)
Total	151	38 % (57/151)	17 % (26/151)

industrial and forest workers groups indicates that weak backs are caused by other factors, but that persons with weak backs do not tolerate heavy work or unsuitable working positions. On this basis, heavy work is only a secondary cause of the symptoms.

g) Significance of Clinical Signs.

Movement.

Normal movement of the lumbar spine indicates good elasticity of the disks, normal muscular tone, and normal function of the small joints. Limitation of the movement of the lumbar spine may be caused by a disturbance of one of these factors. Impairment of the function of the small joints is scarcely ever found in the age groups in question here except in certain systemic diseases, such as ankylosing spondylarthritis. There was only one case of this kind in the present series in the group "transferred", and this factor can therefore probably be ignored. An increase in muscular tone (muscular contraction) must be very considerable to cause appreciable restriction of movement. This is found in most typical form in an attack of acute lumbago or lumbago-sciatica, in which the patient, by an involuntary and exceedingly strong muscular contraction, fixes the lumbar spine in the position that is least painful. A relatively pronounced muscular contraction which helps to restrict movement may be found in certain cases with more or less latent lumbar spine trouble even when the symptoms are in abeyance. This is rather unusual, however, and since none of the patients in this material had violent symptoms at the time of examination, the most common cause of restricted movement in this series was probably impaired elasticity of the disks. The loss of elasticity in the disks is probably closely associated with disk degeneration, and limitation of the lumbar spine movement can therefore probably be used to gauge the frequency of disk degeneration. The difficulty here is the lack of an objective form of measurement of motion. It is simple for the examiner to evaluate severe limitation of movement, but milder forms are difficult to distinguish from the normal state.

Table 29 shows the frequency of limitation of movement in the various age groups in cases with and without spinal trouble. Limitation of movement in the lumbar spine was considered to be present in 129 of the 367 cases examined, or 35 percent. It will be noted that the frequency rises appreciably with age and that it is higher in the group "with spinal trouble." The difference is statistically significant ($p < 0.001$), and there is thus a certain correlation between the occurrence of spinal trouble and limitation of movement in the lumbar spine. Nev-

Table 29. Occurrence of Limitation of Movement of the Lumbar Spine in Different Age Groups Correlated to Lumbar Spine Trouble.

Age group	Limitation of Movement		Total
	Cases without spinal trouble	Cases with spinal trouble	
15-20 yrs. 91 cases	2 % (1/62)	10 % (3/29)	4 % (4)
35-39 „ 87 „	14 % (3/21)	26 % (17/66)	23 % (20)
40-44 „ 102 „	32 % (7/22)	54 % (43/80)	49 % (50)
45-49 „ 87 „	46 % (6/13)	66 % (49/74)	63 % (55)
Total 367 „	14 % (17/118)	45 % (112/249)	35 % (129)

ertheless, a rather large number of cases with spinal trouble, particularly in the younger age groups, showed no limitation of movement. However, since most of these had only had an occasional lumbago attack or mild signs of insufficiency, one could scarcely expect to find any objective clinical signs. Seventeen of the 118 cases with no spinal trouble were considered to have some limitation of movement which, however, was pronounced in only five cases. Even though these five patients had never had symptoms emanating from the lumbar spine, the inference was that they did have disk degeneration, and roentgen examination confirmed that this was indeed the case.

Table 30 shows the correlation between limitation of movement in the lumbar spine and roentgen findings in 273 industrial and forest workers. We see that there is a statistically significant correlation ($p = < 0{,}001$) between positive roentgen findings and limitation of movement. The 13 cases recorded as having considerable limitation of movement all yielded positive roentgen findings. The roentgen changes in some of these 13 cases were surprisingly small (four cases of considerable disk degeneration, six cases of moderate disk degeneration and three cases of small osteophytes only). All 13 had had lumbar spine trouble, most of them on repeated occasions.

Table 30. Correlation between Limitation of Movement in Lumbar Spine and Roentgen Signs of disk degeneration in 273 Industrial and Forest Workers.

Movement		Negative Roentgen	Positive Roentgen
Normal	149 cases	30 %	70 %
Slight limitation	111 „	14 %	86 %
Considerable limitation	13 „	0 %	100 %

Table 31. Occurence of Muscular Contraction in the Lumbar Spine in Different Age Groups Correlated to Lumbar Spine Trouble.

Age group	Muscular Contraction		Total
	Cases without spinal trouble	Cases with spinal trouble	
15-20 yrs. 91 cases	6 % (4/62)	21 % (6/29)	11 % (10)
35-39 „ 87 „	19 % (4/21)	50 % (33/66)	43 % (37)
40-44 „ 102 „	32 % (7/22)	50 % (40/80)	46 % (47)
45-49 „ 87 „	46 % (6/13)	64 % (44/74)	61 % (53)
Total 367 „	18 % (21/118)	51 % (126/249)	40 % (147)

Muscular contraction.

It is even more difficult to distinguish between mild forms and normal conditions in muscular contraction than in limitation of motion. Furthermore, we do not know the cause of muscular contraction. We know that it may be caused by pain, but it is hard to say how it arises in the absence of pain. It appears from Table 31 that the frequency increased with age and that the sign was more common in persons who had at some time had lumbar spine trouble.

Pressure tenderness over the spinous processes: The patient were usually able to state definitely whether there was abnormal tenderness of one or the other spinous processes. Objectivity with regard to this symptom was therefore satisfactory.

Table 32. Occurrence of Pressure Tenderness of the Lumbar Spinous Processes in Different Age Groups and in Cases With and Without Symptoms.

Age group	Cases without spinal trouble	Cases with spinal trouble	Total
15-20 yrs. 91 cases	0 % (0/62)	3 % (1/29)	1 % (1)
35-39 „ 87 „	0 % (0/21)	15 % (10/66)	11 % (10)
40-44 „ 102 „	0 % (0/22)	13 % (10/80)	10 % (10)
45-49 „ 87 „	0 % (0/13)	27 % (20/74)	23 % (20)
Total 367 „	0 % (0/118)	16 % (41/249)	11 % (41)

Table 32 reveals that pressure tenderness was only found among those who reported spinal trouble and that the total frequency in this group

was 16 percent. The sign was actually only present in patients who had trouble at the time of examination or had just recovered from an attack. Furthermore, it was usually confined to one or two spinous processes. In all probability it indicates the level at which the trouble originates, as earlier clinical experience has also suggested.

