

**AN INVESTIGATION INTO FACTORS
PREDISPOSING TO LOW BACK PAIN IN
WORKERS IN A MOTOR VEHICLE PARTS
DISTRIBUTION CENTRE**

Patricia Joan Wallner

Johannesburg, 1998

**AN INVESTIGATION INTO FACTORS
PREDISPOSING TO LOW BACK PAIN IN
WORKERS IN A MOTOR VEHICLE PARTS
DISTRIBUTION CENTRE**

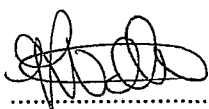
Patricia Joan Wallner

**A research report submitted to the faculty of Health Sciences,
University of the Witwatersrand, Johannesburg in partial
fulfilment of the requirements for the degree of Master of Science
in Physiotherapy.**

Johannesburg, 1998

DECLARATION

I, Patricia Joan Wallner, declare that this research report is my own work. It is being submitted in partial fulfilment for the degree of Master of Science in Physiotherapy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.



.....(Signature of candidate)

18th day of August(month), 1998

ABSTRACT

Low back pain is a common complaint which has a high socio-economic cost. Very little information is available in South Africa as to its prevalence or factors associated with it. A group of material handlers was targeted to investigate these aspects. Two groups were randomly sampled, one who complained of low back pain and the control group who did not. Both groups took part in a structured questionnaire relating to their work environment and also underwent a physical examination. Bending and lifting parts from the floor and the participation in heavy physical activity were factors that were associated with reported low back pain in the subject group as were a decrease in the overall mobility of the lumbar spine and a decrease in strength of rectus abdominis and the oblique abdominal muscles.

ACKNOWLEDGEMENTS

I should like to thank my supervisors, Mrs A. Stewart and Mr J. George for all their help and encouragement; the physiotherapy department as a whole for the time and use of their facilities; Dr P. Bekker, Mrs. E. Viljoen of the Biostatistical Services Department of the Medical Research Council of South Africa, Pretoria and Prof. J. Allen for their statistical help; the staff at the Alexandra Health Centre and University Clinic; the management and staff at the Toyota Parts Distribution Centre; and to my family for their patience and encouragement.

TABLE OF CONTENTS		Page
DECLARATION		ii
ABSTRACT		iii
ACKNOWLEDGEMENT		iv
TABLE OF CONTENTS		v
LIST OF TABLES		ix
ABBREVIATIONS		xi
1.0	INTRODUCTION	1
1.1	Low Back Pain In Industry	1
1.2	Aim Of The Study	2
2.0	LITERATURE REVIEW	3
2.1	Low Back Pain In The General Population	3
2.2	Low Back Pain In Industry	4
2.2.1	Frequency	4
2.2.2	Cost	6
2.2.3	Precipitating factors in the workplace	8
2.2.3.1	Heavy physical work	12
2.2.3.2	Static work posture	12
2.2.3.3	Frequent bending and twisting	13
2.2.3.4	Lifting and forceful movements	14
2.2.3.5	Repetitive work	16
2.2.4	Individual factors	17

	Page
2.2.4.1 Age and sex	17
2.2.4.2 Height, weight and leg length discrepancies	19
2.2.4.3 Posture	21
2.2.4.4 Spinal Mobility	21
2.2.4.5 Muscle Strength	24
2.3 Treatment	28
2.4 Prevention	30
 3.0 MATERIALS AND METHODS	 33
3.1 Subjects	33
3.2 Procedure	36
3.2.1. Part 1	36
3.2.2. Part 2	37
3.3 Statistical analysis	40
 4.0 RESULTS	 41
4.1 Part 1: Questionnaire	41
4.1.1 Participants in the survey	41
4.1.2 Period prevalence of low back pain	41
4.1.3 Age of the subjects	42
4.1.4 Area of work	42
4.2 Part 2: Structured Interview Regarding Work Habits	44
4.2.1 Distribution of subjects in terms of area of work	44
4.2.2 Length of working time in the parts distribution centre	44

		Page
4.2.3	Loss of working days	45
4.2.4	Daily working activities which caused reported low back pain	46
4.2.5	Leisure activities which caused reported low back pain	48
4.2.6	Neurological symptoms	48
4.2.7	Action taken to decrease the symptoms	48
4.3	Part 2 : Results Of The Clinical Examination	50
4.3.1	Physical characteristics	50
4.3.2	Range of lumbar movement	51
4.3.3	Abdominal muscle strength	53
4.3.3.1	Rectus abdominis	53
4.3.3.2	Oblique abdominal muscles	54
4.3.5	Quadriceps muscle strength	55
4.3.6	Trunk extensor strengin	56
4.3.12	Observation of lifting technique	57
5.0	DISCUSSION	58
5.1	Part 1 : Questionnaire	58
5.1.1	Participants in the survey	58
5.1.2	Period prevalence of low back pain	58
5.2	Part 2 : Structured Interview Regarding Work Habits	60
5.2.1	Age	60
5.2.2	Distribution of subjects in terms of their work area	60
5.2.3	Material handling exposure	60
5.2.4	Loss of working days	61

	Page
5.2.5 Daily working activities that caused reported low back pain	61
5.2.5.1 Standing for long periods of time	61
5.2.5.2 Bending and twisting	62
5.2.5.3 Lifting	63
5.2.5.4 Participation in heavy physical work	64
5.2.6 Neurological symptoms	65
5.2.7 Action taken to decrease the pain	65
5.3 Part 2 : Clinical Examination	67
5.3.1 Physical characteristics	67
5.3.2 Range of lumbar movement	67
5.3.3 Abdominal muscle strength	68
5.3.4 Quadriceps muscle strength	69
5.3.5 Trunk extensor strength	70
5.3.6 Observation of lifting technique	71
5.4 Recommendations	72
 6.0 CONCLUSION	 73
 APPENDIX A Subjects information and consent form	 74
APPENDIX B Subject questionnaire (Part 1)	75
APPENDIX C Interview regarding work habits (Part 2)	78
APPENDIX D Clinical examination (Part 2)	85
REFERENCES	88

LIST OF TABLES

	Page
2.0 Approximate load on L3 disc in a person weighing 70 kg (Nachemson 1981)	11
3.1 Name of each area and description of typical work activities carried out in the PDC	35
3.2 Flow chart of the study procedure	38
4.1 Mean age of the subjects in years	42
4.2 Response rate categorised into areas of work	42
4.3 Frequency of subjects in group 1 and 2 categorised into areas of work	43
4.4 Frequency distribution of subjects in relation to their work area	44
4.5 Mean years of work in PDC	44
4.6 Responses of group A, in percentages to questions on whether applicable activities during work hours caused low back pain	46
4.7 Comparison of affirmative responses from subjects in Group A.	47
4.8 Percentages of subjects who undertook various actions to decrease their low back pain	48
4.9 Mean weight for groups A and B	50
4.10 Mean height for groups A and B	50

	Page
4.11 Mean range of movement of the lumbar spine in intervals of ¼'s represented as percentages of the total number of subjects in group A and B	51
4.12 Ability to achieve full range movement	52
4.13 Percentages of subjects in each group categorised in terms of Manual Muscle Test grading achieved for the rectus abdominis muscle	53
4.14 Percentages of subjects in each group categorised in terms of Manual Muscle Test grading achieved for the oblique abdominal muscles	54
4.15 Percentages of subjects in each group categorised in terms of Manual Muscle Test grading achieved for the quadriceps muscle group	55
4.16 Percentages of subjects in each group categorised in terms of Manual Muscle Test grading achieved for the back extensor muscle group	56
4.17 Percentages of subjects in each group employing stoop lifting and crouch lifting	57

ABBREVIATIONS

χ^2	Chi square value
cm	centimetres
df	degrees of freedom
Exp	expected
Freq	frequency
kg	Kilogram
LBP	low back pain
MMT	Manual muscle testing
N	Newton
n	number of subjects
NLBP	no low back pain
(NS)	not statistically significant
Obs	observed
PDC	Parts Distribution Centre
(S)	Statistically significant
S.D.	standard deviation
USA	United States of America

1.0 INTRODUCTION

1.1 Low Back Pain In Industry

Numerous studies have shown that low back pain (LBP), i.e. pain experienced in the lumbar area of the back, is a common complaint and cause of lost production time in the industrial sector of the economy (Bigos, et al.1986, Troup, et al.1981). This is costly not only to the particular industry but also to the health care providers (Spengler, et al. 1986). Workers involved in lifting and material handling are particularly at risk of developing LBP (Andersson, 1981, Frymoyer, et al. 1983). No studies have been found by the researcher to illustrate factors which may predispose material handlers to LBP in South African industry.

The Alexandra Health Centre and University Clinic in Johannesburg, in conjunction with The Institute of Urban Primary Health Care offers a Workers' Health Outreach Clinic at the Toyota National Parts Distribution Centre. The Primary Health Care Nurse, who runs the clinic, reported that a large number of the workers attending the clinic complained of low back pain.

As many of these workers are involved in the lifting and handling of materials it was considered worthwhile by the researcher and the Primary Health Care Nurse to investigate the prevalence of back pain as well as possible factors that may be associated with it, in this South African situation. If these factors could be identified possible preventative action to decrease the prevalence of LBP may be implemented.

1.2 The Aim Of The Study

The aim of this study was to:

- i. establish the period prevalence of low back-pain among material handlers and to
- ii. identify factors which may be associated with or predispose to the development of low back pain in workers involved in the storing and retrieving of parts in a motor vehicle parts warehouse.

2.0 LITERATURE REVIEW

In this literature review, the researcher will attempt to provide a broad overview of the prevalence and cost of LBP globally and then also examine literature that highlights factors which may be associated with the incidence, treatment and prevention thereof.

2.1 Low Back Pain In The General Population

The large amount of literature on the subject of LBP may give an indication of the enormity of the problem. It has been estimated that between 60 and 80 percent of people experience a period of LBP some time in their lives (Frymoyer, et al. 1983, Biering-Sorensen, 1984). Chaffin and Park (1973) concluded that "low back pain is a major source of incapacitation, suffering, and cost to the world today. It tends to strike younger workers and is recurrent in nature, though between episodes the person is often pain-free." Rowe (1969) reported that LBP is second only to upper respiratory tract problems as a cause of time lost in the mixed-job industrial complex (Kodak Eastman) that he studied.

The 3 year prevalence of LBP ranges from 23 to 46 percent according to Frymoyer, et al. (1983) who surveyed 1221 men between the ages of 18 and 55 who had been treated at a family practice in the USA. Biering-Sorensen (1984) conducted a longitudinal health survey of all the 30, 40, 50 and 60 year old inhabitants of a suburb of Copenhagen. He found that the overall point prevalence at the time of examination for "pain or other trouble in the lower part of the back" was 14 percent; the 1 year prevalence was 45 percent and the lifetime prevalence was 62 percent. As the subjects were taken from a cross sectional age in the

community these figures could act as a baseline for the prevalence of back pain in a community. The report does not, however, illustrate the demography of the community. Different socio-economic and cultural groupings may show different incidences of reported LBP.

Low back pain is classically episodic and often recurrent with pain free periods in between (Troup, 1981, Rowe, 1969, Chaffin and Park, 1973). The onset can be acute or insidious. A person complaining of LBP is likely to regard an activity to be the cause of the pain if it comes on suddenly. The cause is often very difficult to establish because of the episodic nature of the symptoms (Chaffin, 1974).

2.2 Low Back Pain In Industry

The literature relating to back pain in general and to LBP in industry, in particular, is substantial. The published studies dealing with the frequency and causative factors of LBP in industry are often difficult to evaluate because the subject groups and design of the studies differ vastly. The main difficulty is related to the fact that most of the population groups are from mixed occupations and so it is very difficult to establish prevalence or associated factors related to LBP in any one particular occupational group.

2.2.1 Frequency

A literature review carried out by Andersson (1981) presented data that was collected from industries in the United Kingdom, Scandinavia and the United States indicating the frequency of occurrence and the cost to society. Much of the data related to back pain in general and not to LBP specifically.

From the literature it seems that between 12 and 19 percent of occupational injuries are those related to the back or lower back (Kelsey, et al. 1979 and Spengler, et al. 1986) .

Kelsey, et al. (1979) reported that 15 - 18 percent of all occupational injuries were related to the back and that 2 percent of all employees in the USA receive compensation for back injuries each year from a review of statistics illustrating the impact of musculoskeletal disorders on the population in the United States of America collected from the Bureau of Census. It is unclear from this article from which occupational group the population was sampled and which area of the back was affected.

Fourteen percent of all compensated injury in Quebec, Canada in 1981 was due to a spinal disorder according to the Quebec Task Force, (1987) who investigated the frequency of people with spinal disorders who obtained compensation from the Quebec Workers Compensation Board.

An extensive retrospective study was carried out at The Boeing Company, a large industrial manufacturer in Washington State in the USA , with the aim of evaluating the impact of back injury on industry. Analysis of the injury information provided by the company on 31 200 hourly paid workers showed that 19 percent of all injuries over a 15 month period were back related (Spengler, et al. 1986). As in the previous two studies these figures relate to back pain in general and no statistics on LBP specifically can be extrapolated.

Magora (1973) conducted a study in Israel on 3316 subjects from 8 different occupational groups, namely bank and post office clerks, policemen, nurses, bus drivers, farmers and light and heavy industry workers. He found that 13 percent of subjects complained of LBP over a twelve month period.

2.2.2 Cost

The socio economic cost of LBP is measured in the literature in terms of loss of productivity time and in terms of medical and or compensation expenses associated with it.

Frymoyer, et al. (1983) reported that subjects complaining of LBP were unable to work for between 22 and 35 days. From figures extrapolated from the study to the 50 million working men in the 18 - 55 year group in the USA, the authors suggested that 217 million work days were lost annually. That equates to 11 billion US dollars in lost wages every year based on the reported annual income for American men. In considering medical costs they reported that a "striking" 3.4 percent of this sample population had undergone surgical treatment for their back pain.

Hutson (1993) reported that in the year 1988 -1989, 36 million working days were lost in the male population in the United Kingdom and 16 million in the female population in the industrial sector alone. He stated that workers involved in heavy industry were more vulnerable to back pain than sedentary workers.

The Quebec Task Force (1987) reported that only 19 percent of total costs associated with back troubles were used to pay for medical care. The remainder were in lost wages and compensation i.e. salary replacement due to temporary disability.

In the Boeing study (Spengler, et al. 1986), 19 percent of all injuries were related to the back but 41 percent of the compensation claims costs, that is approximately 1.8 million US Dollars, were paid out to those with back injury. The researchers showed that 10 percent of all back injury claims accounted for 79 percent of the total back injury costs. These they called high cost injury claims. The low injury costs made up the difference.

A similar finding was shown by the Quebec Task Force where 7 percent of back injured people who were absent for longer than six months accounted for 75 percent of the total compensation costs with regard to spinal problems.

Lehmann, et al. (1993) conducted a study on the prediction of long term disability on 55 patients with disabling chronic LBP. They found that blue collar workers were mostly affected and that the costs were related to compensation claims.

Andersson, et al. (1983), in his study of recovery and return to work in people with LBP, reported that blue collar workers have a significantly longer average sickness period compared to their white collar counterparts. This the author attributed to the fact that as mechanical factors are known to be important in LBP it is more difficult to return to work with even a slight pain if the work is physically demanding.

According to Andersson(1981) surveys in Sweden showed that between 9 and 19 percent of sickness absence days were related to back pain. The average sickness absence period was 36 days but 40 percent of the periods were shorter than 1 week.

Studies suggest that an individual with LBP who is absent from work for more than 6 months has a 50 percent likelihood of returning to work; after an absence of one year the likelihood drops to 25 percent and after 2 years to virtually nil (Mc Gill, 1968 , Frymoyer and Cats Baril,1987).

