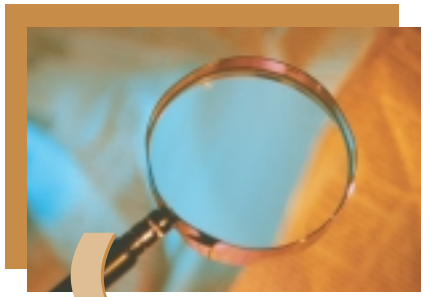

Research on work-related low back disorders

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A great deal of additional information on the European Union is available on the Internet.
It can be accessed through the Europa server (http://europa.eu.int).

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FOREWORD

One of the aims of the European Agency for Safety and Health at Work is to assist in the development of common research programmes and the sharing of research information in the field of Occupational Safety and Health (OSH). Work-related lower back disorders are one of various work-related musculoskeletal disorders (MSD). MSD are a designated priority work area for the Agency. Due to the prevalence of work-related back disorders, and in order to compliment a previous Agency research report on neck and upper limb disorders it was decided to make a research report into work-related low back disorders. This also supports the research priority of ergonomics, particularly in regard to manual handling, that has been indicated by the Member States.

Furthermore, a European Week for Safety and Health at Work has been organised for October 2000 to promote both awareness raising and prevention activities across the Member States on musculoskeletal disorders at work. "Turn your back on work related musculoskeletal disorders" is the message to all European workplaces. One of the aims is that European Week's focus on MSD will promote the sharing and exchange of good practice solutions to prevent work related MSDs. It is hoped that this report too will play its role to help further knowledge on work-related back disorders and their prevention.

The work to facilitate this report on work-related low back disorders for the Agency was carried out by Prevent (Institute for Occupational Safety and Health, Belgium) within the framework of the Agency's Topic Centre on Research - Work and Health. This Topic Centre consists of a consortium of 10 major OSH research institutes in Europe. The report was prepared by Lic. Rik Op De Beeck and Dr. Veerle Hermans. A workshop of experts was used to provide input into the report and comment on an early draft. A consultation process was carried out by sending the manuscript to members of the Agency Thematic Network Group on Research-Work and Health, which includes European social partners and the European Commission. Further input from experts was also sought. After the consultation process the final report was prepared and published.

The Agency wishes to thank all those who contributed to the report and especially Prevent for drafting the report.

Bilbao, October 2000

European Agency for Safety and Health at Work

EXECUTIVE SUMMARY

Work-related low back disorders, covering both low back pain and low back injuries, are a significant and increasing problem in Europe. This report covers the prevalence, origin, work-related risk factors and effective prevention strategies for low back disorders. The report is limited to low back disorders although some of the findings may be applicable to other types of work-related back problems.

Size of the problem

Studies suggest that between 60% and 90% of people will suffer from low back disorders at some point in their life and that at any one time between 15% and 42% of people are suffering (depending on the study population and the definition of back pain used). Data from the European survey on working conditions reveal that 30% of European workers suffer from back pain, which tops the list of all reported work-related disorders. In a recent report on the State of Occupational Safety and Health in the Member States (European Agency, 2000b) some Member States of the European Union have reported an increase in manual handling injuries and back injuries.

Although in most cases patients make a full recovery from an episode of low back pain (60-70 % recover within 6 weeks, 70-90 % within12 weeks) this still adds up to a very large amount of lost time from work. In addition the recurrence rate for low back disorders is very high. In one year the recurrence rate is between 20% and 44% and over a lifetime recurrences of up to 85% are reported. It is important to remember that once injured, the back can become susceptible and re-injury is more likely if there are risk factors in the work place that are not corrected.

Although very common across all types of industries and jobs, several studies have demonstrated that low back disorder rates are particularly prevalent in certain types of industries and within certain occupations. Particularly high prevalence rates are found for example among: agricultural workers; construction workers; carpenters; drivers including truck and tractor operators; nurses and nursing assistants; cleaners, orderlies, domestic assistants. It appears that the prevalence of low back disorders in the European Union is similar among men and women.

Although precise figures do not exist, estimates from Member States of the economic costs of *all* work-related ill health have been estimated to range from 2.6 to 3.8% of Gross National Product. However the figures maybe higher as the true social costs are difficult to estimate. A study from the Netherlands estimated the total cost of back pain to society to be 1.7% of the gross national product in 1991.

Origin of Low Back Disorders

Low back disorders include spinal disc problems such as hernias and spondylolisthesis, muscle and soft tissue injuries. In addition to the normal degenerative aging process, epidemiological studies reveal that poor ergonomic factors in the workplace contribute to low back disorders in a healthy back or accelerate existing changes

in an already damaged back. Poor ergonomic work factors increase the load or strain on the back. This may arise from many situations, for example lifting, twisting, bending, awkward movements, stretching, and static postures. Tasks include physical work, manual handling and vehicle driving (where whole body vibration is known to be another contributing factor).

Although spinal disc related problems maybe detectable by x-rays or bone scans, other abnormalities, such as muscular and other soft-tissue injuries, can often not be detected in this way. In fact, 95% of low back disorders are termed "non-specific". Evidence suggests that the common approach suggested below can be taken to prevent and reduce all types of work-related low back disorders.

Work-related risk factors

Many reviews have been published of studies concerning the risk factors of low back disorders, including a multitude of physical, psychosocial and/or personal risk factors. The number of epidemiological studies addressing psychological risk factors during work is considerably smaller than studies focussing on physical load. In addition, the strength of the association is generally higher for biomechanical factors. However, the evidence to link psychosocial factors with low back disorders is growing, especially where they occur at the same time as the physical factors. The incidence of low back disorders has also been strongly associated with low job content and poor work organisation. The main work-related risk factors are given in Box 1.

Box 1: Work factors that increase the risk of low back disorders

Physical aspects of work
- Heavy physical work
- Lifting and handling of loads;
- Awkward postures (for example: bending; twisting; static postures)
- Whole body vibration (for example truck driving)

Psychosocial work-related factors
- Low social support
- Low job satisfaction

Work organisation factors
- Poor work organisation
- Low job content

Strategies and effectiveness of prevention

Strategies to prevent low back disorders include both workplace based and health care based interventions. Increasingly there is recognition that an integrated approach including both types of intervention is needed to really tackle the problem effectively. Prevention, training, health surveillence, rehabilitation etc. should all be approached together. In the workplace there is growing support for the effectiveness of ergonomic interventions. Ergonomics interventions are based on a "holistic" or systems approach that considers the effect of the equipment, the work environment and the work organisation as well as the worker. The full participation of workers in the ergonomics approach is important for its effectiveness.

A summary of the main prevention strategies is given in Box 2. These cover both strategies for both primary prevention (eliminating the causes) and secondary prevention (treatment and rehabilitation). Again expert opinion is that although the focus should be strongly on primary prevention, all these factors need to be looked at together. For example studies show that training alone is unlikely to be effective if the ergonomic factors in the work remain poor and basic training, for example, needs to include how to spot potential risks and what to do if found as well as safe physical handling techniques. Finally, prevention of low back and other work-related musculoskeletal disorders should form part of employers overall prevention plan for all health and safety risks.

European employers are already provided with important information to protect workers from back injury from manual handling work in the "Manual Handling Directive" (Council Directive 90/269/EEC), which was made with the particular goal of preventing risks of back injury

during the manual handling of loads. Based on current knowledge, it includes minimum health and safety requirements that follow an ergonomic approach, with a list of risk factors provided in the schedule to the directive. Employers should to pay attention to these risk factors when making an assessment and selecting prevention measures. They include:

- Characteristics of the load (for example: is it heavy or difficult to hold);
- Physical effort required (for example: strenuous; twisting; body in an unstable position);
- Characteristics of the working environment (for example: not sufficient room or other constraints on the posture of worker such as working height too high or low; uneven or slippery flooring);
- Requirements of the activity (for example: prolonged activity or effort; insufficient rest periods; excessive distances to move loads; imposed work rate)
- Individual factors (for example: clothing etc. restricting movement; inadequate knowledge or training)

It is thought to be somewhat artificial to separate out low back disorders from other work-related back problems as there is no strict divide between back problems and other musculoskeletal disorders. A common approach is needed to all musculoskeletal problems in the work place. In this context it is helpful to view the risks in terms of combined "overload" on the musculoskeletal system (for example the combination effect of force, sustained force, static force, work organisation, stress etc).

Box 2: Strategies to prevent low back disorders in the workplace

- Reduction of physical demands
- Improvements in work organisation
- Education/training (as part of an integrated approach)
- Medical treatment and rehabilitation (as part of an integrated approach)
- Cognitive and behavioural strategies (for example coping strategies)

Need for research and consensus

There is support in the literature for the ergonomics approach, contained in the "Manual Handling Directive", as the basis for employers to take action. To assist its application the report suggests that the main focus of future research should be on how the ergonomics approach can be used most effectively in practice. Such research may include:

- Satisfactorily evaluated studies of "holistic" intervention strategies (for example: application of ergonomics; ergonomics integrated with rehabilitation and health surveillance)
- Studies to develop and evaluate practical risk assessment methods for use in the workplace
- Studies of the effect of combinations of factors and their practical assessment

Although it is proposed that the main focus of future research be on strategies to prevent injury in the work place, a number of areas concerning laboratory analysis of the problem are suggested (for example: exposure measurement techniques; joint movement measurement methods and studies to further understand the biochemical and biomechanical properties of the vertebra, disc and ligaments).

1.

INTRODUCTION

There is a growing interest in the subject of musculoskeletal disorders (MSDs) related to the workplace, due to the increasing amount of workers suffering from these disorders. Also within the European Agency for Safety and Health at Work, documents on this subject have been published recently:

- Repetitive Strain Injuries in the Member States of the European Union: the results of an information request (European Agency, 2000a)
- Work related neck and upper limb musculoskeletal disorders (European Agency, 1999 - Buckle and Devereux)

With the current publication, the focus is entirely on the low back and the reported findings should not be related as being applicable to all types of disorders. Nevertheless, work-related upper limb disorders and back disorders should be seen on a continuum, since the same general prevention approach applies to both.

This report has addressed the following questions:

What is the extent of work-related low back disorders within European member states?

What is the current knowledge on the origin of low back disorders?

What is the epidemiological evidence regarding risk factors?

Which strategies for prevention of low back disorders are present and what do we know about the effectiveness of these intervention strategies?

Which risk assessment methodology can be used for the prevention of low back disorders?

What are the most important future research topics?

Non-occupational back disorders such as infectious diseases, inflammatory disease, tumours, metabolic disorders or other non-mechanical disorders will not be included in this document. Also primary psychiatric disorders with psychosomatic low back pain are not the focus of this report.

Approaches used to prepare the report

Information retrieval from databases

To write this status report, a thorough literature examination was performed, concentrating on scientific peer-reviewed epidemiological review journal articles, but including individual articles with specific additional value. Individual studies included in the review articles were accepted after passing a thorough selection regarding

methodological issues. Attention is given to review studies addressing cohort or case-control studies. Papers submitted or in press to scientific peer reviewed journals and providing additional important information are also mentioned. The individual researchers provided these papers. Furthermore, recent textbooks, reports of the European Agency for Safety and Health at Work and other documents or government reports were consulted. Searches were carried out on computer-based bibliographic databases: Medline® , NIOSHTIC® (a database of the National Insitute of Occupational Safety and Health, USA), and HASTE (the European Health and Safety Database).

The literature search focused upon the following areas:

- Prevalence of disorders
- Origin
- Work-related risk factors
- Strategies and effectiveness of prevention

Most important keywords were: (low) back pain, (low) back disorder, origin, aetiology, work, risk factors, epidemiology, prevention, strategies, interventions, methods, assessment, statistics, prevalence, review.

Expert Workshop

An expert workshop (see appendix 1 for membership of the panel and summary of the discussion and conclusions) was held in Brussels 21 June 2000. The aims of the meeting were to discuss: the proposed structure and key elements of the document; sources of information and definitions; the contents of the document, including what conclusions could be drawn from the literature survey; and recommendations for future research and regarding prevention of low back disorders. The workshop resulted in an action plan for the authors with a summary of information how to develop the report further.

Consultation and liaison

The second draft report was sent for comment to the members of the Thematic Network Group on Research - Work and Health. This group consists of research experts from the Member States and observers from the European Social Partners and European Commission. Also the draft report was sent to the European Agency's Topic Centre on Good Practice - Musculoskeletal Disorders and other experts in the field. Based on the comments received and additional information, the final report has been prepared.

It is recognised that the opportunities and resources available for this process have been limited. It is hoped that wider consultation and more extensive views will be gathered following final publication of the report.

RESEARCH

2.

THE NATURE OF WORK-RELATED LOW BACK DISORDERS

2.1 INTRODUCTION: LOW BACK DISORDERS AND WORK-RELATED LOW BACK DISORDERS

In a systematical review of the available scientific evidence on the causes of low back pain and the effectiveness of interventions to prevent it, Frank et al. (1996) mention two terms that are usually used to describe the phenomenon of low back pain. Low back pain is any back pain between the ribs and top of the leg, from any cause. Work-related low back pain, is any back pain originating in the context of work and considered clinically to have been probably caused, at least in part, or exacerbated by the claimant's job. However in practice it is often impossible to distinguish back pain "caused" by work from pain of uncertain origin that makes the patient's work impossible to carry out. This report is limited to low back-pain and injuries although some of the findings may be applicable to other types of work-related back disorders.

2.2 PREVALENCE OF LOW BACK DISORDERS

Back pain is a major health problem in the Western world. The lifetime prevalence has been estimated at 59% to 90%, and the point prevalence varies between 15% and 42%, depending on the study population and the definition of back pain. The annual incidence of back pain has been reported to be approximately 5% (Andersson, 1999; Hoogendoorn et al., 1999). For instance, in the UK, the annual incidence of low back pain in the general population is 4.7%, the point prevalence 19%, the prevalence during the last 12 months 39% and the lifetime prevalence 59% (Hillman et al. 1996). In a recent study of the general population in The Netherlands, the prevalence during the last 12 months was found to be 46% for men and 52% for women. This study also showed that the high prevalence of back pain has important consequences in terms of disability, the utilisation of health services, and sick leave. 28% of the people with low-back pain were restricted in their daily activities, 42% underwent medical treatment, 23% took time off work, 8% received a (partial) disability pension, and 6% changed jobs or had adaptations in the workplace (Picavet in

Hoogendoorn et al., 1999). Also other studies mentioned that only half of the low back pain problems are followed by medical advice (Hillman et al., 1996; Ozguler et al. 1999).

Regarding the relationship with work, in the Second European Survey on Working Conditions (Paoli, 1997) 30% of European workers reported that their work causes back problems. Table 1 represents the percentages of each country.

Workers in agriculture and construction are particularly concerned, whereas for the more white-collar workers (e.g. clerks) the percentages are much lower. In addition, 34% of the European workers are required to handle heavy loads in the work (Table 2). Also for this factor workers in the agriculture and construction sectors were more exposed. The least exposed were the more white-collar workers (Paoli, 1997). These results are presented in Table 3.

