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Epidemiology of Sciatica and Herniated Lumbar Intervertebral Disc

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SOCIAL INSURANCE INSTITUTION
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Abstract


The general aim of the present study was to provide basic epidemiological data on sciatica and herniated lumbar disc. In a prevalence study that was part of the Mini-Finland Health Survey of the Finnish population aged 30 or over, a physician diagnosed either sciatica or herniated lumbar disc for 5.1% of the men and 3.7% of women. Half of the patients were assessed to be in need of medical care. Disability was common and 6% of the population's work disability was estimated to be attributable to sciatica or herniated lumbar disc. In a subsample of 195 subjects with a previous history of low back pain, several radiological measurements describing the sizes of lumbar vertebral canals were found to be narrowed in the presence of sciatica. In the Mobile Clinic Health Examination Survey, hospital discharges for herniated lumbar disc or sciatica were followed up over a period of 11 years in 57,000 men and women. Occupations of industrial workers and motor vehicle drivers, symptoms suggesting psychological distress, body height and obesity proved to be significant predictors of herniated lumbar disc or sciatica.

Key words: epidemiology, intervertebral disc displacement, low back pain, risk factors, sciatica

Tiivistelmä


Avainsanat: epidemiologia, iskias, lanneselkä, vaaratekijä, välilevytyrä
PREFACE

This study is based on two comprehensive epidemiological projects of the Social Insurance Institution, the Mobile Clinic Health Examination Survey and the Mini-Finland Health Survey. The principal aims of these projects are to provide information which can be used to prevent diseases and disabilities, to improve treatment and rehabilitation, and to plan and evaluate health care. The surveys have been carried out jointly by the research units of the Social Insurance Institution, i.e., the Research Institute for Social Security, Helsinki, and the Rehabilitation Research Centre, Turku. The present study was undertaken to provide basic epidemiological data on sciatica, a specific low-back pain syndrome, usually caused by herniated lumbar intervertebral disc.

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The author
CONTENTS

1. LIST OF ORIGINAL COMMUNICATIONS ........................................... 1

2. INTRODUCTION ........................................................................... 2

3. REVIEW OF THE LITERATURE ...................................................... 4
   3.1. Clinical entity of lumbar disc syndrome ......................... 4
      3.1.1. Sciatica ................................................................. 4
      3.1.2. Herniated lumbar intervertebral disc .................. 7
      3.1.3. Diagnosis ............................................................. 8
      3.1.4. Natural course and prognosis ............................... 9
   3.2. Problems of epidemiological research ......................... 10
   3.3. Incidence and prevalence ............................................. 10
      3.3.1. Symptoms ........................................................... 11
      3.3.2. Disease history .................................................. 12
      3.3.3. Visits to physician ............................................ 13
      3.3.4. Hospitalizations and operations ....................... 13
      3.3.5. Disability ......................................................... 14
      3.3.6. Overall estimates of incidence and prevalence .... 17
   3.4. Risk determinants ....................................................... 17
      3.4.1. Previous studies ................................................ 17
         3.4.1.1. Ad hoc epidemiological studies ...................... 17
         3.4.1.2. Population studies on low back pain .......... 19
         3.4.1.3. Series of patients ....................................... 21
      3.4.2. Review of risk determinants ............................. 23

4. AIMS OF THE STUDY ................................................................ 35
   4.1. General aims ............................................................... 35
   4.2. Specific aims ............................................................. 36

5. STUDY POPULATIONS AND METHODS ..................................... 37
   5.1. The Social Insurance Institution’s Mini-Finland Health Survey ..... 37
      5.1.1. Sample ............................................................... 37
      5.1.2. Methods used in the screening phase ................... 37
      5.1.3. Methods used in the clinical phase ................. 41
         5.1.3.1. Diagnosis of low back syndromes ............... 41
         5.1.3.2. Need for care ............................................. 42
         5.1.3.3. Working capacity and functional ability .... 42
      5.1.4. Extensive clinical examination ......................... 43
         5.1.4.1. Methods used at the examination ............. 43
         5.1.4.2. Radiographic measurements .................... 44
      5.1.5. Sensitivity of screening and reliability of diagnosis .... 45
   5.2. The Social Insurance Institution’s Mobile Clinic Health Examination Survey ......................... 45
      5.2.1. General design ................................................. 45
8.2. Lumbar vertebral canals in sciatica and herniated lumbar disc ........ 91
8.3. Risk determinants ................................................. 91

9. YHTEENVETO .......................................................... 93
  9.1. Esiintyvyys, hoidontarve ja toimintakyvyttömyys .................. 93
  9.2. Selkäydinkanavan koko ja välilevyyoireyhtymä ............... 94
  9.3. Vaaratekijät .................................................... 94

REFERENCES .......................................................... 97

ORIGINAL COMMUNICATIONS ..................................... 117
1. LIST OF ORIGINAL COMMUNICATIONS

This study makes use of the following original articles, which are referred to with Roman numerals in the text:


2. INTRODUCTION

When the nucleus of a lumbar intervertebral disc extrudes through the enveloping annulus fibrosus capsule, the adjacent nerve roots may be compressed. Sciatica, a pain radiating to either of the lower limbs in the distribution of the sciatic nerve, often accompanied by motor or sensory dysfunction, is the most characteristic symptom of the herniated lumbar intervertebral disc. There are a number of conditions other than herniated disc which can cause sciatica. However, the close relationship between the symptoms and the abnormalities in the lumbar intervertebral discs has been the justification for calling this entity ‘the lumbar disc syndrome’.

Back pain is a major public health problem. Perceived back trouble, especially disability resulting from low back pain, has shown a continuously increasing prevalence during the last 20 years. The Finnish national health interview surveys of the Social Insurance Institution show that the prevalence of self-reported chronic back disease was 3.6% of the adult population in 1964 and 7.1% in 1976 (Klaukka et al. 1982). The prevalence has been reported as less in nonindustrialized societies, which suggests environmental influences (Fahrni and Trueman 1965; Bremner et al. 1968). Developing methods to prevent low back diseases is thus a real challenge for research. Little epidemiological research has thus far been conducted, and the risk factors for low back pain are still mainly unknown.

As part of the low back problem, the lumbar disc syndrome clearly has a large impact on populations of the industrialized countries. It causes a great deal of suffering, much loss of work, and not inconsiderable disability (The challenge of... 1977).

The difficulty of diagnosing various types of low back pain exactly and reliably has been a hindrance for research. Lumbar disc syndrome differs from other types of low back syndromes in that specific investigations have been developed for its diagnosis. This, in principle, provides a sufficient basis for epidemiological research, or, at least, a more solid biomedical basis than exists in other common types of low back pain.
The incidence and prevalence of sciatica and herniated lumbar disc are imprecisely known. Thus far, the reported prevalences are based on interview surveys; statistics on sciatica and herniated lumbar discs treated in primary health care and hospitals; and statistics on disability pensions or sick-leave compensations. Such data are of uncertain validity. On the other hand, these statistics are a good reflection of impact on public health of the lumbar disc syndrome.

Thus far, three epidemiological studies have focused on risk factors for herniated lumbar intervertebral disc or sciatica (Hrubec and Nashold 1975; Kelsey and Ostfeld 1975; Kelsey et al. 1984a). The studies have consistently supported the view that mechanical stresses on the spinal structures contribute to lumbar disc herniation, and several determinants for its occurrence have been identified. The results also suggest that some of risk factors may be suitable objects for intervention.

The present report is a review of studies conducted as part of two extensive epidemiological projects. A study on musculoskeletal diseases including the prevalence and public health impact of the lumbar disc syndrome was a part of the Social Insurance Institution’s Mini-Finland Health Survey carried out in 1977 - 1980 in a representative sample of the adult population (Sievers et al. 1985). An earlier project of the Social Insurance Institution, the Mobile Clinic Health Examination Survey (Aromaa 1981; Reunanen et al. 1983), was a longitudinal study to follow up morbidity in an extensive cohort of Finnish adults. The follow-up procedure included record linkage with the national hospital discharge register (Heliövaara et al. 1984). This information was used to study incidence and risk factors for herniated lumbar intervertebral disc and sciatica leading to hospitalization.
3. REVIEW OF THE LITERATURE

3.1. Clinical entity of lumbar disc syndrome

Lumbar disc syndrome serves as an appropriate term for the clinical manifestation of low back pain radiating to one or both legs, with or without weakness, sphincter disturbance, or sensory or reflex abnormality (Paine and Haung 1972). Although the clinical appearance is the same, the etiological factors are more complex. Sciatica may be caused by a number of other conditions in addition to lesions of intervertebral discs. On the other hand, abnormalities in lumbar discs are common among symptom-free persons. The construction of a solid framework for an epidemiological study is therefore problematic.

3.1.1. Sciatica

Sciatica is a pain radiating along the course of the sciatic nerve to the lower extremity, often accompanied by loss of motor or sensory function of the nerve. The symptoms and findings of sciatica vary. In the most definite form, it is characterized by radiation into the leg in a segmental distribution, the straight leg raising test is positive, neurological findings are present, and straining, coughing, sneezing, and similar activities give rise to pain in the engaged radicular segment. Nachemson and Andersson (1982) have suggested that this definite form of sciatica should be called 'rhizopathy'.

Sciatica is a symptom or syndrome, whatever the cause or pathogenesis. It has traditionally been considered to be a consequence of mechanical compression of the lumbar nerve root.

The mechanism by which a disc herniation or other intraspinal expansion irritates the lumbar nerve root is not understood. A mechanical compression can be expected to cause ischaemia and ipsilateral neurologic dysfunction, but not pain. The anatomic fixation of the nerve root within the neural canal appears to be important in this regard, as heightening of the disc space increases the contact force between the nerve root for a simulated disc herniation in cadavers (Spencer et al. 1984). Besides the mechanical compression, there may well be some chemical mechanisms. An injured disc can result in the production of irritant substances which may drain into the spinal canal, thus irritating
nerves (Crock 1986). In an animal model used in a recent study, experimental mechanical stimulation of dorsal root ganglia and nerve roots increased the amounts of an undecapeptide, substance P (Badalamente et al. 1987). The authors suggested that substance P may modulate nociception when lumbar nerve roots are stimulated mechanically.

Four elements of the nervous system may be involved in the sciatica resulting from lumbar intervertebral disc lesion: nerve roots, spinal nerves, dorsal rami and sinuvertebral nerves (Bogduk 1976). According to the traditional view, a herniated disc produces low back pain and lower limb symptoms by affecting a nerve root. Sciatica has also been viewed as referred pain from the structures innervated by the posterior rami rather than by direct root compression (Bogduk 1976; King and Lagger 1976). The posterior rami receive afferent branches from many structures, including the posterior longitudinal ligament and the facet joints. The two mechanisms may be active, as disc lesions may result in secondary changes of the facets. Injection of irritant fluid into the facet joint causes referred pain patterns indistinguishable from a pain associated with a herniated lumbar disc, and injection of steroids and local anesthetic into the facet joint has been presented as a diagnostic-therapeutic procedure (Mooney and Robertson 1976).

According to the clinical experience, a typical sciatica usually is caused by a herniated lumbar intervertebral disc, and it is the more likely the more definite the syndrome is. However, no herniated intervertebral disc has been found in 10% - 20% of patients operated upon for sciatica (Eckols and Rehfeldt 1949; Raaf 1959; Lansche and Ford 1960; MacNab 1971; Alho et al. 1978). Paine and Haung (1972) emphasized the high frequency of spondylosis and spinal stenosis in patients with a lumbar disc syndrome. They examined 227 patients who had sufficiently severe symptoms to warrant consideration for surgical treatment, and found herniated lumbar discs in 62% of the patients. A disc herniation was the sole cause in only 31% and combined with spondylosis or stenosis in the other 31%.

Sciatica resulting from collapse of a lumbar intervertebral disc with degenerative changes in the facet joints has been verified by many authors (Gill 1976; Mooney and Robertson 1976; Kirkaldy-Willis and Hill 1979; Crock 1981; Leyshon et al. 1981; Venner and Crock 1981; Fast et al. 1985). When the intervertebral disc is narrowed, the root can be compressed by the over-riding superior facet
against the pedicle in the foramen (Gill 1976). This can occur also from spondylyosis, from congenital facet hypertrophy, and from previous trauma to the facet joint. Entrapment of the lumbar nerve root laterally in the root canal produces symptoms similar to those caused by herniated lumbar disc, as the pain may have the same distribution. Unlike the sciatic pain caused by herniated lumbar disc, the lateral root entrapment syndrome tends to be unrelieved by bed rest, straight leg raising is not greatly affected, and there are often no abnormal neurologic signs (Porter et al. 1984). Porter et al. (1984) assessed that a root canal lesion was responsible for 11% of patients attending a first referral back pain clinic. Penttinen (1987) reported a clear-cut positive association between sciatic pain and arthrosis of lumbar facet joints in Finnish farmers.

A possible etiological theory for lumbar nerve root irritation is the degenerative instability of lumbar vertebrae (Knutsson 1944; Kirkaldy-Willis and Farfan 1982; Malmivaara and Vanharanta 1984; Nachemson 1985). In the presence of rotatory instability, the intervertebral foramen can be narrowed when the processus articularis superior is shifting forwards, resulting in lateral entrapment of the nerve root (Kirkaldy-Willis and Farfan 1982). Degenerative instability often seems to be connected with herniated intervertebral disc, as the two conditions may have partly the same etiology.

Crock (1986) postulated that an internal disc disruption without bulging of the annulus fibrosus can cause sciatic pain. This hypothesis suggests that the syndrome results from the production of chemical substances by the damaged disc tissues.

Conditions other than herniated lumbar disc or spinal stenosis can occasionally cause sciatica by affecting either the lumbar nerve roots or the sciatic trunk. Lumbar arachnoiditis often appears to be present in failed back surgery syndrome patients (Burton 1978). Rare causes described in published case reports are intraspinal tumours (Lansche and Ford 1960; Wiss 1982; Kurz et al. 1985), tumours of sciatic nerve (Prusick et al. 1986), sciatic nerve entrapment at the piriformis muscle (Freiberg 1941; Solheim et al. 1981), adhesions about the nerve root (Lerman and Drasnin 1975), ‘claudication’ of the sciatic nerve due to atheromatosis in the internal iliac artery (Lamerton et al. 1983), sciatic trunk irritation due to sacroiliac joint involvement (Hiltz 1976), trochanteric or ischiogluteal bursitis (Little 1979; Swarthout and Compere 1974), avulsion fracture (Miller et al. 1987) or Paget’s disease (Chrisman et al. 1964) of the ischial tu-
berosity, myositis ossificans of the biceps femoris (Jones and Ward 1980), migration of an intra-uterine device (Elmer 1978), endometriosis on the sciatic nerve (Björnsson 1976), and even Addison’s disease (Zaleske et al. 1984).

3.1.2. Herniated lumbar intervertebral disc

The herniated lumbar intervertebral disc was first clinically described and operated on by Mixter and Barr in 1934. Herniated intervertebral disc develops when the gelatinous centre of the disc, the nucleus pulposus, protrudes from its surrounding fibrocartilaginous ring, the annulus fibrosus. In principle, the condition can occur as a sudden injury or as a slow, gradual process (Adams and Hutton 1985), but there are no clinical data on the development of the herniation. The herniation most frequently protrudes in a posterior lateral direction, and then tends to compress the adjacent nerve root.

Herniation of the lumbar intervertebral disc can be classified as either protrusion or prolapse. In the protrusion type the overlying posterior longitudinal ligament remains intact, whereas in the prolapse type the ligament has been ruptured and part of the disc has extruded into the epidural space. Histologically, two entities of herniation can be distinguished: a herniation of the annulus fibrosus without involvement of the nucleus pulposus, and a herniation of the nucleus pulposus in which the nucleus pulposus protrudes through a fissure in the annulus fibrosus (Yasuma et al. 1986).

Herniated lumbar intervertebral disc occurs most often at the L4 and L5 levels, that is, in the disc between the fourth and fifth lumbar vertebrae, and the disc between the fifth lumbar vertebra and the sacrum (Raaf 1959; Lansche and Ford 1960; Naylor 1974; Schuh 1974; Vogt 1974; Kelsey 1975b; von Bele et al. 1976; Hurme 1985). At these levels, the roots run to the sciatic nerve. Effects on the femoral nerve as the result of a herniation in the disc between third and fourth lumbar vertebrae are less common, contributing to between two and seven percent of cases (Raaf 1959; Lansche and Ford 1960; Naylor 1974; Schuh 1974; Vogt 1974; von Bele et al. 1976; Hurme 1985).

Lumbar intervertebral discs protrude because of attritional and degenerative changes, and the collagen make-up of the nucleus pulposus and the annulus fibrosus may be the key to this process (Coventry 1968). Disc degeneration is probably an important factor in the etiology of low back pain, and it is also likely
to play a role in the herniation of intervertebral discs. In fact, the degenerative changes seem to be more marked and to occur at an earlier age when evidence of disc herniation is also present (Lawrence 1969; Vernon-Roberts and Pirie 1977; Wiikeri et al. 1978). So far, however, the relationship between degeneration and herniation has not been adequately elucidated (Wood et al. 1985).

The discs show early signs of progressive degeneration, and such changes occur throughout the spine (Hirsch 1966). Basically, the intervertebral disc consists of collagen and mucopolysaccharides. The collagenous fibres form a fine network. The ground substance of the intervertebral disc consists primarily of proteoglycans (Buckwalter et al. 1985). The molecular meshwork of proteoglycans entrapped in the collagen network endows cartilage with a compressive stiffness, whereas collagen provides tensile properties (Lipson and Muir 1981; Buckwalter et al. 1985). The water content of the protein-polysaccharide complex diminishes with age and the nucleus pulposus loses its gelatinous properties. The annulus fibrosus has a considerably denser and more regular collagenous pattern than the nucleus pulposus does. The fibrils of the annulus are attached to the hyaline end plate which divides the bony structure of the vertebra from the intervertebral disc itself. The annulus is thicker in its ventral aspect than its dorsal. The dorsolateral corner is the weakest, most vulnerable part of the disc (Farfan et al. 1970; Bobest et al. 1986). At the age of about 20 the collagenous bundles begin to show signs of deterioration, and this process continues throughout life (Wiltse 1971). In the lower lumbar discs the changes are most extensive dorsally and dorsolaterally (Hirsch 1966), where the symptomatic herniations also tend to be situated.

3.1.3. Diagnosis

The diagnosis of sciatica is mainly based on symptom anamnesis and physical examination (Cailliet 1981; Rowe 1983; Morris et al. 1986). More elaborate investigations are usually unnecessary, because most cases recover spontaneously within a few weeks. Thus demonstration of the anatomical abnormality causing sciatica remains necessary only in severe or prolonged syndromes.

All the conditions mentioned in chapter 3.1.1. should be considered in the differential diagnosis of sciatica. Back pain radiating down to the leg with a segmental distribution and aggravated by coughing or straining suggests a nerve root compression resulting from a herniated lumbar intervertebral disc. Weak-
ness of muscles, decreased sensation, hyporeflexia of leg or foot, and the painful stretching of sciatic nerve (Lasegue’s test, Kernig’s test, or straight leg raising test) suggest disc herniation, although an absence of these symptoms or findings does not exclude it (Woodhall and Hayes 1950; Edgar and Park 1974; Shiqing et al. 1987). Nerve root compression caused by a herniated disc is typically confined to a single nerve root, but also more than one root may be compressed simultaneously. Plain x-rays may disclose a small intervertebral disc space or may show changes of tumour, spondylolisthesis or spondylarthrosis. Electromyography may reveal neuropathic changes within muscles supplied by the affected root.

Confirmatory examinations such as myelography or computed tomography (CT) are mainly used in the patients for whom surgery is considered (Cailliet 1981; Rowe 1983; Bell et al. 1984). Nuclear magnetic resonance (NMR) is currently being adapted for use as a diagnostic tool, as it promises to yield information which is superior to that obtained from myelography or even from CT scanning (Modic et al. 1986). Discography, especially when combined with CT, can also demonstrate internal disc disruptions (Crock 1986; Vanharanta et al. 1987b). Availability, use and interpretation of these modern techniques vary.

In general, the common diagnostic methods serve the decision-making processes of therapeutic management and throw little light on etiology or the pathomechanism of the condition. Their nature is probabilistic rather than absolute, and no uniform standards seem to exist. This must be considered when data obtained from health care records are used for epidemiological purposes.