Bester (1996) reported, in a retrospective study of the prevalence of LBP at a large South African mining house, employing nearly 70 000 people, that almost 5 percent of all patients seen by the physiotherapy service were workers with LBP. Each physiotherapy attendance involved the loss of one shift. The average number of attendances per patient was 6.7 which equated to 1.2 weeks away from work. Eighty-four percent of workers with LBP returned to their normal jobs, 15 percent required job changes and 1 percent were repatriated because of the severity of their pain. South Africa has a much less developed compensation system than most Western countries.

2.2.3 Precipitating factors in the workplace

An extensive prospective study was conducted by Rowe (1969), at a mixed job industrial complex in the USA that employed over 28 000 people. The study attempted to delineate the natural history and describe and define the causal factors of LBP in industry. Five hundred male patients were included in the study.

Each subject underwent an evaluation which included a history, physical examination, X-ray and laboratory studies. Rowe described the lack of a convincing relationship between trauma and LBP. Sixty five percent of his sample group could not identify any unusual circumstances that could be attributed to cause of the LBP.

Bester (1996) in the South African survey of mine employees reported that 44 percent of subjects experienced some kind of trauma to their backs, 32 percent claimed insidious onset while 24 percent complained of chronic pain for longer than 3 months. The study population included both heavy manual workers such as underground miners and surface workers including clerical staff. Because of these differences one cannot use this survey to ascertain the specific prevalence or cost of LBP in any particular kind of job.

Numerous factors in the workplace have been linked to the phenomenon of LBP. Manning, et al. (1984) conducted a questionnaire survey of mixed job workers in a motor vehicle assembly plant of almost 14 000 employees. They interviewed 401 employees who were absent from work or were restricted at work due to back pain. They questioned the subjects on their body movements and the events associated with the onset of back pain. They found that nearly 30 percent of these employees reported accidental injury as the cause of their back pain. Another 30 percent attributed non accidental injury, (injury which occurred during the subjects' normal working activity-without the intervention of any unforeseen event other than the pain itself) as the cause of their back pain. Forty percent of subjects reported an insidious onset. Significantly more of those with non accidental injuries involved

load handling. They also found that a significantly higher proportion of non accidental injury occurred at home and a higher proportion of accidental injury at work. One of the limitations of this study is the lack of clarity as to how soon after the onset of the pain the subjects were interviewed. The longer the time elapses the less accurate the subjects' recall as to the movement or onset factor of the back pain.

In the literature review undertaken by Andersson(1981) he listed the following six vocational factors as associated with an absence from work due to back pain; heavy physical work, static work posture, frequent bending and twisting, lifting and forceful movements, repetitive work and vibration. He stated that the commonality in all of these factors was the physical loading on the spine. The association with any single vocational factor is not easy to establish as they often occur at the same time. Any increase in mechanical load increases the pain in those already symptomatic.

Slips and falls are also seen by various researchers as important factors to consider when investigating LBP at work (Bigos, et al.1986a, Manning, et al. 1984, Bester, 1996).

Nachemson (1981) measured the intradiscal pressure of the third lumbar intervertebral disc in over 100 individuals in various resting and working postures over a period of 20 years. As can be seen from Table 2.0 working in a forward flexed, rotated position while lifting a load increased the pressure in the third intervertebral disc by 400 percent as compared to the upright standing position.

Table 2.0 Approximate load on L3 disc in a person weighing 70 kg**(Nachemson 1981)**

Position	Load measured in Newtons
Supine, awake	250
Upright sitting, without support	700
Sitting with lumbar support, back rest inclination 110 degrees	400
Standing, at ease	500
Coughing	600
Forward bend 20 degrees	600
Forward bend 40 degrees	1000
Forward flexed 20 degrees and rotated 20 degrees with 10kg	2100
Lifting 10kg, back straight, knees bent	1700
Lifting 10kg, back bent	1900
Holding 5kg, arms extended	1900

Chaffin (1974) reported on a longitudinal study that was conducted on over 500 people working on jobs that required various amounts of manual weight lifting. A greater incidence of LBP was reported in workers involved in jobs that required a high lifting strength than in those who did jobs in which very little or no lifting was required.

A clear association between biomechanical factors and low-back disorders was reported by Marras, et al.(1993) in the USA . They analysed 400 different repetitive lifting jobs in 48 different industries using electrogoniometry. They developed a model that indicated that a combination of five workplace and trunk motion factors distinguished between high and low risk of developing occupational related low back disorders. These factors were; lifting frequency, load moment, lateral trunk speed, trunk twisting velocity, trunk sagittal angle (trunk flexion or extension angle).

2.2.3.1 Heavy physical work

It is difficult to evaluate the relationship between heavy physical work and the actual loading of the spine. Studies have been conducted which related LBP symptoms and jobs that require physical work; Rowe (1969) reports 47 percent of heavy material handlers made visits to the medical department with LBP over a 10 year period whereas only 35 percent of sedentary workers had done the same; Magora (1973) reported a 21 percent prevalence of LBP in subjects who did heavy physical work and 19.4 percent in bank employees who were involved in non heavy physical work activities..

Zwerling, et al. (1993) showed in his study of mixed job postal workers which had 154 subjects with low back pain and 942 controls, that jobs which required heavy lifting contributed significantly to the risk of developing LBP.

2.2.3.2 Static work posture

Bigos, et al. (1986a) reported that more than 11 percent of the compensation claimants in their study attributed their back pain to work in awkward positions.

Magora (1972) reported that sitting or standing for long periods in a day, i.e. more than 4 hours, was associated with LBP. He reported almost a complete absence of LBP in people who could sit for brief, repeated periods in the day. The same author, Magora (1973), reported a 19 percent prevalence of LBP in bank employees who have predominantly seated or standing jobs.

Occhipinti, et al. (1993) in drawing up a model to establish the baseline of the distribution and characteristics of spinal disorders in a group of male workers not exposed to occupational spinal risk factors specified that people who i) sit for prolonged periods (more than 4 hours per day), ii) stand for more than 4 hours per day or iii) drive vehicles for more than four hours a day are at risk of developing spinal disorders. Once again this study relates to spinal disorders generally and not to LBP specifically.

2.2.3.3 Frequent bending and twisting

Bending and twisting movements are especially representative of body movements that contribute to non accidental injury. These non accidental injuries are most likely to occur at home as routine domestic activities involve such movements. This has been shown in a study by Manning, et al. (1984) which relied on recall. The Magora (1973) observational study provides more useful information. He is very specific in his definition of bending and specified that it needs to be done at least 15 times every hour or that a major part of the day is spent in this position to qualify for risk of development of low back pain. He conceded that bending may contribute to the causation of low back pain but he states that the actual sudden maximal movement and the lack of preparedness is the crucial factor in the development of pain. He believed that regular movements of bending and twisting were less likely to cause low back pain than are the unexpected movements done when the back is not in the correct posture ready to prepare for the movement.

Biering-Sorensen (1983b) found that the most common aggravating factor to the increase in LBP, reported by his subjects, was stooping. He also shows that the

movements of bending and twisting are risk factors in the development of LBP.

Frymoyer, et al. (1983) however did not examine this specifically in his questionnaire study.

2.2.3.4 Lifting and forceful movements

It is well documented that repetitive lifting and forceful movements such as pushing and pulling heavy objects are associated with LBP (Zwerling, et al. 1993, Biering-Sorensen, 1983a, Frymoyer, et al. 1983, Bigos, et al. 1986(a), Troup, et al. 1981, Andersson, 1981, Chaffin and Park, 1973). Low back injury may occur when there is a mismatch between the job demands and the person's physical capacity (Frymoyer and Cats-Baril, 1987).

Frymoyer, et al. (1983) showed that when analysing the subject's occupations, the most important prognostic variable in the development of LBP was repetitive heavy lifting. Between 47 and 53 percent of the subjects complaining of LBP did work that required repetitive heavy lifting of 20kgs or more. This information was gathered using a self administered questionnaire which relies on recall and honesty. Magora (1972), in his study in which activities done throughout the day were specifically prescribed and observed by the researcher, reported that the weight lifting of more than 5kg more than ten times every hour was linked to the onset of back pain and that the actual lifting technique was also important to consider. People who lifted using two hands were usually lifting heavy objects, e.g. bales, boxes etc. and they required forward or side flexion of the body to enable the objects to be brought close to the body. This movement increases the load on the lumbar spine markedly as was shown by Nachemson (1981).

Occhipinti, et al. (1993) described the term manual handling as the lifting of heavy loads of more than 5 kg at least 10 times per hour or more than 20 kg at least once an hour. Troup, et al. (1981) showed in their prospective study that 30 percent of accidental injuries occurred during material handling.

Bigos, et al. (1986a) in their retrospective study in a large industrial concern showed that 63 percent of back injuries were associated with lifting and material handling and that at least 34 percent of workers with back injuries attributed improper lifting techniques as the cause of their injury. The lifting of heavy objects was the most commonly reported injury to the lower back in the one year mining survey done by Bester (1996).

Manning, et al. (1984) stated that a smaller percentage of his subjects attributed the movement of sudden unexpected loads and material handling to the initial event that caused their back injury. This is backed up by the Magora (1973) study.

Chaffin (1974) reported on a study in which he examined isometric lifting force in a large sample population of people required to lift weights in their jobs. He showed that there was a sharp increase in the LBP incidence rates for those people who had poor isometric lifting strength. Mandell, et al. (1993) conducted isokinetic lifting strength tests and found no difference between those with LBP and those without pain. Their sample of postal workers was deconditioned and for this reason no useful conclusions relating to lifting forces could be deduced from this study.

Marras, et al. (1993), using a different approach, namely electrogoniometric and other anthropometric data, to measure movement and distance from the work surfaces, noted that the frequency of lifting and the increase in load lifted has a direct link to the risk of developing occupational LBP. This study was conducted on a large number of subjects in the actual working environment and for this reason could be considered one of the more useful studies that could assist workplace design in order to minimise occupationally related LBP.

Kelsey, et al. (1984) reported in an epidemiological study on factors associated with lumbar disc prolapse, that the lifting of objects more than 25 times per day with a weight of 11.3kg or more, while twisting the body without the knees bent is estimated to be associated with a sevenfold increase in risk. The information gathered for the study was by interview and therefore subject recall was necessary. It is also unclear as to the specific test used to reach this conclusion. For this reason this finding should be viewed with caution.

2.2.3.5 Repetitive work

Frymoyer, et al. (1983) showed that 35 percent of his subjects over a 3 year period who complained of moderate to severe LBP were involved in work that required repetitive lifting. Quantification of the repetition is not clearly defined by the author. Occhipinti (1993) did define repetitive manual handling of loads as mentioned previously.

Although Andersson (1981) and Frymoyer (1988) mention repetitive work as a factor responsible for the cause of LBP the literature supporting this notion until the

early nineties was minimal. The study conducted by Marras et al (1993) was extensive and used sophisticated equipment to study movements most commonly undertaken in the task of manual material handling generally. The study did indeed indicate that repetitive material handling work that involved lifting loads and frequent bending and twisting was linked to the risk of the development of LBP.

2.2.4 Individual factors

2.2.4.1 Age and Sex

Many studies have shown that the incidence of LBP occurs in a person's most productive years, namely between 25 - 60 years . The first indications of the problem are often noticed for the first time before the third decade and the most severe problems occur in the 30's or 40's as this is the time people are most at risk of developing more serious low back injury. (Bigos, et al., 1986b, Frymoyer, et al., 1983, Biering-Sorensen, 1983a)

Frymoyer, et al. (1983) surveyed 1221 men between the ages of 18 - 55 and found that the average age of the subjects with moderate to severe low back pain was between 32 and 33 years. This was a similar finding to Rowe (1969) who examined 500 male patients with LBP in which 70% of the patients were in their 30's and 40's and only 12 percent in their 20's and 13 percent in their 50's.

Lehmann, et al. (1993) in their report of a much smaller sample size (55 subjects), showed that people with low back injuries, who were referred to an occupational physician, were absent from work for an average of 4 weeks and that their average age was 37 years. Sixty seven percent of this sample group were male.

Frymoyer and Cats-Baril(1987) reported that men apply for compensation of back injuries more often than women and are more likely to become disabled. The literature examining LBP in the industrial sector specifically, shows a predominant slant toward examining males (Andersson, et al.1983, Frymoyer, et al.1983, Rowe,1969). This may explain the above finding.

The literature review by Andersson(1981) revealed that "sex factors seem to be without importance with respect to low back pain symptoms, while disc herniations occur more frequently in men than in women."

Men have a higher incidence of back pain than women. This could be explained by the difference in the physical demands of their jobs. The steady decrease in incidence of spinal disorders with age in both sexes could be related to the changes in task assignment in the evolution of a career as the worker ages according to the Quebec Task Force on Spinal Disorders (1987)

Employees younger than 25 years had a statistically higher risk of low cost back injury at work while those in the 31 - 40 age group were most susceptible to high cost back injury (Bigos, et al. 1986a, a co-investigator in the Boeing study). No suggestions for the reason for this finding were postulated by the authors. The distribution of total incurred compensation costs was proportional to the distribution of employees according to sex. While women had a greater number of high cost claims than expected, they had fewer low cost claims.

Troup, et al. (1981) in a prospective study of 802, predominantly male subjects, from mixed occupational backgrounds, who had been interviewed and examined after reported episodes of back or sciatic pain, found that the mean age was 41 years.

A study done by Kelsey, et al.(1979) analysing statistics relating to the impact of musculoskeletal disorders in the United States showed that impairments of the back and spine were the most frequent cause of limitation of activity in the age group under 45 years. This study failed to relate the sex of each sufferer to the impact of these impairments.

Manning, et al. (1984) in their study of 401 predominately male subjects, showed that there was no significant difference in the age distribution of the subjects who had sustained a back injury.

2.2.4.2 Height, weight and leg length discrepancies

There is conflicting evidence regarding anthropometric data (Frymoyer, 1988 and Andersson, 1981). There is no strong correlation between height, weight, body build and back pain, although according to Andersson(1981) there is evidence to support a higher than average risk of LBP in people who are taller or more obese than average.

Pope, et al. (1985), Bigos, et al. (1986b), Biering-Sorensen (1984) and Rowe (1969) reported that height, weight and leg length differences were of no significant consequence to the occurrence of LBP. Biering-Sorensen (1984) did find, after

extensive interview and clinical evaluation of his subjects, that the men who had LBP in the past when compared to those who had never had LBP, were in fact taller, heavier and had greater femoral epicondylar breadth. Leg length differences showed no predictive power for the first time occurrence of, or persistence of LBP. He did find that significantly more of the people in the group who had previously had LBP had leg length discrepancies than those who had never had back pain. This survey was of a general population and had a large age variation and did not include industrial workers specifically. It may have included people who had severe deformities caused from previous conditions e.g. polio, arthritis, fractures etc. and may therefore not be a reliable factor in the consideration of factors related to LBP.

Rowe (1969) found that leg length differences were of no significant consequence whether the person had LBP or not in his study of 500 men who were employed in an industrial setting.

The study by Troup, et al. (1981) included a clinical examination but no mention of basic anthropometric data was made. Manning, et al. (1984) examined body movements in relation to accidental and non accidental back injury and also failed to take height and weight into account.

Bigos, et al. (1986b) found no difference in the height or weight of people who had back injury who were high cost claimants versus those who were low cost claimants.