Also other recent studies have demonstrated that low back disorders rates vary substantially by industry, occupation, and by job within given industries of facilities. High prevalence rates are found, in particular, for non-sedentary occupations (Hoogendoorn et al., 1999). This corresponds with a Finnish study where for farmers the odds ratios (OR: proportion of cases exposed to the risk factor versus the proportion of non cases exposed) were 2.1, for manual workers 1.8 and for white-collar workers 1.4 (Leino-Arjas et al., 1998). A German study even mentions an odds ratio of 0.59 for "desk work" (Latza et al., 2000).

European Agency for Safety and Health at Work has published a report on the "State of Occupational Safety and Health in the European Union" (European Agency, 2000b). This document provides an overview of the current safety and health situation in the European Union with the aim of supporting the identification of common challenges and

Table 1.: Percentages of workers reporting back pain related to work across the member states (Paoli 1997)

B	DK	D	EL	I	E	F	IRL	L	NL	P	UK	FIN	S	A	EU
21	30	30/37	44	32	35	29	13	32	17	39	23	33	31	31	30

A – Austria, B – Belgium, DK – Denmark, FIN – Finland, F – France, D – Germany, EL – Greece, NL – Netherlands, IRL – Ireland, I – Italy, L – Luxembourg, P – Portugal, E – Spain, S – Sweden, UK - United Kingdom

Table 2.: Percentages of workers whose job involves carrying or moving heavy loads across the member states (adapted from Paoli, 1997).

Time Period	Total (%)	Member State														
		A	B	DK	FIN	F	D	EL	NL	IRL	I	L	P	E	S	UK
①All or almost all the time	11	11	8	6	6	16	9	15	8	8	6	8	12	16	8	10
②Around ¾ or ½ the time	9	12	11	11	12	10	8	15	6	12	7	8	7	8	10	10
③Around ¼ of the time	14	13	13	18	21	14	15	9	10	15	10	8	8	11	17	17
Total ①+②+③	34	36	32	35	39	40	32	39	24	35	23	24	27	35	35	37

A – Austria, B – Belgium, DK – Denmark, FIN – Finland, F – France, D – Germany, EL – Greece, NL – Netherlands, IRL – Ireland, I – Italy, L – Luxembourg, P – Portugal, E – Spain, S – Sweden, UK - United Kingdom

Table 3.: Percentages of workers whose job involves carrying or moving heavy loads across the different job sectors (adapted from Paoli, 1997)

Time Period	Total (%)	Sector										
		A-B	C-D	E	F	G	H	I	J	K	L	M-Q
①All or almost all the time	11	22	11	15	24	12	8	12	3	5	4	7
②Around ¾ or ½ the time	9	21	9	10	17	10	12	8	2	3	5	7
③Around ¼ of the time	14	18	15	11	16	17	16	12	5	12	10	12
Total ①+②+③	34	61	35	36	57	39	36	32	10	20	19	26

A-B: Agriculture, Hunting, Forestry and Fishing
C-D: Mining, Quarrying and Manufacturing
E: Electricity, Gas and Water Supply
F: Construction
G: Wholesale and Retail Trade; Repair of Motor Vehicles, Motorcycles and Personal and Household Goods
H; Hotels and Restaurants
I: Transport, Storage and Communications
J: Financial Intermediation
K: Real Estate, Renting and Business Activities
L: Public Administration and Defence; Compulsory Social Security
M-Q: Other Services

priority areas for preventive actions. Regarding the question lifting/moving heavy loads, comparable results with the Second European Survey were found. The main causes for accidents identified in the report are "slip/trips and falls" and "manual handling". The most identified sectors were construction and manufacturing. Mainly male operators were involved (on average 79%).

Heliövaara et al. (in Lagasse, 1996) reported on the frequency in percentage terms of different indicators of low back pain (See Table 4).

Table 4.: Frequency in % of different indicators of low back pain (LBP) (Heliövaara et al., in Lagasse, 1996)

Question	Men (age standardised)	Women (age standardised)
LBP ever	76.3	73.3
6 or more episodes	45.3	44.6
LBP continuously	9.4	8.5
LBP during the previous month	19.4	23.3
Number of subjects	3322	3895

2.3

DURATION OF THE PROBLEM

Although the literature is filled with information about the prevalence of back pain in general, there is less information about chronic back pain, partly because of a lack of agreement about the definition. Chronic low back pain is sometimes defined as back pain that lasts for longer than 7-12 weeks. Others define it as pain that lasts beyond 'the expected period of healing' (Andersson, 1999). Overall, most patients with back pain recover quickly and without residual functional loss, 60-70 % recovers by 6 weeks, 80-90 % by 12 weeks. Fewer than half of those individuals disabled for longer than 6 months return to work and, after 2 years of absence from work, return-to-work rate is close to zero.

A survey in the UK estimated that each sufferer of low back pain took 11 days off work in 1995 because of his or her complaint (HSE 1995).

Several models have been developed to predict the return to work after a period of low back pain. However, the differences in the population studied, time of the evaluation, working conditions and socio-economic differences make these studies difficult to compare. Some studies mention age and location of the symptoms as the most predictive factors, whereas others mention work environment and psychosocial factors.

In addition to the duration of the problem, it should be mentioned that the recurrence rate of low back disorders is very high, seeming to be part of its natural history. Lifetime recurrences of up to 85% are reported, one year recurrence between 20 and 44% (Andersson, 1999). Van den Hoogen et al. (1997) mention that the reappearance of low back pain can even rise to 75% in the first following year, without absence from work.

2.4

COST TO SOCIETY

Although precise figures do not exist, estimates from Member States of the economic costs of all work related ill health range from 2.6 to 3.8% of Gross National Product (European Agency, 1998).

In 1991, the total cost of back pain to society in The Netherlands was estimated to be 1.7% of the gross national product (Van Tulder et al., 1995). The costs were estimated as follows:

- Total direct medical costs: US $367.6 million (total costs of hospital care: US$ 200 million)
- Costs due to absenteeism: US $3.1 billion
- Costs due to disablement: US $ 1.5 billion

All these costs can be attributed to lost production, staff sickness, compensation and insurance costs. Indirect costs such as losing experienced staff and costs of recruiting and training new staff, are not included. It is difficult to compare direct and indirect costs of low back disorders between countries, e.g. the average annual cost per worker varies between FRF100-150 in France, the Netherlands and in the UK, whereas the cost is FRF 600 in the USA. The data from Germany is somewhere between (Inserm 2000). The differences in these data are attributed to the different organisation of insurance systems. Data from the USA reveals that low back disorders significantly increase workers compensation costs. For example, low back disorders account for only 16-19% of all worker compensation claims, but 33-41% of the total cost of all work compensation costs (Marras 2000).

In the UK, 12.5% of all sick days are related to low back disorders, this corresponds with data from Sweden, where 13.5% of sick days are reported (Andersson, 1999). A survey from the HSE estimated 4.8 million working days lost in Britain in 1995 due to back disorders (HSE 1995). Calculations based on a HSE report (1997) have estimated that back disorders cost employers between £315 million and £335 million. The Clinical Standards Advisory Group in the UK (Rosen, 1994) crudely estimated the lost production costs to be approximately £3.8 billion and social security benefits £1.4 billion. A study by the Trade Union Congress (1998) reported that only 17% of employers had actually calculated the costs of low back disorders, only a third provided treatment, physiotherapy or rehabilitation and fewer than half monitored the number of workers suffering from and the number of days lost due to low back disorders.

Lombaert et al. (1996) studied the cost of different illnesses of Belgian employees: colds, flu, of low back pain and psychosocial stress. The average duration of the total sick leave was significantly higher in the case of low back pain and psychosocial stress. Furthermore the medical costs were the highest in the case of low back pain diagnosis (costs of radiology, treatment by physiotherapists and specialists).

2.5 ORIGIN

The exact origin (or aetiology) of low back disorders are often not clear. Current knowledge cannot always determine the exact medical cause of low back pain by clinical examination or laboratory tests. While there is sometimes a relationship between pain and findings on magnetic resonance imaging of disc abnormalities (such as with a herniated disc or clinical findings on nerve compression), the most common form of back disorders is "non-specific symptoms" (Bernard et al., 1997). On average 95% of low back disorders are called "non-specific" or "strain/sprain" because the source of the pain is unknown. Furthermore, the pain may arise from any of the spinal structures - disc, facets, ligaments, vertebrae, tendons and muscles – and a differentiation between the multiple causes is often impossible (Frank et al., 1996a). Conventionally, the origins of low back pain are grouped under four categories: discogenic/neurological, muscular/ligamentous, structural, and other disorders (Khalil et al., 1993). In this review, the first two main categories of disorders are discussed, since structural disorders are often mentioned together with the first category and other disorders (e.g. psychiatric disorders) are not the purpose of this report. Furthermore, the knowledge on the relation between low back pain and psychosocial aspects is mentioned.

2.5.1 Intervertebral disc-related disorders

The lumbar back is subjected to high compressive loads during normal activities. The main function of the intervertebral disc, located between two vertebrae, is to resist this compression. Therefore, the three anatomical structures that make up the disc are very important. The nucleus pulposus is a viscous gel, which transforms compressive loading into hydrostatic pressure, which is directed as tensile stress in the annulus fibrosus, constituted of concentric lamellae. The cartilaginous endplates, the layer between the annulus and the vertebral body, is important for the diffusion of nutrients to the intervertebral disc (Goel et al., 1999).

Degeneration of the lumbar discs reduces the stability of the lumbar spine. A high biomechanical demand on such an unstable lumbar spine leads to a high demand on the ligamental, capsular and muscular structures and the facets. The disc degeneration process is slow and is the cumulative effect of many factors over time. The proportion of people with degenerated discs at the age of 40-60 is between 40 and 60% (Lawrence, 1969). In a magnetic resonance imaging study the prevalence of disc degeneration among 20-39, 40-59 and 60-80-year old persons was 34, 59 and 93% respectively (Boden et al., 1990). For many patients, physiological ageing of the spinal elements – the vertebra, discs, and ligaments – is a potential source of back problems.

In addition to the age-related natural degenerative process, epidemiological studies have revealed that ergonomic factors in the workplace can lead to accelerated degenerative changes in the discs and other structures (Riihimäki, 1991; Luoma et al., 1998). Understanding the role of mechanical factors in

producing disc degeneration is essential for comprehension of low back pain aetiologies and preventive measures. The degenerative process is hypothesised to result from cumulative damage to the spinal components induced by acute or chronic loading. This loading can be caused by many situations, e.g. lifting, twisting and bending the trunk during heavy physical work, or postures with sustained static loading, or vibration from activities like vehicle driving. It has been commonly accepted that compressive loads on the vertebral end plate of 3400 Newton represent the level at which vertebral end plate micro-fractures begin to occur. Marras (2000) mentions that this compression tolerance to spinal loading appears to be modulated by additional factors. Firstly, spine tolerance is reduced as the frequency of loading increases and it is known that a disc hernia from a single application of force is rare. The risk increases significantly when the disc is subjected to repeated loading. Secondly, the relative position or posture of the spine when the load is applied appears to be of great significance to the tolerance of the spine. Finally, hydration is important and related to the time of day: tolerance would be expected to vary throughout the working day.

How can these types of loads lead to degeneration of the lumbar disc? During axial compression on the vertebral spine, the discs bear most of the load. Experimental studies revealed that failure occurs first in the endplate, where micro-fractures are caused (van Dieën et al., 1999). In many cases these fractures will heal and the associated pain will disappear after a limited period. However, further damage may occur and this may lead to a decrease in the diffusion area for the nutrition of the disc. As a result, the chemistry of the disc and the mechanical behaviour of the constituents may be altered, a rupture in the annulus occurs and the nucleus pulposis bulges (Goel et al., 1999). This may lead to spinal cord or nerve root compression, resulting e.g. in sciatica in which pain radiates into one or both legs (Scheer et al., 1996). Other indications of disc degeneration are separation of the laminae of the annulus and rupture of ligaments and facets during higher than normal loads. Spinal osteoarthritis refers to an accelerated and increased level of degeneration, which affects discs, facet joints and vertebrae. With spondylolisthesis, a forward subluxation of the fifth (and sometimes the fourth) lumbar vertebra is mentioned (Goel et al., 1999).

Regarding the aetiology of chronic low back pain, Freemont et al. (1997) mentioned the importance of nerve growth into the intervertebral disc. In the healthy back, only the outer third of the annulus fibrosus of the disc is innervated. Among the patients with chronic low back pain, nerves extended into the inner third of the annulus. Often isolated nerve fibres were found, nerves not accompanied by blood vessels. Since these findings were associated with pain, this suggests an important role for nerve growth into the intervertebral disc in the pathogenesis of certain types of chronic low back disorders.

2.5.2. Soft tissue related disorders

Although it is not possible at this time to identify definitively paraspinal muscles as an etiological site of low back pain, muscular and other soft-tissue injuries are suspected when no other structural or neural abnormalities can be identified on the basis of radiographs or bone scans. Both injuries are sometimes related: if the lumbar spine is unstable because of the degeneration of the discs, soft tissues are exposed to a high mechanical burden. Since these structures contain a lot of pain receptors, low back pain may result (Krämer 1994).

Roy and De Luca (1996) consider muscle impairment as two types of disorders, primary and secondary disorder. Primary disorders result from direct muscle injury, most commonly as the result of muscle strain injuries than direct trauma. Few experimental studies investigated the cause of strain. Garret et al. (in Roy and De Luca, 1996) indicated that injuries usually occur as a response to excessive load or stretch and are most common during eccentric contractions, e.g. forward bending of the spine. Furthermore, prolonged activation of motor

units in the muscle may lead to localised muscle tension, due to the continuous and relatively high activity of some type I motorunits (e.g. Hägg et al., 1991). This could lead to strains or fatigue and other soft-tissue damage. Indeed, work characterised by prolonged isometric contractions of the back muscles has been linked with elevated rates of disorders (Videman et al., in MacGill et al., 2000). The paraspinal muscle fatigue can decrease the muscular support to the spine, causes impairment of motor co-ordination and control and may result in increased mechanical stress to its functional components. The occurrence of muscle fatigue is often examined by evaluating the changes in the electromyographic signal of the muscle during sustained or intermittent work (Hermans et al., 1997).

With secondary disorders, the onset of pain initiates neuromuscular and behavioural responses to prevent or reduce further pain. The body responds involuntarily to pain by the production of a muscle spasm that immobilises or protects the painful area to allow for recovery. This may even aggravate the sensation of pain by restricting circulation and promoting the accumulation of muscle metabolites that are irritants to nerve endings.