Roentgen findings were positive in 90 percent of the 41 cases with spinous process tenderness (five cases with osteophytes only and 36 cases with other signs of disk degeneration also).

Lasègue's sign.

Table 33. Number of Cases with Lasègue's Sign in Different Age Groups.

Age	Without spinal trouble	With spinal trouble	Total
15-20 yrs. 91 cases	0 % (0/62)	0 % (0/29)	0 %
35-39 „ 87 „	0 % (0/21)	6 % (4/66)	5 % (4/87)
40-44 „ 102 „	0 % (0/22)	6 % (5/80)	5 % (5/102)
45-49 „ 87 „	0 % (0/13)	9 % (7/74)	8 % (7/87)
Total 367 „	0 % (0/118)	6 % (16/249)	4 % (16/367)

Lasègue's sign was only found in patients who had trouble – primarily sciatica – at the time of examination.

Of the 16 cases with Lasègue's sign, 14 had roentgen signs of disk degeneration.

Neurologic signs.

Table 34. Number of Cases with Neurologic Signs Correlated with Spinal Trouble.

Age	Without spinal trouble	With spinal trouble	Total
15-20 yrs. 91 cases	0 % (0/62)	3 % (1/29)	1 % (1/91)
35-39 „ 87 „	0 % (0/21)	10 % (7/66)	8 % (7/87)
40-44 „ 102 „	0 % (0/22)	20 % (16/80)	16 % (16/102)
45-49 „ 87 „	0 % (0/13)	15 % (11/74)	13 % (11/87)
Total 367 „	0 % (0/118)	15 % (35/249)	10 % (35/367)

Ten percent of the patients examined had neurologic signs, and all of them are found in the group "with spinal trouble". On the other hand, the neurologic signs, unlike pressure tenderness of the spinous processes and Lasègue's sign, were not found only in cases with more or less

current spinal trouble, but sometimes represented residual signs of an attack of sciatica far in the past. Of some interest is the fact that one patient with clear right-sided extensor paresis of the great toe and one patient with loss of the right ankle-jerk and sensory disturbance in the S_1 dermatome reported lumbar insufficiency only and denied that they had ever had symptoms of sciatica. This may indicate that radicular pressure resulting from disk prolapse may sometimes develop imperceptibly and gradually cause destruction of certain nerve fibers without at the same time producing symptoms of sciatica.

Roentgen findings were positive in 89 percent of the 35 cases with neurologic signs (four cases with osteophytes only and 27 with signs of disk degeneration).

To summarize the signs emanating from the lumbar spine, it can be said that pressure tenderness of one or more of the spinous processes, Lasègue's signs and neurologic signs were found in persons who had current symptoms of the lumbago-sciatica type, meantime, the neurologic signs were also found in persons who did not have current symptoms but had a history of trouble of this kind. Muscular contraction and limitation of movement, on the other hand were present in mild degree in some individuals who had never had lumbar spine trouble, although they were more common in those with trouble. With certain exceptions, limitation of movement in the lumbar spine is probably a sign of degenerative changes in the intervertebral disks. Further evidence of this assumption is provided by the rise in frequency of the sign with increasing age.

Since as a rule the signs do not appear until after symptoms have been experienced, it is impossible to determine by clinical examination whether a person who has never had spinal trouble will have it in the future. Therefore we have no way of prophesying whether a man with no history of spinal symptoms is suited for work which is a strain on the back. The same is true of persons with moderate static postural deformities (pelvic tilt, lordosis or kyphosis), which do not appear to cause a disposition for spinal trouble. Only in the case of persons who frequently have attacks of incapacitating spinal trouble can we definitely recommend transfer to a less strenous occupation.

b) Frequency of Roentgen Signs.

Roentgenograms were made under the direct supervision of a roentgenologist (Sjögren), who also evaluated the pictures. Frontal and lateral exposures were made of the lumbar spine, as well as pictures in the bent position according to Knutsson (lateral exposures with

maximum forward and backward flexion). Changes frequently observed were signs of disk degeneration and various types of anomalies (sacralization, lumbalization, asymmetrical vertebrae, etc.). Narrowing of the disk, sclerosis of those parts of the vertebrae adjacent to the disks, abnormal range of movement (instability), and vacuum phenomena or calcium deposits in the disk were considered to be signs of disk degeneration. The presence of osteophytes on the margins of the vertebral bodies, regarded as minor signs of disk degeneration, was recorded separately, and a group of "osteophytes only" was established. A handful of cases were considered uncertain on the basis of the X-rays, but since they did not affect the correlations, they were not described separately.

The frequency of cases with osteophytes only and of cases with other signs of disk degeneration also is shown in Table 35. We see that 56 percent of all the adults showed roentgen signs of disk degeneration, that a further 21 percent had osteophytes only, and that only 23 percent showed no X-ray signs. Roentgen examination was negative in 28 percent of the industrial workers and only 15 percent of the forest workers, a difference that is statistically probable ($p = 0.01$–0.02). There is no difference if the cases with osteophytes only are deducted, but, since osteophytes are considered to be a result of disk degeneration (Keyes and Compere, 1932 and Lob, 1933), it should probably be assumed that the frequency of disk degeneration in the lumbar spine in this material was somewhat greater among forest workers than among industrial workers.

Table 35. Frequency of Roentgen Signs of Disk Degeneration in Industrial and Forest Workers.

Vocational Group	Negative roentgen	Osteophytes only	Disk degeneration
Industrial workers 159 cases	28 %	15 %	57 %
Forest workers 114 „	15 %	31 %	54 %
Total 273 „	23 %	21 %	56 %

Table 36 shows clearly that roentgen signs of osteophytes and disk degeneration become increasingly common with rising age. While roentgen examination was negative in 96 percent of the group of youths, it was only negative in 13 percent of the 45 to 49-year-olds.

Table 36. Frequency of Roentgen Signs of Disk Degeneration in Different Age Groups.