3.1.4. Natural course and prognosis

The natural course of sciatica due to herniated lumbar intervertebral disc is usually favourable (Weber 1978 and 1983; Johnson and Fletcher 1981). Nummi (1974) followed up 254 patients with classical sciatica and found that 75% of the victims recovered completely or almost completely within half a year, and only 17% were operated on. Weber (1983) followed up a group of patients and observed that two thirds of them were free from radiating pains after ten years. A possible operation did not influence the prognosis in the long-term. Nevertheless, relapses of sciatica and work disability occurred frequently. Back pain was the most common complaint at the final examination.
3.2. Problems of epidemiological research

With reference to epidemiological research, it seems that a differentiation of the lumbar nerve root compression syndromes into etiologically different groups is theoretically difficult. The following points are problematic:

- Almost all patients with a diagnosed lumbar disc herniation suffer from sciatica (Raaf 1959; Hirsch and Nachemson 1963; Marin 1974), but herniated discs are common also among symptom-free persons (Andrae 1929; Hisselberger and Witten 1968; Wiesel et al. 1984; Powell et al. 1986).
- Factors aggravating sciatica in the presence of herniated lumbar intervertebral discs are mostly unknown.
- A definite sciatica is most usually caused by a herniated lumbar disc, but many other causes are responsible for a significant proportion of cases.
- The pathological processes causing sciatica with slight symptoms or spontaneous recovery remain undiagnosed in clinical practice, and the contribution of herniated lumbar discs to such syndromes is not known.

From the epidemiological point of view, the intermittency of symptoms is of particular difficulty. Resolution without subsequent disability is common. Furthermore, sciatica and herniated lumbar intervertebral disc may represent an episode in the course of a chronic degenerative back disease (Rowe 1983), which makes differential diagnoses of even definite syndromes difficult. Cross-sectional studies therefore miss a considerable proportion of cases. Retrospective assessments, usually depending on uncertain records or memory, are likely to be unreliable while prospective studies may be too costly.

3.3. Incidence and prevalence

The lumbar disc syndrome is not the most common type of low back pain but it is important because of the associated disability and need for surgical treatment. The diagnosis of lumbar nerve root compression may be difficult, and no diagnostic criteria which would be both acceptable clinically and feasible in population surveys have been presented. For example, myelography, computed tomography, magnetic resonance imaging or even electroneuromyography would hardly be considered as suitable methods for a population study. No
epidemiological studies based on clinical examination of a representative population sample have been published, nor are there any other accurate estimates of the frequency and impact on public health of the lumbar disc syndrome. The available estimates are based on insurance and hospital discharge statistics, interview data and selected clinical materials.

3.3.1. Symptoms

In surveys undertaken by the Arthritis and Rheumatism Council in the United Kingdom in the 1950s, 1,800 men and 1,500 women aged 15 and over were given a symptom interview and a lumbar x-ray examination (Lawrence 1969 and 1977). Forty per cent of the men and 33% of the women aged 35 or over gave a history of low back and leg pain. The pain was present at the time of the survey in 11% of males and 19% of females. Sciatica suggesting a herniated lumbar disc was recorded in 3.1% of all men and 1.3% of women (Lawrence 1977). In the 55-64 age group of men the prevalence was 9.6%, and in women the maximum prevalence of 5% occurred in those over the age of 64. Diagnostic criteria were not reported, and they may have varied with time and between the populations studied. The great regional differences ranging from 1.3% to 12% in men suggest that the criteria did not remain unchanged.

According to the combined results of several surveys conducted among 2,684 male British industrial employees, a 'disc disease' was recorded in 12.2% (Anderson 1971 and 1986). The disc disease was considered to be present, if there was a history of recurrent or prolonged pain in the back or neck that could be localized accurately, and a history of pain radiating along the distribution of a spinal root at some time though not necessarily with every attack. This disease category also included cervical syndromes. The prevalence of 'disc disease' increased steeply with age, unlike the prevalence of 'vague pains in back or neck'. Of the patients with 'disc disease', 43% had consulted a general practitioner because of pain in the back or neck during the past year, 12% had been hospitalized at some time, and 46% had had at least one spell of absence from work lasting three weeks or more. The high frequencies of significant consequences suggest strict diagnostic criteria.

In a representative sample of the female population aged 15 to 71 of Gothenburg in Sweden, 13.8% of the women reported at an interview having had referred leg-pains of the sciatic type (Hirsch et al. 1969). The life-time history of sciatica
was 3.6% in those younger than 25 but rose gradually to 22.4% among those aged 45-54.

Eleven per cent of a sample of 4753 men aged 40 to 59 years employed by large enterprises in Copenhagen reported the presence of sciatic pains during one year of observation (Gyntelberg 1974).

A sample of 295 male Finnish concrete reinforcement workers aged 15 to 64 years were interviewed on musculoskeletal symptoms at the Institute of Occupational Health in Helsinki (Wickström et al. 1978). In all 42% of the men and as many as 60% of those aged 45 or over reported a life-time history of sciatica. The formulation of the question ("Have you ever had sciatica?") and the fact that the men were engaged in heavy physical work including prolonged stooping may explain the high prevalence.

Six per cent of the inhabitants aged 40-49 and 10% of those aged 50-64 reported having experienced lumbosacral pain radiating to the right lower extremity during the preceding year in Säkylä and Köyliö situated in southwestern Finland (Takala et al. 1982). Equal prevalences were obtained for the left-sided sciatica, and no differences were found between the sexes.

Random samples of 764 Finnish female qualified nurses and 453 nursing aides were asked about previous occurrence of sciatic pains by postal questionnaire (Videman et al. 1984). Of the qualified nurses 38%, and 43% of the nursing aides, had experienced pain of sciatic distribution at least once previously. Reports of six or more previous episodes were given by 18% of the qualified nurses and 23% of the nursing aides. Among 370 nursing school applicants aged on an average of 22.1 years 5% reported a previous history of sciatic pain (Cedercreutz et al. 1987).

3.3.2. Disease history

According to the United States Health Interview Survey (Bonham 1978), 1.3% of persons aged 17 or over and 2.7% of those aged 45 to 64 suffer from trouble with 'a slipped or ruptured disc' each year. The overall incidence, defined as onset of the condition within 12 months, was estimated to be 0.12%. Chronic conditions are generally underreported in interview surveys. These rates are therefore difficult to interpret.
3.3.3. Visits to physician

In an incidence study from a suburban general practice in south-eastern London, Dillane et al. (1966) recorded 605 attacks of low back pain during 24,977 person years. As regards herniated lumbar disc, incidence rates of 2.0 and 1.2 per 1000 person years for men and women, respectively, can be derived from their results. They accepted the diagnosis of herniated lumbar disc only if there was objective evidence of nerve-root pressure: paralysis or wasting of muscle or an area of anaesthesia.

3.3.4. Hospitalizations and operations

Sciatica is usually resolved by using conservative treatment, but it may also lead to hospitalization and operation. The most important indications for surgery are cauda equina syndrome, severe or progressing paresis, especially peroneus paresis, and poor response to conservative treatment (Nummi 1974; Langenskiöld 1978; SITRA 1979; Andersson and Sundén 1982). The majority of operations are elective. For example, at the Turku University Hospital in southwestern Finland only 6% of the disc operations between 1980 and 1982 were emergency operations (Hurme 1985).

In 1974, about 5,000 persons (109.3 per 100,000 population) were discharged from Finnish hospitals with a diagnosis of either sciatica (31.0/100,000) or herniated intervertebral disc (78.3/100,000) (Koota 1979). In 1977, the annual frequency of the diagnosis of herniated intervertebral disc in hospital discharge records for men aged 15-44 and 45-64 years were 126.1 and 262.4 per 100,000, respectively, the corresponding rates for women being 102.5 and 145.8, respectively (Nikiforov 1984). Comparisons between the years 1967 and 1977 showed no substantial changes during the decade (Nikiforov 1984).

In the United States, 125.3 persons per 100,000 population were discharged from short-stay hospital with first-listed diagnosis of herniated lumbar intervertebral disc in 1983 (Kozak and Moien 1985). The corresponding rates for persons aged 15-44 and 45-64 years were 157.2 and 213.4 per 100,000, respectively. The overall rates were 151.7 and 99.9 per 100,000 for men and women, respectively.
In 1978, 69.5 persons per 100,000 of the U.S. population were operated on with a diagnosis of herniated intervertebral disc (Pokras et al. 1982). The rates for men and women aged 45-64 were 156.8 and 114.4 per 100,000, respectively. The corresponding rates in Finland are considerably lower. In southwestern Finland between 1975 and 1979 the operation incidence varied from 31 to 36 per 100,000 persons (Hurme et al. 1983; Hurme 1985). The annual number of disc operations in the whole of Finland in 1982 was 41 per 100,000 population (Soini and Snellman 1983). In England and Wales in 1970 it was only about 10 per 100,000 (Benn and Wood 1975).

Hospitalized or operated cases of sciatica represent a minority of the patients (Barker 1977). The figures reviewed above therefore greatly underestimate incidence of the lumbar disc syndrome.

3.3.5. Disability

In Finland, 7,208 persons (4,433 males and 2,775 females) were granted disability pensions by the Social Insurance Institution in 1980 on the basis of displaced intervertebral disc or sciatica. This was 3.7% of all disability pensions. The numbers also include other than lumbar disc lesions. The computerized statistics of the Social Insurance Institution (SOVAKA 1986) show a three-fold increase in the numbers of persons with sciatica or herniated intervertebral disc in 1970 - 1985 among the population aged 55-64, whereas the increase in the younger population has been modest (Figure 1). The trend is very different in comparison with the disability pensions arising from other back conditions, which increased four-fold during the same period. The number of new annual disability pensions granted on the basis of disc displacement or sciatica has remained rather constant during the last fifteen years, varying between about 500 and 1,000 (Alaranta 1985). In 1980 the rate was 19.2 per 100,000 population aged 16 to 64, accounting for 3.0% of all new disability pensions, 10.8% of the pensions granted because of musculoskeletal diseases and 18.3% of the pensions granted because of back diseases (Table 1; Kansaneläkelaitoksen tilastollisia vuosikatsauksia... 1982).

The nature of the disability statistics must be considered. In the follow-up study by Alaranta et al. (1983) 18% of the patients operated on for herniated lumbar disc developed work disability postoperatively over two years. The prognosis of the other patients can be assumed as still more favourable, in particular
Figure 1. Number of current disability pensions having been granted by the Social Insurance Institution on the basis of sciatica or intervertebral disc displacement (ICD codes 353.99, 725.00 - .99) by sex, age and calendar year.

since the operation seems not to substantially affect survival from work disability (Weber 1978 and 1983). Thus the true incidence and prevalence of herniated lumbar disc are at least five times higher than is shown by the rates derived from pension statistics.

Absence because of sickness is probably the most important consequence of back pain in the working population, and the label 'disc disease' accounts for a considerable proportion of these absences (Benn and Wood 1975; Anderson 1980 and 1986). The contribution of herniated lumbar discs to those absences has not been assessed in the literature. In Finland in 1980, 780 sickness insurance periods per 100,000 population aged 16 to 64 were due to sciatica or intervertebral disc displacement (Table 2; Kansaneläkelaitoksen tilastollisia vuosikatsauksia... 1982). This accounted for 6.0% of all such periods and 23.7% of the periods resulting from musculoskeletal diseases. However, the validity of the diagnoses labelled by physicians on certificates is not known.
Table 1. New disability pensions granted by the Social Insurance Institution on the basis of sciatica or intervertebral disc displacement (ICD codes 353.99, 725.00-.99) by sex and age in 1980.

<table>
<thead>
<tr>
<th>Rate</th>
<th>Total</th>
<th>Sex</th>
<th>Age</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16-34</td>
<td>35-44</td>
<td>45-54</td>
<td>55-64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>608</td>
<td>350</td>
<td>258</td>
<td>20</td>
<td>115</td>
<td>280</td>
<td>193</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. per 100 000 population</td>
<td>19.2</td>
<td>22.2</td>
<td>16.2</td>
<td>1.3</td>
<td>18.6</td>
<td>51.0</td>
<td>40.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of all causes</td>
<td>3.0</td>
<td>3.2</td>
<td>2.7</td>
<td>0.7</td>
<td>5.9</td>
<td>4.6</td>
<td>0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of musculoskeletal conditions</td>
<td>10.8</td>
<td>14.6</td>
<td>8.0</td>
<td>14.9</td>
<td>30.3</td>
<td>15.5</td>
<td>5.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of back conditions</td>
<td>18.3</td>
<td>21.2</td>
<td>15.5</td>
<td>47.6</td>
<td>50.0</td>
<td>24.8</td>
<td>10.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. National sickness insurance spells due to sciatica or intervertebral disc displacement (ICD codes 353.99, 725.00-.99) per 100 000 population by sex and age in Finland in 1980.

<table>
<thead>
<tr>
<th>Sex</th>
<th>16-34</th>
<th>35-44</th>
<th>45-54</th>
<th>55-64</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>401</td>
<td>1 228</td>
<td>1 397</td>
<td>864</td>
<td>797</td>
</tr>
<tr>
<td>Women</td>
<td>332</td>
<td>1 285</td>
<td>1 474</td>
<td>641</td>
<td>764</td>
</tr>
<tr>
<td>Total</td>
<td>368</td>
<td>1 256</td>
<td>1 436</td>
<td>738</td>
<td>780</td>
</tr>
</tbody>
</table>
3.3.6. Overall estimates of incidence and prevalence

A tentative estimate of 5% for the prevalence of herniated lumbar intervertebral disc has been made in Great Britain using data from various registers of general practitioner consultations, admissions to hospital and sickness incapacity certifications (The challenge of arthritis and rheumatism 1977); ‘incidence’, determined as the proportion of persons experiencing the onset of symptoms during one year, was estimated to be 1%.

To sum up, the reliability and clinical relevance of the results cited above are uncertain. The data on physician visits, hospitalizations, operations, sick-leave and invalidity pensions reflect the local practice of health care and social insurance rather than the occurrence of sciatica. Validity of the interview data is unknown. Nothing definite can be said about variation according to time, place or population. However, the figures give a general idea about the frequency and impact on public health of the lumbar disc syndrome.

3.4. Risk determinants

3.4.1. Previous studies

Risk factors for lumbar disc syndrome have been investigated in only three epidemiological studies. One of them was longitudinal (Hrubec and Nashold 1975), the data on risk factors antedating the development of symptoms, whereas the two other studies were cross-sectional and case-controlled (Kelsey and Ostfeld 1975; Kelsey et al. 1984a). Little other epidemiologic research has been focused on determinants of low back pain without any special reference to disc lesions. Factors associated with herniated lumbar intervertebral disc or low back pain have also been investigated in a number of clinical series of patients, but the relevance of reference groups has been problematic in those studies.

3.4.1.1. Ad hoc epidemiological studies

Hrubec and Nashold (1975) identified 1 095 male patients who had been admitted to U.S. Army Hospitals because of herniated lumbar intervertebral discs in 1944 and 1945. They selected a control subject of the same age for each patient and compared the data, obtained from military records, of induction into
service for the two groups. Of the men 96% were between 20 and 39, and 58% between 25 and 34 years of age. The authors presupposed that early manifestations of low back disease had been sufficiently screened through the physical examination made upon entering military service and that good availability of medical care led to ready detection of the subsequently herniated lumbar discs. The following factors were found to have a statistically significant ($p < 0.05$) positive association with the risk: occupation of craftsman or foreman, married status, rural residence, body height, body weight, heavy body frame, ‘good posture’, defects relating to back or legs, military specialization in ground combat, and rank of sergeant or staff sergeant. Factors showing a negative association with admission for herniated lumbar disc were clerical occupation, two or more battle stars earned and the rank of officer. The authors concluded that the results were consistent with the general hypothesis that disc disease results from mechanical stresses on the spinal structures.

Another epidemiologic study to detect risk factors for herniated lumbar intervertebral disc was made by Kelsey and co-workers in New Haven, Connecticut (Kelsey 1975a and 1975b; Kelsey and Ostfeld 1975). Cases were found from persons aged 20 to 64 who had lumbar x-ray examinations in all three hospitals in the New Haven area and at the office of two of the private radiologists. The design was based on the assumption that the patients could be identified sensitively by these means. The patients having lumbar x-ray examination were interviewed within a few weeks and their medical records were reviewed to identify those with an acute herniated lumbar intervertebral disc. Those cases who reported previous severe back problems or whose symptoms had lasted over a year were excluded. Two control subjects were selected for each case: a person of the same age and sex who was x-rayed for a condition not related to the spine, and a person who had low-back radiographs but who was not classified as having herniated lumbar disc. No control group from the general population was available. The most important risk factors among the many variables considered were driving of motor vehicles at or away from work, sedentary occupations, suburban residence, and previous full-term pregnancies (Kelsey 1975a and 1975b; Kelsey and Hardy 1975; Kelsey et al. 1975). An association with the risk was also suggested for the high social class among females, chronic cough or chronic bronchitis, participating in baseball, golf or bowling, and lack of physical activity other than at work (Kelsey 1975b). The authors emphasized the elementary and exploratory nature of their study and stated it to be important to have their findings tested in other epidemiological
studies. The cross-sectional design and the lack of control group from the general population were the most critical limitations.

In 1979 - 1981, Kelsey et al. (1984a) repeated the former study with minor methodological modifications. On this occasion, the cases with herniated lumbar discs and two groups of control patients were selected from one neurosurgical private practice, two orthopaedic private practices and three hospitals in the New Haven and Hartford areas. A more detailed questionnaire on background factors than the one used formerly was conducted. Cigarette smoking, the number of hours spent in a motor vehicle and frequent lifting at work were found to be associated with an increased risk of herniated lumbar disc, whereas no association was found with the number of pregnancies, height, weight or participation in various sports.

3.4.1.2. Population studies on low back pain

It is often claimed or presumed that most cases of low back pain with or without sciatica may be discogenic in origin (Massie 1969; Nachemson 1971; Vanharanta et al. 1987b; Mooney 1987). Although there is no consensus about this generalization and Kelsey (1982) has emphasized that degenerated discs should be distinguished from herniated discs in epidemiologic studies, sciatica and other types of low back pain may have the same causative risk factors. Thus, selected epidemiological studies on determinants of low back pain are considered in this review.

Magora (1970) conducted a survey of 3,316 subjects employed in eight preselected occupations. The subjects were interviewed for present and past low back pains. The highest prevalence was found in heavy industry workers, bus drivers and nurses, the lowest in policemen. The subjects not satisfied with their occupation, and who felt that a high degree of responsibility and mental concentration was required of them, had a higher prevalence of low back pain than the other subjects (Magora 1973). Plain lumbar radiographs were taken from a random sample of 372 subjects with low back pain and 217 controls (Magora and Schwartz 1976). Contrary to many other studies, no relation was found between spondylarthrosis and low back pain. Neither was there any relation between spondylarthrosis and occupation or special occupational physical requirements. On the other hand, increased body weight showed a positive association with degenerative changes in the lumbar spine.
A sample of 295 male Finnish concrete reinforcement workers were interviewed about musculoskeletal symptoms and radiologically examined using plain radiographs of the lumbar spine at the Institute of Occupational Health in Helsinki (Wickström et al. 1978; Wiikeri et al. 1978). Disc degeneration showed a close association both with the history of lumbago and with the history of sciatica. The occurrence of sciatica or lumbar disc degeneration was not found to be associated with the length of reinforcement work, although a group of computer technicians who served as control had a significantly lower prevalence of sciatica. In a later study based on a new sample, sciatic pain proved to be significantly more common in reinforcement workers than in the reference group of house painters (Riihimäki 1985). In both occupational groups occurrence of sciatic pain during the previous 12 months was associated with earlier back accidents, and the higher accident rate of the reinforcement workers seemed to explain their higher rate of sciatic pain.

Frymoyer et al. (1980 and 1983) analysed the records of 3,920 patients who had attended a family practice unit. Medically reported low-back pain was found to be positively associated with occupational factors such as truck driving, lifting, pulling, pushing, twisting, using of jackhammers or machine tools, and exposure to vibration. The low-back pain sufferers were more likely to be cigarette smokers, joggers and cross-country skiers, to report episodes of anxiety and depression, and to have a higher number of previous pregnancies. A more detailed questionnaire in a subsample of 1,221 men revealed a relationship between automobile exposure and the frequency of getting into and out of a vehicle with low-back complaints (Damkot et al. 1984). Subgroups of 106 men who had never experienced low-back symptoms, 144 men who had moderate low-back pain and 71 men who had severe low-back symptoms had standardized physical measurements. These three subgroups showed no differences in height, weight, body mass index, lumbar lordosis, or leg length inequalities, while back-pain patients had less flexor and extensor strength (Pope et al. 1985). The authors concluded that their study cannot permit causal inference, although it suggests a series of significant relations that can be pursued. Interestingly, the determinants identified were mainly the same as those found to be associated with herniated lumbar intervertebral disc in other previous studies (Chapter 3.4.1.1.).