2.5.3 Psychosocial mechanisms

Regarding the relationship between psychosocial factors and low back pain, Davis and Heany (2000) summarised the different mechanisms that have been hypothesised. First, psychosocial factors are directly related to low back pain by influencing the loading on the spine. This means that jobs with high biomechanical demands are associated with high psychosocial demands (high stress, low job satisfaction). Second, psychosocial factors influence various chemical reactions in the body during the performance of job tasks. An increased muscle tension is found with poor psychosocial factors, this may reduce blood flow resulting in the accumulation of metabolites that result in muscle pain. A third potential mechanism links the presence of psychosocial factors with a reduced pain tolerance. In a stressful environment people might be more sensitive to pain and more likely to report injury or pain.

Recently, the European Agency published a review "Research on Work-Related Stress" (European Agency, 2000c) where the mechanisms of stress-related physio-pathology are further explained.

RESEARCH

3.

RISK FACTORS

There are several epidemiological studies investigating risk factors of low back disorders. Epidemiology is the study of the distribution and determinants of health problems in specified populations and the application of the study to the control of the problems (Last, 1995). Studies in epidemiology seek to find associations between exposure and disease (or cause and effect). Conceptual models are used to represent the relation between these two factors. The multifactorial nature of low back disorders necessitates the presentation of different categories of risk factors in these models.

3.1

MODELS FOR PATHOGENESIS

Several models have been developed to present the possible pathways that could lead to the development of musculoskeletal disorders. Some models focus on mechanical exposure (e.g. Van der Beek and Frings-Dresen, 1998), whereas other authors focus on psychosocial aspects (e.g. Hurrell and Murphy, in Hales and Bernard, 1997). Recently The National Research Council (1999) outlined a broad conceptual framework (figure 1), indicating the roles that various work and other factors may play in the development of musculoskeletal disorders. This framework serves as a useful tool to examine the diverse literatures associated with musculoskeletal disorders, reflecting the role that various factors can play in this development - work procedures, equipment and environment; organisational factors; physical and psychological factors of individuals; non-work-related activities; organisational factors; and social factors-. Its overall structure suggests the physiological pathways by which musculoskeletal disorders and thus low back disorders can occur or, conversely, can be avoided.

The authors explain the model as follows. The central physiological pathway shows, firstly, the biomechanical relationship between load and the biological response of the body. Loads within a tissue can produce several forms of response. If the load exceeds a mechanical tolerance or the ability of the structure to withstand the load, tissue damage will occur. For example, damage to a vertebral end plate will occur if the load borne by the spine is large enough. Other forms of response may entail such reactions as inflammation of the tissue, oedema, and biochemical responses. However, imposing a certain biomecanical load on musculoskeletal tissues may also have a strengthening effect and adaptation may occur.

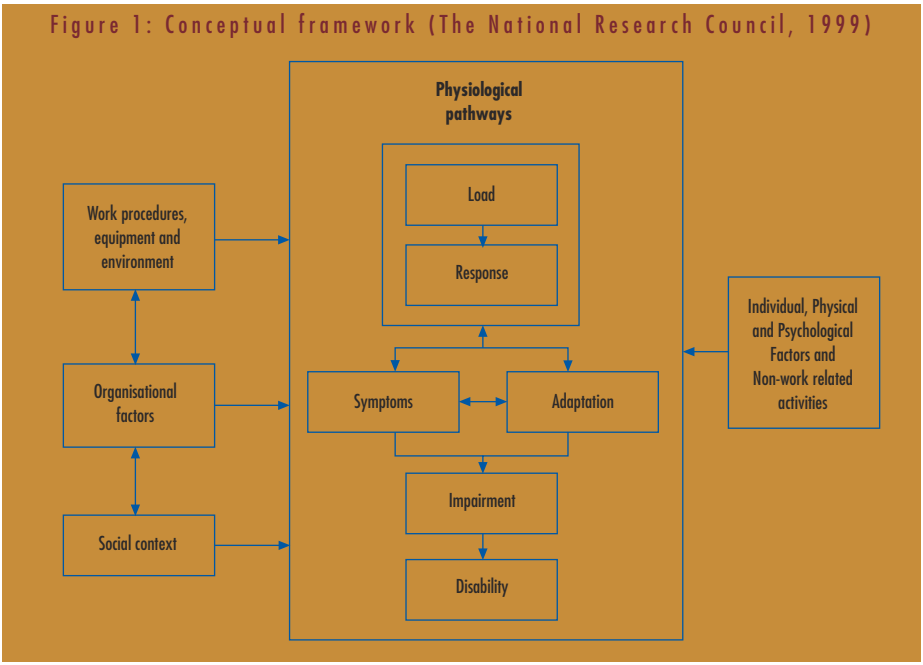
Biomechanical studies can elucidate some of these relationships. Biomechanical loading can produce both symptomatic and asymptomatic reactions. Feedback mechanisms can influence the biomechanical loading and response relationship. For example, the symptom of pain might cause an individual to use his or her muscles in a different manner, thereby changing the associated loading pattern. Adaptation to a load might lead individuals to expose themselves to greater loads, which they might or might not be able to bear.

The responses, symptoms and adaptations can lead to functional impairment. In the workplace this might be reported as a work-related musculoskeletal disorder. If severe enough, the impairment would be considered a disability and lost or restricted workdays would result.

The left part of the framework shows environmental factors that might affect the development of musculoskeletal disorders, including work procedures, equipment, and environment, organisational factors and social context.

The right part of the framework shows the influence of individual physical and psychological factors, as well as non-work-related activities, which might affect the development of musculoskeletal disorders.

Figure 1: Conceptual framework (The National Research Council, 1999)



This framework can accommodate the diverse literature regarding musculoskeletal disorders by characterising the pathways that each study addresses. For example, an epidemiological investigation might explore the pathways between the physical work environment and the reporting of impairments or the pathway between organisational factors and the reporting of symptoms. An ergonomic study might explore the pathways between work procedures and equipment and the biomechanical loads imposed on a tissue. This framework also focuses attention on the interactions among factors.

To understand more about the concept of pain see the publication of Johansson and Sojka (1991). The authors introduced a patho-physiological model for the cause of muscular tension and pain in occupational pain syndromes and chronic musculoskeletal pain syndromes. This model may be important to explain that not only muscles but also the central nervous system is involved in the development and perpetuation of pain syndromes.

3.2

RISK FACTORS

Many review articles have been published investigating the risk factors of low back disorders on the physical, psychosocial and personal domains. These factors may interact in different ways to cause low back disorders. In one situation the psychosocial risk factor may be the main contributor, whereas in other cases it may be the physical risk factors that are the primary causes. Thus, in every situation the risk factors would interact in a different manner to reach a critical tolerance level unacceptable to the person, and resulting in reporting of low back pain. The comparison of the different studies is not always easy, due to different definitions of risk factors or categories of risk factors. Especially in the non-biomechanical domain, as the terms such as psychological, psychosocial, psychic, individual and personal are often used with overlapping meanings. Hagberg et al. (1995) have discussed the meaning of work organisational and psychosocial work: "Psychosocial factors at work are the subjective aspects as perceived by workers and the managers. They often have the same names as the work organisation factors, but are different in that they carry 'emotional' value for the worker. Thus, the nature of the supervision can have positive or negative psychosocial effects (emotional stress), while the work organisation aspects are just descriptive of how the supervision is accomplished and do not carry emotional value. Psychosocial factors are the individual subjective perceptions of the work organisation factors." With individual factors, factors related to the subject but outside the work organisational context are stressed.

It should be mentioned that a combination of possible risk factors might increase the development or occurrence of low back disorders. Vingard et al. (2000) reported that a combination of high physical and psychosocial load increased the care seeking for low back pain in working men and women.

Below is a brief discussion of some of the most important risk factors of the different domains, based on several review studies that use thorough selection criteria to identify relevant articles (e.g. Riihimäki, 1991; Hales and Bernard, 1996; Bernard et al., 1997; Burdorf and Sorock, 1997; Ferguson and Marras, 1997; Frank et al., 1996a and 1996b; Bongers et al., 2000; Hoogendoorn et al., 2000). Emphasis is laid on risk factors related to the working environment, although some information on personal risk factors is provided.

An effort is made to summarise the relationship between low back disorders and the risk factors (Table 5). The classification system of Bernard et al. (1997) and the classification of Hoogendoorn et al. (2000) was used to characterise the strength of evidence for work-relatedness, examining the contribution of each physical risk factor to low back disorders.

The evidence for a relationship is classified into one of the following categories:

- Strong evidence of work-relatedness (+++): provided by generally consistent findings in multiple high quality studies.
- Evidence (++): provided by generally consistent findings in one high quality study and one or more low quality studies, or in multiple low quality studies

Table 5. The work relatedness of low back disorders: overview of the risk factors.

Category of risk factor	Risk factor	evidence
Physical factors		
	Heavy manual labour	++
	Manual material handling	+++
	Awkward postures	++
	Static work	+/0
	Whole-body-vibration	+++
	Slipping and falling	+
Psychosocial/work-organisational factors		
	Job content	+/0
	Work/time pressure	+/0
	Job control	+/0
	Social support	+++
	Job dissatisfaction	+++
Individual factors		
	Age	+/0
	Socio-economic status	+++
	Smoking	++
	Medical history	+++
	Gender	+/0
	Anthropometry	+/0
	Physical activity	+/0

- Insufficient evidence (+/0): only one study available or inconsistent findings in multiple studies.

3.2.1 Physical risk factors

3.2.1.1 Heavy manual labour

Definition

In the NIOSH-review (Bernard et al, 1997) heavy physical work has been defined as work that has high energy demands or requires some measure of physical strength. Some biomechanical studies interpret heavy work as jobs that impose large compressive forces on the spine (Marras et al., 1995). In this review, the definition for heavy physical work includes these concepts, along with investigators' perceptions of heavy physical workload, which range from heavy tiring tasks, manual materials handling tasks, and heavy, dynamic, or intense work.

Conclusions

A general consensus has been found on the association of low back disorders and heavy

manual work (Bernard et al., 1997). Evidence for a positive association was provided, despite the fact that the studies included defined disorders and assessed exposures in many ways.

3.2.1.2 Manual materials handling

Definition
Manual materials handling include lifting, moving, carrying and holding loads. Bernard et al. (1997) defined lifting as moving or bringing something from a lower level to a higher one. The concept encompasses stresses resulting from work done in transferring objects from one plane to another as well as the effects of varying techniques of patient handling and transfer. Forceful movements include movement of objects in other ways, such as pulling, pushing, or other efforts.

Conclusions
There is strong evidence that low-back disorders are associated with work-related lifting and forceful movements (Marras et al., 1995; Bernard et al., 1997; Hoogendoorn et al., 1999).

In some studies where no association was found, it is reported that this is probably due to subjective measures of exposure. When objective measures are used to examine specific lifting activities, the risk estimates even increase. The magnitude of risk estimates or odds ratio's (Odds Ratio-OR is the proportion of cases exposed to the risk factor versus the proportion of non-cases exposed) range from 1.5 to 3.1 (Hales and Bernard, 1997; Hoogendoorn et al., 1999).

The extent of spinal loading during manual load handling can be modified by (Karwowski et al., 1992).

- load dimensions, shape and weight
- horizontal and vertical patterns of dynamic lifting motions
- degree of flexion and rotation of the spine
- task frequency
- environmental factors

Also Marras (2000) demonstrated the importance of frequency of loading and the relative position of the spine with his laboratory experiments.

3.2.1.3 Bending and/or twisting (awkward postures)

Definition
Bending is defined as flexion of the trunk, usually in the forward or lateral direction (Bernard et al, 1997). Twisting refers to trunk rotation or torsion. Awkward postures include non-neutral trunk postures (related to bending and twisting).

Conclusions
Results are consistent in showing positive between low-back disorders and work-related awkward postures association (Bernard et al.,1997; Hoogendoorn et al. 1999). There is an increased risk of back disorder with exposure, despite the fact that studies defined disorders and assessed exposures in many ways. Several studies found risk estimates above an odds ratio of 3 and dose-response relationships between exposures and outcomes.

3.2.1.4 Static work, sitting and standing

Definition
Static work postures include positions where very little movement occurs, along with cramped or inactive postures that cause static loading on the muscles (Bernard et al, 1997). This includes prolonged standing or sitting and sedentary work. In many cases the exposure was defined subjectively and/or in combination with other work-related risk factors.

Conclusions
Due to the technological innovations, the number of static work has increased tremendously (e.g. office/VDT work, control tasks). Hales and Bernard (1996) concluded in their review that prolonged sitting is a potential risk factor for the development of low back pain. During sitting, a prolonged compression force may increase the risk of disc problems (Videman et al., 1990), or the continuous activity of some type I motor units of (back) muscles may contribute to the development of fatigue (Hägg et al., 1991). The fact that several investigations mention an increased risk for low back disorders when jobs have to be performed

sitting, compared with jobs where frequent changes in posture are adopted, increased the development of new types of chairs to promote "dynamic sitting". By allowing movement of the back support and/or chair seat, a dynamic sitting pattern is created which could have a positive prevention effect. However, Jensen and Bendix (1992) found in their experimental study no effect of a movable chair seat. Moreover, in several reviews conflicting results are mentioned (Bernard et al., 1997; Hoogendoorn et al., 1999). Recently, van Dieën et al. (2000) found that dynamic office chairs offer a potential advantage over fixed chairs, but the effects of the specific task that a subject has to perform (e.g. reading or working with a computer) appeared to be more pronounced. Regarding prolonged standing as a possible risk factor, inconsistent results are mentioned, no evidence for an effect of prolonged standing can be found (Hoogendoorn et al., 1999).

3.2.1.5 Vibration and driving

Definition

Whole-body-vibration (WBV) refers to mechanical energy oscillations that are transferred to the body as a whole (in contrast to specific body regions), usually through a supporting system such as a seat or platform. Typical exposures include driving cars and trucks, and operating industrial vehicles, such as forklifts.

Conclusions

There is agreement among international investigators that long-term whole-body-vibration from engines and vehicles is an important mechanical stress factor contributing to early and accelerated degenerative spine diseases, leading to back pain and prolapsed discs. Poor body posture, inadequate seat support and fatigue of back muscles have been described as co-factors in the pathogenesis of musculoskeletal disorders of the spine in operators/drivers (Hulshof ,1998; Johanning, 2000). Two principal pathological mechanisms of vertebral damage due to whole-body-vibration have been suggested. Firstly, induction of micro-fractures at the endplates, with callus formation during healing and the altered disc dimension under the load, may reduce the rate of nutrient diffusion. Secondly, vibration-induced mechanical overload, causing continuous compression and stretching of the spinal structures, may result in tissue fatigue. Spinal muscle fatigue can increase the effect (Johanning, 2000).

High prevalence of low back disorders has been consistently reported among vibration-exposed occupational groups, i.e. tractor drivers, truckers and bus drivers, crane or earth moving equipment operators and helicopter pilots (Hulshof, 1998). Also among operators of rail-vehicles with relatively low vertical but high lateral vibration, the prevalence is high. The highest levels of vertical vibration were found in off-road vehicles and forklifts (Johanning, 2000).