2.2.4.3 Posture

Rowe (1969) stated that structural characteristics of the lumbosacral spine, namely lordosis, kyphosis or scoliosis, using anterior-posterior and lateral X-ray examination films of the lumbar spine and pelvis, did not affect whether the person had LBP or not. Andersson(1981) in his literature review quoted numerous sources that claim that structural characteristics have no effect on the incidence of low back pain. He did mention however that some evidence does exist that a scoliosis greater than 80 degrees may be associated with low back pain especially if the vertex of the curvature is in the lumbar region. This may explain why Biering-Sorensen (1984) did not examine structural aspects such as scoliosis, kyphosis, and increased or decreased lordosis in his, otherwise thorough, investigation.

Frymoyer(1988) stated that variations in spinal posture, i.e. lordosis or scoliosis of less than 60 degrees do not appear to increase the risk of back pain or sciatica. The Bigos and Spengler et al (1986) retrospective study failed to examine variations in posture. Neither Manning, et al.(1984) nor Troup, et al.(1981) examined postural changes.

2.2.4.4 Spinal mobility

Troup, et al.(1981) found that a decrease in spinal mobility, as was measured using a fluid goniometer, was age related. The authors argue that this sign relates to the phases of the degenerative process in the disc and apophyseal joints that occur with increasing age. Movements of flexion, extension and lateral flexion were taken into account. No rotation movements measurements were undertaken

in this study. Mandell, et al. (1993) also measured only flexion and extension using an inclinometer and found that subjects with LBP had reduced flexibility.

Biering-Sorensen(1984) found, using the fingertip to floor trunk flexion test, that men were less flexible than women and that as one aged the trunk became less flexible in both sexes. In addition a modified Schrober test was used to ascertain trunk flexibility which entails the measuring of distance change on the surface of the skin of the lumbar spine before and after trunk flexion. He showed that there was prognostic value for the first time experience of low back pain using this test, in that males with more mobile lumbar spines were more likely to get low back pain. He found exactly the opposite in women. The modified Schrober test is a measure of lumbar mobility specifically whereas the fingertip floor test is significantly correlated to the length of the hamstrings. He also showed that reduced spinal mobility is more pronounced in those who experienced recurrence or ongoing low back trouble over the 1 year follow up period. This study failed to ascertain the mobility of the lumbar spine in the movements of extension, lateral flexion and rotation. A more complete evaluation of this aspect may have been more useful.

Pope, et al.(1985) reported that subjects with LBP had diminished range of motion in spinal extension and axial rotation. This study included all spinal movements.

Frymoyer and Cats-Baril(1987) found that reduced spinal mobility was related to disability caused by LBP. Andersson(1981) is in agreement with that, although he did not reference this statement in his literature review as he stated that no study

to date had considered spinal mobility as the causative factor in the development of LBP.

The issue of reliability in the measurement of range of movement of the lumbar spine is highlighted by a study by Rondinelli, et al. (1992) where they showed that surface inclinometry measurement was not in fact a reliable method of testing spinal flexion on healthy subjects. A similar finding was made by Boline, et al. (1992) who studied the inclinometric measurement of lumbar rotation in chronic LBP patients and subjects without LBP. Fitzgerald, et al. (1983) showed that the use of goniometry in the measurement of lumbar extension and right and left lateral flexion is associated with some degree of interrater reliability. The importance of standardisation of measurement is highlighted in a comprehensive review of the reliability and validity issues related to goniometry by Gajdosik and Bohannon (1987).

The use of visual estimation of range of movement of the lumbar spine as a clinical tool is not well documented. Maitland (1986) developed a model of patient assessment incorporating a quick visual estimation test to ascertain range of movement prior to manual therapy and then to compare that movement after therapy to ascertain the effect of the treatment administered. It is a quick and easy test to execute and it is performed by the same therapist shortly after the initial assessment. It is used often by physiotherapists and may have clinical value as an assessment and retest tool.

2.2.4.5 Muscle strength

Andersson (1981) in his review of the literature of LBP in industry reported some debate relating to the effect of trunk muscle weakness. The question of whether muscular weakness is primarily or secondarily related to LBP still needs to be clarified. The difficulties in measuring trunk muscle strength using reliable and credible tests make assessment of possible correlations difficult (Andersson, 1979).

Troup, et al. (1981) used the inability to perform a "sit up" with knees bent as a test to determine a decrease in muscle strength of the abdominal muscles. They tested muscle function of the extensors of the trunk and hip in the prone position. They examined muscle strength of the lower limbs by using a test in which the subjects were asked to squat down and up, keeping their backs straight. All these tests are crude indicators of muscle strength as no grading scale was used to indicate the strength relative to other subjects nor were the muscles being tested well isolated. They could rather be said to be tests of functional ability. According to Troup, et al. (1981) dynamic strength of trunk flexor muscles was of clinical value in predicting recurrence of back pain in a study they did over a two year period. Forty-five percent (45) of his sample had a decrease in "sit up"(abdominal muscle) strength. Fifty-eight percent (58) revealed a decrease in back extensor strength. He found that weakness of the abdominal muscles and hamstrings was significantly more common as his population aged. Abdominal weakness, pain or weakness on resisted hip flexion and back extensor weakness or pain was apparent in subjects who had reported three episodes of back pain. These

findings are questionable in terms of their validity, bearing the limitations of the testing procedure in mind.

Biering-Sorensen (1984) conducted more sensitive dynamic abdominal muscle testing using a grading system from 1 – 4 on over 900 subjects. Each subject was required to perform a sit up from the supine position and alter the position of their arms, to alter the lever effect. The specific grades that he used in the manual muscle testing was not, however, standardised to the 0 – 5 grades specified in Daniels and Worthingham's *Muscle Testing* (1995). He also measured the maximum voluntary contraction achieved for the movement of trunk flexion and extension using a strain gauge dynamometer. A test for trunk extensor endurance was also used. His description indicates that the muscles were all well isolated and all the testing was carried out by the researcher himself. He reported in his prospective study that good isometric endurance of the back extensor muscles seemed to prevent first time experience of low back trouble in men. He also found that weak trunk musculature was more pronounced in subjects who experienced recurrent episodes of back pain one year after the initial examination. He also examined the flexion extension ratio and found that the individual ratios were of no prognostic value for future recurrences of low back trouble.

Hemborg and Moritz (1965) used a strain gauge to test abdominal and back extensor strength in 20 construction workers who were mainly electricians. They found that patients with LPB had a 25% reduction in abdominal strength. They reported no difference in extensor strength compared to the pain free control group. Holmstrom et al. (1992), in a larger study on 203 construction workers using

the same testing methods as Hemborg and Moritz (1985) found that isometric trunk extensor endurance was significantly lower in a group with LBP compared to the pain free group.

Muscle strength testing in the clinical field is often carried out by physiotherapists using a manual muscle testing (MMT) approach as described by Daniels and Worthingham (1995) using a qualitative scale, e.g. Zero, Trace, Poor, Fair, Good, Normal or Grade 0,1,2,3,4,5. The literature relating to the use of MMT as a research tool is controversial. Florence, et al.(1992) showed that the use of MMT grades with the numerical scale 0-5 was a reliable measurement tool, when recorded by the same examiner in the clinical research setting in a population of boys with Duchenne's muscular dystrophy. They also found that the tests used for the proximal muscle groups showed higher reliability values than the more distal groups.

Wadsworth, et al. (1987) tested the intrarater reliability of MMT and muscle testing using hand held dynamometry on a small sample of subjects. The MMT system used was that of Daniels and Worthingham(1980) and Kendall and Mc Creary (1983). A "break" test was performed in which 12 ordinal values were assigned to the descriptive classification levels in order for the test to be compared to the dynamometry reading test method. The researchers found that both methods were reliable testing methods with test-retest reliability coefficients for MMT ranging from 0.63-0.98 and dynamometry testing from 0.69-0.90. This is in agreement with Bohannon(1986) who tested knee extension strength using MMT and a

dynamometer. He showed that the two scores were significantly correlated and that both procedures measure the same variable, namely strength.

Manual muscle testing of the middle trapezius and gluteus medius muscle by 10 therapists on 110 patients showed poor interrater reliability in a study by Frese, et al. (1987). The testing positions were not standardised as the research was carried out in the clinical setting, allowing the therapists to use various methods of testing. For this reason a more standardised testing procedure regarding the starting position of the subjects may have yielded different results.

Lee, et al. (1995) conducted a study using a device to test isokinetic values related to the strength of the trunk and the lower extremities. They concluded that the subjects with LBP had significantly lower strength in the trunk and the lower extremities. The clinical usefulness of this study is questionable if one considers the limitations in the use of isokinetic equipment in testing and using the information to make clinical inferences as discussed in an extensive critique of the literature by Rothstein, et al. (1987).

The study by Mandell, et al. (1993) investigated isokinetic trunk strength and lifting measures using Cybex Isokinetic Trunk Extension/Flexion and Torso Rotation devices and the Cybex Liftask device. The subjects used were postal workers with (n=58) and without (n=21) back pain. The study revealed that the symptomatic group had significantly lower strength in both flexion and extension but there was no difference between the two groups in relation to trunk rotation. They also found no significant difference in the isokinetic peak force lifting measurements but one

should bear in mind that the "normal" subjects in this study were in fact unfit and deconditioned so the results should not be accepted at face value. The other area of concern is that no reliability testing of the tests used was presented by the authors.

It is the opinion of this researcher that the main difficulty regarding the issue of muscle weakness in people with LBP is whether it is a cause or an effect of the pain. This would need to be evaluated in an extensive prospective, longitudinal study.

2.3 Treatment

In a review of the treatment of back pain, Waddell (1987) reports that there is no evidence to suggest that rest has a beneficial effect in the treatment of acute LBP, in fact he suggests that it is most harmful in entrenching the illness behaviour associated with chronic LBP. He advocates early movement and return to work as the most appropriate method of management of LBP. The role of physicians and physiotherapists should then be one of active rehabilitation back to normal activities. The goal of a good rehabilitation programme for people with LBP is to return the injured individual to their full working potential by restoring function and reducing pain (Khalil, et al., 1992). They reported that elements of such a programme include physical as well as occupational therapy among others. Physiotherapy modalities included the following; muscle stretching and strengthening, heat, ice, electrotherapy, joint mobilisation and progressive resisted exercises.

A meta-analysis was carried out by Koes, et al. (1991) to determine the quality of randomised controlled trials of exercise therapy for back pain. From the 16 randomised controlled trials that were located no conclusions could be drawn about whether exercise therapy was better than any other conservative treatment or whether a specific type of exercise was more effective. This would be in general agreement with a study undertaken by Faas, et al. (1993) who concluded that exercise therapy for patients with acute low back pain had no advantage over usual care from the general practitioner. The fact that these patients were suffering from acute pain may explain why they derived no benefit from the exercise therapy.

Therapeutic exercise is used by physiotherapists as one of the conservative treatment modalities in the management of LBP with the aim of allowing the muscular support to protect the back from further injury by improving posture and tone. Following an acute episode of back pain a programme of gentle active and passive exercises of the spine and the hips is carried out when the pain has subsided considerably, usually after a period of bed rest. Resisted exercises of the abdominal and erector spinae muscles are then taught. These exercises have traditionally included the sit up, straight leg lower and prone trunk extension (Smidt and Blandpied, 1987). According to these authors these exercises are poor discriminators of trunk muscle strength and they lack the range or resistance to cover the spectrum of trunk strength capability.

Kennedy (1980) described a holistic programme for the management of back problems after a thorough assessment. The training included the following; the retraining of a functional movement pattern, body alignment, abdominal bracing,

relaxation, sitting and lying positions , the procedure for pain relief, restoring muscle function and the release of tight structures. She claims that if one only addresses the elimination of pain then the patient will have recurring and deteriorating problems for years. This scholarly paper requires controlled clinical research to substantiate these views.

Frost and Klaber Moffett (1992) in their review advocate a programme which aims at encouraging the patient to take up regular exercise, increasing the patient's confidence in their ability to carry out normal activities of daily living regardless of their pain and helping the patients take control of their own back problem. The comments made by Waddell (1987) would support this approach. Well controlled research into this field is necessary to prove that activity is the most beneficial form of management.

2.4 Prevention

Magora (1972) suggested that effective weight lifting technique training would prove sufficient to either avoid or delay the appearance of low back pain. Biering-Sorensen (1984) suggested that it would be interesting to test the effect of strength endurance training of the back extensors in the prevention of low back trouble.

Gundewall, et al. (1993) conducted a prospective, randomised study among hospital employees. They reported that employees allowed to complete an exercise programme designed to improve back muscle strength, endurance and co-ordination were absent from work significantly less, complained of pain less and

had increased their back muscle strength considerably, compared to the control group who did not participate in the exercise programme.

Magora (1972) reports that subjects accustomed to weight lifting are less prone to developing back pain. He reports that it is not the weight lifting per se that contributes to the pain but rather the unexpectedness of it. Trafimow, et al. (1993) reported that quadriceps muscle fatigue causes the operator to change the type of lift from that of the squat type to that of the stoop type as this decreases the energy demand on the quadriceps muscles.

Snook, et al.(1978) analysed 191 back injuries to evaluate the approach that had been used up until that time to prevent low back injury, namely :i) careful worker selection based on medical history, medical examination and X-ray investigation of the spine, ii) good training on safe lifting techniques and iii) design of the job to fit the worker(ergonomics). They found that selection techniques based on medical and X-ray examinations were not an effective control for low back injury and nor were lifting technique instructions. They found that the only effective control was an ergonomic approach but this was often difficult to implement as it implied cost to the management.

In conclusion, low back pain is a common problem which is costly to society in terms of lost productivity, medical and compensation costs. The factors contributing to the cause of LBP are difficult to identify as the subjects present at varying times in their lives. Studies attempting to identify these factors are not

standardised to any one group and the measuring tools related to physical factors such as joint range and muscle strength are controversial in terms of their validity and reliability. As can be seen from this literature review very little information is available on the incidence of LBP in the South African context. It is for this reason that research into this problem is necessary as South Africa has elements of both a developed and a developing economy. The one major difference that needs to be taken into account is the fact that the workers compensation laws and ability to compensate adequately is not as developed as in the countries in which the authors in the above literature review work. All workers in South Africa are not automatically covered by the Workmen's Compensation Act (1941). There is a very high unemployment rate and for these two reasons there may be a large amount of under reporting of the problem.

3.0 MATERIALS AND METHODS

3.1 Subjects

Permission to undertake this study was obtained from the Committee for Research on Human Subjects (Medical) of the University of the Witwatersrand, protocol number M940532.

The subjects selected were all members of a work force who participated in routine material handling in a motor vehicle parts distribution centre(PDC) warehouse. This material handling involved; the unpacking of containers and trucks containing spare parts of motor vehicles and trucks received from national and international manufacturing centres, the storage of them in the warehouse and then the later redistribution of these parts from different areas in the warehouse into trucks and containers for future distribution around the country.

The warehouse is a large building with multiple levels of storage banks. The parts that required storage or retrieval could be accessed by hand from the lower level banks. The high banks were accessed via stairs leading to platforms, some by using portable ladders and some by using an "auto picker" (a hydraulic and electrical platform which is operated by the material handler). The parts varied considerably in size from a small box of bolts to engine blocks and truck panels and chassis. Fork lift machines were used to lift and transport very heavy and ungainly parts. The smaller parts were either unpacked from or packed into boxes. These boxes were transported from the receiving area or to the dispatch area on pallets that were pulled by small tractors.

The subjects were allocated into eight (8) area groups depending on where they worked in the warehouse. The following table describes the typical work carried out in each area.