Various anthropometric and physical measurements, medical history, symptoms and social variables were studied for their prediction of low-back trouble
over a one-year period among 928 men and women who were selected to represent the adult population of Glostrup, a suburb of Copenhagen (Biering-Sørensen 1984). Body height, obesity (Rohrer’s index), leg length or femoral epicondylar width proved to be unimportant as predictors of low back pain, whereas a previous history of low back pain was found to be positively associated with height, obesity and epicondylar width. The main findings were that good isometric endurance of the back muscles predicted survival from first-time occurrence of low-back trouble and that men with hypermobile backs were more liable to contract low-back trouble (Biering-Sørensen 1984). The author concluded that strong trunk muscles may prevent low back pains. Also gastric pain, daily smoking and previous hospitalizations and operations were predictive for first-time experience of low-back trouble, suggesting that the persons likely to develop low-back trouble do not enjoy good general health even prior to their first episode of low back pain (Biering-Sørensen and Thomsen 1986).

Postal questionnaires were sent to random samples of 764 Finnish female qualified nurses and 453 nursing aides to obtain a history of low back pain, sciatica and various background factors (Videman et al. 1984). Sciatic pains, in particular pain severe enough to limit daily tasks or to make bed rest necessary, had affected nursing aides significantly more often than qualified nurses, but there was no association between self-assessed workload and sciatic pains. A marked gradual increase was observed in the life-time occurrence of sciatica with increased number of childbirths.

A postal survey of 12 000 Finnish farmers revealed that low back pain was positively associated with a history of lifting and carrying heavy loads, whole body vibration, excess weight and smoking (Penttinen 1987). A follow-up survey was made after 3 years for those persons who initially did not report back pain, but the factors mentioned above proved to have no predictive significance.

3.4.1.3. Series of patients

At the Kodak Park, a large manufacturing complex, Rowe (1965) examined all the 160 active male employees who had undergone lumbar disc surgery. Comparable statistics were obtained from a survey of male employees doing the same types of work in the same plant. A history of inguinal hernia was found to be over twice as common in the disc patients as in the other male employees. The disc group were on average nearly 2 inches taller than their fellow
workers. Only 15% of the disc patients were more than 10% overweight, whereas a similar degree of obesity was found in 22% of the nonspecific chronic low-back problem cases, and in 26% of the other men.

Goodsell (1967) analysed the medical records of 402 consecutive patients operated on at a hospital for herniated lumbar disc. He observed an increased proportion of male labourers among the patients in comparison with the census figures for the county. Farmers, as a subgroup of the labourers, proved to be most likely to have unequivocal disc ruptures. The methods used to record and to classify occupations were not reported, no statistical tests were done and age was not controlled in the comparisons.

As part of a study of prognostic factors in lumbar disc herniation, Weber (1978) compared records of 280 consecutive patients admitted to a hospital with available data from other studies and the Norwegian population. He found that the percentage of physically active men in his series was clearly less than in a random sample of Oslo men of the same age group (52.1% vs 78.7%), whereas the means or distributions of body height, sitting height, obesity, occupation and prolonged car-driving did not differ from corresponding figures obtained from other sources. The comparisons must be interpreted with caution, because no control group was included in the study.

Merriam et al. (1983) examined 174 men visiting back pain clinics in Nottingham and 126 control subjects free from low back complaints. The men who were prone to pain in the back had on average 1.78 cm greater standing height than the men who were not. This difference in the standing height was found to be due only to the pelvic component (subischial height subtracted from total leg length).

Alaranta (1985) and Hurme (1985) conducted a thorough examination for 118 men and 102 women who had been operated on for the first time for herniated lumbar intervertebral disc in Turku University Central Hospital. Occupational distribution, physical activity at work and leisure, body mass index and body height of the patients did not differ from corresponding data of the general population as obtained from other sources (Hurme 1985).
3.4.2. Review of risk determinants

Criteria for causal inference commonly applied in epidemiological research include the following items (Susser 1973 and 1986):

- **Time order**: Cause must precede consequence, which can be demonstrated only with longitudinal design.

- **Strength of association**: The stronger the relative risk for any hypothetical cause, the more likely it is to be causal.

- **Dose-response relationship**: Monotonic statistical correlation supports causality, but its absence is not falsifying.

- **Consistency on replication**: A causal association remains in the face of diversity in time, place, circumstance, population or research design.

- **Coherence**: The more it agrees with preexisting theory, knowledge and facts, the more likely the association is to be causal; the criterion of coherence thus includes overall summing up of a multitude of data.

This list of criteria is not complete but includes items that apply to the evaluation of the observations mentioned in this review.

**Age**

Herniated lumbar intervertebral discs occur mostly in persons aged between 20 and 65 years (Raal 1959; Hirsch and Nachemson 1963; Naylor 1974). The risk of undergoing surgery is highest at the age of 30 to 50 years, but the patients with sciatica who not operated on are, on average, somewhat younger than those who do undergo surgery (Kelsey and Ostfeld 1975). The reduced incidence of disc herniations in old persons is probably related to the loss of turgor and elasticity of discs with age, thus reducing the likelihood of the nucleus pulposus bulging out. At very young ages, degenerative changes in the annulus
fibrosus capsule are uncommon, and the disc is well hydrated and resilient, also making a herniation unlikely (Kelsey 1982).

A strong and consistent association prevails between age and onset of lumbar disc syndrome. The risk is highest between about 30 and 50 years of age, as is biologically plausible.

**Sex**

Case series of hospitalized patients consistently show that herniated lumbar intervertebral disc is about 1.5 to 3 times more common in men than in women (Raaf 1959; Hirsch and Nachemson 1963; Paine and Haung 1972; Marin 1974; Naylor 1974; Vogt 1974; Hagen and Engesæter 1977; Kelsey 1982; Thomas et al. 1983). A ratio of males to females of 2 to 1 has been obtained by pooling 52 published case series (Spangfort 1972). Radiological disc degeneration between the lumbar vertebrae has been found to occur in men twice as frequently as in women (Lawrence 1977). On the other hand, no excess of male cases has been observed among patients with sciatica not treated surgically (Kelsey and Ostfeld 1975). Also, back pain radiating to the leg in the general population has been reported as equally prevalent in both sexes (Takala et al. 1982). Thus the difference in the risk of herniated lumbar disc between the sexes may be explained by a greater likelihood of surgery in men than in women.

The predominance of the risk to men of the symptomatic lumbar disc herniation is great and consistent, but neither theoretical models nor biological facts have been presented to explain the sexual difference. The ‘causal’ role of the male sex remains obscure.

**Heredity**

There seems to be a definite hereditary element in disc degeneration (Wiltse 1971; Lawrence 1977). Rowe (1965) found that a history of abdominal hernia was over twice as common in male patients with lumbar disc disease than other men. He suggested that some individuals may have an inherent weakness in their discs which predisposes to herniation. However, frequent lifting or some other non-hereditary factor may have contributed to both disc injury and inguinal herniation, which can explain the coincidence. Using the survey data obtained by the Arthritis and Rheumatism Council in the United Kingdom, Lawrence (1977) estimated that of the 42 first degree relatives of persons with a
suspected disc herniation, five were considered by the physician to have had a herniated lumbar disc compared with 1.4 expected (p = 0.09).

Evidence for the possible role of heredity in intervertebral disc herniation remains to be presented in observational studies.

Size and shape of lumbar spinal canal

Herniated lumbar intervertebral discs are often symptomless (Hitselberger and Witten 1968; Wiesel et al. 1984; Powell et al. 1986). It is therefore important to recognize the anatomical factors associated with symptomatic disc disease. In addition to the size and location of the herniated nucleus pulposus, the volume in the lumbar canal seems important. To function freely, the nerve roots within the vertebral canal need space, and whenever that space is limited, neurological dysfunction may follow (Verbiest 1954 and 1977; Baddeley 1976; Roberts 1978; Critchley 1982; Troup 1986).

Patients with herniated lumbar discs have abnormally small ratios for the size of the canal to the adjacent vertebral body (Ramani 1976). The oblique sagittal diameter of the canal as measured by ultrasound has been proved short in patients with symptomatic disc lesions, particularly at L5 (Porter et al. 1978). Also the midsagittal diameter and the cross-sectional area, measured from radiographs, have been observed as being more shallow in patients with lumbar radiculopathy than in controls without back diseases (Winston et al. 1984; Kornberg and Rechtine 1985). The importance of single transversal distances has not been investigated. No vertebral measurement has been studied for its predictive value among asymptomatic subjects.

Therefore it seems to be well-established that narrowings in the lumbar vertebral canals contribute to nerve root compression syndrome. Further studies are needed to establish the importance of specific measurements at various levels of the lumbar spine.

Obesity

In United States Army recruits, weight recorded at induction into service was positively associated with the risk of developing lumbar disc herniation (Hrubec and Nashold 1975). The cross-sectional epidemiological studies failed to reveal any such relationship (Kelsey 1975b; Kelsey et al. 1984a). Excess weight has
been reported in some series of patients suffering from lumbar disc syndrome or low back pain (Gyntelberg 1974; Burke 1976; Deorio and Bianco 1982), but in the other published series the mean weight has been as expected (Rowe 1965; Hinz and Pohl 1977; Weber 1978; Hurme 1985; Pope et al. 1985). A clear-cut association between obesity and radiological disc degeneration has been observed in one study (Magora and Schwartz 1976) but not in another (Kellgren and Lawrence 1956). In a cohort representing the inhabitants of Copenhagen, the persons who had previously suffered from low back pain were found to be heavier than others, but body weight did not predict the first-time occurrence of low-back trouble over a one-year period (Biering-Sørensen 1984). In a study of 902 Finnish white-collar and blue-collar workers, no association was observed between overweight (relative weight > 120 per cent) and lumbar or sacral disorders either cross-sectionally or in ten-year follow-up (Aro and Leino 1985).

Overweight obviously adds to intradiscal pressures as well as stresses in other spinal structures. However, no studies have been carried out to determine whether compressive overload of the disc arises from obesity as such and whether any biological adaptation in the tissues of the disc follows the development of obesity.

The previous studies do not support the view that obesity is causally associated with lumbar disc syndrome, although such an association would be logical.

**Body height**

In their epidemiological studies, Hrubec and Nashold (1975) found that body height significantly predicted herniated lumbar disc among United States Army recruits. Kelsey (1975b) and Kelsey et al. (1984a) observed no differences between the heights of the patients and control subjects gathered from the New Haven area. An excess standing height (Lawrence 1955; Rowe 1965; Tauber 1970; Weir 1979) or pelvic height (Merriam et al. 1983) has been observed in several series of patients with lumbar disc herniation or sciatica. Gyntelberg (1974) reported a clear-cut association between body height and one-year incidence of low-back pain among male residents of Copenhagen.

The observed positive association between body height and risk of herniated lumbar intervertebral disc is not readily explained by existing theory and knowledge. However, many possible explanations for this association can be
considered. The link may be genetic or mechanical. Size and shape of the spinal canal (Vanharanta et al. 1985; Troup 1986), angulations between vertebral bodies, or intradiscal pressures during physical activity (Nachemson 1966) may be related to body height and make the backs of tall people vulnerable. Lawrence (1955) reported a negative association between back-hip-sciatic pain and headroom at work in coal miners, suggesting that the increased risk of sciatica in tall people might be determined by postural factors.

The association between body height and herniated lumbar intervertebral disc seems to have considerable strength and consistency, suggesting a causal connection. The criterion of time order is not relevant, because such order is self-evident. The specificity of the association further supports causal inference, as tallness is not known to predict any other illnesses in the spine or elsewhere. The biological coherence is speculative, but does not detract from the causal inference.

A causal connection between body height and herniated lumbar intervertebral disc is possible.

Trauma

Many lumbar disc herniations are traditionally thought to be traumatic in origin (Martin 1978). An important question not yet answered is whether the preceding stress or trauma was primarily responsible for damage to the intervertebral disc (Progress in back pain? 1981). In-vitro studies generally show that only previously abnormal discs will herniate posteriorly; the trauma thus acted as a precipitating factor only (Jayson et al. 1973). An attempt to simulate a traumatic disruption of annulus in necropsy specimens did not lead to herniation of the disc, which suggests that a trauma alone is not sufficient to produce a clinically significant disc herniation (Brinckmann 1986).

Nearly half of the patients with herniated lumbar discs regard a mechanical trauma as a causative factor in their first attack of low back pain (Guardjian et al. 1961; Bek and ter Weeme 1975; Weber 1978). Martin (1978), analysing detailed histories of 68 patients whose disc lesions were verified at operation, found history of trauma at the onset of backache in 72% of the cases. Since the forces involved varied from very great to minimal, he concluded that trauma may be a precipitating but not a primary factor.
Traumata may thus contribute to symptomatic lumbar disc herniations. No epidemiological evidence exists for this, however.

**Physical activity**

Physical activity may have either injurious or prophylactic influences, or both, on the lumbar intervertebral discs. Farfan et al. (1970) suggested that torsional stresses encountered in daily activity play a major role in initiating degeneration of the lumbar intervertebral discs. They subjected necropsy specimens of human lumbar spines to torsional loading and concluded that disc rupture, induced experimentally by torsion, produced changes similar to those seen in naturally occurring disc degeneration, suggesting that both changes were the result of the same causative mechanism. Thus, annular fibres do not deteriorate as the result of age only; the deterioration seems mainly due to damage and scarring of annular fibres. Further works by Farfan (1977) also suggest that lifting of heavy loads and rotation of the trunk may induce fissures in the annulus fibrosus.

Participation in baseball, golf and bowling were proved in the epidemiological study by Kelsey (1975b) to be associated with the risk of herniated lumbar intervertebral disc. The swinging motions in these sports involve torsion, which is a possible biological mechanism. However, this association was not observed in the later study made using a similar design in the same area (Kelsey et al. 1984a).

Physical activity may also have prophylactic influences. The muscles of the trunk can diminish sudden forces on an intervertebral disc that might otherwise injure the annulus fibrosus (Troup 1979).

The epidemiologic study by Kelsey (1975b) revealed an association between lack of physical activity other than at work and herniated lumbar intervertebral disc. Weber (1978) reported an unexpectedly small percentage of physically active men in his series of patients with herniated lumbar discs and suggested that physical activity at leisure may prevent sciatica or reduce the severity of an attack. However, Hurme (1985) found no difference in leisure time physical activity between patients operated on and the general population.

A number of studies have been focused on the association between low back pain and physical activity, workload or muscular strength. Among 411 workers
an increased incidence of low back pain was observed in those who were unable to demonstrate a sufficient isometric lifting strength required for the job (Chaffin and Park 1973). In a cohort representing inhabitants of Copenhagen, short isometric endurance of the back muscles significantly predicted the first-time occurrence of low-back trouble over a one-year period (Biering-Sørensen 1984). A negative association between physical activity and occurrence of low back pain was also observed in another Danish population study (Gyntelberg 1974) and in a study of male Finnish conscripts (Karvonen et al. 1980). In a study of 902 Finnish employees in the metal industry, no association was observed between muscle function at baseline and either the ten-year incidence of chronic low back disease or the development of low back symptoms (Leino et al. 1987). Whether physical activity can prevent lumbar disc herniation or its symptoms remains to be tested by future research.

Driving motor vehicles

All three epidemiologic studies focusing on the risk factors for herniated lumbar intervertebral disc consistently suggest that driving a motor vehicle increases the risk (Hrubec and Nashold 1975; Kelsey and Hardy 1975; Kelsey et al. 1984a). In one of the studies (Kelsey et al. 1984a), use of Swedish and Japanese cars was associated with lower-than-average risk of herniated lumbar disc. Both occupational and other driving seem to be involved. Furthermore, associations between automobile use and low back pain have been observed (Gruber 1976; Buckle et al. 1980; Frymoyer et al. 1980; Backman 1983; Damkot et al. 1984; Biering-Sørensen and Thomsen 1986). Also truck driving may contribute to low-back trouble (Brendstrup and Biering-Sørensen 1987).

Whole body vibration while seated, sudden starting and stopping, lack of proper support for the back and the position of the driver’s legs may induce mechanical stresses on the lumbar discs (Troup 1978; Kelsey 1982; Wilder et al. 1982). Also manual handling of materials and lack of activities strengthening both musculature and connective tissues may contribute to lumbar disc syndrome among occupational drivers.

The association between driving of motor vehicles and herniated lumbar disc seems to be close, relevant in time order, dose-related, and biologically plausible. In all, there is much evidence to support the suggestion that driving of motor vehicles is causally associated with the herniated lumbar intervertebral disc.
Occupation

Several observations have aroused the suspicion that occupational factors contribute to herniation of the lumbar intervertebral disc. Physically heavy work in general, and frequent lifting, stooping and postural stress in particular, are known as factors likely to result in low back pain (Lawrence 1955 and 1977; Troup 1965 and 1984; Magora 1970; Cust et al. 1972; Chaffin and Park 1973; Gyntelberg 1974; Anderson 1980; Rowe 1983; Damkot et al. 1984; Videman et al. 1984; Penttinen 1987). Lifting, carrying and twisted or stooped postures increase intradiscal pressures (Nachemson 1966), body vibration strains spinal structures (Troup 1978), and disc degeneration, measured radiologically, appears to occur at an unexpectedly young age among men whose work involves heavy labour (Lawrence 1955 and 1969; Wickström 1978). Also various measurements of the lumbar spinal canal vary according to occupation and history of workload (Vanharanta et al. 1987a). This may be result from work-related degenerative changes in the superior articular facets. Such changes reduce space in the lumbar spinal canal, which may contribute to nerve root compression (Troup 1986).

The previous epidemiological studies do not unequivocally support the view that the risk of herniated lumbar intervertebral disc is particularly high in physically demanding occupations, although increased risks have been reported in craftsmen and foremen, in persons with a history of frequent lifting and in nurses (Cust et al. 1972; Hrubec and Nashold 1975; Kelsey et al. 1984a; Videman et al. 1984). An especially high risk of herniated lumbar disc has been found in jobs involving lifting objects of more than 11.3 kg with the body usually twisted and the knees not bent while lifting (Kelsey et al. 1984b). On the other hand, a previous epidemiological study revealed an elevated risk among sedentary workers (Kelsey 1975a). Neither have the occupational distributions in clinical series of patients with herniated lumbar discs given any clear indication of particular occupational risks (Weber 1978; Hurme 1985). However, Goodsell (1967) has reported that herniated lumbar discs found at operation are particularly common in farmers. Also the high prevalence of sciatica in British rural males suggests an occupational influence, possibly associated with farming (Lawrence 1977).

It is difficult to make a causal inference on the basis of occupational differences in the risk. There is no clear-cut distinction between the types of work which
cause premature degeneration of the spine and those which lead only to
greater incidence of incapacity from symptoms (Troup 1965). This problem for
back pain research was realized over 20 years ago but is still topical today. If
an association between occupation and lumbar disc syndrome exists, one
cannot conclude whether it is connected with the herniated intervertebral disc
itself or only with its consequences. Furthermore, previous studies are con-
found by the high incidence of back pain in the general population and its
There are thus a number of confounding factors that may be associated with
both the occupation and the risk.

On the basis of existing theory and knowledge, one might expect an association
between occupation and herniated lumbar disc, but the results of the previous
epidemiological studies are conflicting. So far, the importance of occupational
factors with the exception of occupational driving is uncertain.

Smoking

Associations between smoking or chronic bronchitis and herniated lumbar in-
tervertebral disc (Kelsey 1975b; Kelsey et al. 1984a) and low back pain (Gyn-
telberg 1974; Frymoyer et al. 1980 and 1983; Svensson et al. 1983; Biering-
Sørensen and Thomsen 1986; Penttinen 1987) have been observed in a number
of studies. Smokers have a lower success rate than non-smokers after lumbar
disc surgery or chemonucleolysis (McFadden 1985).