3.2.1.6 Slipping and falling

Khalil et al. (1993) reported that the most important and detrimental factor in the onset of low back disorders appears to be related to the way in which work activities are performed. The most common event leading to low back pain and injury in their study was slipping and falling, which is an unexpected, uncontrolled event. Slipping and falling on wet surfaces was an especially important risk factor. Although often mentioned as an important risk factor, few studies can be found that investigated its importance. In the review of Ferguson and Marras (1995) only one study mentioned. In this study a positive association between low back pain and slipping/falling was found.

3.2.1.7 Conclusions on physical risk factors

Bernard et al. (1997) report that several studies use indices of physical workload combining several physical risk factors (e.g. lifting and heavy physical work). Frank et al. (1996a) mention that the ability of a study to identify relevant associations is reduced when non-validated measurement instruments are used. Poor measurements of exposure may result in lower

risk estimation and important risk factors will be overlooked. This is confirmed by the NIOSH review, were often higher associations or risk estimates were found when objective measures were used. Nevertheless, two observations support the conclusion that there is reasonably good evidence for a causal relationship between low back disorders and workplace biomechanical exposures:

(1) the consistency of the reports on certain variables (lifting, driving and whole-body-vibration); and
(2) the strength of the associations of certain general characteristics measured objectively (high spinal loading and awkward postures).

Bongers et al. (2000) performed a prospective longitudinal study to analyse possible risk factors that induce low back disorders. Strong bending of the trunk and heavy lifting where the most important physical risk factors.

3.2.2 Psychosocial factors

Burdorf and Sorock (1997) report that the number of epidemiological studies addressing psychosocial risk factors during work is considerably smaller than the studies focusing on physical load. In addition, the strength of the association is generally higher for biomechanical factors. However, the empirical evidence linking these factors with low back disorders is growing. Bongers et al. (1993) were the first to perform a thorough review of the literature on this topic. Recently, Hoogendoorn et al. (2000) reviewed the relationship between psychosocial factors and back pain.

3.2.2.1 Job content

Poor job content includes monotonous work, few possibilities to learn new things and to develop knowledge and skills at work (Hoogendoorn et al., 2000). Several studies (Heliovaara et al., 1991; Houtman et al. in Bernard et al, 1997; Burdorf and Sorock, 1997) have reported associations between monotonous work and reports of back complaints. However, Hoogendoorn et al. (2000) mention that there is insufficient evidence of an effect. In addition, in the NIOSH review, inconsistent findings are reported.

3.2.2.2 Increasing work/time pressure or intensified work load

A number of studies have reported associations between perceptions of intensified workload, as measured by reports of time pressure and high work pace, and self-reports of back pain (Heliövaara et al. and Lundberg et al. in: Bernard et al.,1997). However, Hoogendoorn et al. (2000) mention insufficient evidence of an effect of a high work pace, due to inconsistent findings.

3.2.2.3 Job control

Job control includes aspects as autonomy and influence. Hoogendoorn et al. (2000) found one high quality study where an effect between low work control and low back pain was found but only for manual women workers. In another high quality study an effect between low job control and absences due to low back pain was found, except in lower grade men and higher grade women where the effect was reserved. The authors concluded that there was insufficient evidence of any effect.

3.2.2.4 Social support in the workplace

Social support in the workplace includes social support of co-workers and supervisors, relationships at work and problems with work mates and superiors. Strong evidence for low social support in the workplace as a risk factor for low back pain has been found (e.g. Hoogendoorn et al., 2000).

3.2.2.5 Job satisfaction

For low job satisfaction as a risk factor, strong evidence has also been found (Hoogendoorn et al., 2000). Burdorf and Sorock (1997) also report this relation.

3.2.2.6 Conclusions on work-related psychosocial factors

Based on the review studies, low job satisfaction and low social support were found to have a majority of positive associations with the occurrence of low back pain. These factors increase perceived stress in the working environment. In their prospective longitudinal study, Bongers et al. (2000) report high workload and decreased social support from colleagues or supervisors as being the most important psychosocial prognosis factors.

Inconsistent results for the other psychosocial factors may be attributed to methodological issues, e.g. lack of controlling for potential confusing factors (age, gender, biomechanical factors) or different timing of the exposure and outcome variables (Davis and Heany 2000).

3.2.2.7 Psychosocial factors in the personal situation

Bongers et al. (1993) reported several factors associated with the individual worker (e.g. personality) and extra-work environment (e.g. living alone) that have been linked to back pain and disability. In their recent review, Hoogendoorn et al. (2000) studied the influence of family support, having friends or neighbours, social contact, social participation, instrumental support and emotional support. The only effect found was that high emotional support had a positive effect in an elderly population.

3.2.3 Individual risk factors

Although this report is not focused on individual risk factors, it is important to mention the significant relationships between some factors and low back disorder occurrence. However some of these factors are confounded with employment history (length and type of work).

3.2.3.1 Age/years of employment

It is agreed that the prevalence of low back disorders increase as people enter their working years: by the age of 30, most people have had their first episode of back pain. It would be incorrect to include that low back disorders are a health problem only for older workers, since prevalence rates are also found in younger age groups. In the European study, a prevalence of 25% was found before 25 years and 35% at 55 years and older (Paoli, 1997). Leboeuf-Yde and Kyvik (1998) even mention that by the age of 20 years, more than 50% of young people have had experienced at least one low back pain episode. Burdorf and Sorock (1997) mention twelve studies reporting a positive association between low back disorders and increasing age, but also 15 studies where no association is mentioned.

It is important to investigate also the years of employment. Age and years of employment are often strongly correlated which makes it difficult to disentangle their effects on the occurrence of low back disorders. They both can confound each other's effect. A person of 30 years for instance may experience low back pain but already performs lifting tasks for 10 years. However, also young people with little experience often report low back pain due to unadjusted postures or because they are placed in jobs that require more manual material handling because of their lower seniority.

3.2.3.2 Socio-economic status/education

Lower socio-economic status employees report low back pain more frequently. However, it is argued that this can be caused by the more physically demanding occupations often performed by people with lower education levels. Luoma et al. (2000) investigated the influence of type of work on low back pain frequency. The authors concluded in both studies that machine operators and carpenters reported more sciatic pain than office workers and the latter were indeed more highly educated subjects and the majority of them belonged to a higher social class than the manual workers. Also Leino-Arjas et al. (1998) found higher prevalence of low back pain in farmers and manual workers as compared with office and administrative etc. workers. This

corresponds to the European study where the prevalence of low back pain in office/ administrative workers was on average 20%, compared with 49% in agriculture and 44% in construction (Paoli, 1997). The findings of Latza et al. (2000) support the hypothesis that severe back pain is less prevalent among adults of higher socio-economic status.

3.2.3.3 Smoking

Most studies reviewing the influence of smoking report a relation with low back pain. Several papers have presented evidence that a positive smoking history is associated with low back pain, sciatica, or intervertebral herniated disc (Bernard et al., 1997), whereas in others the relationship was negative (Bongers et al. 2000).

As the postulated mechanisms are mentioned: a decreased blood flow, induced by the nicotine; smoking-induced diminished mineral content of bone causing micro-fractures and the smoking induced coughing that increases abdominal and intradiscal pressure (Hales and Bernard, 1996). In a review of 47 studies, Leboeuf-Yde (1999) concluded that smoking should be considered a weak risk indicator but not a cause of low back pain. There must also be the strong confounding influence of socio-economic status and therefore type of job (manual workers smoke more than non-manual workers) and the link between stress and higher smoking could be a bias.

3.2.3.4 Medical history

A general consensus has been found on previous history of low back pain as one of the most reliable predictive factors for subsequent work-related low back pain (e.g. Lagerstrom et al., 1998). Luoma et al. (1998) found in their study on risk factors of lumbar disc degeneration that all signs of degeneration were related to a history of back accidents. In some studies, a previous history has been interpreted as representing an underlying personality trait ("complainer"), although it could also be indicative of a reduced threshold for injury or pain in spinal tissues (Frank et al., 1996a). Some studies mention the relation between births or final stage pregnancies and low back pain.

3.2.3.5 Gender

It is mentioned that the prevalence of low back disorders in the European Union is equal among men and women (Paoli, 1997). However, some studies report higher rates of severe disorders among the male population, especially for sciatica (Lagasse, 1996). It is important in these studies to consider the possible different types of occupation (Burdorf and Sorock, 1997). In a European Agency study (2000b) it was found that accidents in the workplace were mainly attributed to "slip/trips and falls" and "manual handling", which occurred more in the construction and manufacturing sectors. Mainly male operators were involved (on average 79%).

Recently, Vingard et al. (2000) found that current and past physical and psychosocial occupational factors seemed to be gender-specific. Psychosocial factors alone seemed to be of less importance in women, but "poor job satisfaction" and "mostly routine work without possibilities of learning" increased in men.

3.2.3.6 Anthropometry: weight and height

Although Leino-Arjas et al. (1998) found that the body mass index was associated with back pain among women, most of the evidence in literature appears to be negative. Also for stature and build, in general no strong correlation with low back disorders is found (Bernard et al., 1997; Burdorf and Sorock, 1997). From a review of 65 epidemiologic studies, Leboeuf-Yde (2000) concluded that due to lack of evidence, body weight should be considered only as a possible weak risk indicator, but there is insufficient data to assess if it is a true cause of low back pain.

3.2.3.7 Physical activity: fitness and strength

Regarding the preventive effect of physical fitness on low back disorders, no conclusions can be drawn from the literature. The level of general

(cardio-respiratory) fitness has no predictive value for future low back disorders (Carter and Birrell, 2000). Furthermore, strong spinal and abdominal muscles are not considered as significant factors for the prevention of work-related low back disorders. Weaker muscles may in fact be the result of low back pain, not the cause of it. According to the review study of Hoogendoorn et al. (1999), no evidence was found for an effect of sports activities or total physical activity during leisure time. Furthermore, no evidence was found for participation in specific sports or driving a car during leisure time. The authors mention that the application of physical activity types was different in the different studies and in general not very specific. It may be worthwhile to develop new methods to measure and evaluate this factor more adequately in the future. Westgaard and Winkel (1997) concluded that interventions that actively involved the worker (e.g. physical training or active training in work technique) often achieved positive results, whereas more passive measures (e.g. health education) did not appear to be equally successful.

3.2.3.8 Psychological factors

Andersson (1999) mentions in his review various studies where an association between low back pain and psychological factors is found (e.g. anxiety, depression, stress). The experience of these factors is sometimes, but not always, secondary to back pain. In a few prospective studies, various symptoms that indicate psychological distress predicted the development of low back pain in people who did not have previous back disorders. In a study of Polatin (in Andersson, 1999) the possible etiological importance of psychiatric disorders was investigated. It was concluded from a group of 200 patients that substance abuse (94 %) and anxiety disorders (95 %) precede chronic low back pain, whereas depression (54 %) may develop before or after the onset of chronic low back pain.

However, the relationship between psychological factors and musculoskeletal disorders remains unclear (Feyer et al., 1992). One possibility is that psychological distress is simply a consequence of chronic low back pain, with no etiologic role in the development of the disorder. Alternatively, it is possible that psychological factors may have some etiologic role in the transition from an employee with a history of back pain to the status of an unemployed patient with chronic back pain, due to fear of re-injury, or other factors which would make job performance impossible

3.2.3.9 Conclusions on individual risk factors

The most consistent associations have been found between low back disorders and socio-economic status or medical history, whereas for the association between low back disorders and fitness, many conflicting results are reported. However, this factor may contribute to general health benefits, e.g. by organising fitness programs. Also anti-smoking campaigns or healthy food provision may have this beneficial general health effect.

It is often mentioned that prevention of several of the individual risk factors is not possible: age, gender and medical history cannot be changed. However, the sooner prevention is induced, the more probable it is that a medical history for low back disorders will not develop or even exist. When considering age as a risk factor, the "healthy worker effect" often causes bias: if workers who have health problems leave their jobs, or change jobs to one with less exposure, the remaining population includes only those workers whose health has not been adversely affected by their jobs.

3.3

PROGNOSIS OF LOW BACK DISORDERS AND RETURN TO WORK

Carter and Birell (2000) reviewed pre-placement assessment. They concluded that examination findings, including in particular height, weight, lumbar flexibility and straight leg raising, have little predictive value for future low back disorders or disability. Also the level of general fitness (cardio-respiratory), X-ray and magnetic resonance imaging findings have no predictive value for future low back disorders or disability. Furthermore, back-function-testing machines (isometric, isokinetic or isoinertial measurements) have no predictive value.

They also state that low back disorders are common and recurrent and is not a reason for denying employment in most circumstances. However, care should be taken when placing individuals with a strong history of low back disorders in physically demanding jobs. Attention should be given to adapt work organisational factors.

Verbeek et al. (2000) recently performed an extensive search on articles that dealt with prognosis on low back disorders. They concluded that increased time to return to work is predicted by older age, a higher degree of disability and a specific diagnosis. It is not clear by what mechanism these factors worsen the prognosis of return to work, but the authors suggest the following: for age, the increasing age itself makes it more difficult to resume work tasks. A high level of disability takes more time to resolve and leads consequently to a longer time off work. That a specific diagnosis predicts a late return to work may be caused by the seriousness of the disease and/or by the behaviour of doctors being more cautious in advising return to work. Regarding the working conditions, the authors mentioned that heavy physical work is not a predictor of longer delay until return to work. Other work-related factors such as the possibility of taking breaks and social support were of more importance in predicting a shorter time. However, Meyer et al. (1998) found that workers involved in manual handling had higher frequency and severity of low back disorders than a reference population. The authors state that individual factors are often decisive in the onset of low back disorders, but in the more serious cases material handling is an aggravating factor.

Loisel et al. (1997) developed and tested a model of management of sub-acute back pain to prevent prolonged disability. Workers were placed in one of four treatment groups. It was found that the group receiving full intervention (clinical and occupational intervention) returned to regular work 2.4 times faster than the usual care intervention group. There is preliminary evidence that educational programmes which specifically focus on beliefs and attitudes may reduce future work loss due to low back disorders (Carter and Birrel, 2000).

3.4

ASSESSMENT TECHNIQUES AND RISK FACTORS

Ferguson and Marras (1997) hypothesised that certain risk factor categories may influence different events in the progression of low back disorders in different ways. For each step in the time progression of low back disorders, specific analysis techniques can be used. The authors performed a careful examination of the existing literature (articles were only included when at least one technique was used, at least one risk factor was analysed, and certain methodological issues were respected). Conclusions were made based on 57 studies that fulfilled the above-mentioned criteria:

- Using incidence as analysis techniques results in more positive findings with exposure risk factors
- Analysis techniques indicating more advanced stages of low back disorders (e.g. lost time) had more positive findings with psychosocial risk factors. This suggests that as low back disorders disorders progress to disability, the psychosocial risk factors play a more prominent role.
- The precision of measurement is very important in the attempt to distinguish symptomatic and asymptomatic subjects. Strength measures that require higher levels of motor control were better indicators of low back disorders (e.g. weight-handling skills instead of isometric or isokinetic strength measures).