Table 3.1 Name of each area and description of typical work activities carried out in the PDC

Area number	Name of area	Work activity description
1	Zone 1	Storage and retrieval of truck engine and body parts. These are retrieved using side sitting forklifts at times and often manually using a step ladder.
2	Zone 2	Storage and retrieval of truck engine and body parts. Autopicker used to reach high banks. Low banks are reached manually.
3	Zone 3	Storage and retrieval of sedan and truck parts, e.g. engine blocks and windscreens. Autopicker used to reach high parts. Low banks are reached manually.
4	Zone 4	Storage and retrieval of sedan and truck parts of smaller sizes, e.g. gear plates, brake discs etc. Autopicker used to reach high parts. Low banks are reached manually.
5	Zone 5	Smaller sedan and truck parts, e.g. boxes of air filters, spark plugs etc. This area is divided into two sections by a metal platform that is approximately halfway up to the ceiling of the warehouse. All parts in this section are handled manually, using ladders to reach higher banks. The section on the floor level also uses the autopicker. Parts and boxes are transported via a chute from the higher platform level. All parts are sorted on trolleys that have wheels. Some of the trolleys are waist level at the highest point and have three shelves and some are deep, with sides of approximately 1 metre in height and about 15cm off the ground.
6	Binning	All parts are transported to and from the receiving or dispatch area by people in this department. The larger parts are transported as they are and the smaller ones are packed into boxes and are transported by forklifts or tractors that pull pallets.
7	Dispatch	Here the parts or boxes are scanned to be recorded on a computer and are then packed into containers or trucks for further distribution. The loads are manually lifted and packed into the trucks. Very heavy and ungainly parts, e.g. engine blocks and chassis are lifted using the forklift.
8	Receiving	All parts and boxes are off loaded manually or with a fork lift depending on size and placed on pallets for distribution to various areas of the PDC.

Safety shoes were to be worn at all times. Seating was not provided for the workers for the retrieval or packing process on the PDC floor area between the storage banks. The workers sometimes sat on boxes in which parts were packed. The warehouse had an uninsulated corrugated iron roof and according to the workers the temperatures in winter were very low and in summer very high.

3.2 Procedure

All 196 workers involved in material handling were invited to participate in this part of the study which was designed to ascertain the prevalence of low back pain over the previous six months. One hundred and thirty four (134) people volunteered to take part. All subjects in the study were male, between the ages 23 -59 years.

3.2.1 Part 1

All participants were requested to sign a consent form (appendix A). A self administered questionnaire (appendix B) was completed in order to establish the prevalence of reported low back pain within the last six months. The researcher was present in the event of any further clarification of the questionnaire being required by the subjects. Eight subjects were excluded due to insufficient data recorded by themselves on the questionnaire. Therefore a sample of 126 (64.2% of the total target work force) participated in the prevalence survey.

The subjects were allocated into group 1 if they reported at least one episode of pain in the lumbar region within the last six months. They were required to mark an area on the body chart, below the cross indicating the first lumbar vertebral junction with the twelfth thoracic vertebra and above the last dot that represented

the lumbar sacral junction (appendix B). Group 1 accounted for 54 of the sample of 126, i.e. 42,9 percent.

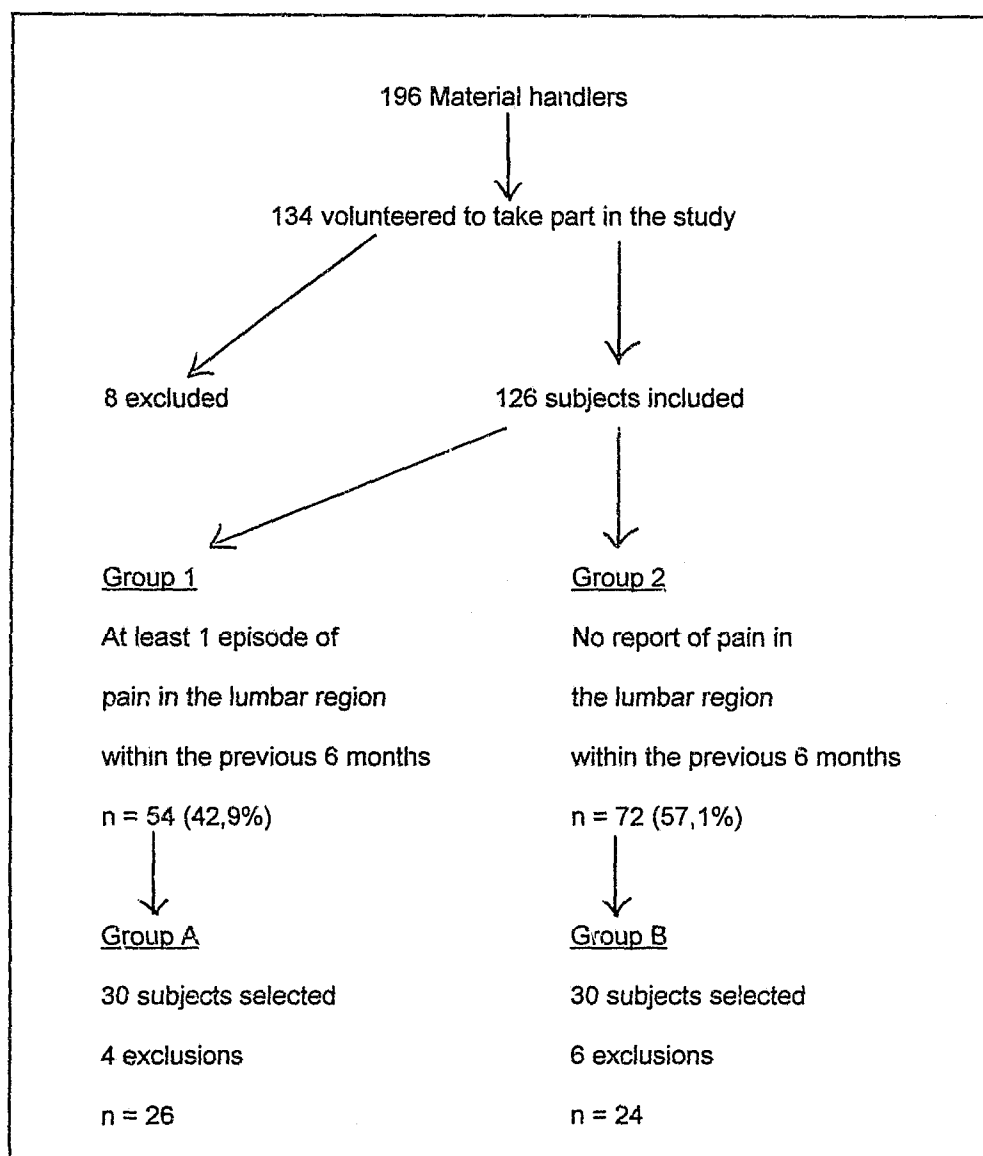
The subjects who reported no episode of pain in the lumbar region within the last 6 months or who did not mark the area specified above were allocated into group 2, i.e. 72 of the sample of 126, (57,1 percent).

3.2.2 Part 2

Thirty subjects were randomly selected from each of the above two groups (Group 1 and 2) to participate in part 2 of the survey.

From the 30 subjects selected from group 1, one subject was excluded due to known kidney pathology being the cause of his LBP and three subjects refused to participate. A total of 26 subjects from group 1 participated in part 2. They were allocated to group A and all agreed to participate in an interview regarding their area of work and pain during daily working activities, (appendix C) and a clinical examination which explored physical characteristics of the subject, e.g. flexibility, movement and associated pain (appendix D). Both the interview and clinical examination were carried out by the researcher.

From the 30 subjects selected from group 2, two subjects refused to participate and four were involved in industrial strike action during the period of the study. A total of 24 subjects participated in part 2 from group 2. They were allocated to group B and all agreed to participate in the interview, (appendix C) and the clinical examination, (appendix D).

Table 3.2 Flow Chart of the study procedure

It was not in the scope of this study to examine and differentiate the exact nature of the LBP and therefore its cause, e.g. inflammatory, discogenic, fracture, osteoporotic etc.

The clinical assessment tools that were used to ascertain mobility of the lumbar spine and muscle strength were chosen as they are simple to perform and required no equipment. They were chosen as they are tests that are frequently used in the clinical setting by physiotherapists and so would be meaningful to them. A full description of each of the tests is clearly presented in appendix D at the end of this report. (Page 84). All tests were carried out by the researcher herself.

3.3 Statistical Analysis

Means, standard deviations and frequency distributions were used to summarise the data.

Comparisons were made between groups 1 and 2 and also between groups A and B using the Student t-test when continuous variables were being compared, i.e. age, weight, height and length of working time.

When categorical variables were being compared the chi-square test was used to test for associations between relevant variables, i.e. frequency of subjects in areas of work, ability to achieve full range of movement, abdominal, quadriceps and trunk extensor muscle strength and lifting technique.

The Mc Nemar test for symmetry was used in order to compare the incidence of pain in different positions within the group with LBP.

Data regarding the interview and clinical examination are presented as percentages.

A p-value of less than 0.05 was considered to be statistically significant in this study.

The statistical analysis was done on Statistix 4.1 and BMDP statistical software packages by Dr P. Bekker and Mrs E. Viljoen of the Biostatistical Department of the Medical Research Council, Pretoria, South Africa.

4.0 RESULTS

4.1 Part 1: Questionnaire.

4.1.1 Participants in the survey.

Out of a pool of 196 males who were involved in 'material handling' 126 (64.2%) subjects volunteered to take part in the study.

4.1.2 Period prevalence of low back pain

Of the sample of 126 subjects who qualified for inclusion in the study, 54 (42.9%) reported incidences of 'low back pain or trouble with their backs' over the last six months prior to participation. They were assigned to group 1 i.e. subjects with LBP.

Group 2 i.e. subjects without LBP, consisted of seventy two (57.1%) subjects and was made up of the following:

- Thirty eight of the 72 subjects (30.1%) answered 'no' to having low back pain or trouble with their backs' during the six months prior to the time of participation in the study,
- Twenty-five of the 72 subjects (19.8%) reported that they did have 'low back pain or trouble with their backs' but marked their area of pain to be outside the specified area on the body chart and could therefore not be regarded as having LBP.
- Nine of the 72 subjects (7.1%) reported 'no' to having low back pain or trouble with their backs but did report leg pain. The cause of this leg pain could not be determined in this part of the survey so even though it could have emanated from their backs it was not in the scope of this study to determine this.

4.1.3 Age of the subjects

In Table 4.1 the mean ages of Groups 1 and 2 are represented.

Table 4.1 Mean age of the subjects in years

Group	n	Mean (years)	Range	S.D.
1	54	34.9	25-59	± 7.9
2	72	34.3	23-46	± 7.3

$$t = 0.45, df = 124, p = 0.65(\text{NS})$$

From the Table 4.1 it can be seen that no statistically significant difference in age was found between the subjects in group 1 and 2 using the Student t-test.

4.1.4 Area of Work

The subjects were allocated into 8 area groupings depending on which area of the parts distribution centre they worked. Table 4.2 shows the response rate categorised into areas of work.

Table 4.2 Response rate categorised into areas of work

Area	No. of possible Respondents	No. of actual Respondents	Response rate as a percentage
1	22	15	68.1%
2	15	9	60.0%
3	17	11	64.4%
4	17	10	58.8%
5	46	27	58.8%
6	20	10	50.0%
7	36	24	66.6%
8	23	20	86.9%
Total	196	126	

From table 4.2 it can be seen that a response rate of at least 50 percent was achieved in each of the 8 areas.

Table 4.3 indicates the expected and observed frequency of subjects in group 1 and 2 categorised into the 8 areas of the PDC. The percentages of subjects in each area in groups 1 and 2 is represented in bold print.

Table 4.3 Frequency of subjects in group 1 and 2 categorised into areas of work

Group	n	Freq	1	2	3	4	5	6	7	8
1 LBP	54	Obs*	3	4	4	5	18	7	6	7
		%	5.6	7.4	7.4	9.3	33.3	13.0	11.1	13.0
		Exp*	6.43	3.86	4.71	4.29	11.57	4.27	10.29	8.57
2 NLBP	72	Obs	12	5	7	5	9	3	18	13
		%	16.7	6.9	9.7	6.9	12.5	4.2	25.0	18.1
		Exp	8.57	5.14	6.29	5.71	12.43	5.71	13.71	11.43

$$\chi^2 = 16.49, df = 7, p = 0.02 (S)$$

Obs* = The actual observed frequency in each cell

Exp* = The frequency expected if no difference existed in each cell.

Using the chi-square test a statistically significant difference between the different areas with regard to low back pain was identified as is reflected in Table 4.3. If no difference existed in each cell when the expected frequency is compared to the observed frequency, it is apparent that there was a greater incidence of subjects with LBP in area 5 than would be expected. Similarly there is a greater incidence of subjects with NLBP in area 7 than would be expected. ($p = 0.02$)

4.2 Structured Interview Regarding Work Habits

4.2.1 Distribution of subjects in terms of area of work

The frequency distribution of subjects in group A and B in relation to their work area is shown in Table 4.4.

Table 4.4 Frequency distribution of subjects in relation to their work area

Area	Group A (LBP) N=26		Group B (NLBP) n=24	
	Frequency	Percentage	Frequency	Percentage
1- Zone 1	0	0%	5	20.8%
2 - Zone 2	2	7.7%	2	8.3%
3 - Zone 3	0	0%	1	4.2%
4 - Zone 4	3	11.5%	3	12.5%
5 - Zone 5	13	50.0%	5	20.8%
6 - Binning	2	7.7%	0	0%
7- Dispatch	2	7.7%	5	20.8%
8 - Receiving	4	15.4%	3	12.5%

From Table 4.4 it can be seen that the highest proportion of subjects complaining of LBP worked in area 5.

4.2.2 Length of working time in the parts distribution centre.

The mean number of years of work in the PDC is shown in Table 4.5.

Table 4.5 Mean years of work in PDC

Group	Mean Years	Range	S.D.
A (n = 26)	8.3	3-18	±4.3
B (n = 24)	7.5	3-22	±4.8

$$t = 0.65, df = 48, p = 0.52 \text{ (NS)}$$

From Table 4.5 it can be seen that when using the Student t-test no statistically significant difference was found between the two groups in the length of time that

the subjects worked in the parts distribution centre, i.e. had been exposed to that particular job.

4.2.3 Loss of working days

Four (15.4%) subjects in group A reported that they had missed work due to their low back pain. Three subjects missed a total of 2 days each and 1 subject missed 1 day.

4.2.4 Daily working activities which caused reported low back pain

The subjects in group A were asked to indicate if any of the activities listed caused their lower back to become painful. Table 4.6 illustrates the responses to questions, in percentages, on whether particular activities during working hours caused LBP.

Table 4.6 Responses of group A, in percentages, to questions on whether applicable activities during work hours caused low back pain.

Activity performed during working hours	Percentage of subjects that answered Yes	Percentage of subjects that answered No	"n"*
Standing for long periods of time	61.5	38.5	26
Sitting	38.5	61.5	26
Walking	26.9	73.1	26
Bending	89.4	10.5	19
Pulling boxes	88.8	11.1	18
Sorting parts into boxes or deep trolleys	90.9	9.1	22
Sorting parts on a table	11.7	88.2	17
Sorting parts onto a waist high trolley	28.5	71.4	14
Pushing boxes along the floor	73.3	26.6	15
Pulling boxes along the floor	82.3	17.6	17
Carrying boxes	86.3	13.6	22
Lifting parts from a height	41.1	58.8	17
Lifting parts from the ground	85.7	14.2	21
Carrying parts	70.0	30.0	20
Turning and placing objects - twisting	60.0	40.0	25
Pulling parts and boxes on the pallet	58.3	41.6	12

* n = the responses of subjects in which that activity was applicable.