Age group	Negative roentgen	Osteophytes only	Disk degeneration
15-20 yrs. 91 cases	96 %	0 %	4 %
35-39 „ 86 „	34 %	17 %	49 %
40-44 „ 102 „	22 %	26 %	52 %
45-49 „ 85 „	13 %	20 %	67 %

Table 37. Frequency of Roentgen Signs of Disk Degeneration in the Lumbar Spine in Different Age Groups of Industrial Workers and Forest Workers With and Without Spinal Trouble.

Cases without spinal trouble

No. of cases in age group	Negative roentgen	Osteophytes only	Disk degeneration
35-39 yrs. 20 cases	50 %	20 %	30 %
40-44 „ 22 „	32 %	41 %	27 %
45-49 „ 13 „	23 %	31 %	46 %
Total 55 „	36 %	32 %	33 %

Cases with spinal trouble

No. of cases in age group	Negative roentgen	Osteophytes only	Disk degeneration
35-39 yrs. 66 cases	29 %	17 %	55 %
40-44 „ 80 „	19 %	23 %	59 %
45-49 „ 72 „	11 %	18 %	71 %
Total 218 „	19 %	19 %	61 %

Table 37 shows the correlation between roentgen signs of disk degeneration and lumbar spine trouble. The totals reveal that, while 36 percent of those without symptoms showed no roentgen signs of disk degeneration, only 19 percent of those who had at some time had spinal trouble showed negative roentgen. The difference is statistically significant ($p < 0.01$) and indicates a connection between roentgen signs of disk degeneration and symptoms from the lumbar spine. This connection is by no means absolute, however, since not less than 64

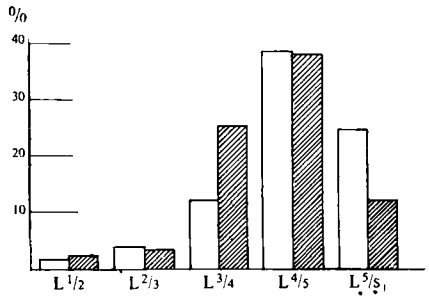
percent of those who had never had lumbar spine trouble showed roentgen signs of disk degeneration. Furthermore, the fact that many of those who had both lumbar spine symptoms and roentgen signs of disk degeneration had only had mild and transitory attacks, indicates that disk degeneration does not necessarely cause pain unless it is combined with other factors. Unlike disk degeneration these factors must be reversible since the symptoms usually come and go.

Diagnosis is complicated by the fact that an indeterminate number of cases with no roentgen signs may nevertheless have disk degeneration. The latter may be present even though not visualized by X-ray, as demonstrated by Friberg and Hirsch with their patho-anatomic examinations and by Lindblom with his discography.

The distribution of roentgen signs of disk degeneration in the different lumbar disks in industrial and forest workers is shown in Table 38. The cases with osteophytes only are not included. The fourth lumbar disk is most often degenerated, the third and fifth about half as often, and the first and second relatively seldom. The fifth lumbar disk is more often degenerated in the forest workers and the third disk more often in the industrial workers.

Instability according to Knutsson was present in 16 percent (25/159) of the industrial workers and was the only definite sign of disk degeneration in seven cases. As a rule it was situated in the fourth lumbar disk. Of the 25 cases with instability, only eight were undergoing or had recently recovered from attacks and three had never had lumbar spine trouble. Instability, therefore, seems to occur relatively often, quite apart from symptoms from the lumbar spine.

Table 38. The Distribution of Disk Degeneration Between the Different Lumbar Disk in Industrial and Forest Workers.



Hatched columns = industrial workers
White columns = forest workers

No. of cases with Disk Degeneration

Industrial workers = 91 cases (57 %)

Forest workers = 61 cases (54 %)

No. of degenerated disks

Industrial workers 129 disks

Forest workers 91 disks

Table 39. Frequency of Anatomic Anomalies in the Lumbar Spine and Their Correlation with Lumbar Spine Trouble (114 forest workers, 159 industrial workers and 91 apprentices).

	No. of cases in percent	No. with lumbar spine trouble	Total frequency of lumbar spine trouble
Spondylolysis or spondylolisthesis	2,5 % (9/364)	67 % (6/9)	64 % (232/364)
Transitional lumbosacral vertebra	16 % (58/364)	64 % (37/58)	64 % (232/364)
Asymmetrical fifth lumbar vertebra	18 % (65/364)	58 % (38/65)	64 % (232/364)
Asymmetry of some other vertebra or disk	14 % (39/273)	80 % (31/39)	80 % (218/273)

The frequency of anatomic anomalies in the lumbar spine recorded on the roentgenograms appears from Table 39. Spondylolisthesis was present in five of the nine cases with spondylolysis. Transitional lumbosacral vertebra, or sacralized fifth lumbar or lumbarized first sacral vertebra, was seen in 16 percent. Asymmetry of the fifth lumbar vertebra in the frontal plane (causing local scoliosis) was present in 18 percent. Asymmetry of some other vertebra or disk in the lumbar spine, which was only observed in adults, was recorded in 14 percent. As also appears from the Table, the frequency of lumbar spine trouble in the various groups with anatomic anomalies does not differ from the total frequency of lumbar spine trouble. It yould therefore appear that cases with anomalies visible on the X-ray do not have a greater disposition to spinal trouble than normal cases. (The cases of spondylolisthesis however are too few in number to be of any conclusive importance). The same discrepancy between morphologic findings and symptoms has already been mentioned in connection with the moderate static postural deformities observed at the clinical examinitation.

i) Correlation with Other Diseases and Certain Medico-physiologic Observations.

An attempt to correlate spinal trouble with certain medicophysiologic findings gave no tangible results. For example, the subjective lumbar spine symptoms showed no relationship with bodily type, according to Rohrer's index.* Nor was there any connection with blood

$$* \text{ Rohrer's index} = \frac{\text{bodyweight in grams} \times 100}{(\text{bodylength in centimeters})^3}$$

pressure, physical tolerance, gastric disorders, allergic conditions, or varices. On the other hand, there appeared to be a parallel between a disposition to spinal trouble and to infectious diseases, which confirms the general impression that spinal trouble often makes its appearance or becomes aggravated in connection with an infectious disease.