In their recent review, Davis and Heaney (2000) found that the association between psychosocial work characteristics and low back pain differed by the type of outcome measure used. More positive associations with psychosocial work characteristics were found when self-reports of symptoms or injuries were used than when low back disorders was determined by physical examination.

RESEARCH

4.

STRATEGIES AND EFFECTIVENESS OF PREVENTION

4.1 PREVENTION STAGES

In general, three prevention stages can be described. With primary prevention, the goal is to avoid low back disorders in the first place, to prevent the onset of low back disorders. The goal of secondary prevention is to halt the further development of low back disorders, to prevent the onset of chronic pain and recurrence of a low back disorder. Studies to determine effective interdisciplinary approaches to the identification of workplace risk factors. In the tertiary prevention stage, the goal is to reduce disability or handicap and a more specific individual approach is necessary, which goes beyond the scope of this report.

Emphasis is placed on primary prevention in the workplace. However, due to the high prevalence of low back disorders in the working environment today and therefore the need to address return-to-work and rehabilitation issues strategies of secondary prevention are also covered. In implementing the secondary and tertiary measures an integrated work-place approach is recommended, with treatment and rehabilitation taking place within the context of a clear focus on eliminating and reducing the work-related risks giving rise to the problems. Details on the possible contents of secondary/tertiary strategies are given in appendix 3.

4.2 PRIMARY PREVENTION STRATEGIES

4.2.1. Types of interventions to reduce work place risks

Elimination of lifting or other types of physical "overload" on the body in the first place should be the first priority for prevention and reduction of work-related disorders. For manual handling tasks this can be achieved through task automation so that the worker only performs a control task (e.g. in car assembly). This solution is very radical and often not practical to establish, and can also lead to the introduction of other work-related problems for example from a change to more repetitive tasks. Therefore other prevention strategies also have to be considered to reduce the amount and physical demands of manual handling tasks. Several strategies are possible (Frank et al., 1996a): adjustments to the work to reduce the physical demands (e.g. using material handling devices) or changes to organisational factors (e.g. organising breaks and job rotation) and training workers to increase their ability to recognise and avoid unsafe lifting situations.

4.2.1.1 Reducing the physical demands

- **Optimisation of workplace factors**

Several general ergonomic solutions can be made to reduce the physical demands of the task:

- design of the work task: reduction of the necessity to handle a load, reduction of the weight of the load, reduction of the shape and size of the load, reduction of the number of moves and the distance of moves.
- design of the work place: allow enough space for body movement, avoid bending of the trunk and optimise the working level. Furthermore, create safe working environments for the prevention of accidental injuries, avoid the risks for slipping or falling.
- design of the work organisation: adequate relation between demands and rests, duration and frequency of lifting.

From a recent prospective longitudinal study, Bongers et al. (2000) mentioned the following recommendations:

- Reduction of physical load at work to help reduce the number of low back problems and absence from work. Attention should be on reduction of high exposure and repetitive lifting: Lifting of 25 kg or more has to be avoided, especially when lifting more than 15 times per day.
- Work situations with trunk bending have to be avoided (especially when bending 60° or more).
- Work situations with trunk rotation during more than 10% of the work time have to be avoided.

A commonly used practice to change work organisational design is job rotation: to move workers from work station to station or to change tasks within one work station on some organised schedule (e.g. every two hours). Job rotation is used for a variety of reasons: to increase motivation; to train a more versatile work force; to reduce fatigue and risk of musculoskeletal disorders. However, Frazer et al. (2000) recently showed that job rotation does not always reduce risk for all workers in the rotation. The effects are not always intuitively predictable because of the complex effect of mixes of tasks that influence both peak and cumulative loading on tissues. It is not only high peak compression and sheer force on spinal tissues that are problematical, but also high accumulation of these forces over the course of a work shift, regardless of whether they are high or not. Again, this necessitates the reduction of repetitive lifting.

- **Material handling devices**

Mechanical lifting and carrying devices are becoming increasingly important in the working environment, with the aim of reducing the stresses imposed on the musculoskeletal system during manual handling work. By introducing a handling device in the workplace, the weight of an external load is reduced and extreme flexion and rotations of the trunk are avoided. When implementing these tools in the workplace, it is important to take into account several other factors:

- Time: it has been found that using a mechanical device sometimes takes longer than manual lifting and may be a reason why devices are not used (Mathisson et al., 1994, Hermans et al., 1999a).
- Work space: manipulating an object with a mechanical device may require more space, which is often very limited. This may influence also the safety of the working environment (Hermans et al. 1999a).
- Instruction: High biomechanical stress on the back can still be a problem, primarily due to the inertia of the device, which produces high acceleration and deceleration phases when utilising the device (Chaffin et al., 1997). In further experiments, Chaffin et al. (1999) found that when subjects were instructed and controlled to keep a comfortable speed, material handling devices had a particularly beneficial effect on reducing the compression forces in the lower back during lowering activities. Training to work efficiently with the device should be provided.

- Total physical load: when implementing the device in the workplace, attention must be given to ensure that no shift of static load to other body regions occurs, e.g. to the upper limbs (Hermans et al., 1999a).

Carter and Birrell (2000) advise on current good practices such as specified in the Manual Handling Directive and associated guidance. Furthermore, it is expected that still more and better mechanical lifting aids will be developed in the future. The introduction of CEN Standards, among other things, including the requirements for ergonomics and safety of machinery, will promote this development (e.g. EN 894-1, EN 894-3, EN 614-1, EN 547-1, EN 547-2, EN 1005-3).

- **Back belts**

Back belts were initially used in medical settings to provide additional support during rehabilitation of back injuries. Later, weight lifting athletes began using leather belts. Today, more than 70 types of industrial back belts exist, usually a lightweight, elastic belt, often called 'back belt', 'back supports' or 'abdominal belts'. The advantages of using a belt are mentioned by (Carter and Birrell, 2000):

- the internal forces on the spine are reduced during forceful exertions of the back
- the intra-abdominal pressure increases, which may counter the forces on the spine
- the spine stiffens, which also decreases the forces
- the wearer is reminded to lift properly

Van Poppel et al. (1999) evaluated the evidence for the hypothesis that trunk motion is affected wearing a belt so that extreme postures are obstructed. A positive association was found in 8 out of 13 studies in the literature. The trunk motion was at least in one of the motion planes decreased, mainly flexion/extension and lateral bending were reduced. No statistical significant effect was found for rotation, which possibly can be explained by the large variation among subjects. Regarding a second hypothesis that intra-abdominal pressure increases wearing a belt without increase of muscle activity so that there is less muscle loading, conflicting results were found in the studies. Also other studies questioned the effectiveness of back belts (e.g. Op De Beeck and Vertongen, 1995; NIOSH 1994). NIOSH concluded from their review that the results can not be used to either support or to refute the effectiveness in injury reduction. In addition, workers wearing back belts may attempt to lift more weight than they would have without a belt. A false sense of security may subject workers to greater risk of injury.

In conclusion, there seems to be strong scientific evidence that lumbar back belts or supports do not reduce low back disorders and work loss (Carter and Birrell, 2000).

- **Chairs**

Harrison et al. (1999) conclude in their review that sitting causes the pelvis to rotate backward and causes reduction in lumbar lordosis, trunk-thigh angle, knee angle and causes an increase in muscle effort and disc pressure. Subjects in seats with backrest inclinations of 110 to 130 degrees, with concomitant lumbar support, have the lowest disc pressures and lowest spinal muscle activity. To reduce forward translated head postures, an inclination of 110 is preferable over higher inclinations. A seat-bottom posterior inclination of 5 degrees and armrests can further reduce the pressures and activity. Subjects give the highest comfort ratings to adjustable chairs, which allow changes in position. Nevertheless, it should be mentioned that in several reviews still no association between low back disorders and prolonged sedentary mentioned was found (Burdorf and Sorock, 1997).

- **Vibration limits**

According to ergonomics recommendations, tractors, heavy vehicles and constructions machinery with frequencies most often between 2 and 5 Hz and operating for an 8 hours day, require a limit of oscillation acceleration of 0.3 – 0. 45 m/s2. These limits are often exceeded but technically they can be achieved by jointly engineering the suspension of the vehicle's axles and the driver's and passengers' seats (Kroemer and Grandjean,

1997). In many studies investigating the relationship between low back disorders and whole body vibration, an action level of 0.5 m/s2 is often mentioned (Hulshof, 1998). The European Union Directive for physical agents proposes an exposure limit figure of 0.7 m/s2 (Johanning, 2000).

Besides considering the acceleration exposure limits, attention should also be given to other work-related factors, including prolonged sitting, lifting and awkward postures. These factors may act in combination with whole body vibration to cause back problems.

4.2.1.2 Education/training

Information and training activities can play an important role, when part of a general prevention strategy focused on reduction of risks in the work place. Previous training efforts have generally fallen into three areas: (1) training of specific lifting techniques; (2) teaching biomechanics-thus increasing the understanding and awareness of back injuries so safe approaches towards lifting are adopted; and (3) training the body via physical fitness so that it is less susceptible to injury.

- **Lifting techniques**

In several reviews, emphasis is laid on manual handling as the most important risk factor. Consequently, in many companies and in lifting schools, the importance of a good lifting technique is emphasised. The most commonly advised technique, dating from the 1940s, is squat or leg lifting: flexing the knees while keeping the back as straight as possible (Kroemer, 1992). This technique has several advantages compared with the opposite technique, called stoop or back lifting where the back is flexed and the legs extended. Although the leg lifting technique has been introduced and applied world-wide, several studies have revealed numerous comments on this technique, e.g. a higher energetic physiologic cost (Kumar, 1984), awkward postures when lifting larger volumes (van Dieën, 1999a) or more balance loss (Toussaint et al., 1997).

Information on the advantages and disadvantages of the leg lift and the back lift is summarised in table 6 (Hsiang et al., 1997). Some of the advantages/disadvantages are in parentheses, indicating that contradictory results are found in some studies. Furthermore, information is given on lifting with the back in a lordosis or kyphosis position, twisting movements and the influence of fast lifting.

Though little scientific evidence of a direct relationship between low back disorders and lifting technique exists, there are certain workplace realities that cannot be ignored (Hsiang et al, 1997):

1. Those responsible for improving occupational safety will continue to train industrial workers in some form of lifting technique,
2. Industrial workers will continue to lift objects as part of their jobs, and
3. For some workers, the way in which they accomplish the lifting task will be related to the techniques they have been taught.

Therefore it is important to understand that focusing only on the position of the back during lifting is not sufficient.

Van Dieën et al. (1999a) advise that for the prevention of low back disorders, training should also be focused on other aspects of lifting: asymmetry, speed of lifting, position of the load, position of the grips of the load, load mass). This is demonstrated by Marras (2000) who found five factors in combination that described very well the relationship with risk of reporting disorders and lost or restricted time from low back disorders. These factors are lift frequency, sagittal torso bending angle, lateral velocity, twisting velocity and external load moment.

- **Broader information and training approaches**

As it is clear from the previous section that training in specific lifting techniques alone does not appear effective. Kroemer (1992) suggests that one reason for this is probably because there

Table 6. Advantages and disadvantages of the leg lift or the back lift (adapted from Hsiang et al. 1997). Pictures from INRS (Institut National de Recherche et de Sécurité).

1. **Leg lift (squat)**

Advantages
- (Small peak compressive on L5/S1)
- Load closer to the body
- Less strain on the low back ligaments
- (Minimises disc compression)
- (Minimises overall strength requirements)
- (Mechanical advantage)

Disadvantages
- Knee muscles not well-suited to prolonged lifting
- Fatigue of quadriceps
- High integral of compression over time at the L5/S1 disc
- Diminishes mechanical advantage of the long moment arm when the hip falls below the knees
- Higher oxygen consumption
- High inspiratory ventilation volume
- Subjectively the most tiring

2. The back lift (stooped)

Advantages
- Produces a relatively small integral of compression over time at the L5/S1 disc
- May result in lower compressive force
- Allows better body control
- Provides better balance
- Allows better knee clearance
- Lowers the estimated energy expenditure rate
- Superior from an effectiveness standpoint because it minimises the change in potential energy of the lifter's body
- Utilises the hip and trunk muscle groups, which are better suited to prolonged lifting than the knee muscles

Disadvantages:
- Produces relatively high peak compressive force on L5/S1 disc
- Produces relatively high shear forces

3. Lordosis (accentuation of the inward lumbar curvature)

Advantages
- Results in more even distribution of stresses on the lumbar disc
- May minimise the hydrostatic pressure in the disc, in contrast to kyphosis
- Provides greater muscle control of the trunk
- Minimises strain on posterior spinal ligaments

Disadvantages
- Forces all torso flexion to be accomplished at the hip joints because lumbar lordosis is maintained by holding the trunk rigid
- Requires greater activity of the erector spinae when the load lifted increases
- Decreases lumbar moment arm
- Increases compressive stress on the posterior annulus when the weight is heavy
- (Results in less compressive strength of the lumbar intervertebral joints)
- (Does not allow posterior spinal ligaments to bear some of the load)

Advantages and disadvantages of the leg lift or the back lift (adapted from Hsiang et al. 1997). (cont.)

4. Kyphosis (lumbar curvature towards more flexion of the spine)

Advantages
- Allows sharing of muscle group distribution of work
- Requires less activity of the erector spinae (than lordosis) when the load lifted increases
- (Increases lumbar moment arms)
- Reduces the compressive stress on the posterior annulus when the weight is heavy
- Improves transport of metabolites in the intervertebral discs when the weight is heavy
- (Results in greater compressive strength of the lumbar intervertebral joints)
- Allows posterior spinal ligaments to bear some of the load
- Reduces the stresses at the apophyseal joints

Disadvantages
- (Results in uneven distribution of stresses on the lumbar disc)
- May increase the hydrostatic pressure in the disc in contrast to lordosis
- Provides less muscle control of the trunk
- Increases the compressive stress on the anterior annulus

5. Twisting

Advantages
- Faster than sagittal lifting
- May allow people to fully utilise the different forces generated from the dominant and non-dominant hands.
- For certain tasks, may involve less energy expenditure than lifting, carrying, and lowering a load

Disadvantages
- Considered damaging to the spine since the annulus fibrous is maximally stressed while least protected by the posterior elements during flexion-rotation
- Increases intradiscal pressure
- Intra-abdominal pressure increases when the trunk is loaded in rotation

6. Fast lifting speed

Advantages
- With sufficient speed at an early phase of lifting, can provide enough kinetic energy to take the load past the individual's weaker lifting levels
- For heavy loads, may reduce stress on the annulus because the amount of load that the annulus can safely transmit decreases with time and time is limited with fast lifting

Disadvantages
- Produces marked increases in compressive force.
- Significantly decreases torque producing capability of the trunk muscles
- Reduces peak dynamic strength

is no one technique that is appropriate for all lifts. Increasing the knowledge of risks and how to avoid them and promoting good practice necessitates determining what should be taught, how much knowledge is needed and tailoring this to the particular work and type of work place. Scheer et al. (1995) investigated the efficacy of "back schools", which represent a collection of educational processes for back care. They generally consist of a series of discussions about anatomy, biomechanics, lifting and material handling and exercise instruction. Many training programmes now also include how to spot risks in the work place and what to do in the circumstances as well as lifting techniques. Training is also required to effectively use lifting devises for example (see section on mechanical devises).