(Highlighted areas indicate affirmative response rates of above 60%)

It can be seen from Table 4.6 that the following activities resulted in more than 60 percent of subjects reporting an increase in pain in their lower backs: standing for long periods of time, bending, pulling and pushing boxes along the floor, sorting parts into boxes or deep trolleys, carrying parts and boxes, lifting parts from the ground and turning and placing objects

Specific responses by the subjects reporting LBP in relation to various activities were compared using the McNemar test for symmetry as can be seen in Table 4.7

Table 4.7 Comparison of affirmative responses from subjects in Group A

Activity		Statistical values
Standing	Sitting	Mc Nemar = 3, df = 1, p = 0.08(NS)
Sorting parts into deep trolleys or boxes	Sorting parts onto a waist high trolley	Mc Nemar = 8, df = 1, p = 0.005(S)
Lifting parts from the ground	Lifting parts from a height	Mc Nemar = 8, df = 1, p = 0.005(S)

Table 4.7 shows that a statistical significant difference exists in the response rates between;

- i. "Sorting parts into deep boxes or trolleys" and "sorting parts onto a waist high trolley" and
- ii. "Lifting parts from the ground" and "lifting parts from a height".

4.2.5 Leisure activities which caused reported low back pain

All subjects in group A were asked to name activities during their leisure time that caused LBP. Sixteen (61.5%) subjects reported pain during their leisure time.

Seven of the subjects cited sitting as an activity that caused pain, 2 cited sexual intercourse, and 5 cited jogging.

4.2.6 Neurological symptoms

Both groups were asked whether they had ever experienced the sensation of pins and needles or numbness anywhere. One (4.1%) subject in group B reported these symptoms. Ten (38.5%) subjects experienced these symptoms in group A.

Group A was asked whether they experienced pain in their legs that radiated from their backs. Two subjects experienced pain on the left side, 3 subjects on the right and a further 3 subjects reported bilateral radiant pain. A total of 8 (30.7%) subjects in Group A reported radiant pain.

4.2.7 Action taken to decrease the pain

Table 4.8 illustrates the action taken by group A to decrease the pain:

Table 4.8 Percentages of subjects who undertook various actions to decrease their low back pain

Action	Percentage of affirmative answers
Lie down	61.5%
Sit down	42.3%
Move around	65.4%
Take tablets	50.0%
Go to the clinic to see the sister	26.9%
Go to the doctor	53.8%

Other measures included the application of a rubbing ointment (46.1%), the use of laxatives (3.8%), purgatives (7.7%) and exercise (3.8%).

4.3 Part 2 : Results Of The Clinical Examination.

4.3.1 Physical characteristics

The physical characteristics of the subjects are shown in Table 4.9 and 4.10.

Table 4.9 Mean weight (kg) for groups A and B

Group	Mean	Range	S.D.
A (n = 26)	72.3	53-101	±11.5
B (n = 24)	69.7	57-94	±9.8

$t = 0.88$, $df = 48$, $p = 0.38$ (NS)

Table 4.10 Mean height (cm) for groups A and B

Group	Mean	Range	S.D.
A (n = 26)	171.6	162.5-187.5	±6.4
B (n = 24)	171.2	161.5-188.0	±6.7

$t = 0.17$, $df = 48$, $p = 0.86$ (NS)

According to the Student t-test, no statistically significant difference was found between groups A and B with regard to weight or height as can be seen in Table 4.9 and 4.10.

4.3.2 Range of lumbar movement

Table 4.11 shows the range of movement recorded by the researcher in intervals of quarters of normal expected full range movement as described by Maitland (1986). This method of assessing spinal mobility of the lumbar area was chosen because of its frequent use in the clinical situation and because it requires no equipment. See appendix D, page 1 for a description of the tests.

Table 4.11 Mean range of movement of the lumbar spine in intervals of ¼'s represented as percentages of the total number of subjects in group A and B

Group	Full Range	¾ Range	Half Range	¼ Range	0 Range	Movement
A	46.2	30.8	19.2	3.8	0	Flexion
B	95.8	0	0	4.2	0	Flexion
A	30.8	42.3	23.1	0	3.8	Extension
B	91.7	4.2	0	4.2	0	Extension
A	46.2	23.1	26.9	3.8	0	L. Lateral Flexion
B	95.8	0	0	4.2	0	L. Lateral Flexion
A	50.0	19.2	26.9	3.8	0	R. Lateral Flexion
B	95.8	0	0	4.2	0	R. Lateral Flexion
A	38.5	7.7	42.3	11.5	0	Left Rotation
B	87.5	0	8.3	4.2	0	Left Rotation
A	30.8	7.7	50.0	11.5	0	Right Rotation
B	87.5	4.2	4.2	4.2	0	Right Rotation

Table 4.11 shows that less than 50% of subjects in Group A achieved full range of movement when examined using the Maitland(1986) concept assessment tool.

Table 4.12 shows the comparison between group A and B in their ability to achieve full range of movement of the lumbar spine.

Table 4.12. Ability to achieve full range movement

Movement	Group	Full range Achieved	Full range not achieved	p value
Flexion	A*	12	14	
	B**	23	1	0.00043 (S)
Extension	A	8	18	
	B	22	2	0.00004 (S)
L. lateral flexion	A	12	14	
	B	23	1	0.00014 (S)
R. lateral flexion	A	13	13	
	B	23	1	0.00099 (S)
L rotation	A	10	16	
	B	21	3	0.00104 (S)
R rotation	A	8	18	
	B	21	3	0.00016 (S)

*Group A, n = 26; **Group B, n=26.

The movement of group B was compared to that of group A using the chi-square test as represented in Table 4.12. Statistically significant differences existed between the groups A and B in their ability to achieve a full range movement.

4.3.3 Abdominal muscle strength

In order to illustrate the clinical application of the results all subjects with a manual muscle test score of 3 (Fair) or less, according to that prescribed by the Daniels and Worthingham's Muscle Testing, 6th edition(1995) were categorised together as these people were unable to obtain a muscular contraction against resistance.

4.3.3.1 Rectus abdominis

Table 4.13 illustrates the manual muscle test grading results of the muscle test for rectus abdominis.

Table 4.13 Percentages of subjects in each group categorised in terms of Manual Muscle Test grading achieved for the rectus abdominis muscle

Group	Manual muscle test grade		
	0 – 3	4	5
A (n =26)	11 (42.3%)	9 (34.6%)	6 (23.0%)
B (n = 24)	2 (8.3%)	12 (50.0%)	10 (41.6%)

$$\chi^2 = 7.59, df = 2, p = 0.023(S)$$

Table 4.13 shows that a statistically significantly higher percentage of subjects in group A obtained a grade 3 or less as compared to group B using the chi-square test.

4.3.3.2 Oblique abdominal muscles (Right and left obliquus externus abdominis and obliquus internus abdominis)

Both right and left oblique abdominal muscles revealed equal strength in each subject when using a manual muscle test. Table 4.14 shows the manual muscle test results of group A and B of the oblique abdominal muscles.

Table 4.14 Percentages of subjects in each group categorised in terms of Manual Muscle Test grading achieved for the oblique abdominal muscles

Group	Manual muscle test grade		
	0 – 3	4	5
A (n =26)	13 (50.0%)	9 (34.6%)	4 (15.3%)
B (n = 24)	4 (16.6%)	12 (50.0%)	8 (33.3%)

$$\chi^2 = 6.46, df = 2, p = 0.04 (S)$$

The chi-square test shows that there was a statistically significant difference between groups A and B with regards to their oblique externus abdominis muscle strength as can be seen in Table 4.14.

4.3.4 Quadriceps muscle strength

Both right and left quadriceps muscle groups revealed equal strength in each subject when tested using the manual muscle strength test according to Daniels and Worthingham's Muscle Testing, 6th edition (1995). Table 4.15 shows the manual muscle test results in group A and B for the quadriceps muscle group.

Table 4.15 Percentages of subjects in each group categorised in terms Manual Muscle Test grading achieved for the quadriceps muscle group

Group	Manual muscle test grade		
	0 – 3	4	5
A (n = 26)	2 (7.6%)	13 (50.0%)	11 (42.3%)
B (n = 24)	1 (4.1%)	6 (25.0%)	17 (70.8%)

$$\chi^2 = 4.12, df = 2, p = 0.13 \text{ (NS)}$$

The chi-square test shows that there was no statistically significant difference between groups A and B with regards to their quadriceps muscle strength as can be seen in Table 4.15.

4.3.5 Trunk Extensor Strength

Table 4.16 shows the manual muscle test results in group A and B for the trunk extensors when tested using a manual muscle strength test according to Daniels and Worthingham's Muscle testing, 6th edition (1995).

Table 4.16 Percentages of subjects in each group categorised in terms of Manual Muscle Test grading achieved for the trunk extensor muscle group

Group	Manual muscle test grade		
	0 – 3	4	5
A (n = 26)	3 (11.5%)	20 (76.9%)	3 (11.5%)
B (n = 24)	2 (8.3%)	17 (70.8%)	5 (20.8%)

$$\chi^2 = 0.86, df = 2, p = 0.65 \text{ (NS)}$$

There was no statistically significant difference, using the chi-square test, between groups A and B with regard to their trunk extensor muscle strength.

4.2.5 Observation of lifting technique

The subjects were all asked to lift a 35 kg cardboard box, similar to one which would contain motor vehicle parts. Two different lifting methods were employed.

Stoop lifting involves forward flexion of the spine and maintenance of knee extension. Crouch lifting involves flexion of the knees and a relatively neutral position of the spine. Table 4.17 illustrates the percentages of subjects in group A and B employing each of the two lifts.

Table 4.17 Percentages of subjects in each group employing stoop lifting and crouch lifting

Group	Percentage of subjects	
	Stoop lifting	Crouch lifting
A (n = 26)	9 (34.6%)	17 (65.4%)
B (n = 24)	8 (33.3%)	16 (66.7%)

$$\chi^2 = 0.01, df = 1, p = 0.92 \text{ (NS)}$$

From Table 4.17 it can be seen that using the chi-square test there was no statistical difference in the lift employed by groups A and B.

5.0 DISCUSSION

5.1 Part 1: Questionnaire

5.1.1 Participants in the survey

The 126 male workers involved in material handling on a daily basis who volunteered to take part in the survey computed to 54.2 percent of the possible sample pool. The response rate of at least 50 percent achieved in all of the eight areas of work means that a representative sample was obtained.

5.1.2 Period prevalence of low back pain

The 43 percent of subjects reporting LBP over the previous six months was similar to the finding by Biering-Sorensen(1984) who reported a one year period prevalence of 45 percent in a general population aged between 30 and 60 years. Magora (1973) found a 13 percent 1 year period prevalence rate in a population of working subjects involved in 8 different occupations. From this one could say that the 6 month prevalence rate in this study was higher than would be expected.

The average age of the subjects in both groups in this study is similar to that reported in the studies by Frymoyer, et al. (1983) and Rowe (1969) who found that the majority of their work force subjects who reported moderate to severe back pain was in their 30's. Bigos, et al. (1986) reported that employees in the 31-40 age group were most susceptible to "high cost" back injury. As the average age of the subjects in this study falls within these parameters this could explain the high 6 month period prevalence.

The statistically significantly higher incidence of reported LBP in area 5 (see table 4.3) could be explained by the fact that the parts that required sorting and packing in this area were in fact smaller and possibly more difficult to reach as many of them were packed into storage boxes. Due to their contents they were heavy to move and required more bending, twisting and lifting than do larger vehicle parts that were more easily located. The sorting of the parts is carried out on trolleys, some of waist height and some that require excessive flexion of the thoracic and lumbar spine as described in Table 3.1 The fact that this particular area has two distinct levels may cause the material handlers to pass parts between levels manually, thus putting them more at risk of lumbar strain and therefore pain. Magora (1973) showed that heavy physical work is associated with LBP. Lifting a 10kg load increases the load on the third lumbar disc to 1700 – 1900N (Nachemson 1981) and lifting a load of 10kg in a rotated and forward flexed position increases the load by even more to 2100N. Previous studies have shown that frequent bending (Magora, 1973), twisting (Manning, et al. 1984) and working in awkward postures, (Biering-Sorensen, 1983b) is associated with LBP. From this it seems plausible that there is an association between work in area 5 and reporting of LBP.

5.2 Part 2: Structured Interview Regarding Work Habits

5.2.1 Age.

The lack of significant difference between groups A and B in terms of their age (See table 4.1) indicates that this is not a factor associated with the prevalence of LBP in this study.

5.2.2 Distribution of subjects in terms of their work area

The highest proportion of subjects with LBP was located in area 5 in part 1 of the study (Table 4.3). Even though area 5 had the highest number of employees a relatively even response rate from each area was achieved in part 1 as can be seen in table 4.2. The highest number of subjects in group A was drawn from area 5 (Table 4.4). From this it can be concluded that the employees in area 5 had the highest reported incidence of LBP over a 6 month period. It is the opinion of the researcher that employees in area 5 would be at risk for LBP in the future.

5.2.3 Material Handling Exposure

No significant differences were noted between groups A and B in the mean number of years of exposure to work in the PDC. (See table 4.5) From this it can be suggested that material handling per se for relatively short periods of time may not be a factor that is associated with the prevalence of reported back pain and that other factors need to be considered.

5.2.4 Loss of working days

Frymoyer, et al. (1983), Hutson (1993) and Andersson (1981)) have described the amount of lost working hours as one of the means of quantifying the socio-economic cost of LBP. In this study 15 percent of the subjects in group A reported absenteeism due to LBP in the previous 6 months. The periods of time were very short however, i.e. 2 days in the case of 3 employees and only 1 day in the case of 1 employee. Frymoyer, et al. (1983) reported that of the 46 percent of subjects complaining of moderate LBP in his survey, a mean of 21 days was lost from work over the previous year. A larger sample size and a longer time period may have yielded different results in this study.

5.2.5 Daily working activities that caused reported low back pain

The findings in this study would be in general agreement with previous studies (Magora, 1973, Manning, et al. 1984, Frymoyer, et al. 1983 and Bigos, et al. 1986a) that show that the following activities have been associated with low back pain in industry;

- standing for long periods of time,
- bending and twisting,
- lifting and
- participation in heavy physical work. (See table 4.6)

5.2.5.1 Standing for long periods of time.

Standing for long periods of time, without the option of sitting for brief intervals according to need or choice, was shown by Magora (1972) to be a factor linked to LBP. Nachemson (1981) showed a 100 per cent increase in load measurement in

the third intervertebral (L3) disc in the standing position as compared to the supine position.

The material handlers in the PDC were involved in the sorting and retrieval of parts for at least 8 hours a day. A lunch break of 30 minutes and two tea breaks of 15 minutes each were given. Many of the workers worked 7 days a week as they were paid more if they worked overtime. A large proportion of their time involved standing and sorting parts into and out of boxes, crates and trolleys. Sixty one percent of those subjects with LBP reported an increase in their pain during this activity. Sitting was not encouraged during working hours as no seating was provided. The lack of formal seating was probably to prevent loss of production time and also because adequate space was needed for the fork lifts and autopickers to be driven between the isles. Tea rooms with chairs were however provided. Crates and large boxes were sometimes used as impromptu seating when a large amount of sorting of small parts was required.

5.2.5.2 Bending and twisting

Activities such as bending and sorting parts into boxes or deep trolleys was reported by the material handlers as causing an increase in pain in 90 percent of the sample which is in agreement with findings reported by Magora (1973), Manning, et al. (1984) and Marras, et al. (1993). Similarly Nachemson (1981) reported that the load on the third intervertebral disc in the 40 degree bending position increases from 500N in the standing position to up to 1000N (see Table 2.0). The material handlers spent a large part of their day in this position sorting out small parts from boxes on the floor or deep trolleys and then storing them onto

the appropriate shelves. This requires a large amount of bending and straightening. If the worker used a trolley of approximately waist height or a table the reported incidence of an increase in pain during that activity dropped significantly from 90 percent to between 28 percent and 11 percent, (see Table 4.6 and 4.7). The fact that some subjects still reported pain is probably attributable to the prolonged standing posture.