The patients themselves often reported that back trouble came periodically, particularly in the autumn and spring, and expressed the opinion that it was associated with damp and cold, a view that corresponds to the popular medical concept and for which, in addition, there is a certain theoretical justification. As Lundgren has demonstrated, a local chill leads to an increase in adrenalin production. In attempts to treat the condition in connection with the investigation, I found that the deep pain in brachialgia and the ache in lumbago could be caused to diminish or disappear by blocking the sympathetic nervous system, either by the local paravertebral injection of procaine or by intravenous administration of tetraethyl-ammonium bromide. If blocking of the sympathetic nervous system relieves the symptoms, it is not impossible that extra production of blood adrenalin due to a local chill, which causes irritation of the sympathetic nervous system, provokes or exacerbates more or less latent spinal trouble. Further study on this point would be interesting. It was peculiar to note that the same momentarily favourable therapeutic effect could be attained in patients of apparently reliable judgement by the local paravertebral injection of physiologic salt solution or four percent dextrose solution. The fact that irritation of the sympathetic nervous system has a deleterious effect on lumbago and brachialgia was later confirmed by several patients, who volunteered the information that fear or nervous unrest brought on more severe symptoms of their condition.

As appears from the chapter on knees and feet, no connection could be proved between lumbar spine trouble, on the one hand, and signs of insufficiency in the knee joints or feet or flatfoot, on the other hand.

j) Similarity between the Stiff Neck-Brachialgia and Lumbago-Sciatica Syndromes.

There are unquestionably many points of similarity between the stiff neck-brachialgia and lumbago-sciatic syndromes. This is particularly true of stiff neck and lumbago and of the nerve root symptoms in brachialgia in the form of pain radiating to the fingers and the nerve root symptoms in sciatica with pain radiating to the legs. Less tangible is the similarity between the deep pain of brachialgia and chronic lumbago or spinal insufficiency. A definite similarity is found in

the intermittent course, as well as the point often made by the patients that the symptoms appear or become worse in connection with a chill or an infectious disease. An extraordinarily close resemblance is found in the total frequency of stiff neck-brachialgia (80 percent of the industrial workers and 80 percent of the forest workers), on the one hand, and of low back pain (78 percent of the industrial and 82 percent of the forest workers), on the other hand. In addition, the different symptoms make their appearance at about the same ages. Stiff neck and lumbago, for example, usually make their debut in the twenties, while brachialgia and sciatica appear later and show an increase in frequency from the 35 to 39-year-olds to the 45 to 49-year-olds. Such signs as could be recorded in cases with trouble at the time of examination indicate that the attacks were most often brought on by changes in the cervical or lumbar spine, i. e. the lordotic and most mobile parts of the spine, in which the major nerve trunks to the upper and lower extremities leave the dural sac and emerge through the intervertebral foramina. There was also a certain connection between disk degeneration in the cervical spine and stiff neck-brachialgia and between disk degeneration in the lumbar spine and lumbago-sciatica. The fact that several cases with roentgen evidence of disk degeneration had no symptoms and that cases with even strongly pronounced disk degeneration generally suffered only benign and transitory attacks, indicates that disk degeneration as such does not necessarily give rise to symptoms, but that the latter are more likely the result of phenomena secondary to the disk degeneration, which often regress without special treatment. One of these secondary phenomena is certainly disk prolapse, although we have little concept of what the others may be. Since the frequency of stiff neck-brachialgia was practically the same as the frequency of lumbago-sciatica, it appears likely that the disk degeneration in cervical and lumbar spine runs a relatively parallel course. It might then be expected that lumbar spine trouble would be more common in persons with stiff neck-brachialgia than without. And this proved to be the case. Of 221 patients who had stiff neck or brachialgia, only 15 percent (34/221) had never had lumbar spine trouble, while 36 percent (20/56) of the 56 patients who had never had stiff neck or brachialgia had also no history of lumbar spine trouble. The difference is statistically significant ($p < 0.001$).

k) Summary.

Symptoms emanating from the lumbar spine (lumbar insufficiency – lumbago-sciatica) showed a very high frequency, 80 percent of the in-

dustrial and forest workers and 15 percent of the 15 to 20-year-olds examined having at some time had such symptoms. The complaint usually made its first appearance before the age of 30 years, and the sociological significance in lost working days was considerable. Moderate static postural deformities (pelvic tilt, lordosis and kyphosis) had no connection which the condition, but were of cosmetic importance only. Nor could any connection be found with bodily type, blood pressure, physical tolerance, gastric disturbances, allergic diseases or varices. Heavy lifting with or without trauma, infectious diseases, as well as cold and damp, sometimes were contributory factors, while irritation of the sympathetic nervous system presumably played a certain part in bringing on the symptoms. Roentgen changes indicating disk degeneration in the lumbar spine were found in 77 percent of the 35 to 49-year-olds examined, and there was a definite connection between low back trouble and disk degeneration. Disk degeneration as such, however, did not appear to cause any symptoms unless combined with changes secondary to the disk degeneration, which seemed to appear haphazardly and often without apparent reason. The best known of these secondary changes is disk prolape, while other factors are only partially understood and require further research for clarification. Anomalies visible on the X-ray (spondylolysis or spondylolithesis, transitional lumbosacral vertebra, asymmetrical lumbar vertebra, etc.) had no apparent connection with lumbar spine trouble. The clinical signs are usually secondary to the symptoms, and it is therefore generally impossible to foresee if a patient who had never had back trouble will at some time develop it or if he is suited to work that is hard on the spine. It is only persons who often have attacks of incapacitating spinal trouble who can be advised to transfer to a lighter occupation. It is interesting to note that even patients with considerable trouble from their backs can become relatively able-bodied if given suitable occupations.

VII. The Dorsal Spine

a) Symptoms.

The dorsal spine differs from the cervical and lumbar, first, because the range of movement is much smaller and, second, because there is not the same anatomic background for root compression from disk prolapse. In the first place the disks are narrow. Furthermore, as a result of the normal dorsal kyphosis the strain on the disks is greatest on the ventral aspect. The latter circumstance, in turn, means that disk ruptures and osteophytes tend to develop in the ventral direction and not, as in the lordotic cervical and lumbar parts of the spine, posteriorly and postero-laterally toward the nerve roots and the sensitive tissues around the spinal canal. This is borne out by the rarity in the present material of symptoms from the dorsal spine of the same type as stiff neck and lumbago or brachialgia and sciatica.