The intervertebral discs are totally avascular from early childhood and therefore
dependent upon a diffusion mechanism for their metabolic balance. Theor-
etically, the largest living avascular structure in the human organism may be
vulnerable to even a minor failure of microcirculation, and an exposure to a
combination of nicotine and carbon monoxide might thus disturb the metabolic
balance of the discs. In fact, Frymoyer et al. (1983), referred to their preliminary
results to show that the amount of nicotine equivalent to that contained in one
cigarette, when injected into dogs, can cause a reduction in vertebral-body
blood flow. Also other causative mechanisms may be operative. Coughing is
known to elevate intradiscal pressure (Nachemson 1971). A fibrinolytic defect
due to smoking has also been suggested as an etiological factor in disc disease
(Jayson et al. 1984), but later on Jayson et al. (1986) rejected their previous
hypothesis by showing that the increase in blood fibrinogen is secondary to the
disc disease.
The smoking hypothesis fulfills the criteria of relevant time order, consistency on replication and theoretical and biological coherence. However, the associations reported have been only weak or moderate. A dose-response relationship has been suggested for low back pain (Frymoyer et al. 1983) but not for lumbar disc herniation. The factual coherence remains obscure, as smoking may be an indicator of other factors affecting the outcome of the lumbar disc syndrome. Potential confounding by other risk factors has not been controlled in previous studies. For example, it is possible that smokers have a psychological profile that is associated with both the smoking habit and the symptomatic disc herniation.

In all, a causal role of smoking in the herniated lumbar intervertebral disc is possible but questionable.

**Pregnancy**

The contribution of pregnancy to disc herniation has been suggested by two studies (O'Connell 1960; Kelsey et al. 1975). According to two other studies, however, herniated lumbar disc during pregnancy is very rare (King 1950; La-Ban et al. 1983). A marked gradual increase has been reported in the life-time occurrence of sciatic pain with an increase in the number of previous childbirths (Videman et al. 1984); the association was close, but the temporal relationship between the events remained undiscovered. Associations between low back pain and pregnancy have also been observed (Mantle et al. 1977; Frymoyer et al. 1980; Biering-Sørensen 1983a and 1983b), but the persistence of women’s disposition to back pain for a long period after delivery is not known.

An increased risk of herniated lumbar disc during pregnancy seems biologically plausible, since mechanical stress from carrying the baby and ligamentous laxity toward the end of pregnancy could both contribute to disc herniation.

A causal relationship between pregnancies and risk of herniated lumbar intervertebral disc seems possible and further testing of this hypothesis is therefore reasonable, but no firm evidence to support causality exists at present.
Psychological factors

The involvement of psychological factors and psychiatric disorders in low back pain seems evident and clinically well established (Crown 1978; Watson 1979). In several series of patients with low back pain, the frequency of neurotic disorders or psychological symptoms has been found to be high (Brown et al. 1954; Natvig 1970; Gentry et al. 1974; Gilchrist 1976 and 1983; Lloyd et al. 1979; Donovan et al. 1981). Reference groups have been included in fewer series. Frymoyer et al. (1980) found an increased prevalence of anxiety and depression among the patients with low back pains compared with other patients selected from open care, but no such difference was observed in another similar study (Becker and Karch 1979). Gilchrist (1976) analysed clinical data of 1 500 patients and found that low back pain was associated with anxiety neurosis but not with depressive neurosis; he thought that depression might be a reaction alternative to low back pain. Joukamaa (1986) performed a thorough psychiatric examination for 220 subjects with significant low-back pains and for 101 subjects who were free from such complaints. In his study based on the Mini-Finland Health Survey, mental disorders and symptoms occurred more frequently in individuals suffering from low back pain than in others. This was true for negative body image, weakness in ego functioning and problems in drive satisfaction. Unfortunately, the six subjects with herniated lumbar disc and the 10 with sciatica did not allow reliable inter-group comparisons.

Several epidemiologic studies have focused on the associations of psychological factors with low back pain, but there are no data about sciatica or herniated lumbar disc. Magora (1973) conducted a questionnaire survey of over 3 000 persons belonging to seven occupational groups. Low back pain occurred most commonly among the subjects who experienced disturbing responsibility or felt dissatisfaction in their jobs. Nagi et al. (1973) interviewed a population sample of over 1 000 persons and found an increased frequency of perceived mental problems among those who reported low back pains. Takala et al. (1982) investigated 2 268 persons in two rural populations and found a close relationship between psychological symptoms and the occurrence of numerous rheumatic complaints including back pain. Biering-Sørensen and Thomsen (1986) observed in their prospective study some psychosomatic symptoms to be predictive for first-time experience of low-back trouble.
In general, previous epidemiologic studies did not distinguish properly between psychiatric disorders, e.g. primary neuroses; psychological responses to pain including secondary depression and pain behaviour; and psychogenic factors that contribute etiologically to back pain ranging from the psychosocial contributors to familial, genetic or iatrogenic factors that affect pain perception. Probably psychological, rather than psychiatric, factors are important determinants of low back pain (Troup and Slade 1985).

It has been suggested that mental stress may produce an increase in the intracellular sodium concentration, with subsequent swelling of the intervertebral disc and radiating pain (Levine 1971). An early experiment in animals demonstrated swelling of the intervertebral discs in stressful situations (Scott 1955).

Since all but one (Biering-Sørensen and Thomsen 1986) of the previous epidemiologic studies were cross-sectional, the psychological disorders may be secondary to disc disease or low back pain. The temporal order of the events and possible confounding by other factors should be controlled in future studies using longitudinal designs.

Psychological factors have close associations with low back pains but hardly play a causal role in the herniated lumbar intervertebral disc.

Comments

Only three previous epidemiologic studies have been focused on risk factors for herniated lumbar intervertebral disc in particular. About 30 epidemiologic studies, on the other hand, have been published on determinants of low back pain, back disability or lumbar x-ray findings.

The nature of low back syndromes with intermittent symptoms and a wide spectrum of outcomes must be considered in the critique of causal appraisals. Therefore the previous studies with cross-sectional or retrospective designs seem to have provided much useful information. However, the current list of hypotheses has no item that can be described as having been firmly researched epidemiologically. Thus, what is needed in addition to new methodological approaches is more basic epidemiology.
4. AIMS OF THE STUDY

4.1. General aims

In general, epidemiological studies should seek to answer the following questions:

- How frequently do herniated lumbar intervertebral disc and sciatica occur?
- Who will develop disc herniation? In particular, which individual characteristics or factors predict the development of the syndrome?
- How would it be possible to prevent disc herniations or sciatica? Which predictors are modifiable and thus suitable objects for intervention?

To sum up the review of literature, neither the incidence nor the prevalence of sciatica or herniated lumbar disc are exactly known. Risk factors for herniated lumbar intervertebral disc have been sought in few epidemiological and clinical studies. The results clearly indicate that risk factors exist, but the search for predictors is still at a hypothesis-generating stage.

The general aim of the present study was to produce basic epidemiological data on the lumbar disc syndrome (herniated lumbar intervertebral disc and/or definite sciatica) in Finland. A study on musculoskeletal diseases was conducted as part of the Social Insurance Institution’s Mini-Finland Health Survey carried out in 1977 - 1980 in a representative sample of the adult population (Sievers et al. 1985). Prevalence and public health impact of the lumbar disc syndrome are to be estimated from these data.

A longitudinal design is most desirable for a study focusing on the risk factors of a disease. The Mobile Clinic Health Examination Survey of the Social Insurance Institution was focused primarily on cardiovascular diseases and their risk factors (Aromaa 1981; Reunanen et al. 1983). For the follow-up of morbidity, the records of the Finnish hospital discharge register have been linked to the study, and also other than cardiovascular diseases can be predicted as part of the follow-up. In this study a search was made for risk factors for herniated lumbar intervertebral disc and sciatica leading to hospitalization.
4.2. Specific aims

Specific aims of this study were

- to estimate the prevalence of lumbar disc syndrome (herniated lumbar disc and/or sciatica)
- to assess the need for care and the use of health services resulting from lumbar disc syndrome
- to assess the contribution of lumbar disc syndrome to disability in the population
- to seek associations between radiological measurements related to the size and shape of lumbar vertebral canals and the occurrence of lumbar disc syndrome
- to identify herniated lumbar disc occupational-risk groups and to generate hypotheses about occupational factors in the development of the syndrome
- to study body height and obesity for their prediction of herniated lumbar disc
- to identify other risk factors for herniated lumbar intervertebral disc and sciatica.
5. STUDY POPULATIONS AND METHODS

5.1. The Social Insurance Institution’s Mini-Finland Health Survey

The study population was representative of Finnish adults aged 30 or over and comprised 8,000 persons (3,637 men and 4,363 women) from 40 areas (Figure 2, Table 3).

The examinations were carried out by the Mobile Clinic of the Social Insurance Institution in two main phases, a screening phase and a clinical phase. All subjects of the sample were asked to attend the screening phase. A total of 7,217 persons (90.2% of the sample) participated (Table 4).

There were 3,775 persons (52% of those examined) who met at least one of the screening criteria for musculoskeletal diseases and were thus asked to come for re-examination. A total of 3,437 (90%) subjects participated (Table 5). To assess the sensitivity of the screening methods, an additional random sub-sample of 740 persons underwent clinical examination irrespectively of the screening results.

5.1.1. Sample

The study population was a stratified two-stage cluster sample (Kish 1965) drawn from the population register to represent the Finnish population aged 30 or over. In the first stage, 320 clusters of municipalities were formed and stratified according to social insurance regions (altogether five), degree of urbanization and proportion of people employed in industry and agriculture. The clusters were arranged in 40 strata and one cluster was selected from each stratum with a probability proportional to the size of the population in the cluster. In the second stage, the subjects were selected by systematic sampling from the 40 clusters in proportion to the relative population size of each cluster. The sample comprised 8,000 persons (3,637 men and 4,363 women).

5.1.2. Methods used in the screening phase

The methods used to study musculoskeletal diseases have been described in detail elsewhere (Sievers et al. 1985).
Figure 2. The study areas of the Mini-Finland Health Survey and the social insurance regions of Finland. The numbers indicate the temporal order of field examinations.

1. Salo, Muuriala
2. Somero, Somerniemi
3. Karjaa, Pohja
4. Helsinksi, Espoo, Vantaa, Kerava, Kauniainen
5. Porvoo
6. Kotka, Karhula, Kymi, Pyhtaa
7. Luumaki, Ylamaa
8. Savonlinna
9. Iitti, Jaala
10. Kuopio
11. Juva
12. Vihti
13. Ilomantsi
14. Suonenjoki
15. Lahti
16. Asikkala, Padasjoki
17. Jyvaskyla, Jykylan mlk, Sainatnsalo, Muurame
18. Aanevoski, Konginkangas
19. Karstuja, Kyyjarvi
20. Iisalmi
21. Kajaani, Kajaanin mlk
22. Oulu, Oulunsalo, Kempele, Hailuoto
23. Kemijarvi
24. Suomussalmi
25. Nurmo
26. Hameenkyro, Viljakkala
27. Valkeakoski
28. Kolari
29. Muhos
30. Kestilu
31. Ylivieska
32. Vaasa
33. Tampere
34. Teuva
35. Pori
36. Eura, Kiukainen
37. Hamelnila
38. Kokemaki
39. Poytya
40. Turku, Raisio, Naantali, Kaarina, Rusko, Vahto
Table 3. The population sample of the Mini-Finland Health Survey by age and sex.

<table>
<thead>
<tr>
<th>Sex</th>
<th>30-44</th>
<th>45-54</th>
<th>55-64</th>
<th>65-74</th>
<th>75-</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>1 447</td>
<td>840</td>
<td>659</td>
<td>490</td>
<td>201</td>
<td>3 637</td>
</tr>
<tr>
<td>Women</td>
<td>1 452</td>
<td>883</td>
<td>821</td>
<td>760</td>
<td>447</td>
<td>4 363</td>
</tr>
<tr>
<td>All</td>
<td>2 899</td>
<td>1 723</td>
<td>1 480</td>
<td>1 250</td>
<td>648</td>
<td>8 000</td>
</tr>
</tbody>
</table>

Table 4. Participation in the screening phase of the Mini-Finland Health Survey by sex and age.

<table>
<thead>
<tr>
<th>Age</th>
<th>Men</th>
<th></th>
<th>Women</th>
<th></th>
<th>All</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>% of sample</td>
<td>n</td>
<td>% of sample</td>
<td>n</td>
<td>% of sample</td>
</tr>
<tr>
<td>30-44</td>
<td>1 343</td>
<td>92.8</td>
<td>1 373</td>
<td>94.6</td>
<td>2 716</td>
<td>93.7</td>
</tr>
<tr>
<td>45-54</td>
<td>781</td>
<td>93.0</td>
<td>828</td>
<td>93.8</td>
<td>1 609</td>
<td>93.4</td>
</tr>
<tr>
<td>55-64</td>
<td>603</td>
<td>91.5</td>
<td>745</td>
<td>90.7</td>
<td>1 348</td>
<td>91.1</td>
</tr>
<tr>
<td>65-74</td>
<td>436</td>
<td>89.0</td>
<td>642</td>
<td>84.5</td>
<td>1 078</td>
<td>86.2</td>
</tr>
<tr>
<td>75-</td>
<td>159</td>
<td>79.1</td>
<td>307</td>
<td>68.7</td>
<td>466</td>
<td>71.9</td>
</tr>
<tr>
<td>Total</td>
<td>3 322</td>
<td>91.3</td>
<td>3 895</td>
<td>89.3</td>
<td>7 217</td>
<td>90.2</td>
</tr>
</tbody>
</table>
Table 5. Number of persons who met the screening criteria for musculoskeletal diseases and their participation in the re-examination phase of the Mini-Finland Health Survey by age and sex.

<table>
<thead>
<tr>
<th>Age</th>
<th>Men</th>
<th>Women</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Screening positive</td>
<td>Participated</td>
<td>Screening positive</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>30-44</td>
<td>417</td>
<td>379</td>
<td>90.9</td>
</tr>
<tr>
<td>45-54</td>
<td>396</td>
<td>359</td>
<td>90.7</td>
</tr>
<tr>
<td>55-64</td>
<td>387</td>
<td>351</td>
<td>90.7</td>
</tr>
<tr>
<td>65-74</td>
<td>267</td>
<td>239</td>
<td>89.5</td>
</tr>
<tr>
<td>75+</td>
<td>110</td>
<td>93</td>
<td>84.6</td>
</tr>
<tr>
<td>Total</td>
<td>1577</td>
<td>1421</td>
<td>90.1</td>
</tr>
</tbody>
</table>
Along with the invitation to attend the examination, the subjects received a basic questionnaire including questions about previous diseases, hospitalizations and operations. The questionnaire also inquired about possible reductions in working and functional capacity and about the diseases that caused them. The questionnaire also inquired about the subject’s ability to perform non-occupational tasks and leisure time activities. A separate, specific interview about the musculoskeletal system comprised questions about low back pain and sciatica and their consequences. An examination comprising ten test movements was carried out to detect functional limitations. However, no test on back function was included. The information about disability pensions drawn because of musculoskeletal diseases was obtained from the registers of the Social Insurance Institution using record linkage.

The subjects with a history, symptoms or findings suggesting musculoskeletal disease were screened for the clinical re-examination phase. The screening criteria for low back complaints were: history of lumbar surgery; absence from work for at least 30 days due to low back pain or sciatica during the previous year; history of back injury, with a permanent handicap; or history of low back pain during the previous month; or two or more episodes of pain radiating from one of the thighs to the foot; inability to perform daily tasks over one month during the preceding five years; the prescription of bed rest over six weeks or at least twice during the last five years; or continuous back pains for more than three months.

5.1.3. Methods used in the clinical phase

5.1.3.1. Diagnosis of low back syndromes

The re-examination included a standardized physical examination carried out by seven specially trained physicians, who worked according to detailed written instructions and uniform diagnostic criteria. The physical examination consisted of the inspection of back curvature, tests of flexion, extension and torsion of the back, the straight leg raising test, and mobility of limb joints. Other findings were recorded individually. The field physicians made the final diagnoses and evaluated the consequences of the diseases using all available information, including the history and the results of the physical examination. The criteria used to diagnose definite and probable low back syndrome and to classify it into
herniated lumbar disc, sciatica or some other low-back syndrome are given in Table 6.

**Table 6. Classification of low-back syndromes.**

<table>
<thead>
<tr>
<th>Syndrome</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herniated lumbar disc</td>
<td>Herniation of the intervertebral disc previously confirmed by operation or myelography</td>
</tr>
<tr>
<td>Sciatica</td>
<td>Typical symptoms or findings of lumbar nerve root compression, but no direct evidence of a herniated intervertebral disc</td>
</tr>
<tr>
<td>Lumbar disc syndrome</td>
<td>Herniated lumbar disc or sciatica</td>
</tr>
<tr>
<td>Other low-back syndrome</td>
<td>Definite or probable low-back syndrome (spondylolisthesis, spondylarthrosis, chronic muscular pain, other defined, or not classified), but no sufficient evidence of lumbar disc syndrome</td>
</tr>
</tbody>
</table>

**5.1.3.2. Need for care**

The physician recorded whether or not the patient was under medical control and whether this care was adequate. The need for medical care was assessed according to current therapeutic practice, taking into account the type and severity of the disease as well as the patient’s age and general state of health.

**5.1.3.3. Working capacity and functional ability**

The clinical examination ended with an assessment of the subject’s working capacity and functional ability. Working capacity was classified as follows: (1) not limited; (2) slightly limited: occasional difficulty in ordinary tasks, or regular difficulty in heavy or demanding tasks; (3) markedly limited: regular difficulty in ordinary tasks, or inability to accomplish heavy or demanding tasks, or long periods of sick leave; or (4) incapable of work. The following classes were used in grading functional ability: (1) not limited; (2) slightly limited: occasional difficulty in light daily activities, or regular difficulty in heavy daily activities; (3) markedly limited: regular difficulty in light daily activities or completely unable
to perform some heavy activity; or (4) almost completely or completely limited: completely unable to perform some light activity.

5.1.4. Extensive clinical examination

About one year after the baseline examination, a sample of 234 persons from South-West Finland reporting low back pain, back injury or sciatic pain with history of recurrence, significant disability or permanent trouble were invited to take part in the extensive examination at the Rehabilitation Research Centre of Social Insurance Institution, and 199 of them were clinically examined and x-rayed (Korpi 1982). Four cases were rejected, three because of technically poor radiographs and one because of lacking records on background factors. 195 subjects (83.3% of the sample, 119 women and 76 men) remained in the material of this study.

5.1.4.1. Methods used at the examination

A physiatrist performed a standardized clinical examination and diagnosed musculoskeletal diseases on the basis of all information obtained, including detailed medical history, symptoms, present physical status, plain radiographs of the lumbar spine, an electromyographic examination of the nerve roots L4 to S1 and the electric reactivity of four leg muscles (vastus lateralis, gastrocnemius, tibialis anterior and extensor digitorum brevis). Radiographs were taken of the lumbar spine of all subjects with standardized technique, using a tube/film distance of 120 cm. These examinations were carried out about one year after the screening phase (Korpi 1982).

Those without a firm diagnosis of radiculopathy were divided into a group with low back pain only (LBP-group) and a group with back and leg pain, including 22 with minor clinical signs of sciatic distribution but not severe enough for inclusion in the sciatica group (leg-pain group). The four groups were thus as follows:

- Herniated lumbar disc group: n = 6; 3 men and 3 women
- Sciatica group: n = 10; 6 men and 4 women
- Leg-pain group: n = 90; 31 men and 59 women
- LBP-group: n = 89; 36 men and 53 women
5.1.4.2. Radiographic measurements

A physiatrist who had not seen any of the patients or their clinical data made the following measurements from the plain lumbar radiographs (Vanharanta et al. 1985):

- interarticular distance (L3 to S1)
- interpedicular distance (L3 to S1)
- midsagittal diameter (L3 to L5)
- anteroposterior foraminal distance (L3 to L5)
- pedicular length (L3 to S1)

The landmarks for measures are presented in Figure 3. A total of 39 radiographs were re-read by the same observer and by a radiologist to study reliability of the measurements. The results have been published elsewhere (Vanharanta

Figure 3. A schematic drawing presenting the landmarks for radiographic measurements (Vanharanta et al. 1985).

c = INTERPEDICULAR DISTANCE
d = INTERARTICULAR DISTANCE
e = MIDSAGITTAL DIAMETER
f = AP FORAMEN
g = PEDICULAR LENGTH
et al. 1985). The intraobserver and the interobserver variations were found to be similar, and the Winer’s R coefficients indicating repeatability proved satisfactory. The best results were achieved in the interarticular distances (at L3, \( R = 0.91 \); L4, \( R = 0.71 \); L5, \( R = 0.59 \); and S1, \( R = 0.82 \)) and the poorest in the midsagittal diameters (at L3, \( R = 0.51 \); L4, \( R = 0.61 \); and L5, \( R = 0.62 \)).

5.1.5. Sensitivity of screening and reliability of diagnosis

Definite or probable lumbar disc syndrome was diagnosed in 42 of the 740 subjects who were examined clinically independently of the screening results. The rates of sensitivity in the screening for herniated lumbar disc and sciatica were 94% (15 out of 16) and 89% (23 out of 26), respectively.