Practitioners have to be aware of possible reasons for disappointing results, which include:

- people tend to revert to previous habits and customs if training in practices to replace previous ones are not reinforced and refreshed
- in emergency situations a sudden quick movement of weight increase may overly strain the body
- if the job requirements are physically stressful, the behaviour modification will not eliminate the inherent risk. Therefore designing a safe job is fundamentally better than training people to behave safely.

Furthermore, it is important to consider the influence of instruction style and media once what should be taught has been determined. Questions such as "Where should the sessions be held?" should be addressed. At the work site has to be preferable to classroom-type instruction, except when emphasis is laid on knowledge and instructional purposes. Or "Is it best to train employees working together as a group, or should the group be split up?" Currently, information is not available on which to base sound judgement. But it is known that materials handling task characteristics and requirements differ considerably even between industries or between tasks/jobs in one industry so customised training to small groups is often recommended (Kroemer, 1992).

In summary reliance on training alone, especially on lifting techniques, is likely to be misleading, particularly where the realities of the working environment prevent or hinder the adoption of safe postures and the use of ideal lifting techniques. In addition frequent manual handling of loads even in ideal conditions will put a strain on the back.

- **Physical training**

There are several types of physical training programs: spinal flexion exercise, extension exercise, isometric strengthening exercise for abdominal and lumbar muscles and aerobic exercise (Scheer et al., 1995). The rational for performing exercises as a prevention method includes strengthening of weak muscles and of tight muscles and ligaments, stabilisation of hypermobile segments, correcting poor posture; decompressions of radicular structures, bony lock or of bulging annulus. In their review of the literature on low back disorder prevention, Scheer et al., (1995) found four studies that were eligible for analysis (after passing a thorough selection regarding methodological issues). A picture of the efficacy of physical training exercise for acute low back pain begins to emerge from the available data. Long-term exercise, particularly when reinforced at work, appears to be beneficial for prevention of backache. Also Westgaard and Winkel (1997) concluded that interventions that *actively* involves the worker (e.g. physical training or active training in work technique) often achieve positive results, whereas more passive measures (e.g. health education) do not appear equally successful.

Frank et al. (1996a) report two important remarks on this type of intervention:

Firstly, the underlying assumption of this type of intervention is that better conditioning and care of the back will translate into a reduced risk of low back pain onset. However the underlying assumption can be perceived negatively, as a form of victim blaming. The interventions imply that the problem of low back disorders are not so much as a result of the work being done as of the workers who are doing it. It should be mentioned that according to the Manual Handling Directive (see Appendix 2), employers are obliged to provide a healthy and safe working environment. Therefore, appropriate working conditions should be developed and not only providing physical training that focuses only on the individual.

Secondly, these interventions can also be considered as a controversial form of pre-placement screening of individuals for job fitness. However, most of the screening efforts (e.g. radiological examinations, pre-employment strength tests) have been ineffective in predicting who will subsequently develop disabling low back pain. Also in the "Occupational Health Guidelines for the Management of Low Back Pain at Work" produced by the Faculty of Occupational Medicine

in London (Carter and Birrell, 2000) the advice is not to routinely include clinical examination of the back, lumbar x-rays, back function testing, general fitness or psychosocial factors in the pre-placement assessment.

4.2.2. Work-organisational factors

Giving attention to the job design and work organisation can contribute to prevention of work-related low back disorders. Westgaard and Winkel (1997) concluded from their review that regarding organisational culture interventions, a possible distinguishing feature of successful interventions relative to those that failed is the extent to which intervention ownership is embedded in the company, including company management. Therefore, the authors suggested that the following intervention strategies have the best chance of success:

- Organisational culture interventions with high commitment of stakeholders, utilising multiple interventions to reduce identified risk factors
- Modifier interventions, especially those that focus on workers at risk, using measures that actively involve the worker

Carter and Birell (2000) mention that there is limited evidence but general consensus that joint employer-worker initiatives can reduce the number of reported back 'injuries' and sickness absences, but there is no clear evidence as to the optimum strategies and inconsistent evidence on the size of the effect. In general, these initiatives should involve organisational culture and high stakeholder commitment to identify and control occupational risk factors and improve safety, surveillance measures and the 'safety culture'. Active health surveillance (e.g. symptom surveys, physical examinations) at the workplace prior to back disorder development is not sufficiently developed (Hagberg et al. 1995). Volinn (1999) mentions two studies focusing on management awareness and commitment with successful outcomes: a reduction in the rate of lost time due to low back pain was found after the intervention. Also Bongers et al. (2000) mentioned in their study that an optimal collaboration with colleagues improves the reduction of low back pain.

Carter and Birell (2000) advise employers that high job satisfaction and good industrial relations are the most important organisational characteristics associated with low back pain and sickness absence rates. So employers should be encouraged to:

- consider joint employer –worker initiatives to identify and control occupational risk factors
- monitor back problems and absence due to low back disorders
- improve safety and develop a 'safety culture'.

4.3

SECONDARY PREVENTION STRATEGIES

This section covers interventions following the occurrence of a work-related low back disorder. The interventions are therefore aimed at preventing reoccurrence and reduction of effects. Given that previous medical history of a low back disorder is linked to the (re)occurrence of a low back disorder, this emphasises the necessity of preventing the on-set of work-related disorders in the first place through primary prevention. Nevertheless an integrated approach to removal of risks and supporting injured workers return to work through treatment and rehabilitation is very important.

Burton and Erg (1997) mention that biomechanic/ergonomic considerations may be related to the first onset of low back pain, but there is little evidence that secondary control based solely on these principles will influence the risk of recurrence or descent into chronic disability. According to the authors, more promising in this respect are programmes that also take account of the psychosocial influences surrounding disability. Work organisational issues are clearly important, but so is the behaviour of clinicians. A proactive approach to rehabilitation should be adopted by recommending, when possible, early return to normal duties as well as complementary psychosocial advice.

One of the important treatment goals should be the carefully guided return-to-work of the patient with a back disorder. A well-planned return-to-work programme should incorporate a risk assessment and a control of hazardous job tasks or conditions to prevent re-injury and continued harm. Both workplace-based and healthcare-based interventions are important.

When looking at treatment and rehabilitation issues it is important to distinguish between the different stages of the development of low back disorders as the recommended intervention differs according to the specific stage (acute or chronic low back disorders). The current state-of-the-art effectiveness of conservative treatments for acute and chronic low back pain was evaluated by van Tulder et al. (1999). The results of their review are summarised in Table 7 below. More specific information on these strategies is presented in appendix 3.

4.3.1 Assessment of the worker with low back disorder

As with primary prevention it is necessary to assess the situation and match the intervention to the situation, being aware of the all the relevant factors. For example whilst there are general recommendations such as "keep active" this can not be recommended in every case.

In his review on occupational back disorders, Johanning (2000) mentions many factors that have a strong influence on the success rate of return to work outcome and the development of chronic low back disorders:

- Job demands, control and satisfaction
- Employer/employee motivation/practice
- Employee age
- Benefit structure/disability case management
- Contractual labour – management arrangement

Table 7.: Effectiveness of conservative treatment for acute and chronic low back disorders (LBD) (van Tulder et al., 1999)

	Acute LBD	Chronic LBD
Strong evidence for effectiveness	NSAIDs (non-steroidal anti-inflammatory drugs) Muscle relaxants Advice to stay active	Exercise therapy Multidisciplinary programs
Moderate evidence for effectiveness	Analgesics Antidepressants Facet joint, trigger point, or ligamentous injections Acupuncture Back schools Behavioural therapy Multidisciplinary programs EMG biofeedback Lumbar supports Physical modalities Spinal manipulation Transcutaneous electrical nerve stimulation	Analgesics Antidepressants Colchicine Epidural corticosteroïd, trigger point, or ligamentous injections Muscle relaxants Advice to stay active Bed rest Lumbar supports Physical modalities Spinal manipulation Transcutaneous electrical nerve stimulation
Strong evidence for ineffectiveness	Bed rest	Traction

- Insurance carrier case management problems
- Adversarial medico-legal (worker's compensation) relationship and management
- Previous history of low back disorders
- Total work loss in past twelve months (low back disorder related)
- Radiating leg pain, nerve root involvement
- Reduced trunk muscle strength and endurance
- Poor physical fitness
- Heavy smoking
- Psychological complications

Loisel et al. (1997) concluded from their study that receiving full intervention (clinical and occupational intervention) resulted in faster return to regular work than a usual care intervention.

Concerning the assessment of the worker presenting back pain, the following should be considered (Carter and Birrell 2000):

- Screen for serious spinal diseases and nerve root problems
- Clinical examination may aid clinical management, but is of limited value in planning occupational health management or in predicting the vocational outcome.
- Take a clinical, disability and occupational history, concentrating on the impact of symptoms on activity and work, and any obstacles to recovery and return to work
- Consider psychosocial 'yellow flags' to identify workers at particular risk of developing chronic pain and disability. Use this assessment to instigate active case management at an early stage.
- X-rays and scans are not indicated for the occupational health management of the patient with low back disorders.
- Ensure that any incident of low back disorders which may be work-related is investigated and advice given on remedial action. If appropriate, review the risk assessment.

The authors also formulated management principles:

Clinical recommendations:

- Advice to continue ordinary activities of daily living as normally as possible if pain is tolerable. This can give equivalent or faster symptomatic recovery from acute symptoms, and leads to shorter periods of work loss,

fewer recurrences and less work loss over the following year than 'traditional' medical treatment (advice to rest and 'let pain be your guide' for return to normal activity).
- The above advice can be usefully supplemented by simple educational interventions specifically designed to overcome fear avoidance beliefs and encourage patients to take responsibility for their own self-care.

Occupational recommendations:
- Communication, co-operation and mutually agreed goals between the worker with low back disorders, the occupational health team, supervisors, management and primary health care professionals is fundamental for improvement in clinical and occupational health management and outcomes.
- Most workers with low back disorders are able to continue working or to return to work within a few days or weeks, even if they still have some residual or recurrent symptoms, and they do not need to wait till they are completely pain free.
- Advice to continue ordinary activities, if pain is tolerable, as normally as possible, in principle applies equally to work. The scientific evidence confirms that this general approach leads to shorter periods of work loss, less pain recurrences and less work loss over the following year, although most of the evidence comes from intervention packages and the clinical evidence focusing solely on advice about work is limited.
- There is general consensus but limited scientific evidence that workplace organisational and/or management strategies (generally involving organisational culture and high stakeholder commitment to improve safety, provide optimum case management and encourage and support early return to work) may reduce absenteeism and duration of work loss.
- Changing the focus from purely symptomatic treatment to an 'active rehabilitation programme' can produce faster returns to work, less chronic disability and less sickness absence. There is no clear evidence on the optimum content or intensity of such packages, but there is generally consistent evidence on certain basic elements. Such interventions are more effective in an occupational setting than in a health care setting.
- The temporary provision of lighter or modified duties facilitates return to work and reduces time off work.

A combination of optimum clinical management, a rehabilitation programme, and organisational interventions designed to assist the worker with a low back disorder return to work is more effective than single elements alone.

4.4

GUIDELINES AND STANDARDS RELATED TO PREVENTION OF LOW BACK DISORDERS

Regulatory actions are based on two distinct elements - risk assessment and risk management. In the former, facts are used to define the health effects of the exposure of individuals or populations to hazardous situations. The latter is a process of integrating the results of risk assessment with engineering data and with social, economic, and political concerns to select the most appropriate regulatory action. For these two elements, a scientific basis of risk assessment is necessary, and therefore both epidemiological studies on human populations and experimental studies have considerable importance (National Research Council in Viikari-Juntura, 1997).

The Manual Handling Directive (Council Directive 90/269/EEC) is made with the primary goal of preventing back injury during the manual handling of loads. Minimum health and safety requirements are given for the manual handling of loads and a series of relevant factors are listed in annexes to the directive (See Appendix 2). Employers should to pay attention to these risk factors when making assessments and selecting preventive measures. They include:

- Characteristics of the load (for example: is it heavy or difficult to hold);
- Physical effort required (for example: strenuous; twisting; body in an unstable position);
- Characteristics of the working environment (for example: insufficient room or other constraints on the posture of worker such as working height too high or low; uneven or slippery flooring);
- Requirements of the activity (for example: prolonged activity or effort; insufficient rest periods; excessive distances to move loads; imposed work rate)
- Individual factors (for example: clothing etc. restricting movement; inadequate knowledge or training)

ISO ergonomic standards are developed with the aim of standardising for example terminology, methodology, and human factors data in the field of ergonomics. In the ISO / TC159 / SC3 group the following items are addressed: anthropometry, evaluation of working postures and human physical strength. The draft standards that are being prepared will be of importance with regard to the physical aspects during work and the occurrence of low back disorders. Until now, the following standards have been developed:

- ISO 7250:1996: basic human body measurements for technological design
- ISO 15534-1:2000: Ergonomic design for the safety of machinery – Part 1: principles for determining the dimensions required for openings for whole-body access to machinery
- ISO 15534-2:2000: Ergonomic design for the safety of machinery – Part 2: principles for determining the dimensions required for access openings
- ISO 15534-3:2000: Ergonomic design for the safety of machinery – Part 3: anthropometric data.

Other guidelines relevant to the prevention of low back disorders include ISO 2631-1 and ISO 5349.

Also working group 4: Biomechanics of the Technical Committee CEN/TC 122 – "Ergonomics" is further developing a European standard prEN 1005 2: "Safety of machinery-Human physical performance-part 2: Manual handling of machinery and component parts of machinery". This European standard has been prepared under a mandate from the European Commission and the European Free Trade Association and supports essential requirements of the Machinery Directive 98/37/EC.

To evaluate lumbar load with respect to the risk of overexertion during manual material handling, the National Institute of Occupational Safety and Health introduced the 'NIOSH' method. A lifting formula (equation), a multiplication model with six task variables, has been proposed to protect healthy workers (see also 5.5).

To obtain more information on the risks of vibration and to calculate an occupational vibration-exposure dose, recommendations and references are given by Johanning (2000).