Nevertheless, 4.3 percent of the adults (6 industrial and 6 forest workers) reported symptoms possibly indicating changes in the dorsal spine. Several patients, for example, stated that some sort of unusual exertion had been followed by sudden pain in the dorsal spine somewhere between the shoulder blades, that the pain was worse in connection with movement and lifting, that it disappeared in two or three weeks, but that it sometimes recurred on exceptional physical strain. Other patients had periodical pain and aching situated in a specific area of the dorsal spine and associated with unilateral or bilateral radiation along the ribs in the same segment, or occasionally as a girdle pain to the epigastrium or to the level of the umbilicus. A few patients had scarcely any discomfort in the spine, but instead a pain in the flank that radiated to the epigastrium or the umbilicus. Others, in turn, stated that during attacks they had a tender spot somewhere in the chest or the flank. Several stressed that the symptoms were most pronounced when they were resting, particularly after a strenous working day

(cf. brachialgia). In general, these symptoms, like those of brachialgia, seemed to be relatively innocuous although several of the patients had sought medical care.

b) Pressure Tenderness of the spinous processes.

Three of the patients with more or less latent symptoms had clinically distinct tenderness over the spinous processes corresponding to the painful segment, in one case the sixth dorsal and in two the ninth to tenth dorsal vertebrae. The first of these three had pain around and beneath the left mammilla and out to the spine at examination, while one of the others complained of periodical intercostal neuralgic pain along the ninth or tenth rib, and the third reported girdle pain toward the umbilicus. It is, therefore, not unlikely that the majority of cases of intercostal neuralgia, a number of indeterminate cases clinically diagnosed as rib fractures, and certain cases with indefinite abdominal pain could be explained by changes in the dorsal spine.

Pressure tenderness over one or more of the spinous processes was found in another 15 cases, which had never had trouble as described above. Pressure tenderness was noted somewhere between the first and the sixth dorsal vertebra in 14 of these cases, 13 (93 percent) of which had had brachialgia. Presumably, therefore, brachialgia may have its origin in the upper dorsal spine as well as in the cervical spine. This corresponds well with the theory of a connection between deep pain and the sympathetic nervous system, since the sympathetic innervation of the arm emanates partly from the five upper dorsal segments.

c) Frequency of kyphosis and its connection with roentgen signs (Scheuermann).

Kyphosis was considered to be present in 14 percent of the adults and in 13 percent of the apprentices, or altogether 51 cases (cf. chapter on static postural deformities). Only one of them had had one attack of mild symptoms of dorsal spinal insufficiency.

Of the above 12 cases with suspected symptoms from the dorsal spine and the 15 cases with pressure tenderness, two, or 7 percent (2/27), were considered to be hump-backed. In other words, kyphosis was not more common among the cases with subjective or objective symptoms from the dorsal spine than among the remainder. As appears from the chapter on static postural deformities, the frequency of lumbar spine trouble was not greater among the kyphotic cases.

Table 40. Frequency of Roentgen Evidence of Scheuermann's Signs.

		Moderate Scheuermann's signs	Pronounced Scheuermann's signs	Total
Apprentices	91 cases	15 %	13 %	28 %
Industrial workers	160 „	12 %	7 %	19 %
Forest workers	114 „	22 %	18 %	40 %
Total	365 „	16 %	12 %	28 %

Roentgen examination of the dorsal spine yielded certain information regarding the causes of kyphosis. For example, there is always wedging of some of the vertebrae, due either to deformity or, more often, to changes in the epiphyseal plates, as described by Scheuermann. Of the 51 patients considered to be kyphotic, 76 percent presented these Scheuermann changes, while the remaining 24 percent exhibited cuneiform deformity of a varying number of vertebrae of more or less unclear origin. Table 40 reveals that Scheuermann changes were present in 28 percent of the whole material and in almost twice as many forest workers as industrial workers.

Table 41 shows that kyphosis was present in 4 percent of the cases without Scheuermann signs, while 59 percent of those with pronounced Scheuermann signs were kyphotic, which is clear evidence of the importance of these changes to dorsal kyphosis. It is interesting to note that almost twice as many forest workers had kyphosis as industrial

Table 41. Frequency of Clinical Evidence of Kyphosis in Cases With and Without Roentgen Signs of Scheuermann's Disease.

		Kyphosis in cases without Scheuermann changes	Kyphosis in caseswith moderate Scheuermann changes	Kyphotic in cases with severe Scheuermann changes	Total of kyphotic changes
Apprentices	91 cases	6 % (4/65)	21 % (3/14)	42 % (5/12)	13 % (12/91)
Industrial workers	160 „	5 % (6/130)	16 % (3/19)	64 % (7/11)	10 % (16/160)
Forest workers	114 „	3 % (2/68)	28 % (7/25)	67 % (14/21)	20 % (23/114)
Total	365 „	4 % (12/263)	22 % (13/58)	59 % (26/44)	14 % (51/365)

workers, and that roentgen evidence of Scheuermann changes was also twice as common in the former category. The natural conclusion is that heavy forest work is a decisive factor in this connection, particularly in view of the fact that most forest workers take up their occupation when they are only 12 to 13 years of age before the ossification of the vertebrae has been completed. On the other hand, Scheuermann changes in the apprentices were almost as common among those with light as with heavy work. It would, therefore, be interesting to examine a group of forest workers of 15 to 20 years.

None of the patients with Scheuermann signs reported symptoms from the dorsal spine. Nor was the frequency of lumbar spine trouble unusually high (Table 42).

Table 42. Frequency of Lumbar Spine Trouble in Cases With and Without Roentgen Signs of Scheuermann's Disease.

		No. of cases with lumbar spine trouble	
		Without Scheuermann change	With Scheuermann changes
Apprentices	91 cases	16 % (11/65)	12 % (3/26)
Industrial workers	160 „	80 % (104/130)	70 % (21/30)
Forest workers	114 „	82 % (56/68)	82 % (38/46)
Total	365 „	64 % (171/263)	65 % (62/102)

d) Frequency of disk degeneration.