Turning and placing of parts or boxes requires twisting movements of the lumbar spine in order to place the object on, or to retrieve it from the various shelves either from the ground or from the autopicker. This movement was carried out frequently during normal working hours which could explain the over 60 percent reported increase in pain during those activities. This would be in agreement with Manning, et al.(1984) and Marras, et al. (1993) who are of the view that the speed at which the twisting movement is done is important in the development of non accidental injury. This finding would also be in agreement with Kelsey, et al. (1984) who showed that twisting the body while lifting, with the knees bent, could increase the risk of lumbar disc prolapse sevenfold.

5.2.5.3 Lifting

The incidence of low back pain increased during lifting activities and is in accordance with the findings by Nachemson (1981), where lifting and holding heavy objects increased the load through the lumbar spine to 1900N. Eighty-five percent of subjects reported that lifting parts from the ground caused an increase in their pain which is significantly different, from the 41 percent of subjects who

reported pain during lifting from a height, where flexion of the body was not required.

The carrying of heavy boxes and parts were activities reported by 86 percent and 70 percent respectively of the sample as causing an increase in their low back pain. The boxes that were carried by the subjects varied in weight . The author was informed that the average weight for a filled box was approximately 35 kg. Parts vary in bulk and weight, from fenders to engine blocks. This is similar to the study by Frymoyer, et al. (1983) who classified "repetitive heavy lifting" if the load was 20 kg or more. Occhipinti, et al.(1993) specified that manual handlers are required to lift loads of 5kg at least 10 times every hour or 20kg or more once an hour. The sample in this study certainly met the above criteria.

Numerous authors found a direct link to lifting being a cause of reported low back pain and injury, (Frymoyer, et al. 1983; Bigos, et al. 1986, Manning, et al. 1984 and Marras, et al. 1993). The amount of lifting and carrying of heavy loads that was required in this particular study seems to have been a factor that was associated with reported LBP.

5.2.5.4 Participation in heavy physical work

This study showed that pushing boxes on the floor caused an increase in LBP in 73 percent of subjects and pulling boxes along the floor in 82 percent. It is clear from the literature that involvement in heavy physical work that requires repetitive heavy lifting, pulling and pushing of heavy objects and turning and placing of heavy objects is associated with the prevalence of LBP in industry, (Rowe,1969 ,

Zwerling, et al.1993, Magora, 1973, Frymoyer, et al. 1983). This together with other findings in this study seems to show that the subjects in this study were at risk of developing LBP by the nature of the physical work that they did due to a possible" mismatch between the job demands and the persons physical capacity" as reported by Frymoyer and Cats-Baril(1987).

5.2.6 Neurological symptoms

It was not in the scope of this study to identify the type of lumbar disorder but it is interesting to note that some degree of neural irritability was identified in the form of parasthesia, (pins and needles) in 38 percent of the subjects in group A and the perception of radiant pain in 36 percent of the subjects in group A.

5.2.7 Action taken to decrease the pain

All subjects had access to a free medical clinic (mornings only) run by a primary health care nurse, with referral possibilities to a nearby urban primary health care facility (the Alexandra Health Centre and University Clinic). It is interesting to note that only 27 percent of the subjects in group A actually used this facility. (See Table 4.8) None of the subjects mentioned physiotherapy attendance as a means of decreasing the pain. This could be explained by the historically poor exposure of this particular demographic group to the physiotherapy profession. The Alexandra Health Centre, at the time, did offer a physiotherapy service.

It is of interest to note that 65 percent of the group used movement as one of the measures to decrease the pain. This would be in agreement with the comments made by Waddell (1987).

Other measures employed by subjects with LBP included the application of rubbing ointment and the use of laxatives and purgatives as is traditional in black South African culture. The use of exercise which was used in 3.8 percent of the subjects indicates a very poor understanding of musculoskeletal causes and solutions to back problems.

5.3 Part 2 : Clinical Examination

5.3.1 Physical characteristics

The fact that there was no significant difference between the average height and weight of the two groups (Table 4.9 and 4.10) was in keeping with reported studies by Biering-Sorenson(1984), Rowe(1969), Kelsey, et al. (1984) and Bigos, et al. (1986b).

5.3.2 Range of lumbar movement

The findings from table 4.11 show that subjects in group A were less able to reach full range of motion in the following normal spinal mobility tests, viz., forward flexion, posterior extension, lateral flexion bilaterally and lumbosacral rotation bilaterally. Backward extension and lumbosacral rotation to the right side was the most limited with only 30 percent of subjects able to attain full range movement. This would be in agreement with the findings by Pope, et al. (1985). Group A had statistically significantly less mobility of the lumbosacral spine overall compared to group B, (see table 4.12). Frymoyer and Cats Baril (1987) and Andersson (1981) reported that decreased spinal mobility is related to the disability caused by back pain. It cannot be said with any degree of certainty that this lack of mobility is a cause or a consequence of LBP.

The issue of the reliability of the measurement tools to ascertaining normal range of movement for the lumbar spine is a controversial one. Rondinelli, et al. (1992) and Boline, et al. (1992) have shown surface inclinometry to be unreliable. The test used in this study, devised by Maitland (1986), is one often employed by physiotherapists in the clinical field. It requires the subject to move through various

positions. The researcher was required to visually estimate the amount of movement in quarters of the expected normal range. The test was carried out by one physiotherapist with 10 years of clinical experience, i.e. the researcher. The test is simple to administer and record and requires no equipment, an important feature when working in a country where physiotherapy services and research opportunities are severely under funded. The participation of another physiotherapist with similar experience in the testing of the subjects would have yielded a measure of inter-rater reliability.

5.3.3 Abdominal muscle strength

Authors such as Troup, et al. (1981) , Pope, et al. (1985), Hemborg and Motitz (1985), Holmstrom, et al. (1992) and Frymoyer and Cats-Baril (1987) have shown that the abdominal muscles exhibit weakness in subjects who have LBP. One would expect people involved in material handling on a daily basis to have relatively good abdominal strength and at least be able to obtain a contraction against resistance.

Rectus abdominis and obliquus externus abdominis and obliquus internus abdominis showed significant weakness in group A as compared to group B. (See table 4.13 and 4.14). Forty-two percent of subjects in group A were able to achieve a contraction of rectus abdominis equal to a grade 3 or less according to the MMT grading scale. Only 15 percent of subjects in group A were able to obtain a full strength(grade 5) contraction of the oblique abdominal muscles. Considering that the sample was material handlers one would expect that the physical activity of the job itself should maintain all muscles at peak strength but if group B is

examined closely it can be seen that only 41 percent of subjects were able to obtain a full strength contraction of the rectus abdominis muscles and only 33 percent of the oblique abdominal muscles.

The inter-rater reliability of manual muscle testing as a tool in the assessment of muscle strength was shown to be poor in a study done by Frese, et al. (1987). The intra -rater reliability, however, was shown to be satisfactory in the studies by Wadsworth, et al.(1987) and Florence, et al. (1992). MMT has the advantage of being clinically versatile and inexpensive to administer. The system is designed to measure the entire range of strength using ordinal values from 0-5. Deviation from the standardised testing procedures and the subjectivity of the grading system are potential sources of error . The researcher in this study used the test and the scale as prescribed by Daniels and Worthingham's Manual Testing. Techniques of Manual Examination. 6th edition (1995) to evaluate the abdominal muscle strength of the subjects and the control group. The test in this study was conducted using only one researcher with 10 years of clinical experience. For the purposes of the study it was necessary to administer a known, simple and inexpensive test for the reasons previously discussed. Bearing all this in mind the results could be said to have some clinical value and should not be rejected out of hand.

5.3.4 Quadriceps muscle strength

There appears to be a dearth of literature relating quadriceps strength to the presence of low back pain. Lifting is carried out on a daily basis in this sample and as the quadriceps muscles are well recruited in the lifting process this muscle group was examined using MMT in accordance with Daniels and Worthingham's

Muscle Testing (1995). Concentric and eccentric quadriceps contraction is a vital part of the lifting procedure especially if the crouch lift is employed. Even though no significant differences were noted in overall quadriceps strength between groups A and B it is interesting to note that only 42 percent of subjects in group A were able to achieve a full strength (grade 5) contraction as compared to 70 percent in group B. Trafimow, et al. (1993) noted that fatigue in the quadriceps muscles caused their subjects to alter their lifting patterns from a more squat type lift to a more stoop kind of lift which did not require as much concentric muscle action. The researcher suggests this could be of interest for further and more sensitive research to ascertain if quadriceps weakness is a possible factor associated with LBP.

5.3.5 Trunk extensor strength

The results of the trunk extensor strength test is in agreement with the well accepted literature (Frymoyer and Cats Baril, 1987, Flicker, et al., 1993, Cassini, et al., 1993) that shows that people with LBP have a decreased trunk extensor strength and some authors (Biering - Sorenson, 1984) even state that good isometric strength seems to prevent first time attacks of LBP. Andersson (1981) raises the issue of whether the weakness is primarily or secondarily related to LBP.

Although no significant difference was observed between groups A and B it is of interest to note how few of the subjects in both groups were able to obtain a full strength contraction and that the majority of subjects in both groups could only achieve a grade 4 contraction.

5.3.6 Observation of lifting technique

Magora (1973) reported that sudden unexpected movements related to heavy lifting was responsible for the incidence of LBP among his subjects. He recommends training into correct lifting practices as one of the ways of decreasing LBP episodes. The subjects in this study were observed lifting a 35 kg box from the floor to a waist high table to assess their lifting style. The majority of the subjects in both groups employed the "crouch lift" rather than the stoop lift, implying that the majority of subjects in both groups employed controlled movements during the lifting process. As no significant difference was noted between groups A and B the actual lifting method did not seem to be one of the factors that predisposed subjects to LBP.

5.4 Recommendations

An intervention programme to try and decrease the prevalence of low back pain in this particular setting would be of value. In order to do this the following steps could be taken;

- i. the ergonomics on the shop floor, especially in area 5, need to be thoroughly assessed and altered where possible to reduce the amount of bending and excessive load handling.
- ii. An exercise programme aimed at increasing the flexibility of the spine and the strength of the abdominal musculature in subjects with LBP may help to decrease the symptoms of pain and also prevent more serious injury in the future.

Both of these steps would have to be done in conjunction with the management and the trade union operating within the PDC.

6.0 CONCLUSION

The following conclusions can be made from this study:

1. The period prevalence rate of reported low back pain was 43 percent.
2. Factors that were found to be associated with the development of low back pain were;
 - i. activities such as bending to do work near the floor surface, lifting objects from the ground and participation in heavy manual work, i.e. lifting, pushing, pulling and carrying of heavy objects.
 - ii. a decrease in the overall mobility of the lumbar spine and
 - iii. a decrease in muscle strength of the rectus abdominis and the oblique abdominal muscles.

SUBJECT INFORMATION AND CONSENT FORM

I am presently conducting research into the factors associated with injury at the workplace. I would like to carry out a study on back pain in the "Parts distribution centre, (PDC)". Should you agree to take part in the study, you will be asked to answer a very short questionnaire on back pain. At a later stage you may be one of thirty people who may be asked to come to the clinic where you will be asked a few questions about yourself and the kind of work that you do. You will also undergo a quick physical examination which involves movement of your back and legs. You will be requested to wear a pair of short trousers, which will be provided, for this examination. All information gathered will be treated in the strictest confidence.

Participation in this study is voluntary and you are free to refuse to participate. Failure to participate will not result in any discrimination against you. If you wish to withdraw from the survey you may do so at any time.

SIGNED..... DATE.....
(Patricia Wallner)

I have been fully informed as to the procedure to be followed. In signing this consent form, I agree to participate in this study and understand that I am free to withdraw my consent and discontinue my participation in this study at any time.

SUBJECT..... DATE.....

PART 1 : SUBJECT QUESTIONNAIRE

PLEASE FILL IN THE FOLLOWING FORM

TOYOTA WORKER NUMBER:.....

JOB TITLE:.....

DATE OF BIRTH.....

HAVE YOU HAD ANY TYPE OF BACK PAIN OR ANY TROUBLE WITH YOUR
BACK OVER THE LAST 6 MONTHS? PLEASE MARK YOUR ANSWER WITH A
CROSS BELOW.

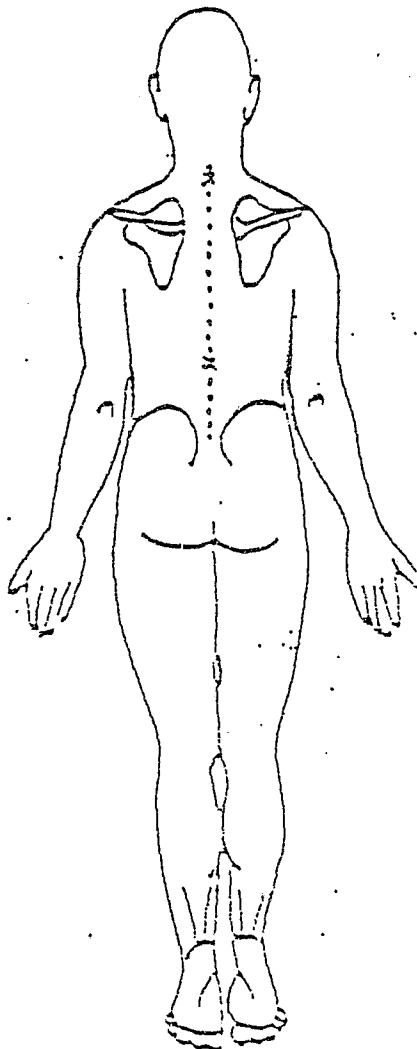
YES.....

NO.....

IF YOUR ANSWER IS NO. PLEASE HAND THIS FORM BACK NOW.

IF YOUR ANSWER IS YES PLEASE TURN OVER THE PAGE.

IF YOU HAVE HAD ANY TYPE OF BACK PAIN OR TROUBLE WITH YOUR
BACK OVER THE LAST 6 MONTHS PLEASE MARK THE AREA IN WHICH YOU
FELT THE PAIN ON THE BODY CHART BELOW.

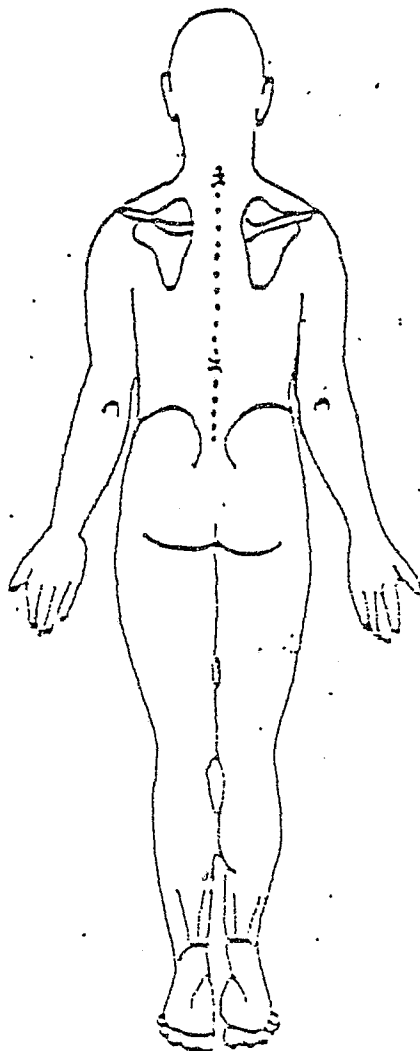


PLEASE TURN OVER.