4.5

CONCLUSIONS ON EFFECTIVENESS OF PREVENTION

The demand for workplace interventions to prevent low back disorders has increased in recent years. Strategies to prevent low back disorders include both workplace based and health care based interventions. Increasingly there is recognition that an integrated approach including both types of intervention is needed to really tackle the problem effectively. Ergonomics interventions are based on a "holistic" or systems approach that considers the effect of the equipment, the work environment and the work organisation as well as the worker. The full participation of workers in the ergonomics approach is important for its effectiveness.

There are dissenting views in the literature on whether or not the programmes work. The discrepancies are often attributed to the different methodological quality of the studies: lack of control groups, lack of randomisation, lack of a placebo group, small number of subjects, no standardisation of the environment, (Nordin, 1997; Volinn, 1999). Other negative factors are high costs of interventions, lack of underlying commitment

from workers or management (Frank et al., 1996a). Furthermore, the presence of several risk factors and the question of the causal effect of the factors, increase the problems for prevention strategies. Volinn (1999) concluded that many studies report a positive effect of the prevention strategies, but the report is mainly pragmatically oriented. It is often mentioned that workplace interventions *may* have an effect on low back disorders.

However, from the previous chapter it is clear that there are strong work-related risk factors that can be related to the occurrence of low back disorders, so it is necessary to modify these factors where possible using prevention strategies. More conclusive studies are necessary to investigate thoroughly the effectiveness of prevention, taking into account the methodological quality. In these studies it is important to use the global participatory ergonomics approach. This approach focuses on the identification and evaluation of risk factors in the task, the equipment, the work environment and the work organisation. This will be further explained in the chapter on risk assessment.

Regarding the reduction of physical demands of the tasks, suitable material handling devices or other workplace aids can be selected and used. Practitioners must be aware of the advantages and disadvantages of these devices. Furthermore, education or training may help to prevent low back disorders. This may be accomplished by teaching the principles of back functioning, training in lifting techniques and training the body via physical fitness. Achieving successful intervention is often related to the extent to which intervention philosophy is embedded in the company, including company management.

To halt the further development of low back disorders or to prevent the onset of chronic pain and recurrence once pain has started, several strategies are also possible. As well as the so-called conservative treatment for low back disorders (e.g. medication, bed rest, exercise therapy) and health-care-based intervention, prevention in the work place is also important in this stage-for example increasing work organisational awareness by actively involving workers and management or reducing the physical demands of the work task.

Expert opinion is that although the focus should be strongly on primary prevention, all these factors need to be looked at together. For example, studies show that training alone is unlikely to be effective if the ergonomic factors in the work remain poor and basic training, for example, needs to include how to spot potential risks and what to do if found, as well as safe physical handling techniques.

Based on the current knowledge on the effectiveness of prevention strategies, employers are provided with information to protect the workers. Guidelines and standardised criteria have been and are being developed to increase the awareness of all possible problems associated with low back disorders, to increase the use of a standardised approach regarding risk assessment and to increase the application of primary prevention in the workplace.

5.

RISK ASSESSMENT METHODS

Since the exact origin or aetiology of the disorder is often not evident and the effect of prevention is not always positive, more research into work-related low back disorders is necessary, both in laboratory studies to reveal more scientific background but also in the working environment itself to quantify specific risks. This scientific knowledge could be used in the development of prevention strategies, so that these will be acceptable to companies and practical for implementation so that practitioners are able to perform effective risk assessments. Buckle and Devereux (European Agency, 1999) report the main criteria for exposure assessment methods.

In this chapter, the focus is mainly on methods related to the work environment. For more information on the clinical examination of workers with low back complaints (interview, medical examination, diagnostic tests, and electro-physiological evaluation) see for example Johanning, 2000.

5.1

METHODS FOR USE IN THE WORKPLACE

In part attributable to the growing interest in ergonomics in industry in recent decades, considerable effort has been made to improve the usability and effectiveness of assessment techniques in the field. An ergonomic approach to work-related low back disorder risks focuses on the identification and evaluation of risk factors in the task, the equipment, the work environment and the work organisation. After an ergonomic intervention, management expects specific advice as to how to improve the working conditions and how to prevent low back disorders. Experts in ergonomics agree that a holistic, participatory and integrated approach to the problem is needed produce effective results. In this methodology, objective and subjective data are linked (Op De Beeck, 1994a). The following items have to be looked at simultaneously:

- objective measurements of the external workload: task, organisation and environment (physical and biomechanical aspects)
- objective measurement of the internal workload: physiological and behavioural reactions of the exposed worker.
- subjective experience of workload: by the use of questionnaires and interview techniques the practical knowledge of the worker can be collected. The use of scales on which the worker can indicate the perceived risk for each task or operation gives a fast risk assessment. The accuracy of self-assessment techniques has been debated, both for in terms of under-estimation and over-estimation (Bernard et al. 1997). The arguments in favour of subjective measurement (Wilson and Corlett, 1995) lie in the independence of the measures and the ability to acquire data that cannot be obtained easily by other methods (e.g. due to size limits).

The combined use of objective and subjective data can better indicate the risks in the work system. This then provides a basis for identifying effective measures for prevention and for assessing the changes that have been recommended following the ergonomic study.

It is important to mention that a method which to one researcher or practitioner is an invaluable aid to their work, may to another be vague or insubstantial in concept, difficult to use and variable in its outcomes. In addition, the validity, reliability and sensitivity of methods may well be application specific.

Some specific instruments or techniques have been developed to evaluate *physical load* on the lower back during work tasks. Regarding assessment of physical exposure, Li and Buckle (1999) published an overview of current technique with emphasis on posture-based methods. To evaluate lumbar load with respect to the risk of overexertion during manual material handling the U.S. National Institute of Occupational Safety and Health (NIOSH) introduced the 'NIOSH' method. This uses a lifting formula or equation with six task variables. A first version was developed in 1981, a second version in 1991 (Walters et al. 1993). The NIOSH method evaluates lifting demands and calculates a recommended weight limit in specific manual materials handling tasks, based on three criteria

(biomechanical, physiological and psychophysiological). The 'lifting index' provides a basis for the identification of hazardous lifting jobs. The 1991 lifting equation is applicable to a wider variety of lifting jobs than the previous method, but there are still certain limits or criteria when the method cannot be used.

A variety of other assessment tools have been used in ergonomic research. 3-D dynamic tools have been developed to measure the postures during lifting (e.g. The Lumbar Motion, The Dortmunder, BackTracker). Furthermore, biomechanical models are developed to estimate the internal loading of the spine. With linked segment models, the lumbar net moment is used as an indicator of back load (van Dieën, 1999). The analysis of electromyographic signals (EMG) is often used to predict the muscle force necessary to perform a task (Hermans et al., 1999a) or to investigate if muscle fatigue is present by investigating the changes in electromyographic parameters over time (Hermans et al., 1999b). To obtain more information on the use of this technique see the publications of the SENIAM project, a large European Concerted Action on surface electromyography.

Studies often use a combination of different methods to address physical load in a specific task. This is necessary to have a complete understanding of the physical load (Hermans et al., 1999a), although sometimes little agreement among the methods is found (Lavender et al., 1999).

Measurement methods for *individual and psychosocial factors* are primarily based on self-reported measures that focus on the appraisal process and on the emotional experience of stress. Measures relating to appraisal need to consider the worker's perceptions of the demands on them, their ability to cope with those demands, their needs and the extent to which they are fulfilled by work, the control they have over work and the support they receive in relation to work. It is necessary to go beyond simply asking workers whether particular demands, etc. are present (or absent) in their work environments and measure various dimensions of demand such as frequency, duration and level. Furthermore, the interactions between perceptions is interesting, such as demand with control or demand and control with support. In this context, the Karasek model is often used. More information on the research on work-related stress can be found in the recent publication on stress of the European Agency (European Agency, 2000c).

5.2

ADDITIONAL LABORATORY METHODS

The understanding of the biochemical and biomechanical properties of the vertebra, disc and ligaments has been broadened by more refined research methods. Many disciplines including bioengineering, basic science research, medicine and epidemiology are now involved in the analysis of low back pain. Careful characterisation of clinical findings and neurological examination of sensory changes and muscular weakness can aid in the localisation of a possible morphological/anatomical lesion and assist in the differential diagnosis and treatment. Recent techniques include: near infrared spectroscopy (NIRS) to measure the low-back extensor oxygenation during prolonged contractions (MacGill et al., 2000); analysis of endplate fractures in vitro or quantification of the fluid redistribution in the spinal motion under compression (van Dieën et al., 1999b); and laser-Doppler flowmetry to analyse myalgia of muscle fibres (Larsson et al., 1999). These techniques are important to understand why some people are at greater risk of developing low back disorders than others and how variability between individuals can be better understood (Marras, 2000).

Wilson and Corlett (1995) presented an overview of methods for the evaluation of human work. They list the main methods for examining psycho-physiological functions (e.g. heart rate variability, critical flicker frequency test).

Furthermore, modern epidemiological research principles have been proposed to improve low back disorder research methods and clinical tests (Johanning, 2000; Dempsey et al., 1997).

6.

FUTURE RESEARCH TOPICS

The European Agency for Safety and Health at Work has surveyed Member States on their future occupational safety and health research needs and priorities (2000d). Psychosocial issues and ergonomics, together with chemical risk factors, emerged overall as the top priority areas for future research. Within the field of psychosocial issues, emphasis was placed on stress at work. In the area of ergonomics, particular priority was given to manual handling and work postures. As the previous chapters illustrated, both these areas are of importance when discussing work-related low back Disorders.

As part of a procedure to prioritise research needs, the UK Health and Safety Exectutive (2000) have made a forward planning table on musculoskeletal disorders in general. The National Research Council (1999), Bongers et al. (2000) and Marras (2000) have also formulated future research topics for low back disorders. Based on these documents and discussion at the expert seminar, a summary table of future research themes is given in table 8. Expert opinion is that the main focus of future research should be the investigation of effective risk assessment methods and intervention strategies in the workplace.

In addition there is a need to promote the sharing of research findings, for example the results of interventions and effectiveness of ergonomic "check lists and assessment methods".

The various back disorders related to loads and other work-related musculoskeletal disorders are a continuum and not discrete topics. The need for a general prevention approach has been explained in the previous chapter "Methods in Risk Assessment". Consequently similar research areas have been mentioned regarding research into other musculoskeletal disorders (for example see Work-related Neck and Upper Limb Musculoskeletal Disorders, European Agency, 1999.)

Table 8: Summary of possible research themes in relation to work-related low back disorders(LBD).

Research topic	Research issue
Extent, frequency and costs of LBD	• The need for consistency in reporting data across all EU Member States: have more standardisation and greater detail in injury reports
Origin	• Further research on the pathomechanisms of LBD (e.g. longitudinal studies of back disorders using techniques such as magnetic resonance imaging) • Develop further models and mechanisms to investigate how tissue responds to repetitive loading, what triggers inflammatory responses and how these are influenced. • Further use of laboratory studies to understand low back disorders
Risk factors	• Focus the approach on "overload" • Studies into the effect of combinations of factors • The need for more detailed quantitative information regarding exposure-disorder relationships. It may be necessary to split up the different types of LBD and possible different risk factors • Analyse if the risks for LBD differ between subjects with different loading capabilities • Understand the influence of non-biomechanical factors upon the biomechanical load-tolerance relation and the risk of injury
Assessment methods	• Studies to determine effective interdisciplinary approaches to the identification of workplace risk factors • Studies to develop and evaluate practical assessment methods, including with the aim of developing standardised approach • Studies to determine effective and reliable approaches to the use of routine health surveillance systems to detect problems • Need for valid quantitative exposure measures within comprehensive epidemiological studies • Further development of practical measurement systems
Intervention strategies	• Need to evaluate the effectiveness of workplace-based actions and interventions using high quality methodological studies, particularly to determine what strategies and types of interventions are most successful and why. • Evaluation of work organisational changes • Evaluation of return-to-work and rehabilitation programmes • Study of interventions to develop criteria of what makes an effective intervention.

7.

CONCLUSIONS

From the data on prevalence and cost to society it is clear that low back disorders are an important issue in today's working environment. However knowledge of low back pain is considerable and improving and clear approaches can be recommended to tackle the problem. Progress has been made in the application of ergonomics in the workplace and in practical and effective assessment techniques. Whilst some discrepancies are still present in the literature it is possible to put forward some consensus on priorities.

The extent of work-related low back disorders within European Member States

Recent data from the second European survey on working conditions reveals that 30% of European workers complain of low back disorders. This survey and several review studies have demonstrated that back disorder rates, although wide spread in many occupations, vary substantially by industry, occupation, and by job within given industries. High prevalence rates are found for workers in the agriculture and construction sectors as well as in the health care sector. Also jobs involving manual handling or driving report high prevalence rates.

Although precise figures do not exist and the lack of standardised criteria makes comparison of data between Member States difficult, it is estimated that the economic cost of *all* work-related ill health ranges from 2.6 to 3.8% of Gross National Product. In 1991, the total cost of back pain to society in The Netherlands was estimated to be 1.7% of GNP.

Current knowledge of the origin of low back disorders

In addition to the age-related natural degenerative process, epidemiological studies have revealed that ergonomic factors in the workplace can lead to increased degenerative changes in the intervertebral discs and other structures due to chronic loading.

Besides the disc related problems, muscular and other soft-tissue injuries are suspected when no other structural or neural abnormalities can be identified on the basis of x-rays or bone scans and 95% of Low Back Disorders are termed "non-specific". Injuries usually occur as a response to excessive load or stretch or as a result of prolonged activation of back muscles. It is therefore useful to look at low back disorders and the work-related risks in terms of overload of workplace demands on the body. As all musculoskeletal disorders can be viewed this way, this facilitates a common approach being taken to all work-related musculoskeletal disorders.

Epidemiological evidence regarding risk factors

Many review articles have been published investigating the risk factors of low back disorders, including a multitude of physical, psychosocial and/or individual risk factors. The number of epidemiological studies addressing psychosocial risk factors during work is considerably smaller than the studies focusing on physical load. In addition, the strength of the association is generally higher for biomechanical physical factors. However, the empirical evidence linking psychosocial factors with low back disorders is growing, especially where physical risk factors are present. Reported risk factors requiring consideration in the work system are in respect to physical aspects: heavy manual labour, manual materials handling, awkward postures (trunk bending and/or twisting), vibration and driving; and in respect to psychosocial work-related factors: low social support and low job satisfaction.

Strategies for prevention of work-related low back disorders and knowledge about their effectiveness

Strategies to prevent low back disorders include both workplace- based and health –care-based interventions. Increasingly there is recognition that an integrated approach including both types of intervention is needed to tackle the problem effectively. Regarding workplace interventions there is growing support for the effectiveness of ergonomics (see below). Ergonomic interventions are based on a "holistic" or systems approach that considers the effect of the equipment, the work environment and the work organisation, as well as the worker. The full participation of workers in the ergonomics approach is essential for its effectiveness.