With regard to the roentgen signs of disk degenerations in the dorsal spine, the width of the disks was difficult to estimate, and we therefore only recorded the occurrence of osteophytes on the margins of the vertebral bodies. The frequency of osteophytes in the various age and vocational groups is shown in Tables 43 and 44.

Table 43. The Frequency of Roentgen Signs of Disk Degeneration (Osteophytes) in the Dorsal Spine in Industrial and Forest Workers.

Vocational group		No roentgen signs	Small osteophytes	Large osteophytes
Forest Workers	114 cases	12 %	49 %	39 %
Industrial Workers	160 „	33 %	53 %	14 %
Total	274 „	24 %	51 %	24 %

Table 44. The Frequency of Roentgen Signs of Disk Degeneration (Osteophytes) in the Dorsal Spine in Different Age Groups.

Age group	No roentgen signs	Small osteophytes	Large osteophytes
36-39 yrs. 86 cases	34 %	51 %	12 %
40-44 „ 103 „	28 %	40 %	30 %
45-49 „ 85 „	9 %	55 %	31 %
Total 274 „	24 %	51 %	24 %

As we see, the frequency rises with age. The industrial workers show a distinctly lower frequency (33 percent without roentgen signs as compared with only 12 percent in the forest workers), and the difference is statistically significant ($p < 0.001$). This is probably connected with the higher frequency of Scheuermann changes in the forest workers, since practically all the cases with these changes revealed osteophytic deposits.

Comparison between the roentgen findings of disk degeneration in the cervical, the dorsal and the lumbar spine (Table 45) reveals that all three are surprisingly similar. The frequency of symptoms, on the other hand, is much higher in the cervical and the lumbar spine than in the dorsal spine, which is further evidence that disk degeneration as such does not cause symptoms. The considerably lower frequency of dorsal back trouble is probably closely related with the fact that the factors favoring the occurrence of posterior or posterolateral protrusion of intervertebral disks are considerably less pronounced.

Table 45. Frequency of Roentgen Signs of Disk Degeneration in the Cervical, the Dorsal and the Lumbar Spine.

Age group	Cervial Spine	Dorsal Spine	Lumbar Spine
35-39 yrs. 86 cases	74 %	66 %	66 %
40-44 „ 103 „	80 %	72 %	78 %
45-49 „ 85 „	89 %	91 %	87 %
Total 274 „	79 %	76 %	77 %

c) Summary.

Symptoms assumed to originate in the dorsal spine were reported in 4.3 percent of the cases, or a considerable lower rate than in the cervical and the lumbar spine (approximately 80 percent). This is probably due to the relatively unusual occurrence of posterior or postero-lateral protrusion of the dorsal intervertebral disks. The symptoms consisted of ache or pain in a circumscribed area in the dorsal spine and radiating pain along the ribs or to the epigastrium or umbilicus. Tenderness over one or two of the spinous processes was found in three cases undergoing attacks at the time of examination and in a further 14 patients, all but one of whom had reported brachialgia. In the latter cases the pressure tenderness was situated between the first and the sixth dorsal vertebra, which suggests that brachialgia may even have its origin in the upper dorsal spine.

Kyphosis was considered to be present in 14 percent and was generally (76 percent) found to be due to Scheuermann changes in the vertebrae. Both kyphosis and Scheuermann changes were found twice as often in forest workers as in industrial workers. Kyphosis did not appear to be accompanied by any increase in the frequency of subjective signs emanating from the dorsal or the lumbar spine, but was of cosmetic importance only.

Roentgen signs of disk degeneration (osteophytes) were about as frequent as in the cervical and the lumbar spine, and were seen more often in forest workers than in industrial workers, which was probably due in part to the higher rate of Scheuermann changes in the former group.

VIII. Hips.

Symptoms emanating from the hip joints were unusual, being reported by only four patients. In all four cases they consisted of periodical ache in one hip, more pronounced following exertion. These patients exhibited slight but definite restriction of movement. Three of them showed roentgen signs of relatively pronounced arthritis deformans of medial type, while the fourth had no definite roentgen changes. All four were able to work at full capacity.

A further five cases showed slight but definite limitation of movement (rotation and lateral motion but not extension-flexion), but had no symptoms. There were no roentgen changes in three of the five, while mild bilateral arthritic signs were seen in one.

In addition to the aforementioned positive roentgen findings, slight but definite roentgen signs of arthritis deformans were observed in five cases, while minimal or suspected changes of this kind were seen in a further nine cases. No limitation of movement or symptoms were noted in any of these. Finally, roentgen in one patient (born in 1910) showed distinct dysplasia with sloping roof of the acetabulum and suggested subluxation of the head, equally pronounced on both sides. Neither limitation of movement nor symptoms were reported.

Table 46 shows the pathologic findings in the hip joints. It reveals that the frequency of roentgen signs of arthritis deformans was higher in the forest workers than the industrial, and that the difference was statistically significant. No symptoms and no pathologic findings in the hip joints were recorded among the apprentices.

Table 46. Frequency of Symptoms and Signs in the Hip Joints.

	Industrial workers 163 cases	Forest workers 114 cases	Total
Symptoms	0.6 % (1/163)	2.6 % (3/114)	1.4 % (4/277)
Limitation of movement	3.1 % (5/163)	3.5 % (4/114)	3.2 % (9/277)
Minimal roentgen changes of arthritic type	2.5 % (4/163)	8 % (9/114)	4.9 % (13/277)
Definite roentgen changes of arthritic type	0.6 % (1/163)	8 % (9/114)	3.6 % (10/277)
Dysplasia (roentgen) ..	0.6 % (1/163)	0	0.4 % (1/277)

To summarize the observations of the hips, it may be stated that the frequency of symptoms was astonishingly low and that roentgen signs of arthritis deformans were clearly more common in forest workers than industrial workers.

IX. Knees.

No pronounced signs or symptoms in the knees were observed in this series. Meantime, certain interesting facts were revealed.

a) Symptoms of Insufficiency and Subpatellar Crepitus.