Concerning the diagnosis of herniated lumbar disc, the agreement was satisfactory between the screening phase and the extensive clinical examination, the kappa value being 0.60 (95% confidence interval 0.28 - 0.92). However, a rather poor agreement (kappa = 0.25; 95% confidence interval 0.02 - 0.48) was found for the diagnosis of sciatica. McNemar’s test showed no significant systematic differences in the prevalences between the two examinations (\( \chi^2 = 0.00 \) for herniated disc and \( \chi^2 = 1.89 \) for sciatica; df = 1; \( p > 0.05 \)).

5.2. The Social Insurance Institution’s Mobile Clinic Health Examination Survey

5.2.1. General design

A cohort of Finnish adults, initially examined by the mobile clinic of the Social Insurance Institution, was followed-up for 11 years using individual record-linkage to the nationwide hospital discharge register. The total follow-up experience of all subjects was referred to for an estimation of the incidence of hospitalization due to low-back disease by sex, age and region. In order to study other factors predicting hospitalization, control subjects matched individually for sex, age and residence were selected for the subjects who had been discharged from hospital with a diagnosis of sciatica or herniated lumbar intervertebral disc (Figure 4). The subjects who had reported back pains at entry were excluded from the matched set analysis, as were those whose initial age was less than 20 or more than 59 years.
Figure 4. Study on factors predicting herniated lumbar disc or sciatica.

5.2.2. Population

Between 1966 and 1972 multiphasic screening examinations were carried out at the Social Insurance Institution's mobile clinic in 34 populations in various parts of Finland (Figure 5). Altogether 57,000 persons aged 15 or over were examined. In each of nine geographical areas, all or a random sample of the inhabitants of one or several rural and urban or semiurban communities as well as the employees of one or several factories were invited to attend the examination. The overall participation rate was 83% (Table 7).
5.2.3. Methods used at the baseline examination

A questionnaire with items concerning marital status, occupation, work strenuousness, various symptoms, history of diseases, use of medicines, smoking habits, leisure time physical activity and, in women, child bearing history was sent to the subjects together with the invitation to attend the medical check-up. The answers to this self-filled questionnaire were checked and completed, if necessary, by a specially trained nurse at the examination.
Table 7. The population sample and the participants of the Mobile Clinic Health Examination Survey by sex and age.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Sample</th>
<th>Participated</th>
<th>Alive at entry of the follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>n</td>
<td>% of the sample</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-19</td>
<td>4 744</td>
<td>3 665</td>
<td>77.3</td>
</tr>
<tr>
<td>20-29</td>
<td>9 410</td>
<td>6 990</td>
<td>74.3</td>
</tr>
<tr>
<td>30-39</td>
<td>7 254</td>
<td>6 394</td>
<td>88.1</td>
</tr>
<tr>
<td>40-49</td>
<td>6 354</td>
<td>5 588</td>
<td>87.9</td>
</tr>
<tr>
<td>50-59</td>
<td>4 682</td>
<td>4 089</td>
<td>87.3</td>
</tr>
<tr>
<td>60+</td>
<td>4 589</td>
<td>3 476</td>
<td>75.7</td>
</tr>
<tr>
<td>Total</td>
<td>37 033</td>
<td>30 202</td>
<td>81.6</td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-19</td>
<td>4 501</td>
<td>3 621</td>
<td>80.4</td>
</tr>
<tr>
<td>20-29</td>
<td>7 131</td>
<td>5 568</td>
<td>78.1</td>
</tr>
<tr>
<td>30-39</td>
<td>5 263</td>
<td>4 790</td>
<td>91.0</td>
</tr>
<tr>
<td>40-49</td>
<td>5 114</td>
<td>4 992</td>
<td>90.5</td>
</tr>
<tr>
<td>50-59</td>
<td>4 515</td>
<td>4 000</td>
<td>88.6</td>
</tr>
<tr>
<td>60+</td>
<td>5 955</td>
<td>4 307</td>
<td>72.3</td>
</tr>
<tr>
<td>Total</td>
<td>32 879</td>
<td>27 278</td>
<td>83.0</td>
</tr>
<tr>
<td>All</td>
<td>69 912</td>
<td>57 480</td>
<td>82.2</td>
</tr>
</tbody>
</table>
The exact name of the present or latest occupation, main industrial category, occupational activity (active/inactive) and partial or complete incapacity to work (capable/incapable) had been reported in the questionnaire. Specially trained research assistants coded the titles at the three-digit level using the Nordic Standard Classification of Occupations (Pohjoismainen ammattiluokittelu 1963), which is an adaptation of the ILO classification (Brockington 1967). The occupational categories used in the present study were based largely on the original main grouping (first digits of codes), but several modifications were made in order to distinguish between subgroups of male and female occupations that presumably involve varying amounts of labour straining the lower back. Thus male non-manual workers, who comprised mainly foremen and related occupations, were distinguished from more professional white-collar workers, forestry workers (mainly loggers) from other agricultural workers (mainly farmers), and motor vehicle drivers from other transport equipment operators. Nurses and related medical workers were distinguished from female white-collar occupations, and cleaners and caretakers from other female service workers.

The men were divided into social classes according to a classification system, which is based on the social status of the occupation (Rauhala 1966). This classification was not used for women, since a large proportion of women worked as housewives and no information on the occupation of the husband was collected.

In the questionnaire, the subjects were asked to classify their work as

1. very light,
2. light,
3. regular,
4. heavy or
5. very heavy.

No definition of strenuousness was provided. Since the frequencies of the extreme classes proved small, class 1 was combined with 2, and 5 with 4 to indicate strenuousness of work in this study.
The subjects were asked whether they suffered from certain symptoms suggesting psychological distress. The five items used in this study were expressed as follows: ‘Have you suffered lately from...’

- nervousness?
- fatigue?
- excessive sweating?
- heart pounding?
- headache?

Subjects could answer ‘yes’ or ‘no’ to each question. A sum index was calculated by giving one point for each symptom.

The following questions were used to obtain data of physical activity, smoking, chronic cough, parity and use of medicines:

- Do you take physical activity in your spare time? (no; yes)
- Do you smoke cigarettes? (no; less than 15 cigarettes per day; 15 or more cigarettes per day)
- Do you smoke cigars? (no; yes)
- Do you smoke a pipe? (no; yes)
- Have you stopped smoking? (no; yes)
- Do you suffer from chronic cough (over 2 weeks)? (no; yes)
- Are you taking pain killers frequently? (no; yes)
- Have you in the past 3 months taken any medicine? (no; yes)
- How many childbirths have you had? (only for women)

As part of the examination, standing height without shoes was measured and read to the nearest centimetre. Participants were weighed, without shoes in light indoor clothing, using a balance calibrated at the beginning of examinations in each study location. The weight was recorded to the nearest kilogram. Body mass index (weight/height$^2$) was used as a measure of obesity. The thickness of triceps skinfold in the right arm was measured with a calibrated Harpenden skinfold caliper according to the recommendations by Tanner (1959). The methods of anthropometric measurements and the data on body height, weight, body mass index and skinfolds have been reported in detail previously (Heliövaara and Aromaa 1980).
5.2.4. Follow-up of hospital admissions

For the follow-up of morbidity, the data of the Finnish hospital discharge register kept by the National Board of Health (Kozak 1980; Nikiforov 1984) have been linked to the study records since the beginning of 1970 (Heliövaara et al. 1984). Since the first populations were examined in 1966 and the follow-up started later, the health examination data were retrospective, if a person had been examined before 1970. In the present study, the follow-up covers all discharge records from the Finnish general hospitals, for 11 years up to the end of 1980.

Only the first hospitalization resulting from back disease was considered in the present study, and thus the first diagnosis acquired was accepted independently of subsequent diagnoses of the patient. The following five-digit codes according to the International Classification of Diseases (ICD 8th revision 1967) indicating the principal diagnosis during the hospitalization were used to form the disease categories in this study:

- 725.10 or 725.19 for herniated lumbar intervertebral disc
- 353.99 for sciatica
- 713.12, 717.00, 728.70, 728.80 or 756.18 for other back diseases (Spondylarthrosis lumbalis, Lumbago acuta, Lumbalgia, Spondylolysis or Spondylolisthesis)

5.2.5. Selection of matched case-control sets

The questionnaires of all participants who had subsequently been hospitalized for back disease were carefully checked. Subjects who had reported a history of low-back pain or symptoms suggesting sciatica were excluded, as were those less than 20 or more than 59 years old at the time of the medical examination. For each case accepted, four control subjects matched for sex, age and place of residence were selected from those surviving at least up to the time of hospitalization of the case. The questionnaires of the controls were checked to exclude subjects who had suffered from sciatica or back pain.

The individually matched case-control sets were created using a programme specifically developed at the Social Insurance Institution. Exact matching was
performed for sex and place of residence, whereas the nearest available matching was used for age within the sex-place strata (Anderson et al. 1980).

At least two controls (on average 3.6) per each case with a herniated lumbar intervertebral disc or sciatica remained in the final material. Compared with the cases, 94.6% of the controls were exactly age-matched, in 0.6% the age difference was -5 to -2 years, in 2.0% -1 year, in 2.0% 1 year, and in 0.8% 2 to 5 years. All the controls were matched exactly for sex and residence.

5.2.6. Validity of the follow-up data

A random sample of 100 cases was selected from all the subjects who had been hospitalized because of back disease during the follow-up (III). The hospital archivists were asked to send copies of the original medical records. In all 78 detailed records were received. The author classified the cases hierarchically as follows:

1. Herniated lumbar disc: recent herniation found at operation or a clearly positive myelogram when no operation performed
2. Sciatica: if not 1, leg pain and a neurologic deficiency or a positive Lasegue's test at 60 degrees or less, or a well documented pain along the sciatic nerve independently of the physical status
3. Other diagnoses

The original medical records revealed that there was no convincing evidence on herniated intervertebral disc in only one of the 19 patients who according to the register had been discharged with this diagnosis (ICD 725.10 or 725.19), resulting in high specificity (Table 8). The criteria of sciatica at least were fulfilled in 15 of the 21 patients who had been discharged with the corresponding diagnosis code (ICD 353.99), which resulted in a specificity of 84%. Nonspecific diagnoses, such as low back pain or disc degeneration, had been coded for four patients with herniated lumbar disc and four patients with sciatica and, thus, approximately one in five cases hospitalized had been omitted from follow-up as a result of inaccurate coding (III).

The best overall validity was obtained by combining hospital discharge codes ICD 353 and 725 (Table 8). The frequencies of false positive and false negative diagnoses were thus brought into balance, and a sensitivity of 80% and a specificity of 81% were obtained (III).
Table 8. Validity of the hospital discharge diagnoses as compared to the diagnoses assessed from the original case histories.

<table>
<thead>
<tr>
<th>Hospital discharge diagnosis (ICD codes)</th>
<th>Sensitivity %</th>
<th>Specificity %</th>
<th>Positive predictive value %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herniated lumbar disc (725.10; 725.19)</td>
<td>76</td>
<td>94</td>
<td>84</td>
</tr>
<tr>
<td>Sciatica (353.99)</td>
<td>37</td>
<td>84</td>
<td>71</td>
</tr>
<tr>
<td>Herniated disc or sciatica</td>
<td>80</td>
<td>81</td>
<td>83</td>
</tr>
</tbody>
</table>

5.3. Statistical methods

In the cross-sectional study (I), age-standardized prevalences were calculated using the direct method (Armitage 1971), with the Finnish population in 1980 as the standard. The impacts of lumbar disc syndrome on disability and use of health care services were expressed as population attributable fractions (Miettinen 1974). The fractions were calculated on the basis of the age-adjusted prevalences of the items among the subjects with and without lumbar disc syndrome. Differences in the age-adjusted prevalences between men and women were tested by means of likelihood ratio statistics based on a logistic model (Cox 1970). Mantel-Haenszel’s statistics were used to test differences in the frequency of disability and use of services between diagnostic categories (Mantel and Haenszel 1959), because the logistic model often proved not to converge for these comparisons.

A general linear model (analysis of covariance) was used to demonstrate independent differences in spinal canal measurements (II) between the subjects who had herniated lumbar disc, sciatica, undefined leg pains and low-back pains only (Searle 1971). The results were expressed as adjusted mean values of the radiologic measurements, and the significance of variation between the back pain categories was tested using F-test (Searle 1971).
In the follow-up study (III), an exponential log-linear survival model (Kalbfleisch and Prentice 1980), an adaptation of Cox’s life-table regression model (Cox 1972), was used to estimate the relative risks and Wald’s test statistics for the categories of sex, age, region and type of population.

In the longitudinal case-control study with individually matched data (III - V), a conditional logistic model was used to estimate the relative risks (odds ratios), their 95% confidence limits, Wald’s test statistics and likelihood ratio statistics (Breslow and Day 1980).

Kappa-coefficients were calculated to estimate agreement between data obtained using various methods or from separate sources (Fleiss 1981). Systematic differences between the prevalences were tested by McNemar’s test (Fleiss 1981). Validity of the methods proper in relation to references was expressed in terms of sensitivity (true positives correctly identified / all true positives) and specificity (true negatives correctly identified / all true negatives). Using these methods, comparisons were made between diagnoses made in the field examination proper and the extensive clinical examination (I), between the self-assessed degree of disability and the corresponding assessments based on the clinical examination (I), and between low-back diagnoses in the hospital discharge register and diagnostic assessments based on the original case histories (III).
6. RESULTS

6.1. Prevalence and public health impact of lumbar disc syndrome

The prevalence study (I) was conducted as part of the Social Insurance Institution’s Mini-Finland Health Survey carried out in 1977-80 in a representative sample of the adult Finnish population (Sievers et al. 1985).

6.1.1. Symptom history

Pain radiating from one of the thighs to the foot proved to be highly common, as almost 40% of the participants reported at the interview that they had previously suffered from it (Table 9). The pain had recurred frequently: over 20% of the population had experienced 6 or more episodes of radiating leg pains. Separate inquiries were not made about the current leg pains, but almost 20% of the population reported having had sciatica at some time and pain either in the back or leg during the last month. Severe or chronic symptoms were less prevalent. Only 3% of the interviewed subjects had been obliged to rest in bed because of sciatica during the preceding five years, and less than 3% reported “a continuous leg pain”. The leg pains were most prevalent in the age groups of 45 to 64 years. Females were significantly more often affected than males, but the absolute difference was small and the profile of leg pain symptoms was similar in both sexes (Table 9).

6.1.2. Prevalence

The prevalences of definite and probable sciatica and herniated lumbar disc are presented in Figure 6 (I). The overall prevalence of lumbar disc syndrome was significantly \( p = 0.005 \) higher in men (5.3%) than in women (3.7%). In both sexes, the prevalence was highest in those aged 45-64. Other types of low-back syndrome, on the other hand, were prevalent also in old age and no significant difference was found between men and women (I). When the observed prevalence (4.3%) was corrected for the approximative screening failure, an overall estimate of 4.8% was obtained.
Table 9. History of sciatica ('Have you ever had pains radiating from one of the thighs to the foot?') and low back pain by sex and age. Proportions (%) of persons with various symptom histories.

<table>
<thead>
<tr>
<th>Item of questionnaire</th>
<th>Men</th>
<th>Women</th>
<th>Age-standardized</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30-44 45-54 55-64 65-74 75+ Total</td>
<td>30-44 45-54 55-64 65-74 75+ Total</td>
<td>Men</td>
</tr>
<tr>
<td>Sciatica ever</td>
<td>24.7 43.8 44.0 39.2 36.5 35.1</td>
<td>31.1 47.3 49.0 43.0 27.4 39.6</td>
<td>35.3</td>
</tr>
<tr>
<td>Sciatica, 6 or more episodes</td>
<td>12.1 27.4 26.5 22.0 22.6 20.1</td>
<td>13.8 25.2 28.1 24.1 15.3 20.8</td>
<td>20.3</td>
</tr>
<tr>
<td>Sciatica continuously</td>
<td>1.3 4.6 3.7 3.0 2.5 2.8</td>
<td>1.2 4.1 3.6 1.3 2.0 2.3</td>
<td>2.7</td>
</tr>
<tr>
<td>Bed rest of 2 weeks or more during the last 5 years because of sciatica</td>
<td>3.1 3.5 3.7 1.8 0.6 3.0</td>
<td>2.8 4.5 3.4 2.3 1.0 3.1</td>
<td>2.9</td>
</tr>
<tr>
<td>Sciatica ever, back or leg pain during the last month</td>
<td>10.2 25.0 23.2 19.7 10.7 17.3</td>
<td>14.4 23.8 27.8 18.7 11.4 19.4</td>
<td>17.0</td>
</tr>
<tr>
<td>Low back pain ever</td>
<td>73.7 81.3 83.1 74.3 66.7 76.9</td>
<td>70.0 78.6 78.9 75.1 61.6 73.7</td>
<td>76.5</td>
</tr>
<tr>
<td>Low back pain, 6 or more episodes</td>
<td>47.2 60.2 65.0 58.7 50.3 55.2</td>
<td>46.9 58.5 62.8 55.1 46.9 53.8</td>
<td>56.9</td>
</tr>
</tbody>
</table>

^1Logistic model.
6.1.3. Disability

The differences in the disability between the diagnostic categories varied similarly in both sexes, and so the results for men and women were combined (I). The fractions of reductions attributable to lumbar disc syndrome in everyday duties apart from work and in leisure time activities were estimated to be 3.5% and 4.7%, respectively (Table 10). According to the field physician, the ability to perform daily activities was at least slightly limited in 56%, at least markedly limited in 21% and severely limited in 5% of the subjects with lumbar disc syndrome. No significant differences were found when the results were compared with the corresponding assessments of the subjects in whom other low-back syndrome was diagnosed.

According to both the self-completed questionnaire and the physician’s assessment at the clinical examination (Table 11), 15% of the subjects less than 65 years old and having lumbar disc syndrome were completely incapable of working in their present or last occupation (I). The fraction of work disability attributable to lumbar disc syndrome was estimated to be 6%.
Table 10. Age-standardized prevalences (%) of various kinds of handicap in men and women with lumbar disc syndrome, other low-back syndrome, and no low-back diagnosis.

<table>
<thead>
<tr>
<th>Handicap</th>
<th>Lumbar disc syndrome</th>
<th>Other low-back syndrome</th>
<th>No low-back diagnosis</th>
<th>Fraction (%) of the population attributable to lumbar disc syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-reported in questionnaire</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obliged to abandon or to reduce duties apart from job</td>
<td>33.0</td>
<td>34.0</td>
<td>18.2***</td>
<td>3.5</td>
</tr>
<tr>
<td>Obliged to cut down or to reduce leisure time activities</td>
<td>40.2</td>
<td>38.7</td>
<td>18.6***</td>
<td>4.7</td>
</tr>
<tr>
<td>Assessed at clinical examination</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At least slightly limited performance for daily activities</td>
<td>55.6</td>
<td>53.4</td>
<td>29.3***</td>
<td>3.7</td>
</tr>
<tr>
<td>At least markedly limited performance for daily activities</td>
<td>21.1</td>
<td>23.7</td>
<td>14.1***</td>
<td>2.5</td>
</tr>
<tr>
<td>Severely limited performance for daily activities</td>
<td>5.2</td>
<td>4.6</td>
<td>2.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Number of subjects</td>
<td>326</td>
<td>927</td>
<td>5,964</td>
<td></td>
</tr>
</tbody>
</table>

Difference to the lumbar disc syndrome as tested with Mantel-Haenszel statistics: *** p < 0.001; unsigned if p > 0.05.

6.1.4. Need for and use of medical services

According to the field physician, 51% of the patients with lumbar disc syndrome needed medical care (Table 12). In 84% of these the need was adequately met. The estimated numbers of patients in Finland are given in Table 13 (I).
Table 11. Age-standardized prevalences (%) of work disability in men and women aged 30 to 64 with lumbar disc syndrome, other low-back syndrome, and no low-back diagnosis.

<table>
<thead>
<tr>
<th>Work disability</th>
<th>Lumbar disc syndrome</th>
<th>Other low-back syndrome</th>
<th>No low-back diagnosis</th>
<th>Fraction (%) of the population attributable to lumbar disc syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least slight</td>
<td>58.2</td>
<td>46.1**</td>
<td>18.1***</td>
<td>7.5</td>
</tr>
<tr>
<td>At least marked</td>
<td>26.8</td>
<td>21.7**</td>
<td>10.1***</td>
<td>7.7</td>
</tr>
<tr>
<td>Complete</td>
<td>14.5</td>
<td>11.1</td>
<td>6.4***</td>
<td>6.5</td>
</tr>
<tr>
<td>Number of subjects</td>
<td>289</td>
<td>660</td>
<td>4 724</td>
<td></td>
</tr>
</tbody>
</table>

Difference to the lumbar disc syndrome as tested with Mantel-Haenszel statistics: **p < 0.01; ***p < 0.001; unsigned if p > 0.05.