Risk assessment methodology for work-related low back disorders

As described above there is evidence of the effectiveness of the ergonomic approach for locating risk factors and devising prevention measures. This approach focuses on the identification and evaluation of risk factors in the task, the equipment, the work environment and the work organisation. Exposure measurements used in work-related studies range from very crude measures to complex analytical techniques. More refined research methods in laboratory conditions are being used and further developed to increase knowledge.

Using this increasing scientific knowledge, guidelines and standards have been developed and continue to be improved and refined. In the case of risks from manual handling of loads employers are already provided with important information to protect workers: The Manual Handling Directive (Council Directive 90/269/EEC) has been made with the particular aim of preventing risks of back injuries during manual handling of heavy loads. It provides minimum health and safety requirements and an approach for risk assessment and prevention. Further development of guidelines and standardised criteria are necessary to increase the awareness of *all* possible problems associated with work-related low back disorders, to increase the use of a standardised approach regarding risk assessment and to increase the application of primary prevention in the workplace.

Future research topics

In a report on future occupational safety and health research needs (European Agency, 2000d) Member States prioritised stress at work and manual handling and work postures as areas for future research. There is support in the literature for the ergonomic approach, contained in the "Manual Handling Directive", as the basis for employers to take action. To assist its application it is suggested that the main focus of future research on low back disorders should be on how the ergonomic approach can be used most effectively in practice. Such research could include:

- Satisfactorily evaluated studies of "holistic" intervention strategies (for example: application of ergonomics; ergonomics integrated with rehabilitation and health surveillance)
- Studies to develop and evaluate practical risk assessment methods for use in the workplace
- Studies of the effect of combinations of factors and their practical assessment

It is proposed that the main focus of future research be on strategies to prevent injury in the work place. However a number of areas concerning laboratory analysis of the problem is suggested (for example: exposure measurement techniques; joint movement measurement methods and studies to further understand the biochemical and biomechanical properties of the vertebra, disc and ligaments).

8.

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RESEARCH

9.

APPENDICES

A.1

APPENDIX 1.
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EXPERT WORKSHOP on WORK-RELATED LOW BACK DISORDERS

21 June 2000, Prevent offices, Brussels

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Summary of discussion and conclusions from expert meeting regarding work-related low back disorders

A summary of the main points covered by the expert meeting regarding prevention is given below:

- **Work-related upper limb disorders and back disorders related to handling of loads etc are a continuum** and this suggests a common, integrated approach should be taken to the prevention of all musculoskeletal disorders (MSD).
- **Risk factors should be viewed in terms of overload** from workplace demands on the body (e.g. combination of force, sustained force, static force, work organisation, stress etc). This enables a continuum approach to be taken with other MSD. It is a reason why for example only focusing on weights when assessing risk can be misleading.
- **Work organisation** is an important risk factor.
- **An Integrated approach** is needed-to prevention, training, surveillance, rehabilitation etc. The effective working of multidisciplinary occupational health services is important.
- **A Holistic approach to health and safety is needed,** for example not only can trips and falls cause injury, but in a susceptible, already weakened back a slight awkward movement such as a slip is more likely to give rise to an injury.
- **Health surveillance** should be used to look at trends in the workplace, not just focus on individuals.
- **Training** will have success only if integrated into the overall prevention approach and should be broader than only lifting techniques.
- **Pre-employment screening:** evidence of its value is sparse.
- **Return to work/rehabilitation**: It is very important to "stay active". However whilst good as a general rule this is not the correct approach for all conditions.
- **Cross Europe common disease classification** would assist a common understanding of low back disorders.
- **The Focus of future research should be on the evaluation of the effectiveness of workplace prevention strategies**. There is currently a lack of good evaluations of high quality, standardised interventions. This research should cover efficacy of risk assessment methods and prevention strategies; developing good practices and feasibility at the workplace; evaluation of work organisational changes; workforce participation strategies; use of routine health surveillance; effective return-to-work programmes. What strategies or types of intervention are successful? What contributes to success? Such research should include assessment of general trends of what is successful and how to make an effective evaluation.
- **Support to encourage and promote the sharing of research activities and results**, ergonomic "check lists" etc is needed.
- **A common, integrated public health approach** to the prevention of low back disorders is needed consisting of combined and complimentary action inside and outside workplace.

A.2

COUNCIL DIRECTIVE 90/269/EEC: MINIMUM HEALTH AND SAFETY REQUIREMENTS FOR THE MANUAL HANDLING OF LOADS (ANNEX I AND II)

Council Directive 90/269/EEC of 29 May 1990 on the minimum health and safety requirements for the manual handling of loads where there is a risk particularly of back injury to workers (fourth individual Directive within the meaning of Article 16 (1) of Directive 89/391/EEC)

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ANNEX 1

(*) REFERENCE FACTORS (Article 3 (2), Article 4 (a) and (b) and Article 6 (2))

1. Characteristics of the load

The manual handling of a load may present a risk particularly of back injury if it is:

- too heavy or too large,
- unwieldy or difficult to grasp,
- unstable or has contents likely to shift,
- positioned in a manner requiring it to be held or manipulated at a distance from the trunk, or with a bending or twisting of the trunk,
- likely, because of its contours and/or consistency, to result in injury to workers, particularly in the event of a collision.

2. Physical effort required

A physical effort may present a risk particularly of back injury if it is :

- too strenuous,
- only achieved by a twisting movement of the trunk,
- likely to result in a sudden movement of the load,
- made with the body in an unstable posture.

3. Characteristics of the working environment

The characteristics of the work environment may increase a risk particularly of back injury if:

- there is not enough room, in particular vertically, to carry out the activity,
- the floor is uneven, thus presenting tripping hazards, or is slippery in relation to the worker's footwear,
- the place of work or the working environment prevents the handling of loads at a safe height or with good posture by the worker,
- there are variations in the level of the floor or the working surface, requiring the load to be manipulated on different levels,
- the floor or foot rest is unstable,
- the temperature, humidity or ventilation is unsuitable.

4. Requirements of the activity

The activity may present a risk particularly of back injury if it entails one or more of the following requirements:

- over-frequent or over-prolonged physical effort involving in particular the spine,
- an insufficient bodily rest or recovery period,
- excessive lifting, lowering or carrying distances,
- a rate of work imposed by a process which cannot be altered by the worker.

(*) With a view to making a multi-factor analysis, reference may be made simultaneously to the various factors listed in Annexes I and II.

ANNEX II

(*) INDIVIDUAL RISK FACTORS (Articles 5 and 6 (2)). The worker may be at risk if he/she:

- is physically unsuited to carry out the task in question,
- is wearing unsuitable clothing, footwear or other personal effects,
- does not have adequate or appropriate knowledge or training.

(*) With a view to multi-factor analysis, reference may be made simultaneously to the various factors listed in Annexes I and II.

A.3

OVERVIEW OF SECONDARY/TERTIARY INTERVENTIONS.

It is important to distinguish the different phases in the history of low back disorders, since prevention will differ according to the specific phase. Often an acute, sub-acute and a chronic phase is mentioned. Regarding the exact duration of the acute phase and the start of the sub-acute phase, often contradictory results are found. The start of the chronic phase (and often mentioned the necessity for tertiary prevention) is mostly mentioned to be 3 months after symptom onset (e.g. Scheer et al., 1997; van der Weide et al., 1997; Frank et al., 1996b).

In this review interventions for acute and chronic low back pain are mentioned, based on several studies. Frank et al. (1996b) compared two reviews on the effectiveness of health care interventions in the USA and in the UK. In the Netherlands, the Dutch standard for low back pain gives several recommendations (Faas et al., 1996) and extensive studies on effectiveness of prevention strategies are performed by Van Tulder and colleagues (1999). Also Abenhaim et al. (2000) and Carter and Birrell (2000) mention guidelines and possible interventions.

1. Interventions for acute Low Back Disorders

1.1 Bed rest

A period of bed rest was traditionally recommended for patients suffering from an attack of acute back pain. The rationale for this was that patients experience relief of symptoms in the supine position and there are indications that intradiscal pressure is minimised in the supine position. However, the importance of intradiscal pressure in patients without a herniated disc (which is the situation in most cases) remains unclear (Koes and van den Hoogen, 1994). The authors concluded from their review that short periods of bed rest (2 or 5 days) were as effective as longer periods (4 or 8 days) and have less side effects (absenteeism from work and return to normal level of activities). Also Scheer et al. (1995) found in the literature three studies that favoured a brief period of bed rest, on average 3 days, for acute non-radicular low back pain. Van der Weide et al. (1997) found limited or moderate evidence for the efficacy of a short period of bed rest for acute low back pain patients and even the avoidance of bed rest. Normal activity should be continued as much as possible. Adverse effects of bed rest are joint stiffness, muscle wasting, loss of bone mineral density, pressure sores and venous thrombo-embolism (van Tulder et al., 1999).

1.2 Spinal manipulation

Van der Weide et al. (1997) found moderate evidence that spinal manipulation is more effective in the short run than other conservative types of treatment, such as physiotherapy, at least for patients without radiating pain. Contrary, van Tulder et al. (1999) mention conflicting evidence.

1.3 Exercise therapy

For a population with more severe low back pain, exercise therapy may expedite a sense of well being sooner than a placebo, but there is insufficient data to substantiate the trend. The benefits of the exercise approach are maximal when individualised (Scheer et al, 1995). Koes et al. (1994) concluded that the most promising type of intervention was the more intensive back schools. Van der Weide et al. (1997) found no evidence that this therapy was more effective than usual medical care. Van Tulder et al. (1999) found strong evidence that exercise therapy was equally as effective as physiotherapy.

1.4 Medication

Van Tulder et al. (1999) reviewed the effectiveness of conservative treatment of acute low back pain. Below some of the effects of medication are summarised.

Non-steroidal anti-inflammatory drugs (NSAIDs) are used for their analgesic potential and their anti-inflammatory action. There is strong evidence that NSAIDs are effective for short-term symptomatic relief in patients with uncomplicated low back disorders, but are less effective or even ineffective in patients with sciatica since they do not relieve radicular pain. There is moderate evidence that analgesics are not more effective than NSAIDS. There is considerable evidence that analgesics provide short-term pain relief. There is conflicting evidence regarding antidepressants versus placebos on pain relief, also regarding colchicine. On

the other hand, there is strong evidence that muscle relaxants reduce pain and that different types are equally effective in cases of acute low back pain. There is moderate evidence that epidural steroid injections are not useful in the treatment of acute low back pain.

2. Interventions for chronic low back disorders

2.1 Bed rest

There is strong evidence that advice to stay active is associated with equivalent or faster symptomatic recovery, and leads to less chronic disability and less time off work than bed rest or usual care (van Tulder et al., 1999). Furthermore, Abenhaim et al. (2000) state that patients should maintain or resume their work activities as far as the pain allows. Implementation of this recommendation should not be problematical, as long as the various stakeholders are convinced of the necessity of minimising the duration of work absence (the chances of a timely return to work decline as the duration of work absence increases), and there are no deleterious effects of early return to work. Of course this depends on the diagnosis and severity of the individual back pain status.

When, after several weeks of treatment, a patient continues to experience problems adapting to occupational activities, physicians should alert the worker's occupational medical staff, if not initiate occupational retraining. This recommendation is yet another reflection of the necessity of minimising the duration of work absence, to avoid compromising the probability of returning to work. These steps should be taken as early as possible, in contrast to the current practice. It is important for all stakeholders to understand the need to address the occupational future of patients earlier than is often the case currently. The probability of returning to work is only approximately 50% after 6 months of work absence and is only approximately 30% after an absence of 1 year. Improving treatment and rehabilitation methods should help to improve these figures.

Also Carter and Birrell (2000) suggest for the management of workers with back pain encouraging the worker to remain in his or her job or to return at an early stage, even if there is still some pain. The following steps can facilitate this:

- Initiate communication with their primary health care professional early in treatment and rehabilitation
- Advise the worker to continue as normally as possible and provide support to achieve this
- Advise employers on the actions required, which may include maintaining sympathetic contact with the absent worker.
- Consider temporary adaptations of the job or pattern of work

2.2 Spinal manipulation

No evidence for the efficacy of spinal manipulation for chronic patients was found, whether compared to a placebo or to other treatments (van der Weide et al. 1997). Also van Tulder et al. (1999) mention conflicting results.

2.3 Exercise therapy

Van der Weide et al. (1997) found no evidence that back school/exercise therapy is more effective than usual care. Van Tulder et al. (1999) found strong evidence that exercise therapy is equally effective as physiotherapy and more effective than usual care by the general practitioner in chronic low back pain. Scheer et al. (1997) could not draw any conclusions for the value of exercise due to a limited group of studies. However, in one of the four investigated studies, reduced work disability days were mentioned when an individual approach was adopted.

2.4 Orthoses

The use of braces or orthoses increases with the duration of pain. The rationale for using orthoses varies from restriction in performing spinal movements, postural corrections (making the patient sit and stand in a supposedly better position) or the increase of the abdominal pressure, allowing a substantial proportion of body-load to be transmitted through the abdomen rather than through the spine. Also that generated warmth (by enclosing the skin) decreases the pain sensation, is suggested (Koes and van den Hoogen, 1994). However, most of these hypotheses have recently been criticised (cf. supra) and it is concluded that no evidence is found that lumbar supports are effective in acute and chronic low back pain.

2.5 Medication

Limited evidence was found for efficacy of antidepressants, but no evidence for non-steroidal anti-inflammatory drugs (van der Weide et al., 1997). Also in a previous review of van Tulder et al. (1996), no evidence was found for the efficacy of analgesics or muscle relaxants. Only one study was found on epidural injections. Again comments on the quality of the studies were given.

3. Cognitive and behavioural strategies

A diverse array of psychological approaches and outcome measures are present, e.g. coping strategies, conditioning, stress reduction or relaxation, biofeedback and/or use of imagery (Scheer et al., 1997). The authors reported the results of five high quality studies and concluded that the idea that cognitive and behavioural strategies were effective in affecting vocational-

ly relevant outcomes could not be supported. Recently, van Tulder et al. (1999) concluded that there was evidence that behavioural therapy had a moderate effect on pain, and a mild effect on disability compared to no treatment in chronic low back pain at all.

Carter and Birell (2000) mention beliefs and behaviours on the part of the patient that may predict poor results:

- A belief that back pain is harmful or potentially severely disabling
- Fear-avoidance behaviour and reduced activity levels
- Tendency to low mood and withdrawal from social interaction
- Expectation of passive treatment(s) rather than a belief that active participation will help

The moderate effect of antidepressants for conservative treatment of acute and chronic low back pain (Van Tulder et al., 1999) may reveal that there are some patients who show psychological signs (such as tendency to low mood and withdrawal from social interaction). This may be related to the vicious circle where not only muscles but also the central nervous system are concerned with pain (Johansson and Soika, 1991).

European Agency for Safety and Health at Work

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