The term "insufficiency of the knees" refers to pain and fatigue in connection with exertion or extra strain. The symptom, as recorded in the present series, was unmistakable though mild and did not cause appreciable invalidity. A few cases of meniscal damage or posttraumatic synovitis were not included in the group.

The symptoms of insufficiency in question were reported in 4.7 percent (13/277) of the forest and industrial workers between the ages of 35 and 49 years. The frequency was somewhat higher in the forest workers (7.9 percent) than the industrial workers (2.4 percent), but the difference is not statistically significant.

Table 47. Frequency of Insufficiency of the Knees in Industrial and Forest Workers.

Vocational Category	35-39 yrs.	40-44 yrs.	45-49 yrs.	Total
Industrial workers				
163 cases	1/54	0/53	3/56	2.4 %
Forest workers				
114 cases	0/53	5/50	3/31	7.9 %
Total 277 cases ..	1/87 1.2 %	5/103 4.9 %	7/87 8 %	4.7 %

By subpatellar crepitus in meant a fine, delicate crepitus, which can be felt with the hand on the patella when the knee is flexed and extented. I divided the patients into three groups in this respect: no crepitus, slight crepitus and pronounced crepitus.

In adults the frequency of crepitus was 22.3 percent, of which 18 percent were slight and 4.3 percent pronounced. With few exceptions this finding was the same in both knees. The figures were somewhat higher for forest workers than for industrial workers, but the difference is not statistically significant.

Table 48. Frequency of Subpatellar Crepitus Among Industrial and Forest Workers.

Vocational group	Age groups 35-39 yrs.	40-44 yrs.	45-49 yrs.	Total
Industrial workers				
163 cases	11 % (6/54)	23 % (12/53)	25 % (14/56)	20 % (32/163)
Forest workers				
114 cases	15 % (5/33)	28 % (14/50)	36 % (11/31)	26 % (30/114)
Total 277 cases ..	13 % (11/87)	25% (26/103)	29 % (25/87)	22.3%(62/277)

Four of the 91 apprentices had mild crepitus, but none reported symptoms of insufficiency.

Comparison between the cases with symptoms of insufficiency and those with crepitus reveals that no one of the 215 patients without crepitus reported symptoms of insufficiency, while 12 percent of those with mild and 58 percent of those with pronounced crepitus stated that they had had symptoms of insufficiency (Table 49).

Table 49. Correlation Between Subpatellar Crepitus and Symptoms of Insufficiency of the Knees in Industrial and Forest Workers.

	Total	No. of patients with symptoms of insufficiency
Without crepitus	215 = 77.7 %	0/215 = 0 %
Mild crepitus	50 = 18 %	6/50 = 12 %
Pronounced crepitus	12 = 4.3 %	7/12 = 58 %
Total	277 = 100 %	13/277 = 4.7 %

There is thus a definite correlation between crepitus and signs of insufficiency. We do not know why only a few of the patients with mild crepitus and only somewhat more than half of those with pronounced crepitus had symptoms. It seems clear, however, that, in addition to the change in the joint that causes crepitus, some unknown

factor must come into the picture before the appearance of symptoms in the form of pain or fatigue. Presumably inadequate local circulation plays a part in this respect. This theory is borne out by the fact that the symptoms make their appearance in connection with exertion that makes immoderate demands on the local circulation, or in connection with a chill that undoubtedly has an adverse effect on circulation. Furthermore, we know that heat in all forms has a palliative effect on the symptoms and that the frequency of the condition increases with age and arteriosclerosis.

No statistically significant correlation can be shown between lumbar and cervical spine trouble, on the one hand, and crepitus or symptoms of insufficiency in the knees, on the other hand. In Table 50, furthermore, no allowance is made for the fact that most of the cases with crepitus or signs of insufficiency are found in the older age groups.

Table 50. Correlation of Lumbar and Cervical Spine Trouble With Crepitus and Symptoms of Insufficiency in the Knees.

	Total no. of cases	No. of cases with lumbar spinal trouble	No. of cases with cervical spinal trouble
With crepitus	61	87 % (53/61)	85 % (52/61)
Without crepitus	215	78 % (167/215)	79 % (169/215)
With signs of insufficiency..	14	79 % (11/14)	86 % (12/14)
Without signs of insufficiency	262	80 % (209/262)	80 % (209/262)

b) Knock-knees and bowleg.

As far as I have been able to determine, no objective method of measuring these deformities has yet been evolved, nor have any standards been set up for the differentiation between normal and abnormal. In cases of genu varum, I measured the distance between the femoral condyles (I C.) with the patient standing with extended knees and the feet parallel and close together. In genu valgum, the distance between the inner aspects of the ankles (I. M.) was measured in the same way. Although there are undoubtedly certain sources of error in this method, it nevertheless does give some information.

We find that pronounced genu valgum was unusual among the adults, only two cases having been labeled knock-kneed (I. M. > 5 cm.). On the other hand, a space between the femoral condyles was rather common. Table 51 shows that the intercondylar distance was at most 2 cm. in 70 percent of the cases, 2 or 4 cm. in 21 percent, and > 4 cm.

in 8 percent, with a maximum distance of 8 cm. To the naked eye, the lastmentioned groups appeared decidedly bow-legged, the middle group slightly bow-legged, while the group with an inter-condylar distance of 2 cm. or less seemed to be normal. There was no difference between industrial and forest workers. Table 51 also reveals the correlation between bow-leggedness measured as above and the frequency of crepitus and symptoms of insufficiency.

Table 51. Correlation between Intercondylar Distance (bow-leg) and Crepitation and Symptoms of Insufficiency of the Knees in Forest and Industrial Workers.

Intercondylar distance	Total no. of cases	No. of cases with	
		Crepitus	Symptoms of Insufficiency
0–2 cm	70 % (191/272)	23 % (44/191)	4.2 % (8/191)
2½–4 cm	21 % (57/272)	23 % (13/57)	5.3 % (3/57)
4½–8 cm	8 % (22/272)	9 % (2/22)	4.5 % (1/22)
Total	99 % (270/272)	22 % (59/270)	4.4 % (12/270)

As shown in the table, neither crepitus nor symptoms of inspfficiency in the knees were more common in persons with bow-leg than those without. Therefore, the present investigation does not confirm the opinion frequently expressed that the articular surfaces in the bow-legged are exposed to extra wear and that arthritis deformans is more common in the bow-legged.

c) Other Symptoms.