APPENDIX B

Page 3

IF YOU HAVE HAD ANY PAIN THAT RUNS DOWN THE BACK OF YOUR LEG
OVER THE LAST 6 MONTHS PLEASE MARK THE AREA IN WHICH YOU
FELT THE PAIN ON THE BODY CHART BELOW.



THANK YOU FOR YOUR CO-OPERATION.

PLEASE HAND THIS FORM BACK NOW.

PART 2 : INTERVIEW REGARDING WORK HABITS

1. TOYOTA WORKER NUMBER:.....
2. DATE OF BIRTH:.....
3. SEX:.....
- 4.a. IN WHICH AREA DO YOU WORK AT PRESENT?

ZONE 1.....	.....
ZONE 2.....	.....
ZONE 3.....	.....
ZONE 4.....	.....
ZONE 5.....	.....
BINNING.. . . .	.. . . .
DISPATCH .. . . .	.. . . .
IMPORT RECEIVING.....	.....
LOCAL RECEIVING.....	.....
- 4.b. HAVE YOU WORKED THERE FOR THE LAST 6 MONTHS?

Yes..... No.....

IF NO, IN WHICH AREA DID YOU WORK?

- | | |
|-----------------|----------|
| ZONE 1..... | ..... |
| ZONE 2..... | ..... |
| ZONE 3..... | ..... |
| ZONE 4..... | ..... |
| ZONE 5..... | ..... |
| BINNING.. . . . | .. . . . |

DISPATCH

IMPORT RECEIVING.....

LOCAL RECEIVING.....

OTHER, SPECIFY.....

5. HOW MANY YEARS HAVE YOU BEEN WORKING IN THE PARTS DISTRIBUTION CENTRE. (PDC)?

.....

- 6.a. IN WHICH AREA DID YOU WORK BEFORE THAT?

.....

- b. NUMBER OF YEARS IN THAT JOB.

.....

- c. CAN YOU DESCRIBE THE KIND OF WORK YOU DID THERE?

.....

7. WHAT PREVIOUS JOBS HAVE YOU HAD?

TYPENUMBER OF YEARS IN THAT JOB

.....

.....

.....

.....

.....

.....

8. LIFTING DEMONSTRATIONA. Crouch.....B. Stoop.....

Yes

No

- | | | | |
|----|----------------------------|-------|-------|
| a. | Stands close to the object | ..... | ..... |
| b. | Feet wide | ..... | ..... |
| c. | Bends knees | ..... | ..... |
| d. | Back straight | ..... | ..... |
| e. | Box held close to body | ..... | ..... |

9. HAVE YOU EVER HAD LOW BACK PAIN?

YES..... NO.....

10.a. HAVE YOU MISSED WORK IN THE LAST 6 MONTHS BECAUSE OF BACK PAIN?

YES..... NO.....

b. IF SO, HOW OFTEN, WHEN AND FOR HOW LONG?

.....

11. DO YOU THINK THAT ANY OF THE FOLLOWING ACTIVITIES CAUSES YOUR BACK TO BECOME PAINFUL?

I. WORK RELATED

- a. Standing for long periods YES.... No.....N/A.....
- b. Sitting YES...NO...N/A.....
- c. Walking YES....NO...N/A.....
- d. Picking:
Bending down while picking YES.....NO.....N/A.....
- e. Pulling boxes along the floor while picking YES.....NO.....N/A.....
- f. Sorting parts into boxes YES.....NO.....N/A.....
- g. Sorting parts on the tables YES.....NO.....N/A.....
- h. Sorting parts on the trolley YES.....NO.....N/A.....
- i. Pushing boxes along the floor YES.....NO.....N/A.....
- j. Pulling boxes along the floor YES.....NO.....N/A.....
- k. Carrying boxes YES.....NO.....N/A.....

If YES, what type of boxes?

Lifting parts:

- l. from a height YES.....NO.....N/A.....
- m. from the ground YES.....NO.....N/A.....
- n. Carrying parts YES.....NO.....N/A.....

If YES, what type of parts?

- o. Turning & placing objects YES.... NO.....N/A....
- p. During driving the forklift YES.....NO.....N/A....
 side sitting YES.....NO.....N/A....
 front sitting YES.... NO.....N/A....
- q. On the "picking machine" YES.....NO.....N/A....
- r. Pulling the "pallet" YES.....NO.....N/A....
- s. Any other activities - specify.....

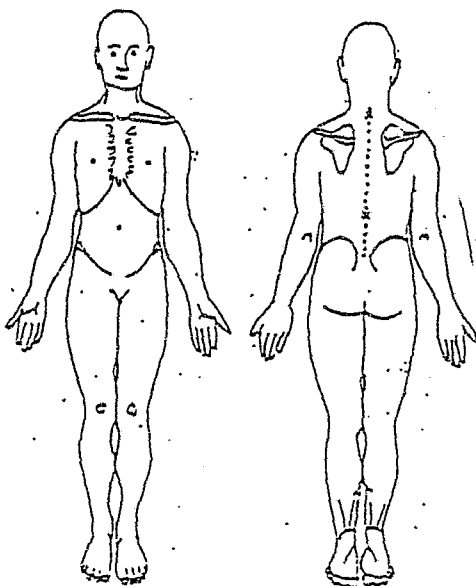
II. LEISURE RELATED

Are there any activities in which you are involved after working hours which you notice causes the pain to become worse, e.g. sport, watching television?

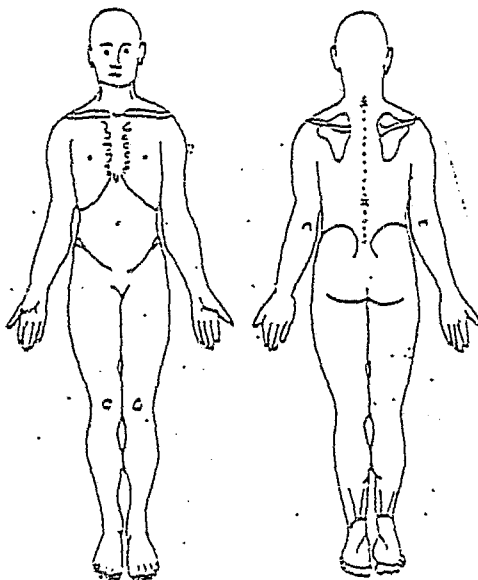
.....

.....

12. DO YOU EVER GET PINS AND NEEDLES OR NUMBNESS ANYWHERE.
IF SO WHERE?(Ask subject to demonstrate and mark the area on the body chart.)



13. DOES THE PAIN EVER GO DOWN YOUR LEG?(Ask subject to demonstrate and mark the area on the body chart.)



14. WHAT DO YOU DO TO MAKE THE PAIN GO AWAY?

a. Lie down Yes.....No.....

b. Sit down Yes.....No.....

c. Move around Yes.....No.....

d. Take tablets Yes.....No.....

If yes, what are they called

e. Go to the clinic to see the sister Yes.....No.....

f. Go to the doctor.....Yes.....No.....

g. Other.....

PART 2 : CLINICAL EXAMINATION

The subject will be asked to perform these tests wearing a pair of short trousers which will be provided by the researcher.

1. **PHYSICAL CHARACTERISTICS:**a. **HEIGHT:**.....cm.b. **WEIGHT:**.....kg.2. **PHYSIOLOGICAL TESTS OF THE LUMBAR SPINE:**

The movement will be recorded in quarters of the visually estimated normal full range of movement. A full range of movement will be deemed so if it is achieved and overpressure is applied and the subject experiences no pain or discomfort.(According to Edeling (1991)after Maitland, 1986).

a. **Flexion**.....

"The therapist stands so the movement may be observed and guided. The patient stands with feet slightly apart, and is asked to place their fingertips on the front of their thighs and to move them down the front of their legs, but to stop at once if pain or other symptoms start or increase. If they feel no change the patient should proceed to the end of range where overpressure is applied."(Edeling,1991)

b. **Extension**.....

"The patient and therapist position themselves as for lumbar flexion. The patient is asked to bend backwards without bending their knees. Overpressure is applied by the therapist placing one hand over the patient's sacrum and the other arm across the clavicular area, or alternatively by placing one hand on each shoulder and guiding the movement with overpressure applied at the end of range."(Edeling,1991).

c. **Lateral flexion to the left**.....

"Therapist and patient still standing as for lumbar flexion, the patient is asked to slide their left hand down the lateral side of their left leg as far as possible. Overpressure is applied by placing the left hand over the patient's left shoulder and the right hand over their right shoulder."(Edeling,1991)

d. Lateral flexion to the right.....

As for lateral flexion to the left except that the patient is asked to slide their right hand down the lateral side of their right leg as far as possible.(Edeling, 1991)

e. Rotation to the left.....

"The patient sits on the couch with his arms crossed, and turns their trunk to the left. Overpressure is applied by the therapists left hand behind the patient's right shoulder and the right hand in front of the patient's left shoulder."(Edeling, 1991)

f. Rotation to the right.....

As for rotation to the left but direction and hand positions are reversed.(Edeling, 1991)

3. ABDOMINAL STRENGTH TEST:

This will be tested with the patient lying in the supine position . It will be performed according to the method prescribed in Daniels and Worthingham's Muscle Testing. Techniques of Manual Examination, 6th edition (1995) and a grade from 0-5 will be recorded according to the result of the test.

a. Rectus abdominis.....

b. Right oblique, i.e. right internal oblique and left external oblique

.....

c. Left oblique, i.e. left internal oblique and right external oblique

.....

4. QUADRICEPS STRENGTH:

The test will be performed according to the method prescribed in Daniels and Worthingham's Muscle Testing. Techniques of Manual Examination, 6th edition(1995) and a grade from 0-5 will be recorded according to the result of the test.

The subject sits with the lumbar lordosis maintained and the knees flexed over the edge of the couch. The knee is extended by the subject and resistance is applied to the anterior surface of the end of the lower leg in the direction of flexion.

Right Grade..... Left Grade.....

5. TRUNK EXTENSION STRENGTH TEST:

The test will be performed according to the method prescribed in Daniels and Worthingham's Muscle Testing. Techniques of Manual Examination, 6th edition(1995) and a grade from 0-5 will be recorded according to the result of the test.

The subject is in prone lying on the examination couch and the arms alongside the body. The subject is asked to lift their trunk up as high as they can.

Grade.....

REFERENCES

- Andersson G. 1979. Low Back Pain In Industry: Epidemiological Aspects.
SCANDINAVIAN JOURNAL OF REHABILITATION MEDICINE 11 : 163 - 168.
- Andersson G.B.J. 1981. Epidemiological Aspects On Low-Back Pain In Industry.
SPINE 6 (1) : 53 - 59.
- Andersson G.B.J, Svensson H. and Oden A.. 1983. The Intensity Of Work
Recovery In Low Back Pain. **SPINE** 8 (8) : 880 - 884.
- Bester R.C. 1996. Low Back Pain. An Overview In The Gold Mining Industry In
South Africa. **THE SOUTH AFRICAN JOURNAL OF PHYSIOTHERAPY** 52 (1) :
11 - 16.
- Biering-Sorensen F. 1983a. A Prospective Study Of Low Back Pain In A General
Population. I. Occurrence, Recurrence and Aetiology. **SCANDINAVIAN JOURNAL
OF REHABILITATION MEDICINE** 15 : 71 - 79.
- Biering-Sorensen F. 1983b. A Prospective Study Of Low Back Pain In A General
Population. II. Location, Character, Aggravating And Relieving Factors.
SCANDINAVIAN JOURNAL OF REHABILITATION MEDICINE 15 : 81 - 88.
- Biering-Sorensen F. 1984. Physical Measurements As Risk Indicators For Low
Back Trouble Over A One Year Period. **SPINE** 9 (2) : 106 - 119.

Bigos S.J. , Spengler D.M. , Martin N.A. , Zeh J. , Fisher L. , Nachemson A. and Wang M.H. 1986a. Back Injuries In Industry: A Retrospective Study. II. Injury Factors. **SPINE** 11 (3) : 246 -251.

Bigos S.J. , Spengler D.M. , Martin N.A. , Zeh J. , Fisher L. and Nachemson A.. 1986b. Back Injuries In Industry: A Retrospective Study. III. Employee Related Factors. **SPINE** 11 (3) : 252 -256.

Bohannon R. W. 1986. Manual Muscle Test Scores And Dynamometer Test Scores Of Knee Extension Strength. **ARCH PHYS MED REHABIL** 67 : 390 – 392.

Boline P. D., Keating J. C., Haas M. and Anderson A.V. 1992. Interexaminer Reliability And Discriminant Validity Of Inclinomeric Measurement Of Lumbar Rotation In Chronic Low-Back Pain Patients And Subjects Without Low-Back Pain. **SPINE** 17 (3) 335 – 338.

Cassini J.E. Robinscn M.E., O'Conner P. and Mac Millan M. 1993. Trunk Strength And Lumbar Paraspinal Muscle Activity During Isometric Exercise In Chronic Low-Back Pain Patients And Controls. **SPINE** 18 (20) : 245 -251.

Chaffin D.B. and Park K.S. 1973. A Longitudinal Study Of Low-Back Pain As Associated With Occupational Weight Lifting Factors. **AMERICAN INDUSTRIAL HYGIENE ASSOCIATION JOURNAL** December : 513 - 525.

Chaffin D.B. 1974 Human Strength Capability And Low-Back Pain. **JOURNAL OF OCCUPATIONAL MEDICINE** 16 (4) 248 - 254.

Daniels L, Worthingham C. Muscle Testing: Techniques Of Manual Examination. 4th ed. 1980. W.B. Saunders Company.

Daniels L, Worthingham C. Muscle Testing: Techniques Of Manual Examination. 6th ed. Edited by Hislop H. J. and Montgomery J. 1995. W.B. Saunders Company.

Edeling J. 1991. Manipulative Therapy. A Beginners Guide To The Maitland Method (Cervical And Lumbar Spine). Butterworth - Heinemann, Ltd.

Faas A., Chavannes A.W., Van Eijk J.T. M. And Gubbels J.W. 1993. A Randomized, Placebo-Controlled Trial Of Exercise Therapy In Patients With Acute Low Back Pain. **SPINE** 18 (11) : 1388 -1395.

Fitzgerald G.K, Wynveen K.J., Rheault W and Rothschild B. 1983. Objective Assessment with Establishment of Normal Values for Lumbar Spine Range of Motion. **PHYSICAL THERAPY** 63 (11) : 1776 – 1781.

Flicker P.L. , Fleckenstein J.L. , Ferry K. , Payne J., Ward C. , Mayer T. , Parkey R.W. and Peshock R.M. 1993. Lumbar Muscle Usage In Chronic Low Back Pain. **SPINE** 18 (5) : 582 - 586.

Florence J. M., Pandya S., King W. M., Robison J.D., Baty J., Miller P. J., Schierbecker J. and Signore L.C. 1992. Intrarater Reliability of Manual Muscle Test (Medical Research Council Scale) Grades in Duchenne's Muscular Dystrophy.

PHYSICAL THERAPY 72 (2) : 115 –122.

Frese E., Brown M, and Norton B.J. 1987. Clinical Reliability of Manual Muscle Testing. Middle Trapezius and Gluteus Medius Muscles. **PHYSICAL THERAPY** 67 (7) : 1072 –1076.

Frost H. And Klaber Moffett J. 1992. Physiotherapy Management of Chronic Low Back Pain. **PHYSIOTHERAPY** 78 (10): 751 - 754.

Frymoyer J.W. and Cats-Baril W. 1987. Predictors Of Low Back Pain Disability. **CLINICAL ORTHOPAEDICS AND RELATED RESEARCH** 221 (Aug) : 89 - 98.