Table 12. Met and unmet need for medical care due to lumbar disc syndrome (definite or probable). Age-standardized percentages.

<table>
<thead>
<tr>
<th>Assessment at the clinical examination</th>
<th>Men</th>
<th>Women</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumbar disc syndrome diagnosed; prevalence</td>
<td>5.1</td>
<td>3.7</td>
<td>4.3</td>
</tr>
<tr>
<td>Prevalence corrected for screening failure</td>
<td>5.6</td>
<td>4.1</td>
<td>4.8</td>
</tr>
<tr>
<td>Need for care</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- proportion of the population</td>
<td>2.7</td>
<td>2.2</td>
<td>2.4</td>
</tr>
<tr>
<td>- proportion of the patients</td>
<td>48.6</td>
<td>53.7</td>
<td>51.0</td>
</tr>
<tr>
<td>Care adequately met</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- proportion of the population</td>
<td>2.2</td>
<td>1.9</td>
<td>2.1</td>
</tr>
<tr>
<td>- proportion of the need for care</td>
<td>80.8</td>
<td>87.8</td>
<td>84.0</td>
</tr>
</tbody>
</table>
Table 13. Lumbar disc syndrome and the need for medical care in the Finnish population aged 30 or over. The estimated numbers of patients are based on age-standardized prevalences corrected for screening failure.

<table>
<thead>
<tr>
<th>Group</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population aged 30 or over</td>
<td>2,651,000</td>
</tr>
<tr>
<td>Patients with lumbar disc syndrome</td>
<td>127,000</td>
</tr>
<tr>
<td>Patients who need medical control</td>
<td>65,000</td>
</tr>
<tr>
<td>Patients whose need for care is inadequately met</td>
<td>9,000</td>
</tr>
</tbody>
</table>

Table 14. Use of health services in men and women with lumbar disc syndrome (herniated lumbar intervertebral disc or sciatica), other low-back syndrome and no low-back diagnosis. Age-standardized percentages.

<table>
<thead>
<tr>
<th>History of health service use</th>
<th>Lumbar disc syndrome</th>
<th>Other low-back syndrome</th>
<th>No low-back syndrome</th>
<th>Fraction (%) of the population attributable to lumbar disc syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least ten visits to physician during the last 12 months</td>
<td>10.8</td>
<td>8.0</td>
<td>3.8***</td>
<td>5.0</td>
</tr>
<tr>
<td>Ever hospitalized because of low-back condition</td>
<td>31.9</td>
<td>8.4***</td>
<td>1.8***</td>
<td>35.9</td>
</tr>
<tr>
<td>Ever operated for low-back condition</td>
<td>21.4</td>
<td>1.4***</td>
<td>0.5***</td>
<td>65.0</td>
</tr>
<tr>
<td>Number of subjects</td>
<td>326</td>
<td>927</td>
<td>5,964</td>
<td></td>
</tr>
</tbody>
</table>

Difference to the lumbar disc syndrome as tested with Mantel-Haenszel statistics: **p < 0.001; unsigned if p > 0.05.

During the last 12 months the subjects with lumbar disc syndrome had visited a physician on average 3.8 times, those with other low back syndrome 3.4 times, and those without back diagnosis 2.3 times, respectively (I). The use of medical services did not differ between men and women. Only their com-
bined results have therefore been given in Table 14. Heavy use of primary health care services (10 or more annual visits to physician) was particularly common in the presence of lumbar disc syndrome, and 5% of this use was estimated to be attributable to the syndrome. Of the subjects with lumbar disc syndrome, 32% had previously been hospitalized and 21% operated on because of low-back condition.

6.2. Lumbar vertebral canals

Several vertebral measurements varied considerably between the four original clinical groups both in the male and female back-pain population, but this total variation was statistically significant only for the interarticular distance of the first sacral vertebra (II). However, measurements did not appear to differ between the subjects who had a history of non-definite leg pains and those with low back pains only.

In the second phase, the original clinical groups were pooled to constitute a dichotomous differentiation into herniated lumbar disc or definite sciatica and other back syndromes and the adjusted means of the radiological measurements were compared between the combined categories of men and women (II). The interarticular distance of the first sacral vertebra was found to be greatly narrowed in the presence of sciatica: the mean difference of the distances was 4.6 mm (p = 0.02) in men and 6.5 mm (p = 0.002) in women (Figure 7). Also the interarticular distance at L3 level was clearly smaller in the sciatica group, although the difference was statistically significant only among females (p = 0.03) but not among males (p = 0.08). The other indicator of transversal dimension, the interpedicular distance, proved equal in the two diagnostic categories at all levels of the lumbar spine. As regards sagittal dimensions, narrowing was suggested particularly in the anteroposterior foraminal distances of all lumbar vertebrae and in the pedicular length of the first sacral vertebra among the male subjects who had herniated lumbar disc or definite sciatica, but the differences to the reference group were quite small and did not reach statistical significance (II).

6.3. Risk determinants

Altogether 1,537 subjects of the 57,000 participants of the Social Insurance Institution’s Mobile Clinic Health Examination Survey were hospitalized because
Figure 7. Mean interarticular distances (mm) of lumbar vertebrae in men and women with (triangles) and without (spots) lumbar disc syndrome. The means were adjusted using an analysis of covariance; age, body height, body mass index, occupation and parity of women were allowed for. P-values indicate statistical significance of the difference at each level of the spine.

of a back disease during the subsequent 558,074 person-years of follow-up (III). The discharge diagnosis was herniated lumbar intervertebral disc in 454 (30%), sciatica in 371 (24%) and other back disease in 712 (46%) cases.

Sex, age, geographical region and type of population were analysed for their prediction of back diseases using the total experience of follow-up, independently of eventual back diseases or symptoms recorded at the baseline examination (III).

Characteristics other than those mentioned above were studied for their prediction of herniated lumbar intervertebral disc and sciatica by comparing the cases with the controls who were matched individually for sex, age and place
of residence (III - V). Both the cases and their controls had been aged 20 to 59 and free from severe back complaints at the baseline survey.

6.3.1. Sex

In relation to women, men had a 1.6-fold risk of herniated lumbar intervertebral disc and a 1.3-fold risk of sciatica, but no significant difference was found in the risk of other back diseases between the sexes (III). These differences agree with the results received in the prevalence study (I).

6.3.2. Age

The risk of subsequent hospitalization because of back disease increased markedly with initial age up to 49 years but thereafter declined gradually (III). The decline was very conspicuous in the risk of herniated lumbar intervertebral disc, smaller in the risk of sciatica, and negligible in the risk of other back diseases. A similar profile of age-specific rates was observed in the prevalence study (I).

6.3.3. Geographical area of residence

The risk of hospitalization because of back disease varied considerably between the six geographical regions as well as between urban, rural and industrial populations, but the variation was different for herniated lumbar disc, sciatica and other low-back pain (III). The relative risk of herniated lumbar disc (0.8) and the relative risk of sciatica (0.9) in rural populations were quite low compared with the urban populations (reference, 1.0), unlike the risk of other low-back pain leading to hospitalization (1.6). In northern Finland, the relative risks of herniated lumbar disc and sciatica were low in comparison with the corresponding rates in southwestern Finland (1.0), whereas the risk of other low-back pain in the northern Finland was high (1.9). These results suggest inconsistency in diagnostic practice for back diseases and, perhaps, differences in the availability of orthopaedic services.

6.3.4. Marital status

The risk of herniated lumbar intervertebral disc or sciatica was independent of marital status (III).
6.3.5. Social class

In men, the risk varied considerably between social classes. The variation was particularly marked when not only herniated lumbar disc but also sciatica was considered to be a diagnostic end-point, but a similar predictive pattern was also found for herniated disc alone (III). The social class gradient of the risk was convex in shape, the risk being highest in the middle classes, especially in the third one (4.0, 95% confidence interval 2.3 - 6.8), and declining towards the lowest social class.

6.3.6. Occupation

In men, the risk of hospitalization because of herniated lumbar intervertebral disc or sciatica varied markedly according to occupation (III, IV). The risk was smallest among men working in professional or other white-collar occupations (Figure 8). Motor vehicle drivers had the highest risk: for lumbar disc herniation it was about three times and for herniated disc or sciatica it was over four times that of professional workers (IV). The relative risks were also high in industrial occupations, especially among metal or machine workers (Figure 8).

The risk according to occupation varied clearly less in women than in men. The housewives who reported no other previous occupation at the initial examination were found to have the lowest risk (IV).

6.3.7. Strenuousness of work

Self-assessed strenuousness of work did not predict herniated lumbar intervertebral disc or sciatica in men, but women who had reported that they did light work showed a significantly lower risk than did women involved in normal or strenuous work (IV, Figure 9). The other explanatory factors including occupational category did not significantly confound this association.

6.3.8. Leisure time physical activity

No association was found between leisure time physical activity and risk of herniated lumbar intervertebral disc or sciatica (III).
**Figure 8.** Relative risk of herniated lumbar intervertebral disc (spotted columns) and that of herniated disc or sciatica (lined columns) in men by occupation. Occupational activity, self-reported work incapability, work load, smoking, chronic cough, symptoms suggesting psychological distress, and use of analgesics allowed for in the statistical analyses.

<table>
<thead>
<tr>
<th>Occupational Group</th>
<th>Relative Risk</th>
<th>Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional and Other White-Collar Workers</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>(Reference Group)</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Intermediate Non-Manual Workers</td>
<td>2.3 (*)</td>
<td>2.36 **</td>
</tr>
<tr>
<td>Forestry Workers</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Farmers and Other Agricultural Workers</td>
<td>1.33 *</td>
<td></td>
</tr>
<tr>
<td>Motor Vehicle Drivers</td>
<td>0.31 *</td>
<td>0.01 **</td>
</tr>
<tr>
<td>Metal or Machine Workers</td>
<td>1.03 *</td>
<td>0.01 **</td>
</tr>
<tr>
<td>Construction Workers</td>
<td>1.47 *</td>
<td>0.01 **</td>
</tr>
<tr>
<td>Chemical Processors and Paper Workers</td>
<td>1.23 *</td>
<td>0.01 **</td>
</tr>
<tr>
<td>Other Industrial Workers</td>
<td>2.11</td>
<td></td>
</tr>
<tr>
<td>Service, Workers and Others</td>
<td>2.33</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Difference from the reference group: *p < 0.05; **p < 0.01; ***p < 0.001.

### 6.3.9. Parity

Parity of women, as measured by the number of childbirths, was suggested to be of some predictive importance (III). Compared with nulliparous women the relative risk of herniated lumbar disc or sciatica in women who had reported one childbirth was 1.8 (95% confidence interval 1.1 - 2.9), but the significance did not persist in multivariate analysis when other predictors were allowed for. Neither did more than one childbirth increase the risk further.
Figure 9. Relative risk of herniated lumbar disc or sciatica in women by strenuousness of work. Occupational category, occupational activity, self-reported work incapability, smoking, chronic cough, symptoms suggesting psychological distress, and use of analgesics have been allowed for in the statistical analyses.

Difference from the reference group: \(^*p < 0.05\).

6.3.10. Smoking and chronic cough

Smoking and a history of chronic cough were weakly associated with an increased risk of herniated lumbar intervertebral disc or sciatica (III). Since no differences in the risk were found between those who smoked at least 15 cigarettes per day and those who smoked less, or between ex-smokers and those who had never smoked, these categories were paired. Among male smokers, as compared with non-smokers, the univariate relative risk was 1.4 (95% confidence interval 1.0 - 1.9), whereas no significant difference in risk was found if sciatica was also considered as an end-point of the follow-up or if other explanatory variables were allowed for. In turn, a history of chronic cough predicted herniated lumbar disc or sciatica (relative risk 1.5, 95% confidence interval 1.1 - 2.0) but not herniated disc alone. Also the women who smoked or reported chronic cough appeared to have an elevated risk, but the relative risks did not reach statistical significance (\(p > 0.05\)). The interaction between smoking and chronic cough analysed separately had no predictive importance.
6.3.11. Psychological distress

Symptoms suggesting psychological distress including nervousness, fatigue, excessive sweating, heart pounding and headache, indicated an increased risk of herniated lumbar intervertebral disc or sciatica, especially among women (III). Univariate analyses showed relative risks from 1.2 to 1.7 in women and 1.2 to 1.4 in men having reported these symptoms, but the independent predictive values of single symptoms were blurred by their strong intercorrelations. The presence of any distress symptom approximately doubled the risk of herniated lumbar intervertebral disc or sciatica in women and this relationship was not markedly confounded by other factors. But the relative risk tended to remain at the same level with an increase in the number of symptoms reported. The risk was also slightly elevated in men suffering from distress symptoms, but not at a significant level.

6.3.12. Use of analgesics

Frequent use of analgesics proved a significant predictor of hospitalization for herniated lumbar intervertebral disc or sciatica among women but not among men (III). The univariate relative risk in women with a history of frequent use of analgesics was 2.1 (95% confidence interval 1.4 - 3.2) and the multivariate relative risk after adjustment for other predictors 1.9 (1.2 - 3.0).

6.3.13. Body height

Body height was a significant predictor of herniated lumbar intervertebral disc in both sexes (V). The relative risk as a conditional logistic function of height increased, on average, 5% among men and 4% among women per one centimetre increase in body height. When the heights were classified at intervals of 5 cm, no clear effect on the risk was found until the height reached 180 cm in men or 170 cm in women; but beyond these critical limits the risk of herniated lumbar disc in the tallest men was over two-fold and in the tallest women over three-fold in relation to those who were more than 10 cm shorter (Table 15). The linearity hypothesis could not be rejected, however, since body height as a classified variable lost its independent predictive significance both in men ($\chi^2 = 5.24$, df = 3, p = 0.15) and in women ($\chi^2 = 4.89$, df = 3, p = 0.18) when
height was allowed for as a continuous variable. Other explanatory factors did not confound the association between body height and risk of herniated lumbar disc, as shown by the results of the multifactorial analyses. Neither did the inclusion of sciatica in the diagnostic category change the results.

Table 15. Adjusted relative risk of herniated lumbar intervertebral disc according to height in men and women. Body mass index, triceps skinfold, smoking, occupation, and social class (only for men) have been allowed for.

<table>
<thead>
<tr>
<th>Height (cm)</th>
<th>No. of cases</th>
<th>Total no.</th>
<th>Relative risk</th>
<th>95 % confidence limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 169</td>
<td>50</td>
<td>267</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>170 - 174</td>
<td>63</td>
<td>300</td>
<td>1.1</td>
<td>0.7 - 1.7</td>
</tr>
<tr>
<td>175 - 179</td>
<td>44</td>
<td>239</td>
<td>1.1</td>
<td>0.7 - 1.7</td>
</tr>
<tr>
<td>180 -</td>
<td>55</td>
<td>173</td>
<td>2.3</td>
<td>1.4 - 3.9</td>
</tr>
<tr>
<td>$\chi^2 = 14.95$, df = 3, p = 0.002</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 159</td>
<td>49</td>
<td>237</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>160 - 164</td>
<td>36</td>
<td>190</td>
<td>1.0</td>
<td>0.6 - 1.6</td>
</tr>
<tr>
<td>165 - 169</td>
<td>20</td>
<td>95</td>
<td>1.2</td>
<td>0.6 - 2.3</td>
</tr>
<tr>
<td>170 -</td>
<td>15</td>
<td>36</td>
<td>3.7</td>
<td>1.6 - 8.6</td>
</tr>
<tr>
<td>$\chi^2 = 9.91$, df = 3, p = 0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.3.14. Obesity

Thickness of triceps skinfold did not prove to be a significant predictor of herniated lumbar disc (V). In addition to the continuous variable, various classifications such as quintiles, deciles and intervals of 3 mm were also tested for their predictive power, with negligible results.

Body mass index as a continuous variable showed no significant association with the risk of herniated lumbar intervertebral disc (V). When classified at in-
Intervals of 2 kg/m², body mass index was, however, of predictive significance in men (Figure 10) but not in women. The linearity hypothesis was rejected, as the classified variable maintained its statistical significance even though the continuous variable was allowed for ($\chi^2 = 12.90$, df = 5, $p = 0.02$). The gradients formed a convex shape, the risk being lowest for the thinnest men with body mass indices below 22.0 kg/m², and declining again for the most obese men (Figure 10). The other explanatory variables considered in the present study had a suppressive effect on the association between body mass index and risk of herniated lumbar disc in men, as the relative risk rates increased when they were included in the predictive model. The predictive power of the body mass index was completely independent of the thickness of the triceps skinfold, although these two measurements of obesity were closely correlated ($r = 0.57$).

**Figure 10.** Adjusted relative risk of herniated lumbar disc in men by body mass index (weight/height squared). Triceps skinfold, height, occupation, social class and smoking were allowed for.

![Bar chart showing adjusted relative risk by body mass index](image)

**BODY MASS INDEX (kg/m²)**

Difference from the reference group: **p < 0.01; ***p < 0.001.**
7. DISCUSSION

7.1. Study populations

The Mini-Finland Health Survey

The representative sample and the high participation rate (90%) allow generalizations about the results to be made (I). The two-staged stratified cluster sampling had satisfactory properties with respect to statistical efficiency, as demonstrated in a previous study by Lehtonen and Kuusela (1986). In particular, the estimated design effects on the prevalences of musculoskeletal conditions in age and sex classes were found to be small.

Subsample for the lumbar x-ray examination

The subject-material for lumbar x-ray examination represents middle-aged men and women with a previous history of significant low-back complaints (II, Korpi 1982). An additional control group of completely symptom-free persons would have been useful to validate the comparisons, but it was unfortunately not available.

The Mobile Clinic Health Examination Survey

The cohort was selected from 34 municipalities in various parts of Finland (III-V). It allows generalization of the results with few reservations. The samples selected in each major area do not constitute a random sample of inhabitants in that area, in particular because none of the largest cities was included. Thus the study population was not fully representative of the whole Finnish population. The total sample was many-sided, however, and its occupational distribution closely resembled that of the whole country. In all, the representativeness of the sample can be considered satisfactory for the purposes of the present study. The quality of the study population cannot have considerably affected the applicability to the whole population of the results.
7.2. Methods

Screening and clinical examination

Little previous experience of low-back screening was available when the methods for detecting musculoskeletal diseases were chosen for the Mini-Finland Health Survey. Quality of the screening and diagnostic judgements was therefore controlled during the field examinations. The methods used to study musculoskeletal diseases have been discussed in more detail elsewhere (Sievers et al. 1985).

The screening of low back pain was sufficiently sensitive, picking up 90% of the subjects who had definite or probable lumbar disc syndrome (I).

The diagnoses were based on standardized clinical examinations by specially trained physicians; the results can therefore be considered accurate. However, even the diagnoses made by skillful physicians may be surprisingly unreliable (Koran 1975). A trial of reliability was therefore constructed within the study design. The agreement in the diagnosis of herniated lumbar disc between the field phase proper and extensive clinical examination was satisfactory, whereas the diagnosis of sciatica proved to be more difficult to reproduce after one year (I). This could be expected, since sciatica is very likely to be labile with time (Weber 1978). The point prevalence of sciatica obtained in the present study is still correct if the diagnosis was reliable and only the clinical course fluctuated with time, but this remained unconfirmed.

Radiological method

The measurements of the size and shape of the lumbar spinal canal obtained from plain lumbar radiographs have been demonstrated as valid compared with bony specimens from cadavers, although systematic shifts of measurements in relation to bony references occur (Eisenstein 1977; Leiviskä et al. 1985; Malmivaara et al. 1986). However, such shifts cannot bias a comparative study such as the present one (II). The radiological measurements performed in the present series have proved repeatable, as described previously (Vanharanta et al. 1985). In all, there is convincing evidence that the radiological method was accurate.
Follow-up by hospital discharge records

Incidence data were obtained by record linkage to the National Hospital Discharge Register (III-V). The follow-up covered only the incidence cases admitted to hospitals, but only a minority of all patients suffering from sciatica are ever hospitalized. According to the results of the Mini-Finland Health Survey, one-third of the persons with lumbar disc syndrome have previously been hospitalized for the syndrome (1). The hospitalized persons are far from representative of all people with herniated lumbar discs. Since the risk factors (III-V) may be associated with the hospitalization rather than the disease condition itself, causal appraisals should be made with caution.