A number of symptoms indicating knee trouble were recorded, in addition to the above-mentioned symptoms of insufficiency. Most of them seemed to be manifestations of disorders of the semilunar cartilages. Two forest workers and three industrial workers showed signs of damage to the medial semilunar cartilage, which were not severe enough to warrant special treatment. A further four industrial workers had undergone operation for medial meniscal damage; three of them had no symptoms and the fourth still had some degree of meniscal trouble. Two of the apprentices had signs of damage to the semilunar cartilages and one had symptoms of Schlatter's disease following a trauma (blow from a hockey stick).

Nothing of interest in addition to the foregoing was noted with regard to the knees.

X. Feet.

a) Insufficiency and Flatfoot.

By insufficiency of the feet is meant foot fatigue from walking and standing. As a rule the patients report that they like to lie down after work in order to rest their feet. The flat foot deformity is difficult to measure objectively and was only evaluated subjectively in the present material. The limit of what is considered normal is undefined and was sometimes difficult to determine. Cases of pronounced flat foot were differentiated from those with a mild to moderate deformity.

Table 52. Frequency of Insufficiency of the Feet and Flat Foot.

		Subjective Insufficiency of the feet	Mild to moderate flat foot	Pronounced flat foot
Industrial workers	163 cases	13 %	26 %	0.6 %
Forest workers	114 „	6 %	22 %	1.8 %
Apprentices	91 „	4 %	22 %	0 %
Total	368 „	9 %	24 %	0.8 %

It is seen from Table 52 that mild to moderate flat foot was present in 24 percent, with approximately the same percentage of cases in all groups. The frequency in the group "boys of 8 to 10 years" was about the same, or 22 percent. Pronounced flat foot was only present in three cases (one industrial and two forest workers). Insufficiency of the feet was somewhat more common in the industrial workers (13 percent) than in the forest workers (6 percent), but it would seem reasonable that the former, most of whom walk or stand on cement floors most of the day, would have more trouble than men who work in the forests.

Table 53 shows the connection between insufficiency of the feet and flat foot. We see that foot insufficiency is definitely more common in those with flat foot. It is interesting to note that four percent of those

with normal feet reported insufficiency, while 77 percent of those with mild to moderate flat foot had no trouble at all.

Table 53. Correlation between Foot Deformity and Foot Insufficiency.

Apprentices, forest and industrial workers	No. of cases	Percentage with symptoms of foot insufficiency
Normal feet	274	4 % (10/274)
Mild to moderate flatfoot	87	23 % (20/87)
Pronounced flatfood	3	100 % (3/3)
Moderate varus deformity	4	0 % (0/4)

b) Correlation with Lumbar Spine Trouble.

Table 54 is noteworthy in that it contradicts the relatively general view that weakness of the feet and flat foot cause spinal trouble. It reveals, for example, that the frequency of lumbar spine trouble in forest and industrial workers with foot insufficiency and flat foot was the same as, or at least not higher than the total frequency of spinal trouble.

Table 54. Connection between Insufficiency and Deformity of the Feet and the Lumbar Spine.

	Total no. of cases	No. of cases with lumbar spine trouble	Total frequency of lumbar spine trouble
Foot insufficiency	28	75 % (21/28)	80 % (220/277)
Flat foot	70	80 % (56/70)	80 % (220/277)

c) Hallux Valgus and Ridigus.

Hallux valgus was present in ten cases (six forest workers, three industrial workers and one apprentice), or 2.7 percent. In none of the cases was this deformity severe enough to call for special treatment. Hallux rigidus was noted in a few cases, all of them with a history of trauma.

XI. Summary

The investigation revealed that so-called rheumatic symptoms were very prevalent, having been present at some time in about 90 per cent of the industrial and forest workers between 35 and 49 years who were examined. With the exception of the cases with specific rheumatic diseases (polyarthritis, ankylosing spondylarthritis, etc.) the rheumatic symptoms were generally referable to two main syndromes, which showed about the same incidence (80 per cent), viz., the stiff neck-brachialgia and lumbago-sciatic syndromes. Weighty circumstantial evidence was found in the literature and the results of clinical and roentgen examinations to support the theory that the stiff neck-brachialgia syndrome is generally a result of changes in the cervical spine, particularly its intervertebral disks, and that the lumbago-sciatica syndrome arises from corresponding changes in the lumbar spine and its intervertebral disks. These changes are represented primarily by degenerative processes in the intervertebral disks, or "disk degeneration", which in themselves do not appear to cause distress. In fact, no symptoms are noted before the development of certain changes secondary to disk degeneration, which seem to occur by chance and often without apparent reason. The best known of these secondary changes is intervertebral disk herniation, which is constantly being verified by surgeons all over the world. Other factors are only partially understood, and further research is required for their elucidation. Not infrequently, infectious diseases, dampness and "draughts", as well as certain forms of hard work, appear to have had a provocative effect. In addition, irritation of the sympathetic nervous system probably plays a certain part in the appearance of the symptoms. On the other hand, the present investigation indicates that moderate static deformities, such as pelvic tilt, lordosis, kyphosis, or flatfoot are of no significance to the spinal symptoms in question. Nor could any connection be established with bodily type, blood pressure, gastric disorders, allergic diseases, or varices.

Although disk degeneration was demonstrated roentgenologically in the dorsal spine just as often as in the cervical and lumbar areas, the incidence of symptoms that could be referred to the dorsal spine was less than 5 per cent. This is assumed to be due to the fact that the anatomic conditions promoting intervertebral disk protrusion giving rise to symptoms are less often present in the dorsal spine.

Symptoms in the extremities and their joints were also relatively uncommon and had little effect on the patients' work output. The sociological importance of the stiff neck-brachialgia and the lumbago-sciatic syndromes, on the other hand, was considerable. It can only be measured partially in lost working hours, since there is unfortunately no way of evaluating the effect of pain and insomnia on the patient's work output, his joie de vivre, and his finances.

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