Frymoyer J.W. , Pope M.H., Clements J.H. , Wilder D.G. , Mc Pherson B. and Ashikaga T. 1983. Risk Factors In Low Back Pain. An Epidemiological Survey. **THE JOURNAL OF BONE AND JOINT SURGERY** 65-A (2) : 213 - 218.

Frymoyer J.W. 1988. Back Pain And Sciatica. **NEW ENGLAND JOURNAL OF MEDICINE** 318 (5): 291- 300.

Gajdosik R.L. and Bohannon R. W. 1987 Clinical Measurement of Range of Motion. Review of Goniometry Emphasizing Reliability and Validity. **PHYSICAL THERAPY** 67 (12) : 1867 – 1872.

Gundewall B., Lileqvist B.S. and Hansson T. 1993. Primary Prevention Of Back Symptoms And Absence From Work. A Prospective Randomized Study Among Hospital Employees. **SPINE** 18 (5) : 587 - 594.

Hemborg B. and Moritz U. 1985. Intra- Abdominal Pressure And Trunk Muscle Activity During Lifting. II. Chronic Low Back Pain Patients. **SCAND J REHAB MED** 17: 5-13.

Holmstrom E., Moritz U. and Andersson M. 1992. Trunk Muscle Strength And Back Muscle Endurance In Contruction Workers With And Without Low Back Pain Disorders. **SCAND J REHAB MED** 24: 3-10.

Hutson M.A. 1993. Back Pain - Recognition and Management. Butterworth - Heinemann Ltd. P 1

Kelsey J.L. , White A.A. , Pastides H. and Bisbee G.E. 1979. The Impact Of Musculoskeletal Disorders On The Population Of The United States. **THE JOURNAL OF BONE AND JOINT SURGERY** 61-A (7) : 959 - 964.

Kelsey J .L.. , Githens P.B. , O'Conner T., Weil U., Calagero J.A., Holford, T.R., White A.A. , Walter S D., Ostfeld A.M. and Southwick W.O. 1984. Acute Prolapsed Lumbar Intervertebral Disc: An Epidemiological Study With Special Reference To Driving Automobiles And Cigarette Smoking. **SPINE** 9 : 608 -613.

Kendall F.P, Mc Creary E.K.: Muscles: Testing and Function, ed 3,1983. Baltimore MD, Williams and Wilkins.

Kennedy B. 1980. An Australian Programme for the Management of Back Problems. **PHYSIOTHERAPY** 66 (4) : 108 - 111.

Khalil T.M., Asfour S.S., Martinez L.M., Waly S.M., Rosomoff R.S. and Rosomoff H.L.1992. Stretching In The Rehabilitation Of Low Back Pain Patients. **SPINE** 17 (3) : 311 -317.

Koes B.W., Bouter L.M., Beckerman H. , Van der Heijden G.J.M.G. and Knipschild P.G. 1991. Physiotherapy Exercises And Back Pain: A Blinded Review. **BRITISH MEDICAL JOURNAL** 302 : 1572 - 1576.

Lee J., Ooi Y. and Nakamura K. 1995 Measurement Of Muscle Strength Of The Trunk And The Lower Extremities In Subjects With History Of Low Back Pain. **SPINE** 20 (18): 1994-1996.

Lehmann T.R, Spratt K.F. and Lehmann K.K. 1993. Predicting Long-Term Disability In Low Back Pain Injured Workers Presenting To A Spine Consultant. **SPINE** 18 (8): 1103-1112.

Magora A. 1972 Investigation Of The Relation Between Low Back Pain And Occupation. III. Physical requirements: Sittin , Standing and Weight lifting. **INDUSTRIAL MEDICINE** 41 : 5 - 9.

Magora A.1973. Investigation Of The Relation Between Low Back Pain And Occupation. IV. Physical Requirements : Bending, Rotation, Reaching and Sudden Maximal Effort. **SCANDINAVIAN JOURNAL OF REHABILITATION MEDICINE** 5: 186 - 190.

Manning D.P., Mitchell R.G. and Blanchfield L.P. 1984. Body Movements And Events Contributing To Accidental And Non-accidental Back Injuries **SPINE** 9 (7) : 734 - 739.

Maitland G.D.1986. Vertebral Manipulation. 5th Edition. Butterworths

Mandell P.J., Weitz E., Bernstein J.I., Lipton M.H., Morris J., Bradshaw D., Page Bodkin K. and Mattmiller B. 1993 Isokinetic Trunk Strength And Lifting Strength Measures. **SPINE** 18(16) : 2491 - 2501.

Marras W.S., Lavender S., Leurgans S.E., Rajulu S.L., Allread G., Fathallah F.A. and Ferguson S.A. 1993. The Role Of Dynamic Three Dimensional Trunk Motion In Occupationally Related Low Back Disorders. **SPINE** 18 (50 : 617 - 628.

Mc Gill C.M. 1968. Industrial Back Problems. A Control Program. **JOURNAL OF OCCUPATIONAL MEDICINE** 10 (4) : 174 - 178.

Nachemson A.L. 1981. Disc Pressure Measurements. **SPINE** 6 (1) 93 - 97.

Occhipinti E. , Colombini D. and Grieco A.. 1993. Study Of Distribution And Characteristics Of Spinal Disorders Using A Validated Questionnaire In A Group Of Male Subjects Not Exposed To Occupational Spinal Risk Factors. **SPINE** 18 (9) :1150 - 1159.

Pope M.H., Bevins T., Wilder D.G. and Frymoyer J.W. 1985. The Relationship Between Anthropometric, Postural, Muscular, And Mobility Characteristics Of Males Ages 18 - 55. **SPINE** 10 (7) : 644 - 648.

Quebec Task Force On Spinal Disorders. 1987. Magnitude Of The Problem. **SPINE** 12(Supplement) : S12 - S15.

Rondinelli R., Murphy J., Esler A., Marciano T. and Cholmakjian C. 1992. Estimation Of Normal Flexion With Surface Incliniometry. A Comparison Of Three Methods. **AM. J. PHYS. MED. REHABIL.** 71. (4) : 219 – 224.

Rothstein J. M., Lamb, R. L. and Mayhew T. P. 1987. Clinical Uses Of Isokinetic Measurements. Critical Issues. **PHYSICAL THERAPY** 67 (12) : 1840-1844.

Rowe M.L: 1969. Low Back Pain In Industry. A Position Paper. **JOURNAL OF OCCUPATIONAL MEDICINE** 11 (4) : 161 - 169.

Smidt G. and Blandpied P. 1987. Analysis Of Strength Tests And Resistive Exercises Commonly Used For Low Back Disorders. **SPINE** 12 (10) : 1025 - 1034.

Snook S.H., Campanelli R.A. and Hart J.W. 1978. A study of three preventive approaches to low back injury. **JOURNAL OF OCCUPATIONAL MEDICINE** 20 (7) 478 -481.

Spengler D.M. , Bigos S.J. , Martin N.A. , Zeh J. , Fisher L. and Nachemson A. 1986. Back Injuries In Industry: A Retrospective Study. I. Overview And Cost Analysis. **SPINE** 11 (3) : 241 -245.

Trafimow J. H., Schipplein O. D., Novak G.J. and Andersson G.B.J. 1993. The Effects of Quadriceps Fatigue on the Effect of Lifting. **SPINE** 18 (3) : 364 – 367.

Troup J.D.G, Martin J.W. and Lloyd D.C.E.F. 1981 Back Pain in Industry. A prospective Survey. **SPINE** 6 (1) : 61 –69.

Waddell G. 1987. A New Clinical Model for the Treatment of Low-Back Pain. **SPINE** 12 (7) : 632 – 644.

Wadsworth C.T., Krishnan R., Sear M., Harrold J and Nielsen D.H. 1987. Intrarater Reliability of Manual Muscle Testing and Hand-held Dynamometric Muscle Testing. **PHYSICAL THERAPY** 67 (9) : 1342 –1347.

Zwerling C., Ryan J. and Schootman M. 1993. A Case Control Study Of Risk Factors For Industrial Low Back Injury. The Utility Of Pre-Placement Screening In Defining High-Risk Groups. **SPINE** 18 (9) : 1242 - 1247.

Corrections Made To The Research Report

Title: An Investigation Into Factors Predisposing To Low Back Pain In Workers In A Motor Vehicle Parts Distribution Centre

Candidate: Patricia Joan Wallner

The report from the examiner was most useful to me and I thank him/her for the constructive manner in which the criticism was levelled. I hope that in the revision of this project the criticism has been addressed and meets with approval.

In accordance with the comments, I have altered the layout of the project substantially in order to present it in a more manageable fashion. The correction notes that follow relate page numbers to the **first submission**.

Abstract

Wording altered to exclude the presence of a lumbosacral lordosis and strength of quadriceps muscles as factors associated with LBP.

Table of contents

Altered to reflect changes made to the body of the report. Exact changes are reflected in each section below.

List of tables

Altered to reflect changes made to the body of the report. Exact changes are reflected in each section below.

Abbreviations

List of abbreviations used in the report is given.

1.0 Introduction

- Corrections made to the section in accordance with the suggestions made by one of the examiners on Page 1 and 2.

2.0 Literature Review

- An attempt has been made to show that critical analyses of studies and data presented have been made by making changes to the main body of the text.
- General outline of what is attempted in the literature review is provided in accordance with the examiner's suggestion on Page 3.
- The use of words that pass value judgements, e.g. LBP sufferers have been replaced e.g. subjects who experience LBP.
- All of the examiner's comments and suggestions annotated in the text in the original submission have been addressed. They are too numerous to mention page by page. Extensive changes are listed below.
- Page 4, Study by Balague, et al. (1993) has been removed as it is not relevant.
- Page 10, Paragraph relating to the study by Troup, et al. (1981) and the Table 2.1 has been excluded as it leads to confusion.
- Page 14, Paragraph referring to motor vehicle operators has been removed.
- Page 19, Sections on vibration and slipping and falling accidents have been removed to decrease the variables discussed in an attempt to keep the review specific to the study itself.
- Page 24, Section relating to cigarette smoking has been removed for the same reason.

- Page 28, The section related to muscle strength has been completely rewritten. An attempt has been made to review the literature more critically and to avoid the use of poor studies and to include more studies relating to the reliability of measurement. Additional literature has been included; Hemborg and Moritz, (1985), Holmstrom, et al. (1992), Wadsworth, et al. (1987), Bohannon (1986), Frese, et al. (1987), Lee, et al. (1995) and Rothstein, et al. (1982). The following studies were excluded; Frymoyer and Cats-Baril(1987), Pope, et al. (1985), Nouwen, et al. (1987), Smidt, et al. (1983), Flicker, et al. (1993), Cassisi, et al. (1993), Jull, et al. (1993) and Salminen, et al. (1992).
- Page 32, The section on spinal mobility has been rewritten in order to critically review the literature and include more studies relating to the reliability of measurement. The following studies were included: Rondinelli, et al. (1992) and Boline, et al. (1992). Salminen, et al. (1992) was excluded.
- Page 33, The sections relating to flexibility other than the spine, neurological signs and physical fitness have been removed to streamline the review.
- Page 37, The section relating to pre-employment screening has been removed.
- Page 37, The section relating to treatment has been altered to include a review by Wadell, (1987) and to exclude the following studies: Richardson, et al. (1990), Richardson, et al. (1992), Norris (1995b) and Risch, et al. (1993).
- Page 41, The section relating to prevention has been altered to add a study by Trafimow, et al. (1993) and to exclude Norris (1995a) and Jayson (1992).

3.0 Method

- Annotated suggestions made by the examiner have been addressed in the text.
- Group X and Y have been renamed to Group 1 and 2 to avoid confusion between groups A and B.
- Page 48, Revised the section 3.2 Procedure to read more easily.
- A flow chart has been included to clarify the procedure, section 3.2.
- Page 50, Section 3.3 Statistical analysis : Specified the statistical test used on each variable.
- All tests used in the clinical examination are clearly defined and described in appendix D at the back of the report.

4.0 Results

- Decreased the presentation of the number of examined variables in order to make the report more manageable as suggested by the examiner. The following have been excluded:

Marital status, page 54

Hand Dominance, page 54

Travelling time, page 54

Smoking, page 55

Previous similar working experience, page 56

Complaint of previous back pain, page 57

Participation in regular sport, page 59

Words used to describe the pain, page 60

Reported pain according to the visual analogue scale, page 61

Scoliosis and lordosis, page 62

Toe touch test, page 64

Flexibility of gastrocnemius, soleus and hamstring muscles, page 65

True leg length test, page 66

- The issue of the reliability of the tests used is addressed in 5.0 Discussion.
- Each variable is defined in the body of this text and is also referenced in the appendix D.
- All statistics checked and corrected if necessary. The range is included, if applicable, as suggested by the examiner.
- Each statistical test is named and explained as to the necessity of its use as suggested by the examiner.
- *Ambiguous statements corrected.*

5.0 Discussion

- Page 72, more theoretical argument is given to back up the significant finding of the higher prevalence of reported pain in area 5 of the working area.
- Various sections have been excluded in accordance with the exclusion of the variables in 4.0 Results chapter, i.e.
 - Page 73, Travelling time, Cigarette smoking
 - Page 79, Leisure activities
 - Page 82, Lumbosacral postural characteristics
 - Page 83, Lower limb muscle flexibility
 - Page 84, True leg length
- Range of lumbar movement section 5.3.2 has been altered to include a discussion on the reliability issue of the test and the reason for its use.

- Abdominal muscle strength section 5.3.3 has been altered to include a discussion on the reliability issue of the test and the reason for its use.

6.0 Conclusion

- The following have been removed as factors associated with low back pain;
 - The presence of a lumbosacral lordosis and
 - a decrease in the strength of the quadriceps muscles.

Appendix A and B

- These remain unchanged.

Appendix C

- This appendix has been amended to reflect only the items that have been discussed in the main body of the project. The following have been excluded;
 - Page 93, Number 4, relating to travelling time.
 - Page 93, Number 5, relating to smoking
 - Page 93, Number 6, relating to handedness
 - Page 98, Number 15, relating to description of pain
 - Page 100, Number 19, relating to the behaviour of the pain
 - Page 100, Number 20, relating to the intensity of the pain.

Appendix D

- This appendix has been amended to clarify that the tests used in the case of the assessment of spinal mobility are according to the Maitland (1986) concept

as described by Edeling(1991). The muscle strength assessment is in accordance with the Daniels and Worthingham's Muscle Testing (1995).

- The following tests which are not discussed have been removed from the appendix;
 - Page 104, Observation
 - Page 105, Toe Touch Test
 - Page 106, Gastrocnemius Stretch
 - Page 107, True Leg Length
 - Page 107, Hamstrings Tightness
 - Page 107, Soleus Stretch

References

These have been amended to reflect the literature reviewed and used in the body of the text.

Author Wallner P J

Name of thesis An Investigation Into Factors Predisposing To Low Back Pain In Workers In A Motor Vehicle Parts Distribution Centre Wallner P J 1998

PUBLISHER:

University of the Witwatersrand, Johannesburg

©2013

LEGAL NOTICES:

Copyright Notice: All materials on the University of the Witwatersrand, Johannesburg Library website are protected by South African copyright law and may not be distributed, transmitted, displayed, or otherwise published in any format, without the prior written permission of the copyright owner.

Disclaimer and Terms of Use: Provided that you maintain all copyright and other notices contained therein, you may download material (one machine readable copy and one print copy per page) for your personal and/or educational non-commercial use only.

The University of the Witwatersrand, Johannesburg, is not responsible for any errors or omissions and excludes any and all liability for any errors in or omissions from the information on the Library website.