The coverage of the hospital discharge register and the reliability of diagnoses coded for the discharge records affect the results. In a previous study, the follow-up information proved to be sufficiently valid for stroke and myocardial infarction (Heliövaara et al. 1984). It was also concluded that the results can be generalized to apply to other diseases and that no selection bias is expected in prospective studies where the outcome of disease is predicted by characteristics of individuals. This concerns age, sex, smoking, parity, distress symptoms and anthropometric measurements (III, V).

According to the previous study (Heliövaara et al. 1984), the coverage of identifiable records in the hospital discharge register can also be generalized to be about 80% for sciatica and herniated lumbar disc. According to this study (III), the sensitivity of the diagnosis codes (ICD 353 or 725) was 80%. Thus, about 20% of the incidence cases actually hospitalized for sciatica or herniated lumbar disc were omitted because of incomplete coverage of the follow-up data and a further 20% as a result of diagnostic inaccuracy. This loss may be related to geographical region (Heliövaara et al. 1984). The variation in the risk found between regions and types of population may thus have been confounded by the selectively incomplete accuracy of the follow-up (III). However, this possible bias has not affected the comparisons within the matched case-control sets.

The first admission to hospital because of any back disease was considered in the follow-up. This methodological choice was made for practical reasons to simplify the data-analysis. The true incidence cases, whose diagnoses of sciatica or herniated lumbar disc were preceded by an admission with other diagnoses, have therefore been omitted. However, it is unlikely that this has affected the results.
Identification of risk factors was based on comparisons between subjects who had developed herniation of lumbar intervertebral disc or sciatica and individually matched sets of control subjects from the same place of residence (III-V). The matching was necessary, because the availability of hospital services might vary substantially between the populations studied. Although the occupational distribution of the subjects participating in the baseline examinations closely resembled that in the whole of Finland, individual localities differed markedly from each other. Agricultural workers were concentrated in rural areas, where certain other occupational groups were lacking, whereas blue-collar workers were over-represented in industrial communities. The case-control selection used in the present study has very possibly led to over-matching in relation to occupation and hence the results obtained may underestimate the true predictive power of the occupational classifications (IV). Such overmatching is unlikely for the other risk factors (III, V).

**Questionnaire data**

The questionnaire used in the Mobile Clinic Health Examination Survey mainly concerned clear concepts and matters such as marital status, occupation, smoking, symptoms, diseases and use of medicines (III-V). The answers to these questions can be considered sufficiently reliable in general. Specific items of the questionnaire are discussed in association with the results in a later chapter (7.3.5).

In questionnaires, people tend to under-report the occurrence of diseases or symptoms (Aromaa et al. 1986). Validity and reliability vary between disease categories, but few specific evaluations concerning history of low back pain have been published. Reproducibility of the data on low back pain is far from complete (Westrin 1974; Biering-Sørensen and Hilden 1984; Mågi et al. 1984). However, the intermittency of low back pain and sciatica makes the assessment of questionnaire data reliability particularly difficult.

In the Mini-Finland Health Survey, all subjects with definite lumbar disc syndrome reported previous back pains and 96% gave a history of pain radiating from one of the thighs to the foot. However, 56% of those who had another type of low-back syndrome and 31% of those for whom no low back disease at all was diagnosed had previously experienced such leg pain. No combination of the items of the standard interview (leg pain ever, six or more episodes of leg pain, bed rest of two weeks or more because of leg pain, back or leg pain during
the previous month) could predict the lumbar disc syndrome diagnosed by a physician at the clinical examination.

In the longitudinal study (III-V), the exclusion of those cases who had a low-back disorder at the beginning of the follow-up was based on a questionnaire. The accuracy of the questionnaire data on disease history cannot be assessed precisely, but the rates obtained may give some evidence. Of the subjects subsequently hospitalized for herniated lumbar disc or sciatica 28%, and 10% of their matched controls, had questionnaire evidence on low-back complaints at entry. The proportion of the excluded controls was lower than the prevalence of low-back syndrome diagnosed by a physician at clinical examination (I) but about twice as high as the prevalence of lumbar disc syndrome (I). This and the large proportion of previous low-back sufferers among the cases hospitalized suggest that the method of excluding prevalence cases was sensitive.

**Anthropometric measurements**

The methods used to measure height, weight and triceps skinfold have been evaluated in detail in a previous report (Heliövaara and Aromaa 1980). These measures can be considered sufficiently valid and reliable for the purposes of the present study (V).

7.3. Results

7.3.1. Prevalence

Lumbar disc syndrome (herniated lumbar intervertebral disc or sciatica) was diagnosed in 5.3% of men and 3.7% of women representative of the Finnish population aged 30 or over. The syndrome proved to be less prevalent than radiating leg pains recorded in previous surveys (Hirsch et al. 1969; Gynelberg 1974; Wickström et al. 1978; Takala et al. 1982) but much more prevalent than a disease history of ‘intervertebral disc displacement’ reported in the United States National Health Examination Survey (Bonham 1978). However, no true discrepancy exists, since within the present study leg pains and the disease history were poor predictors of the diagnosis made by the physician.

Potentially comparable prevalences have been derived from the surveys undertaken by the Arthritis and Rheumatism Council in the United Kingdom in
1950 (Lawrence 1977), although the methods and criteria used to determine 'sciatica suggesting a herniated lumbar disc' were not reported. A comparison of age and sex specific prevalences between those surveys and the present study (I) show divergent profiles in the age and sex specific prevalences (Figure 11). This suggests differing diagnostic criteria between the studies rather than unequal prevalences of lumbar disc syndrome between the countries.

Using data from various registers on general practitioner consultations, admissions to hospital and sickness incapacity certifications, a tentative prevalence estimate of about 5% has been made in Great Britain (The challenge of arthritis and rheumatism 1977). The authors did not mention whether the prevalence was calculated for total or adult population. Nevertheless, the estimate approximately equals the prevalence obtained in the present study for the population aged 30 or over.

Whether the prevalences obtained in the present study apply to other populations must be shown. So far, no definite conclusions can be made about possible variation of the prevalence between countries.

Figure 11. Prevalence (%) of lumbar disc syndrome observed in the United Kingdom (Lawrence 1977, broken line) and in Finland (I, continuous line).
7.3.2. Need for care and use of health services

According to the present study (I) 80% of the patients with lumbar disc syndrome are under adequate medical control in Finland.

As stated in the literature, there is no general agreement on principles in the treatment of chronic low back pain (Nachemson 1980; Flohr and Turk 1984; Management of the acute back 1984; Saloheimo et al. 1986), and thus, no standards were available by which to judge the medical control of the patients. In general, the validity and reliability of such assessments are uncertain (Koran 1975). In the present study, the assessments made on the need for and adequacy of care referred to the current, accepted clinical practice, and the results can be seen as reflecting the opinions of a group of trained observers.

The patients whose medical control was rated as inadequate had often failed to consult physicians, although they suffered from pain and disability. This might have resulted from their experience of unsuccessful treatment of pain. It seems obvious that the development of therapeutic methods rather than of the health care system is necessary to improve the treatment of lumbar disc patients. Need for surgical care cannot be evaluated on the basis of the present study, because the results reflect the prevalence of chronic syndromes.

As much as 10% of frequent use of primary care services, defined as ten or more annual visits to a physician, was found to be attributable to lumbar disc syndrome. However, this rate refers to the persons having lumbar disc syndrome rather than to the disease itself. The patients with low back complaints are increasingly disposed to other disorders, which may explain their tendency to consult a physician (Nagi et al. 1973; Takala et al. 1982; Troup and Slade 1985).

7.3.3. Disability

Slight disability was very common in lumbar disc syndrome, but severe functional limitations were rare (I). This was observed in both sexes for both herniated disc and sciatica. No significant difference in the prevalence of disability was found compared with the patients who had other low-back syndromes.
The patients and the field physician were in satisfactory agreement (kappa = 0.66) in their assessments of work disability (I). Also a previous study has demonstrated a close correlation between self-rated working ability and clinically evaluated working ability (Takala 1984).

Both the subject’s self-reported experience and the physicians’ assessment were used to indicate various types of disability and handicap. The questionnaire data had the benefit of being independent of diagnostic judgements and were thus suitable for comparisons between persons with and without back syndromes, whereas the clinical assessment as made by the same physician who diagnosed the syndrome may involve bias in these comparisons. Furthermore, many subjects were assumed to have no functional limitations, since they did not participate in the clinical examinations. Thus the fractions of disability attributable to the lumbar disc syndrome may have overestimated the true impact of the syndrome, with respect to the doctor’s assessments on functional limitations. Although there was a 30% disagreement between self-reported limitations of activities and disability assessed by a physician (kappa = 0.38), the two methods gave almost equal results (I).

In 1980, 3.7% of all persistent disability pensions granted by the Social Insurance Institution to Finnish adults, aged 30 to 64, were due to lumbar disc syndrome. However, these records indicate no diagnoses other than the primary one, and many cases may have been recorded using codes of low back pain with nonspecific diagnosis. Thus the proportion of work disability attributable to the syndrome, estimated by the present study as 5.7%, obviously reflects the true impact of the condition more accurately than the insurance statistics (I).

7.3.4. Lumbar vertebral canals

In the present study, the lumbar spinal canal of men and women who suffered from herniated lumbar disc or definite sciatica was in several dimensions more shallow than it was among persons with other types of low back pain (II). The narrowing was most distinct in the interarticular distance of the first sacral vertebra.

The results, in general, are in agreement with the hypothesis that a shallow spinal canal contributes to lumbar radiculopathy. This is consistent with the findings of Ramani (1976), Porter et al. (1978), Winston et al. (1984), and Korn-
berg and Rechtine (1985) except that, unlike their data, in this series there was no significant difference in the midsagittal diameter.

The narrowing of the interarticular distance at S1 reported here applied to both sexes. This is in contrast to the narrowing at the same level associated with restricted lumbar mobility which Vanharanta et al. (1985) reported in women but not in men. They considered that the association between symptoms and interarticular narrowing arose from the normally smaller dimensions in women. With regard to neurological dysfunction, there remains a question concerning the space requirement for the cauda equina and nerve roots. The present results indicate that the bony dimensions associated with neurological dysfunction in men remain significantly broader than those in women similarly disabled. The female root may be smaller and need less space or it may be more adaptable to encroachment. The unknown factor concerns the magnitude of the soft tissue hypertrophy accompanying the bony encroachment.

The size of the spinal canal may play a contributory role in the herniated lumbar disc syndrome. It may be significant also in other types of low back pain (Porter et al. 1980; MacDonald et al. 1984; Drinkall et al. 1984). The clinical value of the measurements from plain lumbar radiographs will remain unclear until more refined studies are done, such as prospective clinical studies in which confounding factors are effectively controlled.

Radiographs of the lumbar spine are usually taken when examining low-back patients, although the plain radiography of the spine has very little value for determining causes of low back pain (Frymoyer et al. 1984). Radiography may still be justified in order to exclude major abnormalities and serious disease. A quantitative reading of the films might often be reasonable. Vanharanta et al. (1985) concluded that measurements relating to the size and shape of the spinal canal and foramina substantially increase the diagnostic value of plain lumbar radiographs and may render the more elaborate investigations unnecessary. The present study (II) supports this view, particularly if signs or symptoms of radiculopathy are present.
7.3.5. Risk determinants

7.3.5.1. Demographic factors

Sex

According to clinical series published previously, herniated lumbar disc requiring surgery affects males twice as frequently as females (Spangfort 1972), whereas sciatica treated conservatively (Kelsey and Ostfeld 1975) and back pain radiating to the leg (Takala et al. 1982) have been reported as equally prevalent in both sexes. According to the present study, however, interview data on sciatic pains are inaccurate indicators of the disease. The present study confirmed the clear-cut male dominance in the definite lumbar disc syndrome, both herniated lumbar disc and sciatica (I, III).

As discussed in the previous chapter (7.3.4.), there are a number of differences according to sex in the bony diameters of the lumbar vertebral canals and in the associations of these diameters with lumbar mobility (Vanharanta et al. 1985). This suggests different pathogenetic factors in the two sexes. On the other hand, low back pain without definite sciatica affects women as frequently as men (I, III). Thus the explanation for the male majority in the lumbar disc syndrome should be sought from such factors and mechanisms that contribute to nerve root compression.

Age

In the present study both incidences (III) and prevalences (I) of herniated lumbar intervertebral disc and sciatica were found to be highest in the wage earning years. The risk of being hospitalized because of these conditions was highest between 40 and 50 years of age (III). The prevalence was highest at about 10 years older age (I). The peak occurred at clearly younger ages than the corresponding top rate of other low-back syndromes (I, III). These results are in close agreement with the age distributions of patients presented previously (Raaf 1959; Spangfort 1972; Kelsey and Ostfeld 1975; Kelsey 1982).

Young and middle-aged adults are the most considerable target groups, when preventive measures are planned.
Region

The inconsistent variation in the incidence of herniated lumbar intervertebral disc and sciatica found in the present study (III) between main geographical regions and between urban, rural and industrial populations may be related to the method of case-identification. A previous study based on the same cohort suggested that hospital discharge records of stroke and myocardial infarction are not valid for geographic comparisons, because the results may be confounded by the selectively incomplete coverage of the follow-up (Heliövaara et al. 1984). Furthermore, availability of orthopaedic services may vary, and precision in the use of diagnostic techniques may vary from centres to centre.

In the present study (III), urban residents had a somewhat greater risk than rural residents. No similar difference has been reported previously, but three studies have resulted in contrary findings (Kelsey 1975b; Lawrence 1977; Kelsey et al. 1984a).

So far, nothing certain is known about the possible regional variation in the incidence of herniated lumbar disc or sciatica. This is also true for comparisons between countries. Comparable population studies based on reliable standard methods are needed.

Marital status

In the present study, no differences in the risk of herniated lumbar intervertebral disc or sciatica were found between the categories of marital status (III). Previous studies have resulted in divergent findings. In United States Army recruits during World War II, married civil status significantly predicted herniated lumbar discs leading to hospitalization (Hrubec and Nashold 1975). No variation in the risk of herniated lumbar disc according to marital status of men was observed in either of the two epidemiologic studies done in the New Haven area, whereas in both studies the risk among married women was found to be about twice as high as for other women (Kelsey 1975b; Kelsey et al. 1984a).

Social class

In the present study the risk of herniated lumbar intervertebral disc or sciatica was found to be clearly highest in the men who were ranked in intermediate
social classes (III). The women were not grouped into social classes, because no sufficient data were collected.

In a previous epidemiologic study done in the New Haven area, the social class of men was negatively but that of women positively associated with the risk of herniated lumbar disc (Kelsey 1975b).

Interpretation of the social class gradients of the risk is difficult. Social class is a general determinant summing up a multitude of factors, and it seems therefore natural that its predictive importance differs between sexes as well as between countries.

7.3.5.2. Occupation, workload and physical activity

In the present study (IV), marked occupational differences were observed in the risk of herniated lumbar disc or sciatica leading to hospitalization. In men, the risk varied significantly between occupational categories, but the self-assessed strenuousness of work had no predictive capacity. In women the self-assessed strenuousness of work was positively associated with the risk, but the variation between occupational categories was smaller than in men. Leisure time physical activity was not associated with the risk (III). A number of theoretical and methodological problems must be considered when interpreting these results.

The longitudinal design and the quality of the population followed-up permit generalizations about the results of the present study. A common problem in occupational epidemiology is that ill people tend to switch to jobs that do not require full physical performance - "the healthy worker effect" (Fox and Collier 1976; Wen et al. 1983; Hernberg 1984). This effect has been avoided, at least partly, as the data on occupation and physical activity refer to the time before the development of symptoms in the back or leg. The case-control selection used in the present study may have led to overmatching in relation to occupation and hence to underestimation of the true predictive power of the occupational categories. Such an overmatching is unlikely in relation to physical activity at work or at leisure.

The nature of the follow-up data has critical effects on the interpretations. In the present study, occupation and quality of work may have contributed either to herniation of intervertebral discs, to aggravating symptoms of an old herniation,
to proneness of the patient to seek surgery, to the decision-making of physicians, or even to all of these events combined. Etiological appraisals must be made with caution, because it is possible that the variations in the risks observed were not due to disease incidence but rather to a varying likelihood of hospitalization. On the other hand, correct identification of occupational risk groups for preventive measures may be of practical value.

The questionnaire data on occupation were sufficiently detailed to allow classifying the subjects into the categories used in the present study. Much attention was paid to both checking the answers and coding the occupations in the baseline survey. The occupational classification was obviously accurate enough for present purposes. On the other hand, no fixed criteria for strenuousness of work or physical activity during leisure were given in the questionnaire. It is difficult to assess the amount of physical activity that a person performs in population studies (Malkia 1983), and imprecise measurement makes it hard to find an association, if there is one. The crude information of the present study on physical activity at leisure may be of limited value as an indication of strain on the lower back. The results do not therefore exclude the possible influence of specific strains or the influence of vigorous exercise on the risk.

The findings of the present study implying that the risk of herniated lumbar intervertebral disc or sciatica was high in occupations involving heavy labour and in women who assessed their work as strenuous (IV), challenge the view that sedentary work as such contributes to disc herniation (Kelsey 1975a). Evidence suggesting that heavy labour predisposes people to lumbar disc herniation has also been presented from other epidemiological studies (Hrubec and Nashold 1975; Kelsey et al. 1984a).

In the present study in men, the risk of being hospitalized as a result of herniated lumbar intervertebral disc or sciatica proved high among motor vehicle drivers (IV). This finding further supports the view that car driving is etiologically important (Hrubec and Nashold 1975; Kelsey and Hardy 1975; Troup 1978; Kelsey et al. 1984a). Driving of motor vehicles may also be significant in the development of other types of low back pain (Damkot et al. 1984). Thus, intervention studies should be conducted both to test the hypothesis and to develop methods for prevention. The postural stress due to driving is to a great extent avoidable, since enough is known about the design of automobiles with such
seats and cabs which can limit the effects of vertical vibration, shock and major disturbances of spinal postures (Troup 1978).

The risk of herniated lumbar intervertebral disc was only moderate among male agricultural workers (IV). This finding is not consistent with the previous observations that herniated lumbar discs are particularly common in farmers (Goodsell 1967; Lawrence 1977). The risk was also unexpectedly low in female cleaners and caretakers, although frequent lifting and stooped postures are characteristic for their jobs. On the other hand, a relatively high risk was found among nurses and related medical workers (IV), which is in agreement with previous studies (Cust et al. 1972; Videman et al. 1984).

7.3.5.3. Body build

Height

Body height proved to be a significant predictor of herniated lumbar intervertebral disc in both sexes (V). In tall men ( > 179 cm) relative risk was 2.3 and in tall women ( > 169 cm) 3.7 in relation to persons who were at least 10 cm shorter (relative risk 1.0). Since the measurement of height was highly reliable and no selection bias in identification of the incidence cases can be expected, the differences in the risk by height must be true.

The present study thus confirmed the suggestive findings of previous studies (Rowe 1965; Tauber 1970; Gytelberg 1974; Hrubec and Nashold 1975; Weir 1979; Merriam et al. 1983). That Kelsey (1975b) and Kelsey et al. (1984a) did not find any association between height and herniated disc may be a result of their case-control designs. However, the disagreement may also be related to the nature of the population of New Haven. Further observational studies are needed to assess the consistency of the association between body height and herniated lumbar disc syndrome.

Several possible explanations can be advanced for the association between body height and risk of herniated lumbar intervertebral disc. Postural stresses on the lumbar intervertebral discs may correlate with body height. A considerable hypothesis arises from varying correlations between body height and measurements of lumbar vertebrae. Body height is positively correlated with the volume of the disc and thus, perhaps, with the extent of herniation. If the lumbar canal is shallow in relation to a herniation, it is likely to result in nerve
root compression. Biomechanical calculations would help to refine this hypothesis.

It is unlikely that any preventive measures can usefully be taken for the high-risk group of tall persons. If further studies confirm the significance of body height as a causal risk factor for herniated lumbar disc, the ergonomic intervention of occupational exposures among tall manual workers or pre-employment selection may emerge as possible measures.

**Obesity**

In the present study in men, though not in women, a moderately elevated body mass index strongly predicted development of herniated lumbar disc, while severe obesity exceeding 30 kg/m² appeared to carry less risk than moderate obesity (V).

The measurements of body mass index and triceps skinfold were sufficiently reliable for the purposes of the present study (Heliovaara and Aromaa 1980). Validity of these measures of obesity is conditional. The body mass index correlates closely with total body fat and also reflects lean body mass, whereas the triceps skinfold is independent of lean body mass and takes no account of central fat tissues (Montoye et al. 1966; Shephard et al. 1969; Florey 1970; Garn et al. 1971; Ward et al. 1975; Noppa et al. 1979).

That the thickness of triceps skinfold proved unimportant either as an explanatory or a confounding factor (V) was very unexpected in spite of its close correlation with body mass index (r = 0.57). The importance of central obesity with thin or normal deposits of peripheric fat tissues becomes considerable. Anatomical distribution of adiposity in relation to low-back morbidity merits attention in future research, as does the possible role of muscularity or lean body mass.

It seems unlikely that the method of case-identification used in the present study affected the results. However, the factual coherence of the results is uncertain. Rather than being a direct contributor to disc herniation, obesity may indicate unknown behavioural factors affecting either the risk of lumbar disc syndrome or the tendency to be hospitalized when the condition has occurred.
The previous epidemiological studies have revealed only a slight association (Hrubec and Nashold 1975) or no association at all (Kelsey 1975b; Kelsey et al. 1984a) between body weight and risk of herniated lumbar intervertebral disc. However, no true discrepancy with the results of the present study exists. If the n-shaped relationship found in the present study in men for body mass index with risk of herniated lumbar disc is true, the designs and the numbers of cases in the former studies were insufficient to demonstrate such a relationship.

The significance of obesity as a risk factor of herniated lumbar disc seems complex and open to interpretation. If future studies repeat the observations of the present study, obesity will merit special attention involving the construction of new hypotheses.

Obesity is an important risk factor for many common diseases, and considerable efforts to further public health education are being made. For the present, however, treatment or prevention of obesity in order to prevent herniated lumbar discs or other low-back conditions is not a reasonable measure.

7.3.5.4. Other factors

Parity

The results suggested that previous pregnancies may be of limited predictive importance for sciatica, but other factors tended to confound the association (III). No dose-response relationship between the number of childbirths and the risk was observed. The questionnaire method can be assumed to be accurate for obtaining the number of previous childbirths.

The results of the present study were based on a long follow-up period and this may tend to conceal any short-term association between pregnancy and lumbar disc syndrome. This limits comparability with the results of previous studies. Nevertheless, the results of the present study resemble the results previously obtained by Kelsey et al. (1975), although no potential confounding factors were controlled in their series.

According to clinical experience and previous studies, a pregnancy may precipitate or aggravate low back pain (Mantle et al. 1977; Frymoyer et al. 1980; Biering-Sørensen 1983a and 1983b) as well as sciatica (O’Connell 1960; Videvand et al. 1984). However, even a great number of childbirths is unlikely to
result in a substantial long-term increase in the risk of herniated lumbar disc
or sciatica.

**Smoking**

The present study suggested that smoking is of slight predictive importance for
herniated lumbar disc or sciatica (III). The questionnaire method used to
identify smokers can be considered sufficiently valid and reliable. However, it
is possible that smoking is related to a likelihood of hospitalization once sci-
atica occurs, which limits etiological appraisals.

Similarly to the present study, Kelsey (1975b) and Kelsey et al. (1984a) ob-
served an association between smoking and herniated lumbar intervertebral
disc. There was a possibility of selection bias also within their studies, because
the cases were identified from patients who were seeking medical care.
Nevertheless, the association between smoking and low back pain is quite
consistent in a number of studies (Gyntelberg 1974; Frymoyer et al. 1980 and
1983; Svensson et al. 1983; Biering-Sørensen and Thomsen 1986; Penttinen
1987), and the hypothesis that smoking or chronic coughing can impair inter-
vertebral discs seems biologically plausible (Nachemson 1971; Frymoyer et al.
1983).

Whatever the mechanism of the association, smoking should be considered as
a possible risk factor or confounding factor in future epidemiological studies.
Disc abnormalities detectable by modern radiological techniques should be
studied for their associations with smoking history in the search for a missing
link.

For the present, the hypothetical influence of smoking on the human back is
not a sufficient argument for additional anti-smoking campaigns.

**Psychological distress**

The involvement of psychological factors and psychiatric disorders in low back
pain is well established by previous studies (Brown et al. 1954; Natvig 1970;
Gentry et al. 1974; Gilchrist 1976; Lloyd et al. 1979; Donovan et al. 1981; Jou-
kamaa 1986). Several studies have demonstrated an association between low
back pain and various symptoms suggesting psychological distress such as
headache, nervousness, fatigue and gastrointestinal symptoms (Gyntelberg
1974; Magora 1973; Svensson et al. 1983; Biering-Sørensen and Thomsen 1986). However, it has not been clear whether various psychological characteristics are at all connected with the development of back syndromes or whether they are secondary to back problems. Only one of the previous studies (Biering-Sørensen and Thomsen 1986) was prospective. No previous epidemiological studies have been focused on a possible role of psychological factors in the development of sciatica.

In the present study (III), distress symptoms predicted hospital admissions for herniated lumbar intervertebral disc or sciatica during a long follow-up among women who reported no severe back trouble at entry. This indicates the primary importance of psychological factors and extends their significance from back pain in general to herniated lumbar disc and sciatica.

Self-reported symptoms similar to those used to indicate psychological distress in the present study are items of a standard symptom interview; the items reflect anxiety, depression and somatization (Derogatis et al. 1974). However, the set of items was very limited compared with the sophisticated standard questionnaires developed to measure various dimensions of psychological or psychiatric disorders. Such an accurate method could presumably reveal a closer association between psychological factors and the risk of sciatica than did the present study.

The most likely interpretation is that psychological distress is related to a tendency to seek medical care in general, and hospitalization in particular, rather than to herniation of the intervertebral disc. Distress may increase the pressure for surgery, and an indication for surgery at times appears to be the need to "do something" (Waddell et al. 1986). That the frequent use of analgesics by women also proved to be a significant predictor suggests an inherent pain-prone behaviour of the female patients. In contrast, the predictive value of distress symptoms remained rather scanty in men, and the use of analgesics by men was not significant.

Whatever the mechanism of the association, psychological factors including distress symptoms should be considered in future epidemiological studies on low back pain or sciatica as potential risk or confounding factors.
7.4. Needs for further epidemiological research

Sciatica as a syndrome seems to constitute a continuum of more or less manifest symptoms (I). This also applies to lumbar disc lesions demonstrated by myelography (Htseleberger and Witten 1968), computed tomography (Wiesel et al. 1984) or magnetic resonance (Powell et al. 1986): herniated intervertebral discs have been found in about one of every four to five asymptomatic subjects. Thus, few victims of herniated disc develop typical sciatica, a minority of them remain chronically affected, and a relatively small proportion of even chronic syndromes result in severe disability. In turn, indefinite leg pains are common in the general population, but the contribution of herniated lumbar discs to these pains is unknown. The entity lumbar disc syndrome, with its wide spectrum of outcomes, offers many challenges for future epidemiological research. First of all, diagnostic criteria based on standard methods should be defined to make comparable population studies possible.

Marked differences in the risks of herniated lumbar intervertebral disc and sciatica were found between occupational groups (IV). The great variation in the risk rates suggests that primary prevention of lumbar disc lesions would have considerable potential if adequate tools could be identified. Various ergonomic measures and instructions on manual handling and lifting are widely believed to be prophylactic, although sufficient evidence of their effectiveness is lacking (Chaffin and Park 1973; Progress in back pain? 1981). However, if the occupational variation observed (IV) is not due to disease incidence but rather to greater likelihood of hospitalization, then primary prevention by ergonomic measures may prove elusive. The results of the present study emphasize the need for intervention trials in occupational medicine (IV).

Both the review of the literature (3.4) and the preceding discussion on risk factors suggest that causal inference is scarcely within reach at the present time. A primary goal of epidemiological research therefore continues to be the generation of hypotheses, and observational studies on low back pain including nerve root compression syndromes are greatly needed.
7.5. Prevention

Several of the suspected risk factors for herniated lumbar intervertebral disc and sciatica are modifiable. This suggests that prevention is possible. The overall potential of primary prevention is probably great, if adequate tools for prevention can be developed. The question whether a risk factor contributes to bulging of lumbar intervertebral disc or only to the outcome when bulging occurs remained unanswered in the present study (III-V). However, from the point of view of preventive potential the exact nature of the causative association is not essential. No specific recommendations for preventive measures can be given yet. Much further research is needed before it can be reasonably considered that primary prevention programmes of sciatica are effective.
8. SUMMARY

The present report is a review of studies conducted as part of two extensive epidemiological projects. A study on musculoskeletal diseases was a part of the Social Insurance Institution's Mini-Finland Health Survey carried out in 1977-1980 on a representative sample of the adult population. The prevalence and impact on public health of the lumbar disc syndrome were determined from these data (I).

A subsample of persons who reported low back pain with a history of recurrence or significant disability were invited about a year later to attend a thorough low-back examination including plain radiography. Measurements related to the size and shape of the lumbar spinal canal were subsequently made from the radiographs. Various types of back syndromes were studied for their associations with these measurements (II).

An earlier project of the Social Insurance Institution, the Mobile Clinic Health Examination Survey, was a longitudinal study to follow up morbidity in an extensive cohort of Finnish adults. The follow-up information was used to study incidence and risk factors for herniated lumbar intervertebral disc and sciatica leading to hospitalization among the subjects who were free from back complaints at entry (III-V).

8.1. Prevalence and impact on public health

Prevalence of lumbar disc syndrome (herniated disc or typical sciatica) was estimated in a sample of 8,000 persons representative of the Finnish population aged 30 or over, 7,217 persons (90% of those invited) participating in the examination. On the basis of medical history, symptom history and standardized physical examination, a physician diagnosed lumbar disc syndrome in 5.3% of men and in 3.7% of women. The age distribution was convex in shape, the prevalence being highest in those between 45 and 64 years of age.

Half of the patients were assessed to need medical care, and over 80% of this need appeared to have been adequately met. A third of all cases diagnosed had previously been hospitalized because of back disease and a fifth had un-
dergone lumbar surgery. A considerable proportion of the patients reported having visited physicians very frequently.

At least slight disability was found in almost 60% of the patients, but severe limitations of function were rare. Approximately six per cent of the population's work disability was estimated to be attributable to the lumbar disc syndrome.

8.2. Lumbar vertebral canals in sciatica and herniated lumbar disc

Herniated lumbar disc or definite sciatica was diagnosed in 16 out of 195 men and women who had reported a history of low back pain in the health survey and were invited to clinical examination including lumbar radiography. Measurements related to the size and shape of the lumbar spinal canal were subsequently made from the plain radiographs and compared between various types of back syndromes. By using analysis of covariance, age, body height, body mass index, occupation and parity of women were controlled as potential confounding factors.

Several diameters of lumbar vertebral canals appeared smaller in the subjects who had herniated disc or definite sciatica than in others. In particular, the interarticular distance of the first sacral vertebra was found to be narrowed in the presence of sciatica, the difference of the adjusted distances from the other back pain category being in men 30.5 mm versus 35.1 mm (p = 0.02) and in women 23.8 mm versus 30.3 mm (p = 0.002), respectively.

8.3. Risk determinants

The study population consisted of 57,000 men and women who had participated in the screening examinations for cardiovascular diseases between 1966 and 1972. Morbidity and mortality of the subjects have continuously been followed up with record-linkage using various registers of social insurance and health care, including the hospital discharge register. The experience totalled over 400,000 person-years.

To identify factors predicting sciatica, subjects aged 20 to 59 at entry were included. Hospitalization because of herniated lumbar disc or sciatica was considered as the end-point of the follow-up. When those who had a history of low back pain at entry were excluded, 592 incidence cases remained in the final
material. Four control subjects, matched individually according to sex, age and place of residence, were selected for each case. The conditional logistic model was used to assess relative risks (odds ratios) for the predictive factors.

Body height was found to be a potent risk factor for herniated lumbar disc in both sexes (V). The men with a height of 180 cm or more had a relative risk 2.3, and the women 170 cm or more 3.7, compared with those who were more than 10 cm shorter. Although there seemed to be a threshold for the effect of height, linearity of the risk function could not be rejected at significant level.

Obesity proved to predict lumbar disc herniation in men, but not in women (V). In men, the gradient was convex, the risk being smallest in the thinnest men who had a body mass index below 22 kg/m² increasing gradually, but declining again in the most obese men exceeding 30 kg/m².

In men, the risk of herniated lumbar disc or sciatica was lowest in white-collar occupations, significantly higher in all other groups, and highest among industrial workers and motor vehicle drivers (IV). In women, the differences in risk between occupations were less pronounced, but the risk was significantly associated with self-assessed strenuousness of work (IV).

Other factors which had independent predictive significance were smoking, parity, and various symptoms suggesting psychological distress such as nervousness, fatigue, excess sweating, palpitation and headache (III). Marital status or leisure-time physical activity were not associated with the risk of herniated lumbar disc or sciatica (III).

Occupational strains, body height and obesity may be causal factors in the herniated lumbar intervertebral disc. However, the follow-up experience considered only those cases admitted to hospital. Uncertainty remained, therefore, as to whether the predictive factors were associated with risk of disc herniation or only hospitalization once the condition occurred.

So far, little epidemiological research has been focused on low back problems. Development of reliable standard methods for population studies is needed. Search for risk factors should be continued by further epidemiologic studies to create a basis for intervention, with the ultimate aim of preventing herniated lumbar intervertebral disc and sciatica.
9. YHTEENVETO


Tämän tutkimuksen yleisenä tavoitteena oli tuottaa lanneselän välilevyoireyhtymän (väilevytyrät tai iskiasoireyhtymät) koskevat epidemiologiset perustiedot. Tulokset on aikaisemmin julkaistu viitena artikkelina, joihin tämä yhteenveto perustuu.


9.1. Esiintyvyys, hoidontarve ja toimintakyvyttömyys

Lanneselän välilevyoireyhtymän (väilevytyrät tai tyyppillinen iskias) esiintyvyys arvioitiin Mini-Suomi-terveys tutkimuksen 8 000 henkilötä käsittävästä väestönäytteestä, joka valittiin edustamaan 30 vuotta täyttäneitä suomalaisia. Kutsutun henkilöstä 7 217 eli 90 % osallistui tutkimukseen. Lääkäri diagnosoi tuotannonmenneen, oirenammeen ja statusloydosten perusteella välilevyoireyhtymän 5,3 %:lla miehistä ja 3,7 %:lla naisista. Valilevyoireyhtymä oli yleisin
45 - 64-vuotiailla. Lanneselän muiden oireyhtymien esiintyvyys painottui selvästi vanhemiin ikäluokkiin, ja ne olivat yhtä yleisiä naisilla kuin miehillä.

Diagnoosin tehnyt kenttälääkäri arvioi, että puolet lanneselän välilevoyoireyhtymää sairastavista henkilöistä oli hoidon tarpeessa ja hoitoa tarvitsevista puolestaan yli 80 % oli saanut riittävästi hoitoa. Osa näistä potilaista käytti terveyspalveluita erittäin runsaasti.

Lanneselän välilevoyoireyhtymää sairastavista potilaista arviottiin toimintakyvyn heikentyneen lähes 60 %:lla. Vaikea toimintakyvyttömyys oli kuitenkin harvinainen. Työkyvyttömyys oli yleistä, ja välilevoyoireyhtymän syyosuudet koko väestön työkyvyttömyydestä arvioitiin 6 %.

9.2. Selkäydinkanavan koko ja välilevoyoireyhtymä

Lanneselän välilevytära diagnoositin kuudella ja iskiassoireyhtymä kymmenellä niistä 195 henkilöstä, jotka kuuluivat lanneselän kivuista käräiteä henkilöitä edustavaan otokseen ja joille tehtyi lannerangan röntgentutkimus osana perusteellista selkäikutkimusta. Selkäydinkanavan kokoa ja muotoa kuvastavat mittaukset tehtiin myöhemmin röntgenkuvista, ja näiden mittojen vaihtelua tutkittiin eri oireyhtymien välillä. Ikä, pituus, lihavuusindeksi, ammattiryhmä ja naispotilaaiden aikaisempi synnytysten määrä sisällytettiin näihin monimuuttuja-analyysihin (kovarianssianalyysihin) sekoiittavina muuttujina.

Lannerangan selkäydinkanavan osoittautui monien eri mittojen valossa kapeammaksi välilevoyoireyhtymää sairastavilla potilailla kuin muilla tutkimuilla. Etukäteen ristikuvun ylimmän nikaman fasettinivelten välimatka havaittiin hyvin kapeaksi välilevoyoireyhtymäpotilailla muihin tutkittuihin nähden: vakioitujen keskiarvojen erot naiden kahden ryhmän välillä olivat sekä miehillä (30,5 mm versus 35,1 mm; p = 0,02) että naisilla (23,8 mm versus 30,3 mm; p = 0,002) tilastollisesti merkitsevät.

9.3. Vaaratekijät

Tutkittu väestö käsitti 57 000 miestä ja naista, jotka olivat osallistuneet Kansanelakelaitoksen autoklinikkan seulontutkimuksiin vuosina 1966 - 1972. Tämän väestönäytteen sairastuvuutta ja kuolleisuutta on seurattu poimimalla henkilötunnusta apuna käättäen tietoa eri rekistereistä, mm. yleissairaaloiden


Pituus havaittiin lanneselän välilevytyrän vahvaksi vaaratekijäksi. Vähintään 180 cm pitkien miesten vaarasuhde oli 2,3 ja vähintään 170 cm pitkien naisten 3,7 verrattuna yli 10 cm lyhyempien samaa sukupuolta oleviin henkilöihin (vaarasuhde 1,0). Vaikka riskifunktiossa näytti olevan kynnsä pituuden mainituilla tasolla, ei riskin lineaarisuutta suhteessa pituuteen voitua sulkea pois tila- tollisesti merkitsevällä tasolla.

Lihavuus näytti ennustavan lanneselän välilevytyrää miehille mutta eile naisilla. Miesten riski suhteessa lihavuuden mittana käytettyyn lihavuusindeksiin (paino/pituus²) muodosti kuperan funktion: vaarasuhde oli pienin (1,0) laihimmilla (< 22 kg/m²), kasvai asteittain lihavuuden lisääntyessä ja oli 3,7-ertäinen lihavuusindeksin arvoilla 28,0 - 29,9 kg/m², mutta tätä lihavammillä miehille (> 30 kg/m²) taas pienempi (2,3).

Miesten riski sairastua sairaalahoitoa vaativaan iskiasoireyhtymään tai lanneselän välilevytyrään oli pienin hallinnon, konttoriteknikan, tieteet, teknikan ym. johtavissa tai pitkää koulutusta edellyttävissä ammateissa työskentelevillä (vaarasuhde 1,0). Vaarasuhde oli merkitsevästi suurempi kaikeissa muissa pääammattiryhmissä ja kaikkein suurin autonkuljetajilla (4,6) sekä teollisuus- työntekijöiden ammateissa (2,6 - 4,2). Naisten riski vaihteli ammattiryhmittäin vain vähän mutta oli suorassa suhteessa työn itse arvioituun raskauteen.

Tupakointi, naisten aikaisempien synnyttysten määrä ja erilaiset psykykkiset rasitusoireet (hemostuneisuus, väämys, liiallinen hikoilu, sydämentykytys ja päänsärky) olivat muut tekijät, joilla havaittiin sairaalahoitoon johtanutta väli-
levyoireyhtymää merkitsevästi ennustanut itsenäinen arvo. Siviilisäty tai liikkunnan harrastaminen eivät olleet yhteydessä välilevyoireyhtymän vaaraan.

Todetuista vaaratekijöistä voivat tietty ammatit, pituus ja liikapainoisuus olla lanneselkään kohdistuvien mekaanisten vaikutusten vähityksellä syy-seuraussuhteessa välilevytyrään. Tässä tutkimuksessa seuranta paljasti kuitenkin vain sairaalahoitoon johtaneet välilevyoireyhtymät. Siksi jää avoimeksi, ovatko vaaratekijät yhteydessä välilevytyrän kehittymiseen vai ennustavatko ne vain sairaalahoitoon joutumista välilevyoireyhtymän ilmaantuessa.

Selkäsairauksien epidemiologiaa on toistaiseksi tutkittu hyvin vähän. Tulevia väestötutkimuksia varten tarvittaisiin luotettavien vakiomenetelmien kehitämistä, jotta selkäsairauksien yleisyyttä pystyttäisiin mittamaan vertailukelpoisesti. Lanneselan välilevytyrän, iskiairoreyhtymän ja muiden selkäsairauksien vaaratekijöiden etsintää on jatkettava, jotta ehkäisyyn tähtäävät toimenpiteet pystyttäisiin kohdistamaan oikeisiin tekijöihin ja suuntaamaan oikeisiin väestöryhmiin.
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